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Obsah

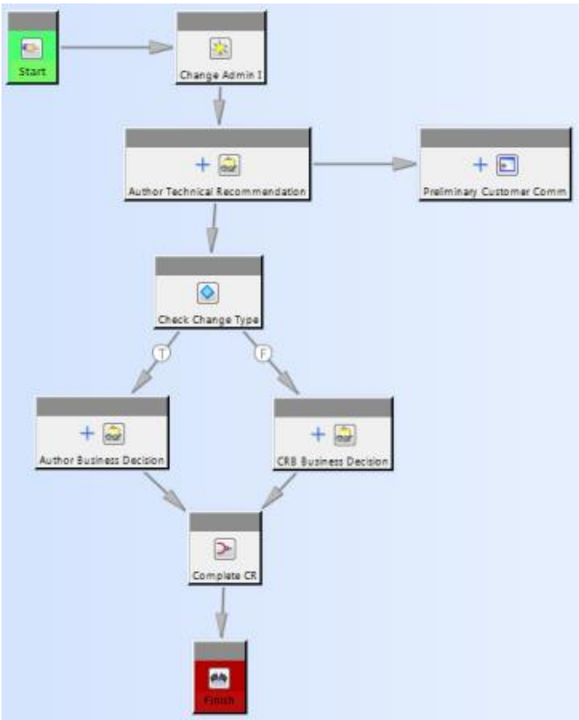
INTEGRÁCIA OBCHODNÝCH PROCESOV DO PLM RIEŠENÍ

Jozef TROJAN – Miriam PEKARČÍKOVÁ– Marek KLIMENT – Ján KOPEC

Abstrakt: Predkladaný článok poukazuje na to, že firemné procesy sú dôležitou súčasťou PLM riešení. Jedine PLM zahŕňa všetky potrebné nástroje, ktoré slúžia firmám na udržanie ich štandardov a pravidiel komunikácie. Popísaním priebehu najkomplexnejšieho a najzložitejšieho procesu v spoločnostiach, teda zmenového riadenia, poukážeme na dôležitosť PLM nástrojov v riadení spoločností. Rovnako sa v tomto článku dozviete ako je nevyhnutná vzájomná spolupráca medzi priemyslami, integrácia s ostatnými aplikáciami ako MS Office, CAD, CAE, CAM a prepojenie s informačnými systémami.
Keywords: Workflow, PLM, Zmenové riadenie, integrácia

Úvod

Firemné procesy predstavujú súbor procesov tzv. Workflow, ktoré sprevádzajú tvorbu a návrh produktu od konceptu až po ukončenie jeho životnosti. Tieto procesy sú veľmi špecifické podľa povahy spoločnosti a druhu produktov. Typickými predstaviteľmi týchto procesov sú napr. Schvaľovacie procesy v rámci spoločnosti, kde je dokument, výrobnej dokumentácie či iná informácia predmetom posúdenia, schvaľovanie, autorizácie jednou alebo viacerými osobami (Obr.1).



Obr. 1 Príklad Workflow

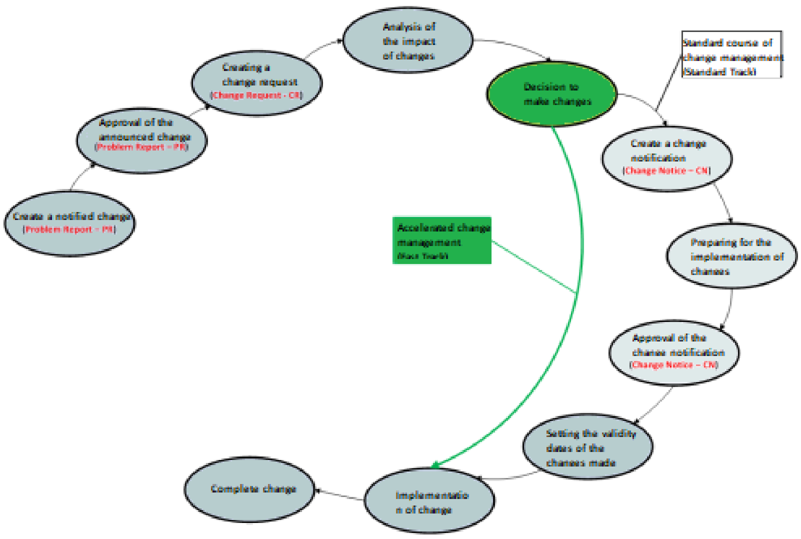
Firemné procesy sú súčasťou PLM riešení, pretože jedine PLM ponúka všetky potrebné nástroje na udržanie firemných štandardov a pravidiel komunikácie medzi jednotlivými útvarmi či celými spoločnosťami v korporátnom usporiadaní. Akonáhle sú všetky firemné procesy súvisiace s vývojom a správou výrobných dát a informácií prevedené do elektronickej podoby, je potom už jednoduché pomocou užívateľských a skupinových oprávnení a rolí udržať priebeh všetkých procesov podľa jednotných pravidiel, ktoré nemožno obísť tak ako v prípade neexistencie PLM riešení. Existujúce firemné smernice alebo unifikované postupy sú v priebehu zavádzania PLM riešenia optimalizované pre čo najefektívnejší priebeh aj s ohľadom na možné zaniknutie niektorých existujúcich pracovných pozícií.

Zmenové riadenie

Zmenové konanie je najkomplexnejším a teda najzložitejším procesom v spoločnostiach a to z dôvodu, že jeho inicializácia a koordinácia je ovplyvňovaná mnohými faktormi po celú dobu priebehu zmenového riadenia. Zmenové riadenie prechádza naprieč celou spoločnosťou, a je teda pre jeho správny priebeh absolútne nevyhnutne potrebná rola koordinátora či administrátora zmenové konania.

Zmenové konanie v PLM riešení spravidla nasleduje metodiku CMII, ktorá je uznávaná za medzinárodný štandard. Zmena môže byť inicializovaná zákazníkom, inovácií v rámci spoločnosti, chybou v dokumentácii a pod. Môže byť jednoduchá, týkajúce sa len jednej súčasti / položky, ale aj pri vysokom stupni unifikácie aj jednoduchá zmena môže vyvolať zložitý proces, pretože položka môže vstupovať do viacerých finálnych produktov s rôznou priebežnou dobou výroby, rôznou sériovosťou a podobne. Zmena ale môže byť tiež veľmi komplexne, zasahujúca až do definície výrobných prostriedkov. Z týchto dôvodov je potrebné rozlišovať viac stupňov zmenového riadenia. Inicializáciu zmeny reprezentuje ohlásenia zmeny (Problem Report - PR), nasledované požiadavkou na zmenu (Change Request - CR) s už návrhom konkrétneho riešenia, toto je potom pomocou zmenového oznámenia (Change Notice - CN) rozposlané zodpovedným útvarom na posúdenie. Je potrebné posúdiť všetky vplyvy zmeny a vyhodnotiť jej realizáciu aj vzhľadom na vzniknuté náklady. Tu práve sa prejaví sila PLM riešenie, pretože s jeho pomocou možno veľmi efektívne a v krátkom čase zistiť všetky dopady, čo všetko zmena ovplyvňuje, a tak možno pomerne veľmi presne odhadnúť náklady na realizáciu zmeny.

Zmenové riadenie PLM býva veľmi často prepojené so zmenovým riadením v podnikovom informačnom systéme a je tu potrebnosťou vzájomnej koordinácie. Vďaka charakteristickej vlastnosti PLM procesov, teda možnosti distribúcie dát v priebehu zmenového riadenia osobám, ktoré sú jeho účastníkmi tak odpadá potrebnosť dohľadávania informácií pre všetkých zúčastnených a tu sa naplno prejavia schopnosti procesov v podaní PLM riešení (Obr.2).



Obr. 2 Priebeh zmenového riadenia

Vzájomná spolupráca

V dnešnej dobe, keď sú spoločnosti nútené neustále znižovať výrobné aj vývojové náklady pre udržanie konkurencieschopnosti, často stoja podniky pred rozhodnutím, ktoré diely pre svoje produkty vyrábať a ktoré naopak nakupovať s ohľadom na svoju výrobnú technológiu. Preto existujú dodávateľské reťazce, spolupráca s externými partnermi, kooperácia. Ďalej je tiež časté medzinárodné korporátne usporiadanie spoločností. Všetky tieto formy spolupráce vyžadujú zdieľanie informácií.

Spoločnosti bez PLM riešení túto spoluprácu riešia predovšetkým emailovú komunikácií, offline výmenou dát, často aj v papierovej podobe, potrebným osobným jednaním pod. Tieto formy spolupráce často vedú k neskorej distribúcií informácií, mnohokrát aj neaktuálnych dát, čo vo svojom dôsledku môže viesť k finančným stratám, neskorým dodávkam tovaru atď.

V prípade existencie PLM riešenia existujú nástroje, ktoré priamo riešia vyššie uvedené problémy s riadenou distribúciou potrebnej dokumentácie. Vďaka webovým technológiám a napríklad už tu spomínanej 4-vrstvovej architektúre PLM riešení, už nie je problémom umožniť externým partnerom prístup do firemnej infraštruktúry, a teda aj dátam, spravovaným PLM riešením.

Samozrejme je tu potrebné rozlišovať úroveň prístupu podľa významu a úlohy partnera. Rozsahom a úrovňou oprávnenia možno priamo riadiť možnosti prístupu, tak aby sa zabránilo úniku firemného know-how, ale zároveň externí používatelia sa dostali k požadovaným informáciám (Obr.3).

Tento prístup môže vyžadovať priamo existenciu klienta PLM riešenia na strane externého partnera, alebo len prístup na webový portál, kde sú nazdieľané potrebné dáta.

Príkladom tejto vzájomnej spolupráce je typicky automobilový a letecký priemysel, ktorý zadáva týmto spôsobom nielen výrobu dielov, ale často tiež aj vývoj samotného dielu na základe špecifikácií a zostavných modelov.

Obr. 3 Vzájomná spolupráca pri zdieľaní informácií a dát

Integrácia s MS Office produktami

S ohľadom na rozšírenosť a použitie kancelárskych softvérových balíkov Microsoft Office v spoločnostiach logicky vzniká potreba nielen vedieť spravovať dáta získané v týchto kancelárskych aplikáciách - ako je Microsoft Word, Excel, PowerPoint a ostatné, ale tiež umožniť užívateľovi priamu integráciu týchto produktov / softvér s PLM riešením, a teda bez potrebnosti spusteného klienta PLM riešenia jednoducho vytvárať, ukladať a editovať dokumenty vyššie uvedených aplikácií prostredníctvom rozšíreného menu samotných aplikácií.

Potom možno teda priamo tieto aplikácie použiť ako zdrojové a už od okamihu vzniku dokumentu je tento spravovaný PLM riešením bez potrebnosti importu dát a pod.
V závislosti od stupňa integrácie týchto produktov možno napríklad prepojiť poštového klienta s riešením PLM a obdržané úlohy v rámci PLM riešenia, ktoré môžu užívatelia prostredníctvom firemných procesov dostávať možno potom priamo spravovať a podieľať sa na týchto procesoch priamo s prostredím poštového klienta MS Outlook.

CAD Integrácia

Ak jadrom každého PLM riešenia je správa životného cyklu produktov, potom CAD integrácia je nevyhnutne potrebnou súčasťou týchto PLM riešení, pretože bez tejto by nebolo možné technickú dokumentáciu produktov a to ako 2D, tak i 3D dokumentáciu spravovať a riadiť. Spravidla každá integrácia / rozhranie má nasledujúce základné funkcionality pre spoluprácu s PLM riešením:

- Ukladanie a správa dát.
- Tvorba a správa kusovníkov.
- Vytváranie verzií dokumentácie.
- Vyhľadávanie existujúcich dát.

Väčšina PLM riešení podporuje viac CAD systémov a rieši ich integráciu a správu dát. Máloktoré PLM riešenie je ale schopné spravovať dáta získané z rôznych CAD systémov - Multi-CAD prostredí. Táto schopnosť v poslednej dobe hrá čoraz dôležitejšiu úlohu pri výbere vhodného PLM riešenia pre spoločnosť. Tento fakt je spôsobený potrebnosťou zdieľania a výmeny dát medzi spoločnosťami z dôvodu spolupráce, kooperácie a podobne. Často sa jedná o výmenu dát medzi rôznymi CAD systémami, a preto je tu potrebná schopnosť PLM riešenie spravovať dáta z rôznych CAD systémov v jednotnom prostredí tak, aby užívateľ nebol zaťažený potrebnosťou konverzie do univerzálnych formátov, ako sú napr. STEP, IGES.

CAE Integrácia

Stále častejšie hrá väčšiu úlohu virtuálna/digitálna validácia produktu vo forme simulácie správaní produktu pod zaťažením, typickým pre jeho aplikáciu a použitie. Nasadenie týchto systémov môže zásadne šetriť náklady na stavbu a testovanie fyzických prototypov. Ide o softvérové nástroje metódy konečných prvkov FEM / MKP, ktoré ako zdroj údajov využívajú 3D dáta konštrukčných systémov.
S použitím PLM pre správu CAD dát sa teda ponúka využitie PLM riešenia aj pre tieto FEM dáta s ohľadom na zabezpečenie konzistencie a platnosti obsahu týchto dát. Pri použití PLM pre správu ako CAD, tak i FEM dát je zabezpečené, že je vždy použitá správna a aktuálna geometria pre definíciu výpočtového modelu a akákoľvek zmena na zdrojovú geometriu, spravovanú vývojom/konštrukcií sa takisto vzápätí prejaví aj vo výpočtovom modely. Táto skutočnosť teda môže zásadne šetriť náklady spoločnosti s ohľadom na trvanie výpočtov, ktoré prebiehajú u zložitých úloh aj niekoľko dní. V PLM možno potom ukladať výsledky týchto analýz v neutrálnych formátoch, tak aby boli dostupné bez potrebnosti použitia špeciálneho a veľmi drahého software pre všetkých užívateľov PLM, ktorí s týmito dátami musia pracovať.

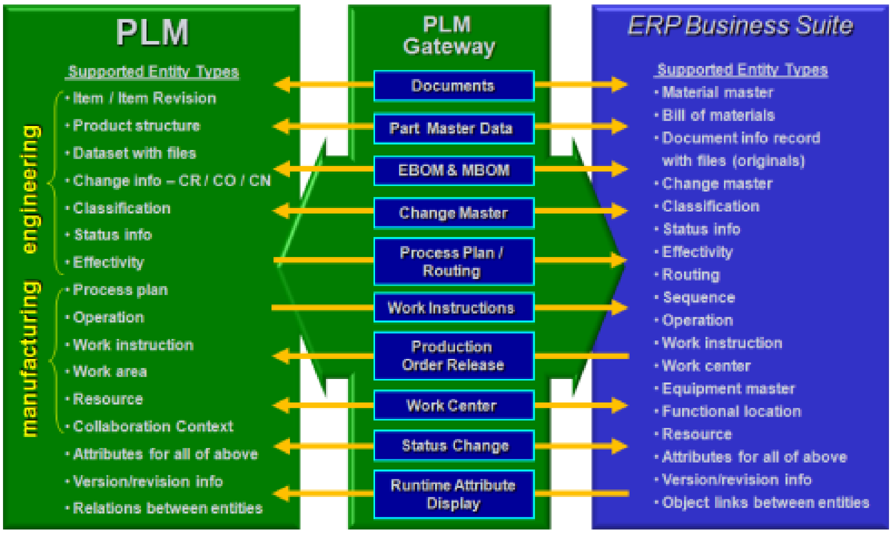
CAM Integrácia

CAM systémy, rovnako tak ako CAE systémy využívajú pre existujúce 3D dáta pochádzajúce z konštrukcie pre následné spracovanie technológie obrábania, kde výsledkom je NC kód pre jeden alebo viacero obrábacích strojov. Dôvod pre využitie PLM riešenia pre riadenie a správu aj týchto CAM dát je rovnaký ako v prípade CAE. Ide opäť o aktuálnosť a konzistenciu zdrojových dát v rámci jednotného prostredia PLM.

Niektoré CAM riešenia v spolupráci s PLM riešením umožňujú distribúciu vygenerovaného NC kódu pre príslušnú operáciu alebo sled operácií priamo do obrábacieho stroja. Tieto definície CAM obrábania často využívajú tiež jednotné zdroje výrobných prostriedkov v rámci PLM riešenia ako sú stroje, prípravky, obrábacie nástroje, ich držiaky a pod. Výhodou tohto riešenia je, že ak existujú CAM dáta pre výrobu dielca, potom tieto dáta môžu byť automaticky uložené ako technologický postup vrátane všetkých výrobných operácií s definíciou všetkých potrebných výrobných prostriedkov. Táto funkcionalita môže výrazne zefektívniť prácu technologických oddelení.
Vyššie uvedené funkcionality integráciou všetkých CAD / CAE / CAM hrajú významnú úlohu v produktivite práce jednotlivých útvarov výrobných spoločností. Preto sa PLM riešenia čoraz viac presadzujú nielen vo vývojových oddeleniach firiem pre správu konštrukčných dát, ale taktiež v ostatných útvaroch spoločností.

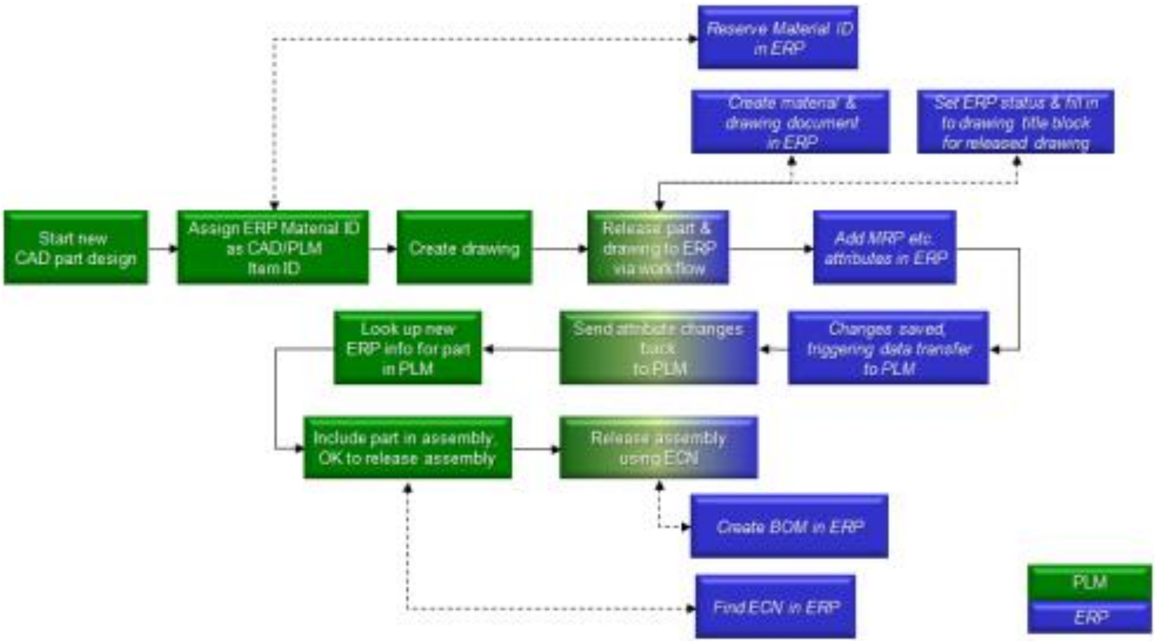
Prepojenie s informačnými systémami

Ak hlavnou úlohou PLM riešenia sú inovácie a vývoj produktov, sledovanie a riadenie informácií a konfigurácií produktov po celú dobu ich životného cyklu, správa výrobných procesov, spolupráca medzi inžinierskymi útvarmi, potom teda môžeme povedať, že PLM je dátovo riadené.
Na rozdiel od podnikových informačných systémov, ktoré spravujú financie, zákazky, procesy výrobných objednávok, plánovania výroby, logistiku a skladové hospodárstvo, tu teda môžeme povedať, že informačné systémy sú transakčne riadené.
PLM a ERP hrajú rôzne, vzájomne sa doplňujúce úlohy v inovácii produktov a ich prevedení, a preto ich vzájomná integrácia pomáha spoločnostiam byť viac efektívnymi vo svojich činnostiach spojených s vývojom a správou výrobného portfólia produktov.
Príkladom tejto spolupráce je obrázok 4, kde môžeme vidieť vzájomné zdieľanie informácií o štruktúre produktov, položkách, zmenách, výrobných informáciách, technologických postupoch a pod.
Táto integrácia musí byť zákonite parametrická, aby bolo možné prepojiť rôzne dátové modely databáz PLM a ERP a tak umožniť zdieľanie sledovaných atribútov vrátane možnosti definície, ktorý systém je pre ktorý atribút riadiaci a ktorý len zdieľa informáciu.



Obr. 4 Rozhranie medzi dátovými modelmi PLM a ERP

Na ďalšom obrázku 5 je uvedený príklad typického procesu vývoja produktu a vzniku dokumentácie. Tento proces je inicializovaný v PLM, avšak ide naprieč celou spoločnosťou, teda nevyhnutne zasahuje aj do oblasti ERP, kde zodpovedné útvary doplnia informácie a riadený procesu, ktorý sa postará o distribúciu týchto informácií do oboch systémov.
Informácie medzi oboma riešeniami možno vymieňať ako offline, tak aj online prostredníctvom programového rozhrania/gateway. Pretože každá spoločnosť je špecifická svojimi internými procesmi, svojou organizáciou, nemožno tieto rozhrania zovšeobecniť a iba použiť podľa zvoleného informačného systému, ale je potrebné ich minimálne konfigurovať, ale mnohokrát tiež aj programovo upraviť tak, aby sa dosiahla vytúžená forma spolupráce s PLM. Tieto programové úpravy a konfigurácia bývajú spravidla najťažšie častí implementácie PLM riešení.



Obr. 5 Príklad vývojového procesu

Záver

Ako vidíme firemné procesy musia byť súčasťou PLM spektra, pretože v dnešnej dobe procesy spoločností, ktoré nie sú integrované do PLM, sú často zdĺhavejšie, chybovejšie a hlavne nákladnejšie. Rovnako dôležitou súčasťou je aj vzájomná spolupráca medzi jednotlivými segmentami trhu, ako aj integrácia s ďalšími existujúcimi aplikáciami, ktoré procesy ešte viac urýchľujú a tým spoločnosti tvoria zisk a konkurenčnú výhodu.

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CREATING A DIGITAL ENTERPRISE PROJECT USING PLM SOFTWARE

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Abstract: The aim of this paper is to show the need for the improvement of the production processes, using digital models and simulations of the production processes, and the creation of 3D production halls. This paper shows the importance of the PLM software in the process of improvement. The content of this paper includes the PLM software and their capabilities, the description of the production process, and its improvements. In the conclusion of this paper, the layout and a simulation can be found, which make the modernized production hall and more effective production process possible.
Keywords: PLM, PLM software resources, Tecnomatix Plant Simulation, simulation, optimization

Introduction

In the 21st century, there is an increasing challenge every day to keep the business competitive. Businesses are modernizing, doing the work that robots do because they are more accurate and reliable than staff. If a company wants to create a product that will have the most valuable features for customers, PLM must have a higher level of software resources. It is important to know what product it will produce, what properties it will have, what machines are used in the production process.
The advantage of using PLM in the production process is mainly clarity. In order for the company to be better and better manufactured, it is forced to know information about the processes that are performed on individual machines. If he knows this data, it is possible to optimize it. PLM includes all conventional production processes, so it is possible to monitor and improve the same part of production outside of it [1] [2].

Definition of PLM

Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company’s products all the way across their lifecycles; from the very first idea for a product all the way through until it is retired and disposed of. PLM is the management system for the company’s products. It doesn’t just manage one of a company’s products. It manages, in an integrated way, all of a company’s parts and products, and the product portfolio. It manages the whole range, from individual part through individual product to the entire portfolio of products.
PLM is focused on “the product”. It addresses the heart of the company, its defining resource, the source of its wealth, its products. That’s the role of PLM, which is why PLM is so important. Products define a company. The company’s products are what the customer buys. They are the source of a company’s revenues. Without its products, a company wouldn’t be the same. There’s little in a company more important than its products, and the way that they’re developed and used. Without those products, there will be no customers and no revenues. As Fig. 1. shows, the product is at the heart of the PLM environment [3].

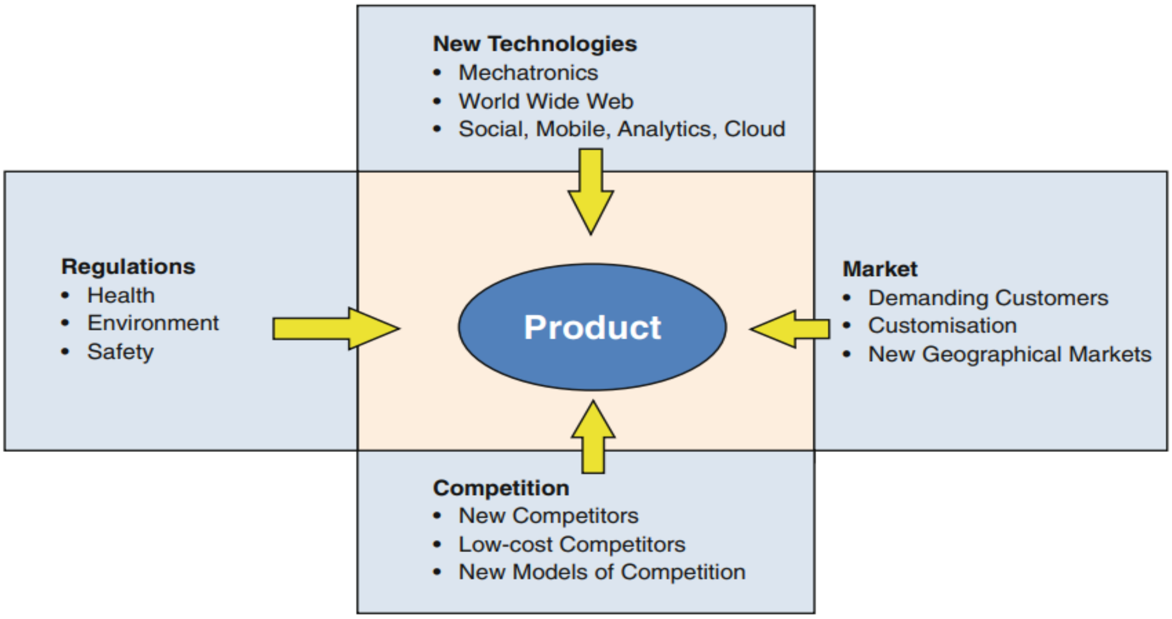

Fig.1 The product is the main goal of PLM [1]

Software of PLM

PLM software manages the product lifecycle, increasing productivity, increasing product quality, improving product quality, accelerating the entire process, increasing revenue, and centralizing data management.

There are many PLM software providers on the market. Every business needs to consider what criteria their PLM software should meet, whether it's price, compatibility with other software tools already in use, software application, software capabilities, degree of enterprise coverage, and ultimately data collection and reuse. when introducing new products into the production process.

The best PLM software includes:

- Autodesk Vault,
- Autodesk Fusion Lifecycle PLM,
- Tecnomatix Plant Simulation a Process Simulate,
- Aras PLM,
- Arena PLM,
- SAP PLM,
- PTC PLM ,
- Upchain PLM [4]

Tecnomatix Plant Simulation a Process Simulate

Tecnomatix Plant Simulation and Tecnomatix Process Simulate are part of Siemens' portfolio. Tecnomatix itself offers a wide range of production solutions on a digital basis, thanks to the functional connection of production activities with product management.

Plant Simulation offers companies simulation, visualization, analysis and optimization of production systems and logistics processes. This software enables material flow optimization, efficient use of resources, logistics for all levels of the production plant and analysis of the entire plant or just individual machines in the production line. The digital model of the production line is based on the real state, and this allows users to make changes in production without any physical intervention in the production process. It is possible to make changes to the digital model and thus optimize production, e.g. time load of production, use of material, wear of tools, personnel requirements for production [5].

Tecnomatix Process Simulate is a digital production solution for verifying the correctness of the production process in a 3D environment. This software is very effective because it enables rapid time-to-market by allowing production organizations to pre-test production concepts. The ability to use 3D product and resource data provides virtual control, optimization and final commissioning [5].

Creating a digital twin and increasing production efficiency

I chose Autodesk Inventor to create a digital twin. Because due to COVID -19, I didn't have access to other creation options. It would be easier to use a scanner and scan the necessary equipment. To increase production, I chose the production of saw blades with cutting inserts.
The production process includes the following machinery:

- laser cutter,
- grooving machine,
- rolling mill,
- polisher,
- oven,
- control device,
- robot,
- welding machine,
- sandblaster,
- grinder,
- control computer,
- laser.

Production machines are also a part of the digital version of the production hall. I modeled the machines in Autodesk Inventor Professional. If the models are in the correct format that Tecnomatix Plant Simulation can recognize, it is possible to insert the models into a digital model. On the toolbar, select the Edit option and then the Import Graphics icon. Clicking on the icon will display the supported 3D model formats. After selecting a specific model, the model is transferred to the digital form of the production hall.

The digital model of the company (Fig.2) consists of a floor, walls, an entrance gate for the import of material needed for production as well as a gate intended for the export of products, entrance doors for company personnel, shelves for clear storage of manufactured products, resp. semi-finished products, changing rooms for company workers, workbenches and production facilities on which the production process takes place. The raised floor serves as office space with stored technical documentation. It is also used to monitor the production process.

Figure 2 3D model of a digital factory

In Fig. 3 is a digital image of a laser cutting workplace. There are 2 employees working at this workplace. And Figure 4 shows a digital model of the oven. Reinforced discs leave this workplace for further processing. Once they are sufficiently reinforced, the furnace is opened, and the reinforced discs are moved for further machining by means of a high-lift trolley.

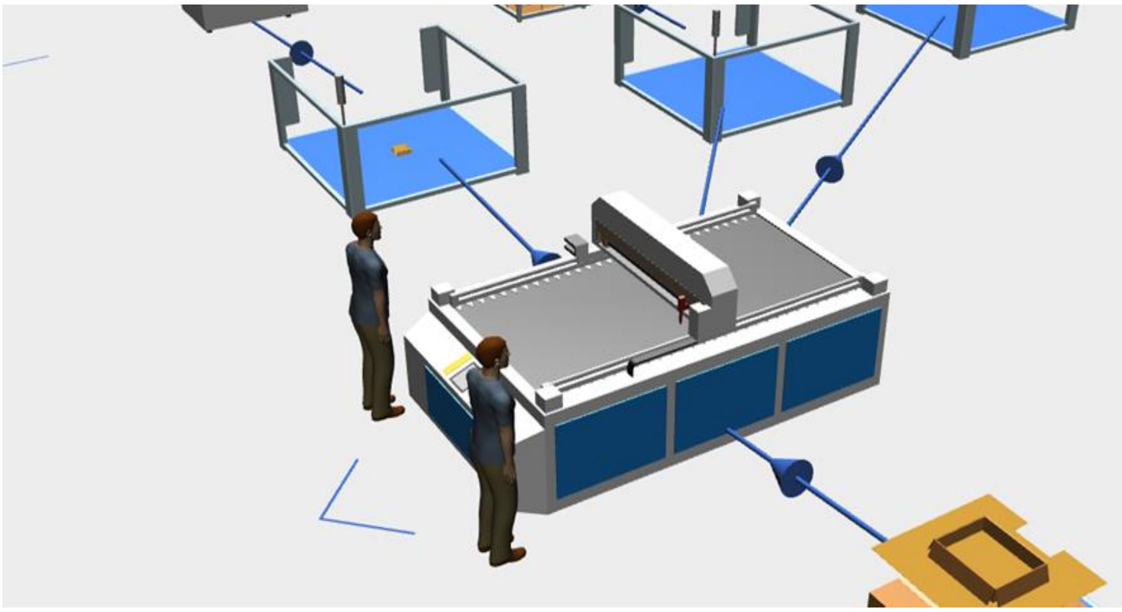

Figure 3 Laser cutter

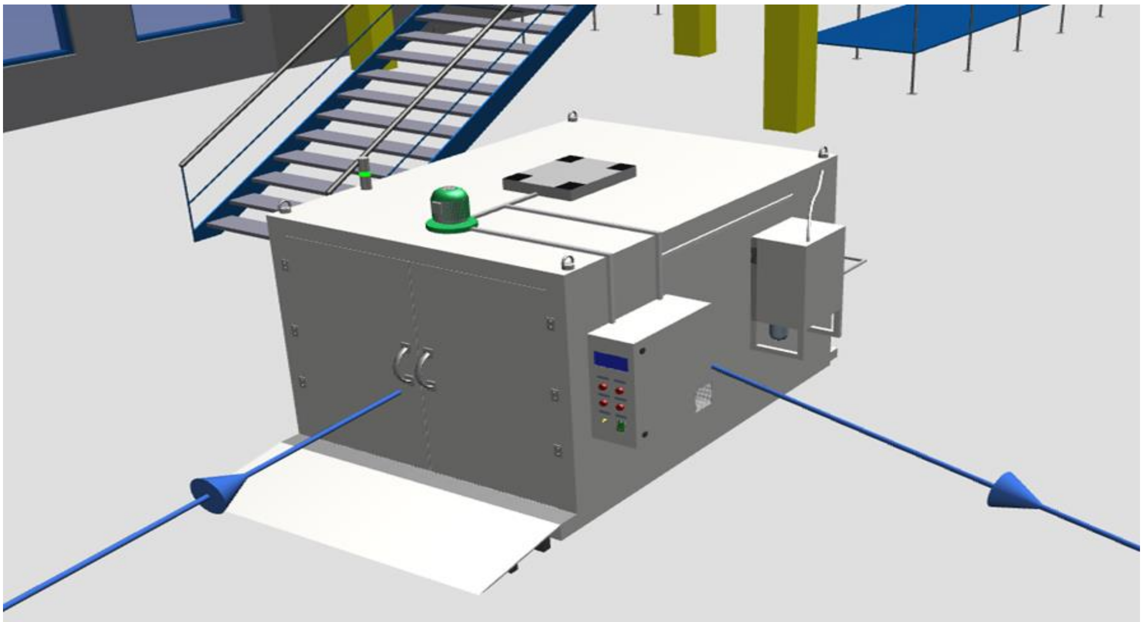

Figure 4 Oven

In Fig. 5 shows the original 2D digital model I created in Tecnomatix Plant Simulation. This 2D model represents the real distribution of production machines, staffing at given production workplaces, time schedule of individual production operations, inputs of materials and components into the production process, as well as outputs of finished products. This 2D model also shows the paths used by workers on arrival and departure from production machines. Tecnomatix Plant Simulation could insert entities into the production process. Entities are components that participate in the completion of the product, respectively. on disassembly of the whole into individual parts. In the case of this production hall, I used exclusively the entities that entered the production and participated in the completion of the product.

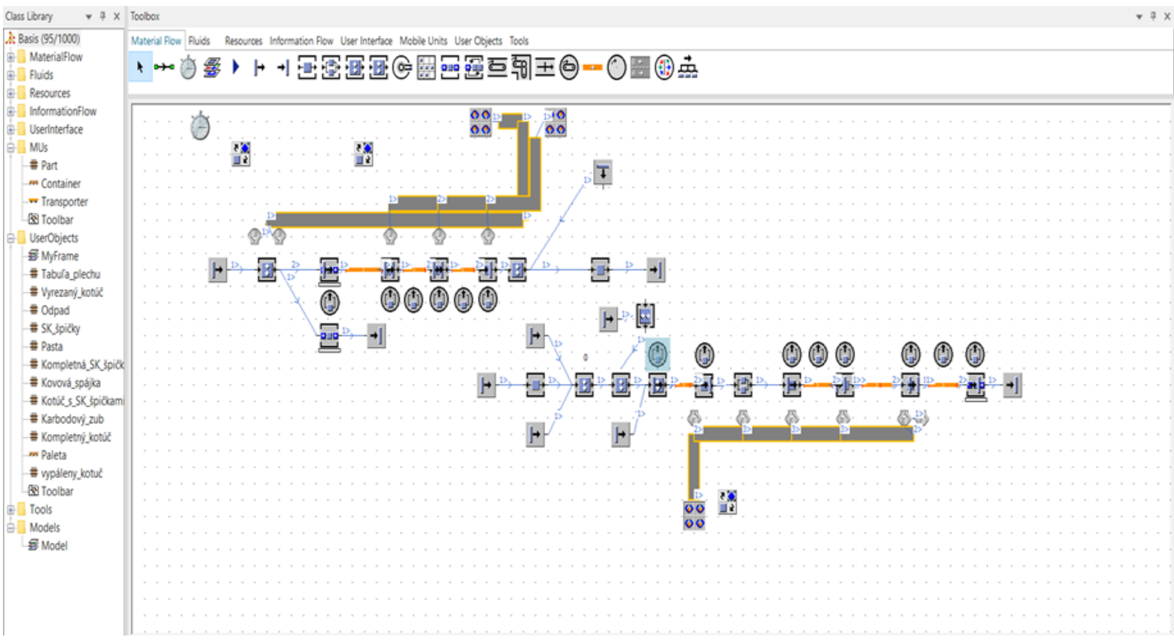

Figure 5 2D digital model

Conclusion

The digitization of the workplace brings many resulting improvements for the production process. It is easier to create the form of a digital twin and then test the accuracy of the data and thus introduce the best option and thus avoid unnecessary mistakes, because they cost money. Tecnomatix Plant Simulation is a quality program with many benefits for the user. Ultimately, such a process can be applied throughout the life of the environment. I believe that the creation of a digital model has helped the company decide how to transform production to produce the greatest possible profits.

Acknowledgements

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INCREASE IN PRODUCTION IN THE COMPANY USING PLM SYSTEMS

Jozef TROJAN – Peter TREBUŇA– Marek MIZERÁK – Štefan KRÁL

Abstract: The subject of this article is the assembly line design using the Process Simulate software of Siemens Tecnomatix. Using the module Process Simulate, which is widely used, production on a given assembly line can be streamlined. The assembly line analyzed was designed and innovated using the software module mentioned above. With this software package it is possible to detect deficiencies or downtime in existing production. Further, verification of the proposed solutions is possible by modeling the selected workplace simulation and confirming time savings or other modifications leading to production optimization.
Keywords: Process Simulate, Simulation, Efficiency, Innovation

Introduction

PLM is an abbreviation of the English term Product Lifecycle Management, which refers to the process of managing the complete lifecycle of a product, from its first concept, through detailed design, manufacturing and after-sales service to disposal.
Sometimes the term is mistakenly understood only as so-called PDM software, which is used in the sub-phases of the PLM process for managing engineering design data and communication between designers. While Product Lifecycle Management, in addition to the necessary computer applications, includes standardized workflows, business systems, key data as well as appropriately trained staff. Such a complex entity can be used as a core system of a manufacturing enterprise or any other company, and its business results in a physical product.
The definition of PLM, as a software solution, includes a smooth collaborative infrastructure of computer applications used to work with product data throughout its "life", its "conception" being understood as recording the first idea of the form or function of a product in that system. As such, the PLM system covers all product data management and electronic communications between all stakeholders, including customers (CRM), all necessary resources (ERP) and the supply chain.

Creating 3D models using SolidWorks software

After opening the SolidWorks software and then creating a new project, we will draw the desired shape in the selected plane in Sketch. We need to pull the given shape of the part or machine into the space, so we leave Sketch on, switch to the Features option, which can be found next to Sketch, and use Extruded Boss / Base. In the following table, enter the specified length. The length is preset in millimeters, but if we have dimensions in larger scales, just write the abbreviation of the scale after the number, e.g. cm, m, etc. We can also use the arrows next to Blind to change the direction of the pull.
Conversely, if we have a rotating part, then it is clear that it is rotated around its axis. That's why we have to think about it when drawing. We proceed as follows, first we enter the axis around which our part shape will later rotate, then we proceed as for a non-rotating part, we draw the shape of the part with all the chamfers and rounding’s. We draw the entire shape of the part above or below the axis of rotation. If there is a hole in the part, we will adjust the distance of the created drawing from the axis accordingly. After drawing the desired shape and taking the distance from the axis into account, reopen the Features option, with Sketch still selected, and select Revolved Boss / Base. In the window, we set the axis of rotation, by clicking

on the drawn axis and we can also enter how many degrees the given drawing should rotate around the axis (Fig.1).

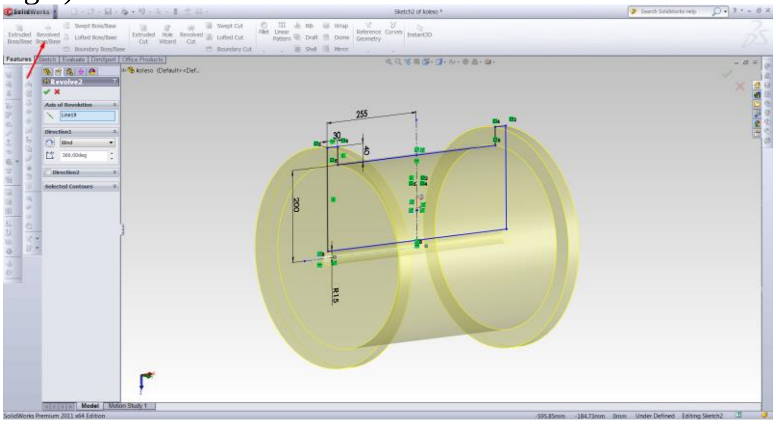

Fig. 6 Rotate the drawing around the axis via Revolved Boss / Base

The next step is to cut the holes using the Extruded Cut tool, which can also be found in Features. The procedure is the same as in the previous step, so we draw the shape we need to cut on the surface of the object in Sketch. Then through Extruded Cut we set the length of the cut and also the direction of the cut.
Using other tools, we will gradually complete all the 3D models needed for the work (Fig. 2). For models that consist of several components, it is necessary to fold them somewhere. The Assembly interface is used for this. First we have to choose a basic part or object that will serve as a matrix for other parts. We insert other components in the same way or just transfer them from the storage location directly to the Assemly workspace using the right mouse button. If we have an inserted matrix and all the necessary components, then through the Mate option, on the main menu of tools, we will gradually start connecting the components with the matrix, or the components with each other. Mate determines the bonds between the edges, between the surfaces, between the surface of the rod and the wall of the hole and so on.

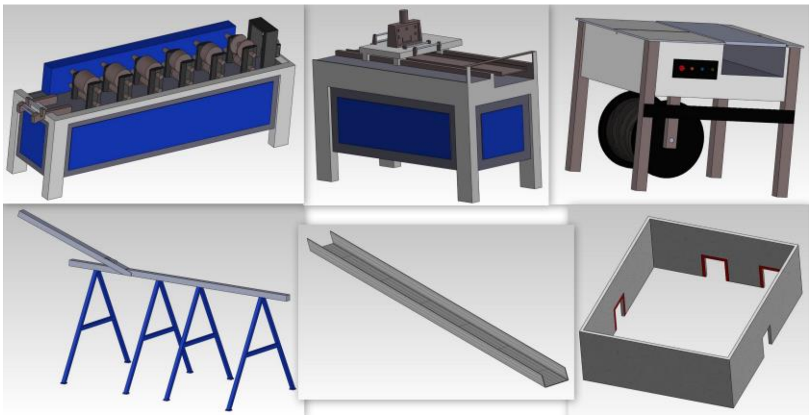

Fig. 7 3D models modeled in SolidWorks

Creating a simulation using drawn models

We insert the modeled parts and machines into the library of the Process Simulate module of the Tecnomatix software. Subsequently, we will insert them into the project from the mentioned library. If we have included all the 3D models in the project, then we must continue to place these models correctly according to the plan for the layout of machines and warehouses in the production hall of the company. So we start from the placement of the wall, through the lines to the placement of individual warehouses.

Click on the displayed model and select the Placement Manipulator option on the top toolbar. The axes are displayed, with which we can move the models horizontally and vertically and we can also rotate it around any of the axes. To make it easier to place the models, it is advisable to create a floor, on which we will show, with the help of fine protrusions, the approximate places of the given models. We can create it in any CAD and convert it to JT format. Similarly, we will place all converted 3D models as they were placed in the given hall of the production plant. We will also create or insert workers who operate the production line and a worker who operates the forklift (Fig. 3).

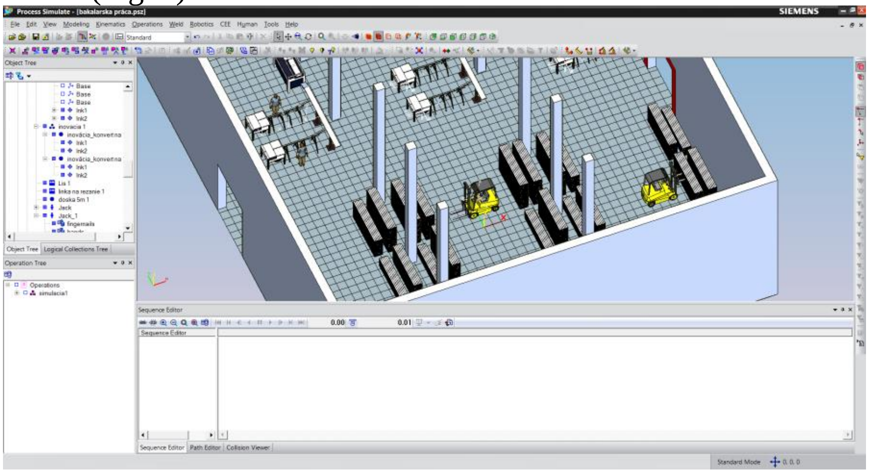

Fig. 8 Location of 3D models, forklift and workers in the production hall

After creating and placing employees, we will return to our models, specifically to the innovation of the flap. First of all, we need to break down our innovation into individual entities in order to be able to further define the poses of the flap. Next, it is necessary to define the kinematics of the valve. First we have to mark our innovation and right-click on it to select the Pose Editor option, in which we will create the poses of opening the "open" flap and closing the "close" flap (Fig.4).

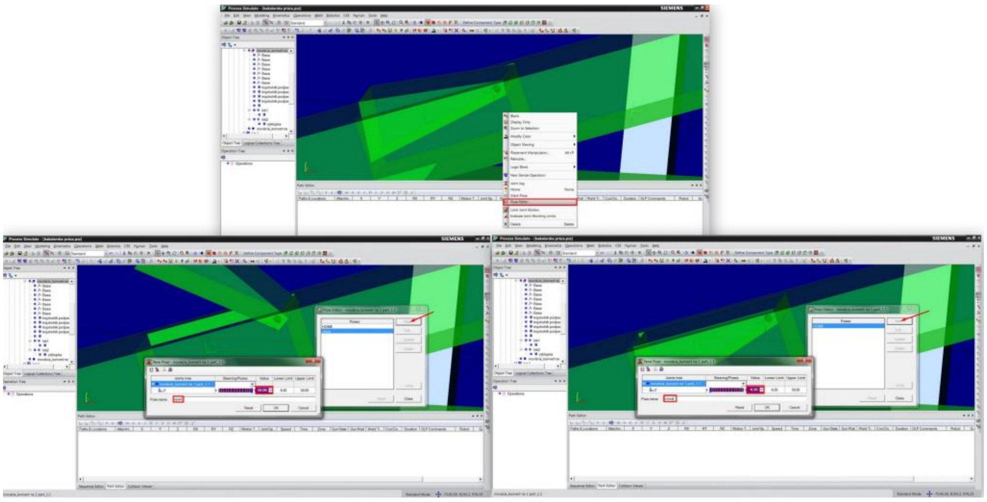

Fig. 9 Creating poses using the Pose Editor

After placing and configuring all variables, we proceed to the simulation itself. We set the paths for the U-profile up to the flap. When flipping, we create a new operation via New Device Operation. We enter the name of the operation, Device, in our case upgrade_convert to 1part_1, Scope will be workplace_1. Next, we define the From pose and enter the "open" end pose, which we created earlier in the Pose Editor. When the flap is raised, we set the path of the U-profile again via the Path Editor so that the U-profile comes out on the raised flap. The first U-profile thus remains on the flap until another strikes it, thus overturning the first profile. After the profiles have been connected, the flap is lowered and the connected U-profiles are lowered by inertial force along a defined path to the sampling table (Fig. 5).

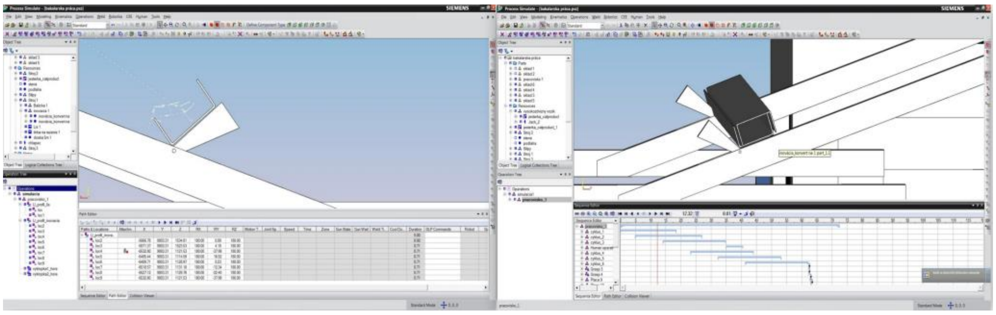

Fig. 10 Innovation - a flap

At the picking table, there is one worker on each side, who is ready to grasp and transfer the mentioned U-profiles into the package. After placing the U-profiles in the package, it is necessary to give the workers the way back through Human, Walk Creator. To allow this cycle to be repeated. In the Walk Creator, click on Path Creator, then on Select a Location and use the axes to return the workers to the specified location. After tying the whole stack in the package, it is still necessary to define the path for the forklift, which will take it and take it to the given warehouse.

Comparison of actual production with simulation

In the simulation, we focused on two shortcomings in production and storage. In production, we found that the mentioned machine for bending and cutting U-profiles was unused. According to the calculations, we found that the machine worked only 50%. This fact was caused by the human factor, when the workers taking the stacks on the bale did not manage to take the machine at a faster cycle. To solve this problem, we designed an innovation in the form of a flap placed on a drop table. With this innovation, we made it possible to speed up the machine up to 70% and while the workers managed to take the mentioned stacks of U-profiles (Fig. 6).

Fig. 11 Comparison of a real pick-up table with innovation

In storage, we found the wrong placement of warehouses, because the worker on a forklift had great problems in storing the stacks produced, had to dial and rotate many times to store them correctly and also in finding the correct stacks when shipping. We solved this problem by better orientation of warehouses, which resulted in taking batches from the lines and faster processing of consignments (Fig. 7).

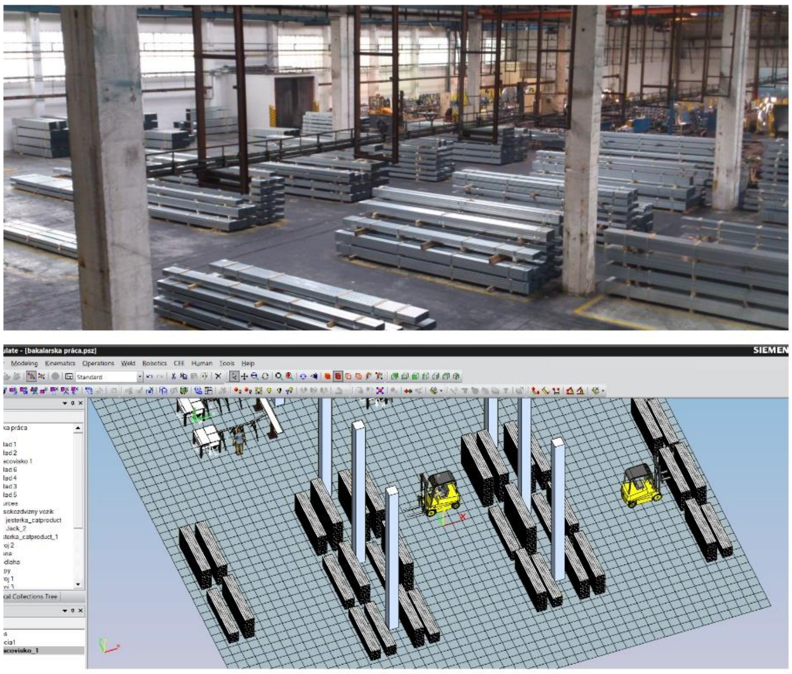

Fig. 12 Comparison of warehouse management in normal operation and in simulation

Conclusion

When analyzing the production line, it was found that the line is used only for 50% of its capacity, which meant the time to pack one stack of U-profiles in an average of 35.4 seconds. These times meant that the increase in orders for profiles produced on the line (as it was not possible to produce faster) made it necessary to introduce overtime and work changes on weekends. Therefore, it was necessary to propose some innovation that would speed up production. After modeling the innovation in the form of a flap on the sampling table and creating a simulation of the production process, a time saving of 5.7 seconds per stack was found. By converting to one production batch, a time saving of up to 1:54 minutes was found. In one work shift (8 hours), one production line produces 4320 profiles. By implementing the proposed innovation, the production line is able to produce the same number of profiles in 6 hours and 30 minutes. This knowledge enables an increase in production capacity by 20% (in the case of a larger number of orders) without increasing the number of employees or the purchase of new machines.

Another problem solved was the distribution of warehouses. When observing the orientation of the workers' ability to orient themselves in the warehouse, great downtime of the worker on the forklift truck was found when searching for orders during their dispatch to the customer. It took 3:20 minutes to ship one production batch. After upgrading the warehouses to change the orientation of the storage, this time was reduced by half a minute to 2:50.

Today, largest companies already use various simulation software to streamline and innovate production. In the future, simulation software such as Tecnomatix will be an essential part of any business, as simulations will save the business money, reduce production times, ensure flexible delivery, eliminate downtime, detect and eliminate problems.

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COMPARISON OF THE USE OF 2D AND 3D VIEWS IN THE TECNOMATIX PLANT SIMULATION PLATFORM

Lucia MOZOLOVÁ - Štefan MOZOL - Patrik GRZNÁR - Milan GREGOR

Abstract: The article compares two views graphics, 2D-only and 3D-only, in the Tecnomatix Plant Simulation platform. On the model example, the article evaluates the accuracy that we can achieve with individual views. The platform has a specific view created for each stage. The area of modelling and simulation today has a strong position in implementing optimisation and investment projects in Slovakia. Such projects' time and financial complexity are derived from the required degree of abstraction and reduction of the simulation model. The Tecnomatix Plant Simulation platform is a tool for implementing simulation models, enabling the creation of models with any degree of abstraction and reduction.
Keywords: modelling, simulation, Tecnomatix Plant Simulation, 2D and 3D view

Introduction

Modelling and simulation are an important area of the digital factory that allows businesses to get answers to questions about modelled processes. Modelling is the process of creating a simulation model based on available information about the real system. Based on the layout of the real system and its abstraction, we are creating a model on which experiments will be carried out later [1]. The model is created on the basis of a layout where the static and dynamic objects that make up this model are inserted. The model is a simplified version of the real system containing all its essential parameters [2]. It is a substitute for the real system by its model, according to certain criteria. On this model we conduct experiments in order to obtain information about the real system. Simulation is a representation of the real system and its dynamic processes in the model. As has already been said at the outset, the simulation aims to obtain information for the real system, with its subsequent optimisation [3]. Basically, it is about preparing, implementing and evaluating individual experiments through a simulation model. Therefore, the simulation is used to support decision-making processes and verify the implications of individual decisions prior to their actual implementation [4]. In general, the difficulty of modelling, which results in a model, depends on various indicators. Specifically, determining the model and the required degree of abstraction is one of them. If, for example, we take into account only a line for simulation, where only means of production and conveyors are installed, then a simple simulation is sufficient that neglects the dimensions of these devices. However, let's take into account workers who perform free movement and must avoid objects whose position changes over time. It is necessary to create a model that also takes this state into account in the simulation. Tecnomatix Plant Simulation is a dynamic simulation software that allows you to model at different levels of abstraction and reduction. In general, it allows display in both 2D-only and 3D-only, the usage of which is currently dependent on the required model properties. At its core, the article describes 2D only or 3D only modes, for Tecnomatix Plant Simulation, their comparison and application with obtained achievements.

Tecnomatix Plant Simulation

It is a simulation tool from Siemens that allows simulation and optimisation of production and logistics systems and their processes. Through Tecnomatix Plant Simulation (TPS), it is possible to optimise material flow, resource utilisation and logistics at all levels of planning in

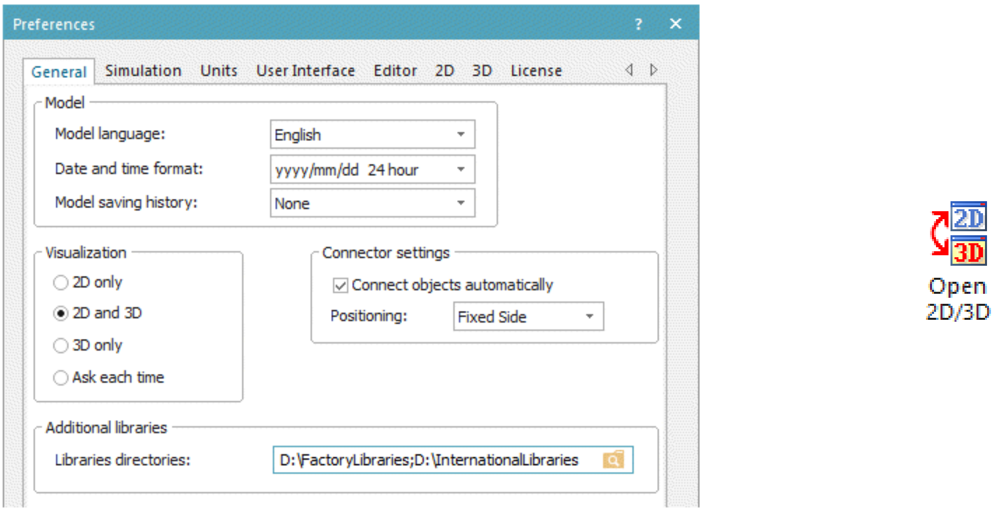
the company. Hierarchical modelling allows us to optimise processes, flows and resources for selected parts of the system (individual devices) or the system as a whole (enterprise).
The digital models make possible to conduct experiments and incorporate the various required changes according to the question "What would happen if?". This tool allows to:

- increase productivity,
- optimising the number of workers and their activities,
- verification of the new layout,
- removal of bottlenecks areas,
- optimisation of logistics,
- reducing the work in progress of production.

By carrying out testing in the digital model without interference with the real system, the pressure resulting from the possible threat to the running of the production process is being exerted. The simulation outputs will provide information on making quick and reliable decisions during the production and early stages of process planning. The program can be imported from other programs, such as MS Office formats (Layout in .pdf format or databases in xlsx format).

Tecnomatix Plant Simulation and views that allows

Platform Tecnomatix Plant Simulation enables three types of 2D-only, 3D-only, and combination (2D and 3D) views. Each of the views has its dominant application, which is defined by the degree of abstraction required. However, the post will only deal with 2D-only or 3D-only display. The select and switch between views window is on Fig. 1.



(a) (b)

Fig. 1 Switch between modes (a) using Preferences; (b) using Open 2D/3D

View in a 2D environment

Modelling in 2D introduces the most important tasks of the modeller face when creating a simulation model. The display is designed for modeling with a higher degree of abstraction and reduction, especially where the object's size for the entity may be neglected. When working in 2D, you can navigate to 3D with those objects after inserting objects, but after changing the view, we find that the dimensions are the same for each object in that class. Precisely because of the recurrent activities of workers, it is necessary to create a so-called footpath in order to keep the distance of the worker's walking in the performance of activities.

View in a 3D environment

The view in 3D introduces possibility to visualising the material flow and seen differentiates between simulation objects, animatable objects, graphic groups, state groups, state graphics, and graphics of the selected object. This type of display is suitable if we need to model objects with medium abstraction and reduction of elements. This means that the object behaves as one in the basic frame, even if it has a multi-part graphical structure, but the overall dimensions of the object are preserved. Base on [5] the dialog Show 3D Graphic Structure show the graphics in a tree structure that visualises the 3D simulation object but not the content of this simulation object. In this mode, when defining the free movement of workers, the worker bypasses the obstacles and behaves like when moving in a physical layout. In this mode, you can also create an animation of objects using Graphic groups. Graphic groups define a possible visual representation of an animatable object and have a name that is unique for this object. This is similar to the 2D icons of the simulation objects. A graphic group can be permanently shown or hidden to enable switching between alternative graphic groups. Each simulation object or animatable object contains at least one external graphic group named default and optionally any number of alternative or additional graphic groups, which you can show or hide independent of each other. The visibility of the graphic groups is a 3D object property which can be inherited as well as the entire graphic structure. This type of display and modelling is especially suitable for visually satisfactory display of the model, especially when presenting to investors or senior management, where we want to subdue our simulation-obtained results. If necessary, model with minimal abstraction and number of reductions, different software is used, namely Tecnomatix Process Simulate.

Compare of 2D-only and 3D-only views in terms of functions

Each of the views, whether 2D-only or 3D-only in Tecnomatix Plant Simulation, has its own specific features. Individual functions, especially in 3D mode, allow you to modify the size of an object, which in 2D, for example, is only possible directly in the parameters of the object. The comparison of functions and modes is in the Tab. 1.

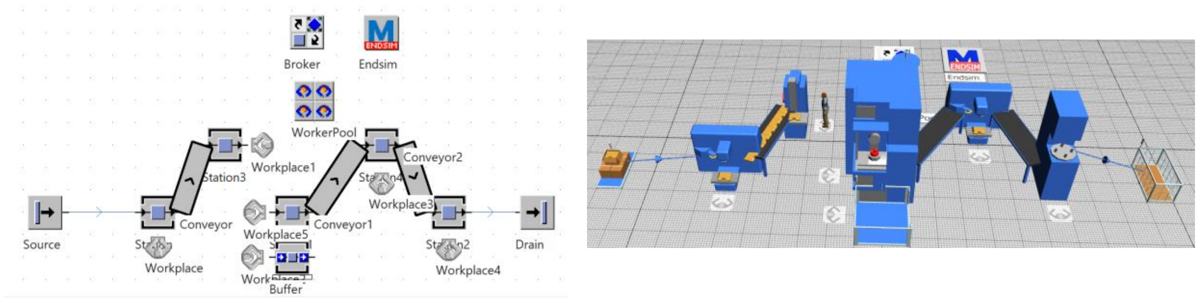
Tab. 1. Comparison of Tecnomatix Plant Simulation function and modes [5]

Function	3D Only	2D Only
Axes origin of the scene	objects can be inserted anywhere, the grid adjusts its size	upper left corner of the Frame window objects can only be inserted within the displayed grid, starting at the position 0.0
Standard Graphic of certain Information Flow Objects	small icon next to label	large icon next to label
Ribbon	Yes	Yes
File Menu	Yes	Yes
Ribbon > Start	Yes	Yes
Ribbon > Debugger	Yes	Yes

Ribbon > 3D > Edit	Yes	No
Ribbon > 3D > View	Yes	No
Ribbon > 3D > Video	Yes	No
Ribbon > Frame > General	No	Yes
Ribbon > Frame > Icons	No	Yes
Ribbon > Frame > Vector Graphics	No	Yes
Ribbon > Method > Edit	Yes	Yes
Ribbon > Method > Tools	Yes	Yes
Ribbon > DataTable > List	Yes	Yes
Context Menu of the Class Library	3D-related commands only general and 3D-related commands	no 3D-related commands general and 2D-related commands
Dialog Window of the Objects > Menus	3D-related commands only general and 3D-related commands	no 3D-related commands general and 2D-related commands
Ribbon > Icon Editor > Edit	No	Yes
Ribbon > Icon Editor > Animation	No	Yes
Ribbon > Icon Editor > General	No	Yes
Dialog of Length-oriented Objects > Tab Curve	No	Yes
Display Panel	No	Yes

Results

A simple simulation model has been created to verify the accuracy of previous claims, consisting of several objects of different sizes in real conditions. The first model is created in 2D graphics and neglects the dimensions of objects, while the worker can move freely. The second model is created in 3D graphics and takes into account the dimensions of objects. Fig. 2 depicts 2D-only a 3D-only models.



(a) (b)

Fig. 2 Display in (a) 2D-only; (b) 3D-only

The results of simulation runs are contained in Tab. 2, where 100 simulation runs were conducted for each model for a period of one shift, i.e. 7.5 hours.

Tab. 2. Comparison of 2D-only and 3D-only simulation model

View	Distance travelled (m)

2D-only	16158.57
3D-only	16244.86

From the results, it can be said that 3D displays, since it also considers the size of objects, are more suitable for the worker's free movement in space without a defined footpath. The results obtained in this way are more accurate and more reflect the real situation. The difference in views is 0.53%.

Conclusion

Modelling and simulation are now a tool through which many manufacturing companies verify their processes or investment intentions. The costs and time requirements for implementing the simulation project themselves depend on the degree of abstraction and reduction of the elements of the model. Tecnomatix Plant Simulation is today one of the most widespread simulation tools in Slovakia ever. A correct assessment of the situation allows the creation of models with any degree of abstraction and reduction, with a specific display created for each stage, namely 2D-only and 3D-only. The article itself compares these two solutions, assessing the accuracy that we can achieve with individual views on a model example. The difference in the model example was 0.53%.

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EVALUATION OF COMPLAINT PROCESSES IN A MANUFACTURING COMPANY USING A BI TOOL

Filip RYBNIKAR – Ilona KACEROVA – Pavel VRANEK – Tea BAJICOVA – Michal SIMON

Abstract: The article discusses the possibilities of using business intelligence tools while working with data in a manufacturing company. It is focused on the data input standardization process, automation of data processing, evaluation, and creation of graphical outputs to increase the efficiency of data processing. A specific case study concerning data about warranty claims received from customers is described. The required output is automatically generated monthly reports. The paper presents a procedure leading to the digitization and automation of the evaluation of warranty claim processes with the subsequent creation of graphical outputs.
Keywords: Business intelligence, Power BI, VBA, Evaluation, Visualization

Introduction

Nowadays, data collection and subsequent analysis belong among the necessary activities for almost every company that wants to succeed in the market. Manufacturing companies are no exception, as they also put emphasis on gaining knowledge from data and implementing decision support tools. However, if a suitable process for data handling is not set up, data analysis and data interpretation can become relatively time-consuming and error-prone activities. The automation of evaluation and digitization of data processing has great potential to increase the efficiency of the whole process.

The above-mentioned facts are also related to the growing importance of Business Intelligence applications. Business Intelligence technologies enable the use of company data not only to analyze events that have already taken place but also to predict potential future developments. Businesses thus have the chance to gain a competitive advantage in the form of early recognition and subsequent exploitation of newly emerging opportunities. As interest increases, new tools are being developed to simplify and speed up the work with data. Extracting knowledge from data is no longer an activity for IT experts only, with the help of these tools it should be manageable for employees in other departments who have no programming knowledge. [4]

The paper focuses on the standardization and processing of data dealing with warranty claims received from customers in a manufacturing company, their subsequent evaluation, and visualization. This involved regular monthly reports required by the parent company, with predetermined requirements for their content and structure. The reports were created each month by exporting individual graphs from an excel file to which data were manually added without any verification of their accuracy. A large part of the required graphs and tables was generated by setting filters in contingency tables, which had to be individually updated each month. In order to reduce the time-consuming nature of the whole process and to eliminate errors, a new way of processing the data was created utilizing the Power BI tool.

Power BI is one of the reporting tools for easier and faster data analysis, which simultaneously offers a wide range of options for their subsequent visualization. It is a Self Service Business Intelligence tool from Microsoft, that enables data upload, editing, follow-up visualization, and sharing with other users. [1]

With Power BI, it is possible to connect to a wide range of data sources such as Excel, PDF, Access databases, SQL Server databases, Google Analytics, as well as SAP and Oracle. After selecting a data source, the data can be edited using the Power Query editor - offering simple edits such as changing the data type, removing blank rows, replacing values, but also merging or joining tables, adding new columns, or structuring data based on custom code in the advanced editor. [2]

In addition to the previously mentioned ones, advantages of Power BI also include the following features [3]:

- The resulting reports are interactive and the end-user can adjust them according to their needs.
- A large number of visuals are available to create visually appealing and insightful reports.
- Reports published on the cloud are regularly updated depending on the changes in the data source. Therefore, they are always up-to-date.
- Power BI is also available in the form of a mobile app that allows users to view the resulting reports almost anywhere, anytime.

Data input standardization

The company's transition to digitalization and automation of data handling in the warranty claims process has led to the need for standardization of data inputs. This standard and the stable structure of the retrieved data is the most important aspect for processing the data, its interpretation, and the creation of outputs using the selected tool. For this reason, initially, it was necessary to create a standardized form for entering information about individual warranty claims. Standardized forms ensure that the necessary data is entered and eliminate the possibility of deviations in the data structure.

Due to the original way of data processing, evaluation, and report creation, where everything was based on several independent spreadsheets, these standardized forms were created using MS Excel, see Figure 1. The standardized forms designed to guide the user uniformly through the entire process of entering the input data were created using the Excel tool extension in the form of Visual Basic for Application (VBA) programming language. A master control program was developed to create the warranty claim record, in which the user is guided step by step through entering the necessary data inputs such as the claim number, part designation or production date, etc.

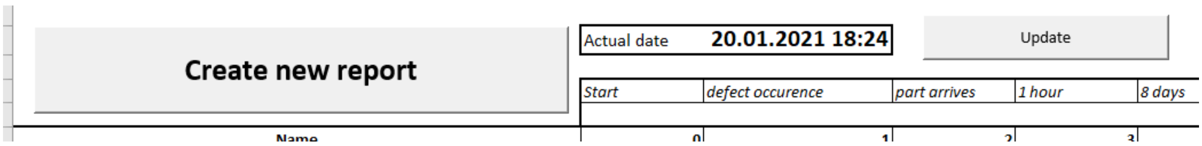


Fig. 13 Creating the warranty claim record

All the entered data are automatically stored in an MS Excel document serving as a single input for the evaluation and reporting. In this document, a user with the appropriate competence is authorized to check and make any additional changes. This way, the data entry process has been automated, and the forms required for subsequent data processing, interpretation, and reporting have been standardized.

Creating relations and calculations for the evaluation of warranty claims processes

Based on the requirements for the generated outputs, three MS Excel documents were used as data sources:

- The control Excel, which is used to enter data into standardized forms and contains information on the current status of the complaint,

• Excel, which stores data on warranty claims related to local production,
• Excel containing data on all warranty claims within the parent company's subsidiaries.

In the Power Query editor, which is a part of the Power BI tool, the data were cleaned and modified (i.e., unnecessary columns were removed, data types were changed, or columns were added as needed for subsequent table linking). Once the data were modified, it was possible to create relations between the tables to ensure proper linking and functioning of the reports, which are shown in Figure 2.

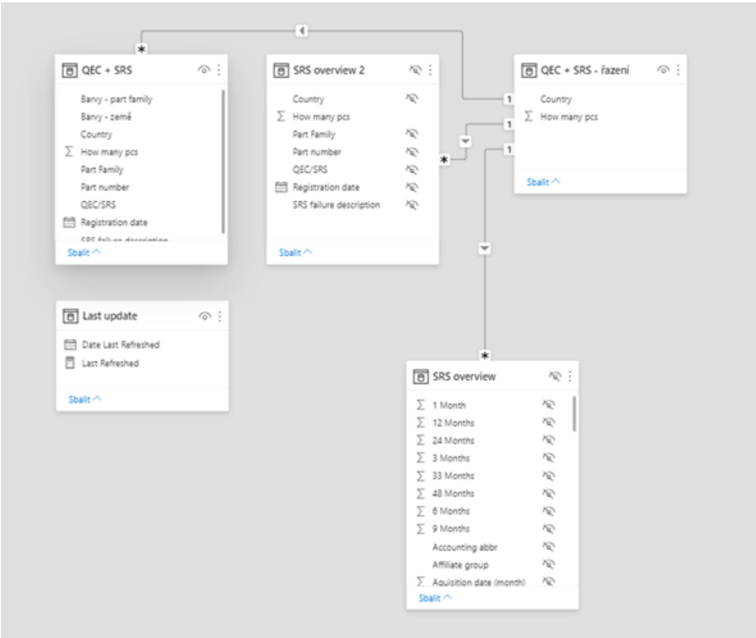


Fig. 14 Relations between tables

Figure 3 shows the difference between the raw data inputs and the cleaned data enriched with the necessary calculations. In this particular case, it was necessary to remove the redundant columns and transpose the entire table. To allow subsequent filtering according to the required criteria, the data table was further modified. A custom column was added to convert the "date and time" data type to "date". Conditional columns were added in this and other tables to ensure the correct ordering of items in the subsequently created visualizations.

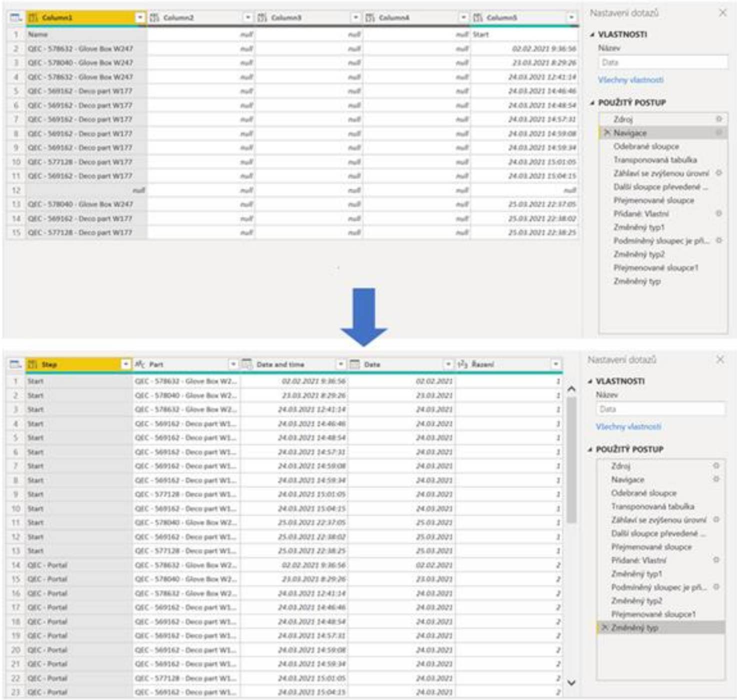


Fig. 15 Data editing

Evaluation output production

According to the output requirements, 22 pages consisting of visualizations of information about received warranty claims were created within the report. The first page contains an introductory menu, which allows the user to access the information that is relevant to them at the given moment. This page also provides an indication of the last update of the file to give the user an insight into the currency of the displayed data (see Figure 4).

Fig. 16 Menu and time of the last update

The following pages show visuals reflecting different aspects of the received warranty claims. Complaints are analyzed and evaluated based on the following perspectives:

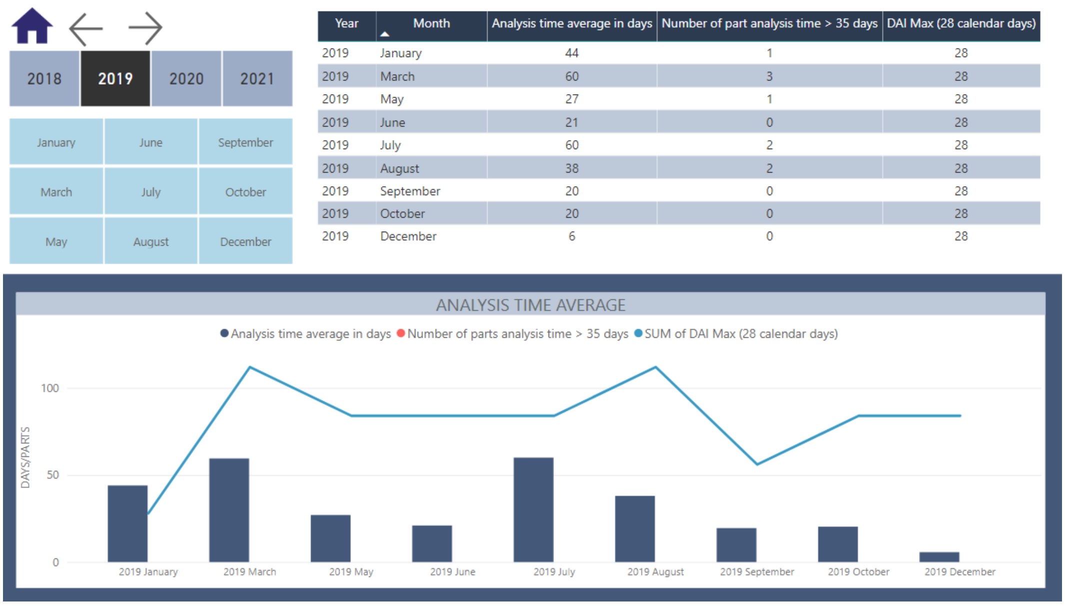
- Time required to find the cause of the fault,
- date of occurrence of the fault,
- the cause of the fault,
- type of fault encountered,
- production date,
- date of rectification of the cause of the failure,
- time of usage, etc.

For visuals, the user can easily filter by the above-mentioned aspects, allowing them to select only the information that is useful to them. The entire report can be exported to a PDF file with the current values or shared to Power BI Service, where interactivity is maintained. This greatly speeds up the creation and sharing of reports with the parent company each month.

In the next section, selected examples of the created assessment reports are described to demonstrate the functionality.

1. “Analysis time average” page

The “Analysis time average” sheet in Figure 5 focuses on the average time it takes to find the cause of a warranty claim, i.e., the reason for a particular failure. The sheet allows filtering by year and month of receipt of the complaint. Both the table and the combined graph show the value of the average time to find the cause over the given period, as well as the number of parts for which this time exceeded the threshold of 35 days. As can be seen in Figure 6, the graph enables changing the detail of the display by scrolling through the hierarchy based on whether aggregated values for the entire year or values from specific months are required.



Year	Month	Analysis time average in days	Number of part analysis time > 35 days	DAI Max (28 calendar days)
2019	January	44	1	28
2019	March	60	3	28
2019	May	27	1	28
2019	June	21	0	28
2019	July	60	2	28
2019	August	38	2	28
2019	September	20	0	28
2019	October	20	0	28
2019	December	6	0	28

Fig. 17 Analysis time average

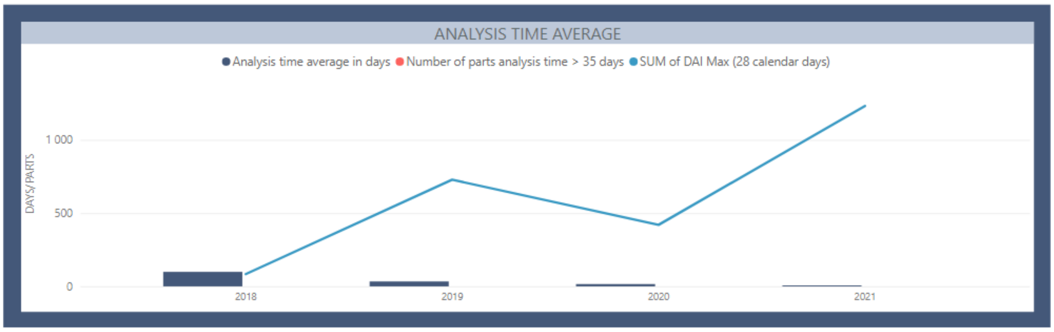


Fig. 18 Detail of the displayed values

2. “Production date” page

The “Production date” page, shown in Figure 7, allows filtering by a timeline that shows the production date of the part being claimed. It is also possible to filter by the cause of the failure that led to the complaint. A stacked bar chart then shows the number of complaints depending on the production date. According to the legend, it is possible to distinguish which failures occurred most frequently.

Fig. 19 Production date

3. “Country of failure” page

Figure 8 shows the “Country of failure” page. As in the previous case, you can filter by the timeline, but you can also select the country in which the failure occurred. After selecting the time period and country, the total number of failures resulting in a complaint is displayed along with a list of specific parts and problems. The selected state is also highlighted on the map.

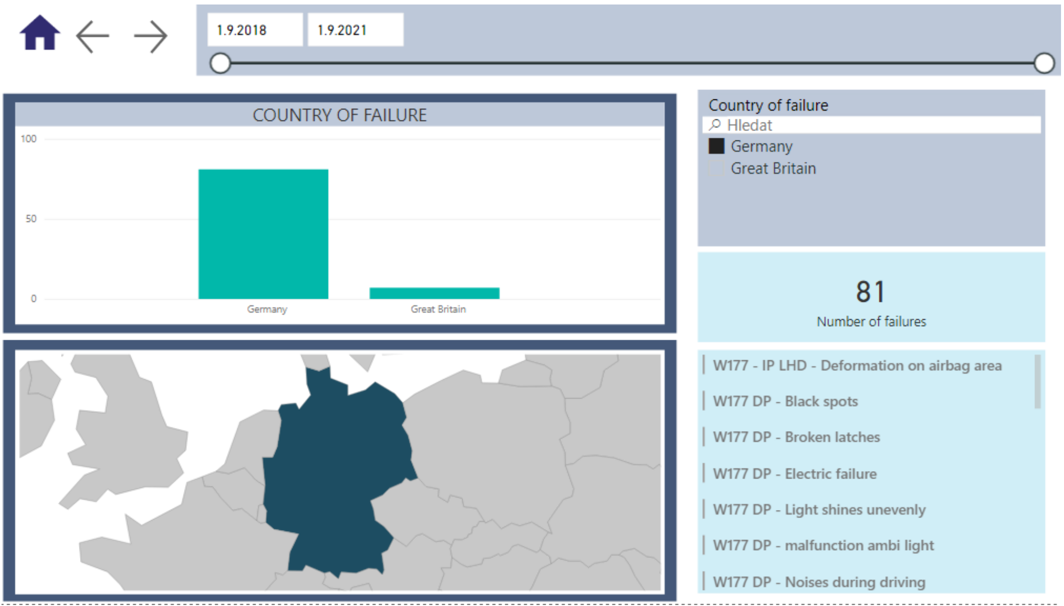


Fig. 20 Country of failure

Conclusion

Efficient data processing and utilization are currently one of the key factors to maintaining the competitiveness of a company. With the growing emphasis on extracting knowledge from data, new tools are also emerging to simplify the work with data. One of them is Power BI, which has been an essential tool for automating the evaluation of warranty claims processes, which was the focus of this article.

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USE OF MODELING IN THE MANAGEMENT OF BUSINESS PROCESSES

Peter TREBUŇA– Jozef TROJAN - Marek KLIMENT – Laura LACHVAJDEROVÁ - Richard DUDA

Abstract: Various management concepts have been and are proposed for the management of companies, the aim of which is to make the best possible operation of companies for the given conditions. We can define different types of production systems according to a number of aspects. The analysis of production systems goes through phases from design through management to measuring the performance and improvement of production systems. In the analysis, we can use model tools in a number of cases. Using the model, it is possible to express the performance of the system and the achievement of goals.
Keywords: Model, Process, Phases

Introduction

The term process currently includes more than a set of certain inputs, where the action of factors and the consumption of resources results in the creation of outputs, although this terminology remains fundamental.
A process in the context of online modeling is a program running in a specific operating system or procedure or. a set of procedures aimed at achieving the set goal.

Stages of business process modeling

Digital modeling of business processes once belonged exclusively to the field of IT. However, employees from various departments represented in companies are increasingly involved in business process modeling. Modeling as such also reaches the sphere of commercial users, on the basis of which the requirements for clarity and availability of tools designed for this increase.

Business process modeling is subject to a certain life cycle consisting of five basic phases [5]:

1. Design phase - in this phase, the existing process is identified and the future process design is proposed. The basic inputs for this phase are goals, quantifiable outputs, responsibilities, computer systems, etc. A common practice in the implementation of this phase is the participation of stakeholders from various departments or. from different divisions of the company due to the nature of the analyzed process.
2. Modeling phase - models are created using complex modeling tools while applying standards for business process modeling.
3. Implementation phase - computer applications providing automation of business processes are used for implementation. Above these individual applications is the superior application that connects them. Such a formalization of the business process model allows the computer technology to correspond to the actual real course of the process, which ultimately brings a number of benefits.
4. Monitoring phase - during monitoring, the performance of the business process is measured. The output of this phase depends on the tools implemented in the implementation phase. The information obtained is then aggregated and displayed on dashboards.

5. Optimization phase - during this phase, the business process is optimized on the basis of obtained and analyzed data from the previous, ie monitoring phase. Optimization can lead to the redesign of an existing business process or to the creation of a new business process, thus bringing the business process modeling back to the design phase as shown in FIG. 1.

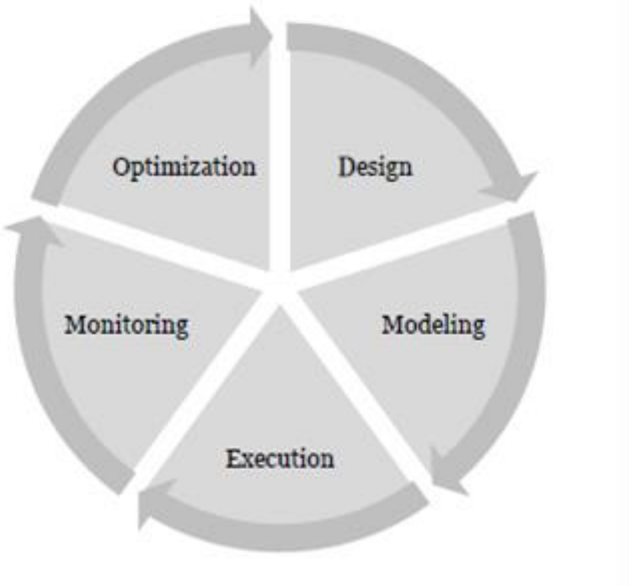

FIG. 1 Business process modeling life cycle [2]

Digital modeling of business processes

Digital modeling of business processes brings a number of benefits, which undoubtedly include:

- Formalization of existing processes - there is a deepening understanding of the existing process on the basis of which there are opportunities for its optimization.
- Facilitate automation - digital business process modeling enables business process parallelism, where a certain process sequence can be implemented independently of another sequence. The outputs of these sequences are combined in the next step of the process for further processing.
- Creating an efficient process flow - creating a process model in a digital environment is characterized by a minimum level of planned downtime.
- Reducing the need for human capital - digitization enables faster processing with minimal human labor consumption.
- Simplification of regulations - the benefit of digital process modeling is the effort to create auditable processes that can be easily controlled and managed.
- Active participation in problem solving - although in digital modeling of business processes the effort is to eliminate the human factor to a minimum, one of the benefits is the flexibility of using specialists in the problem to solve complex problems.

FIG. 2 expresses such an exception in the process, where the problem identified in step D is redirected to a human solver, who returns the process to step E after resolution.

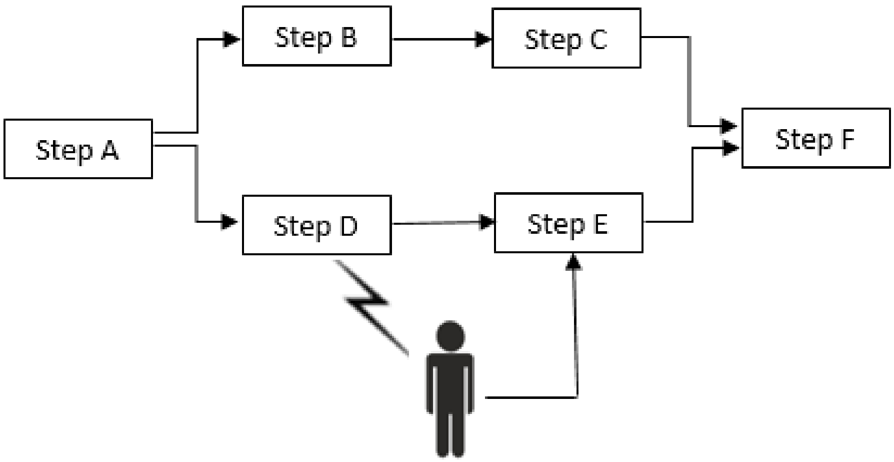

FIG. 2 Scheme of human factor involvement in digital process modeling [4]

For the needs of business process management, process modeling is essential. Only what is defined and functional can be controlled. The future success of the implementation and the achievement of the required outputs in the required quality and quantity depend on the quality of the process model as well as the requirements identified for it.
Subsequently, process management and decision-making can be realized only on the basis of data obtained from the process. For these purposes, the so-called enterprise information systems.

Business process model

The natural output of modeling is a functional business process model. The process model is a systematized description consisting of a series of consecutive activities, while the process itself is the product of activities aimed at the creation of a specific product or. services that include human interactions and computing. [3]
The process model represents a certain algorithm, ie a sequence of steps with appropriate conditions and loops. The process model thus identified is often visualized through various software tools. Basic terms describing the process model include [2]:

- Definition of the process - description of the behavior of the process resp. process algorithm,
- Process instances - occurrence of a process for a specific output,
- Activities - steps occurring in the process. Activities can take the form of:
- Automatic activities - activities are performed directly by the system,
- Manual activities - activities are carried out under the influence of the human factor.

The distinction between automatic and manual activities appears to be extremely important given the ever-increasing cost of human capital and the declining cost of data and data processing.

Conclusion

Production systems management includes activities from aggregate production planning through detailed planning and multi-stage planning, batch sizing, batch placement to real-time production management.
In the planning process, the main production schedule is gradually specified and created.

Multilevel planning is based on the need to plan the entire structure of materials and semi-finished products that will be needed at a certain time and quantity to create the final production. Techniques commonly used to solve multistage planning problems are based on material requirements planning.
Other problems are batch sizeing and batch scheduling for processing over time to specific processors and self-control of production.

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USE OF METHODS AND TECHNOLOGIES TO SUPPORT PRODUCTION MANAGEMENT IN COMPANIES IN SLOVAKIA

Olha KOLESNYK – Peter BUBENÍK – Juraj ČAPEK

Abstract: Changes in customer requirements and technological progress are forcing manufacturers to rapidly transform the production environment. If manufacturers want to remain competitive, they need to make quick decisions, anticipate the future, change their business strategy dynamically and make the necessary changes immediately. Only if a company can do it permanently can it become successful in the long run. Therefore, our research was focused on finding out the state of use of progressive methods and technologies for the management of production processes in companies in Slovakia, which is a basic prerequisite for the immediate implementation of changes.

Keywords: Methods, Technologies, Production management

Introduction

Two basic historical production concepts fulfilled their mission. Ford's production system is based on an assembly line and becomes the basis of the production system. It has more than 100 years of history. As a standard used in industry, it no longer meets future production requirements. As we know, since the late 1990s, the principles of lean manufacturing have also exhausted their potential, [1].

What new production concepts can gradually replace these now historic concepts? The factory of the future is being discussed. But the future begins today. New breakthrough technologies and unprecedented innovative methods have begun to transform today's production. We need to look at future production and its organization with a new perspective. But we can also not forget the present state of the art of renovation methods and technology in enterprises. Therefore, before thinking about changes, it is necessary to find out what methods, technologies are used to manage production processes by companies today.

Research of the state of used production management methods and technology.

A survey of the current state of use of production management methods and technologies that companies use or plan to implement in May was carried out by a questionnaire survey, [2]. A sample of 150 companies took part in the survey, of which 100 questionnaires have been received so far.

Brief description of the representative sample of participating companies on the questionnaire. The largest share of respondents was from the automotive industry (61%), Fig.1.

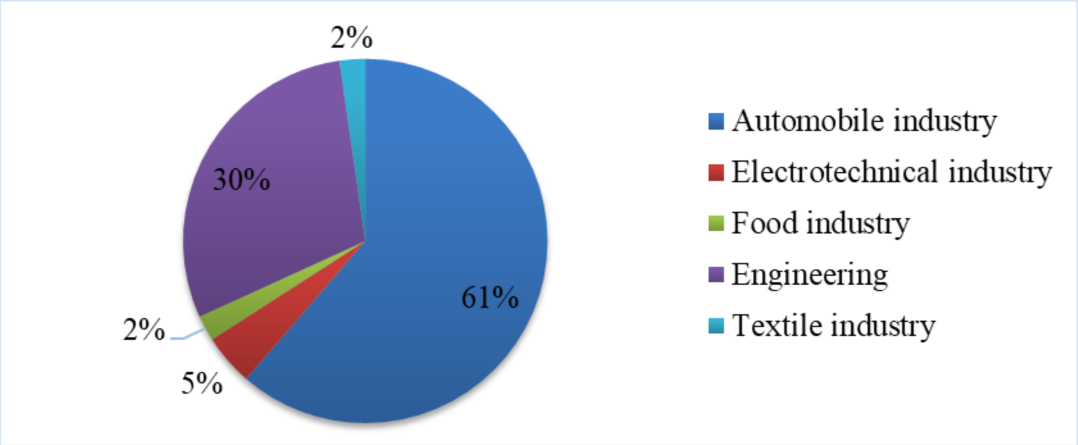

Fig.1. Proportion of industry representation [Autor].

The second question provides information on the type of equipment used in the surveyed companies of the companies participating in the analysis, Fig. 2.

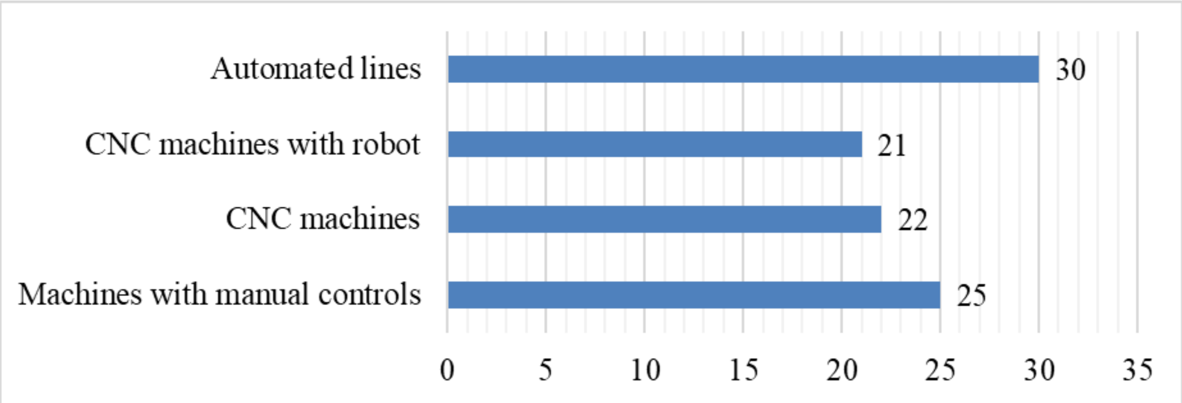

Fig.2. The type of device used [Autor].

Of the number of respondents surveyed, 61% of respondents have a serial type of production, Fig.3.

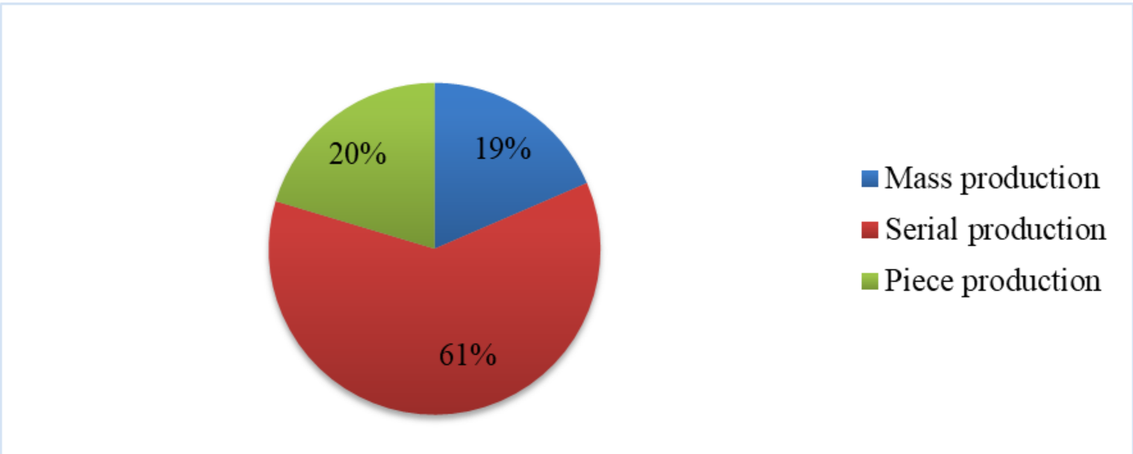

Fig.3.Type of production according to different degrees of repeatability [Autor].

Also important is the division of the production process in terms of the method and degree of repeatability of production. The analysed sample represents a 32% share of respondents with a continuous production process, Fig.4.

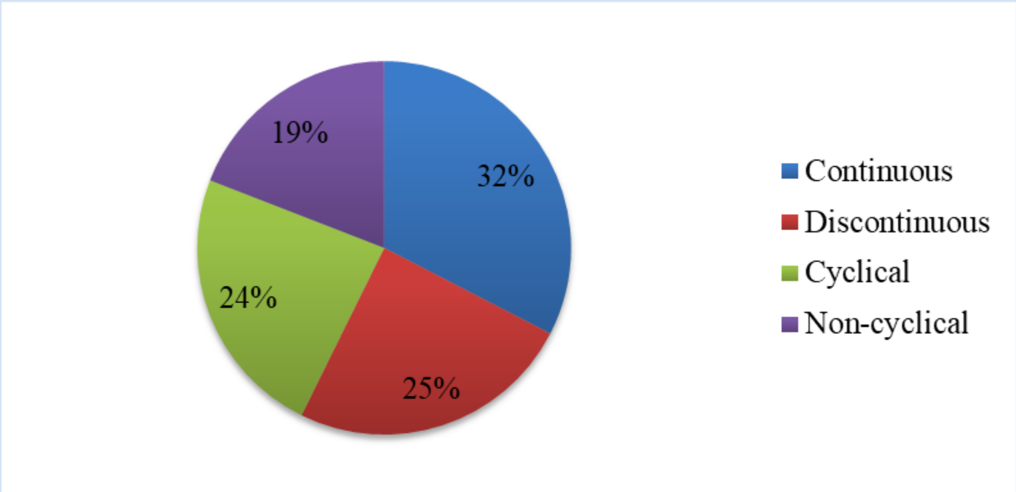

Fig.4. Production process in terms of the method and degree of repeatability of production [Autor].

An important part of the survey was to determine the use of management methods in production. The survey shows that the most used methods are Kanban and MRP. The goal of the MRP method is effective inventory planning. MRP ensures that the right material is available in the right quantity at the right place in production. Kanban's goal is to optimize the production line production, using certain elements of "agility" - visual communication and employee involvement, Fig.5.

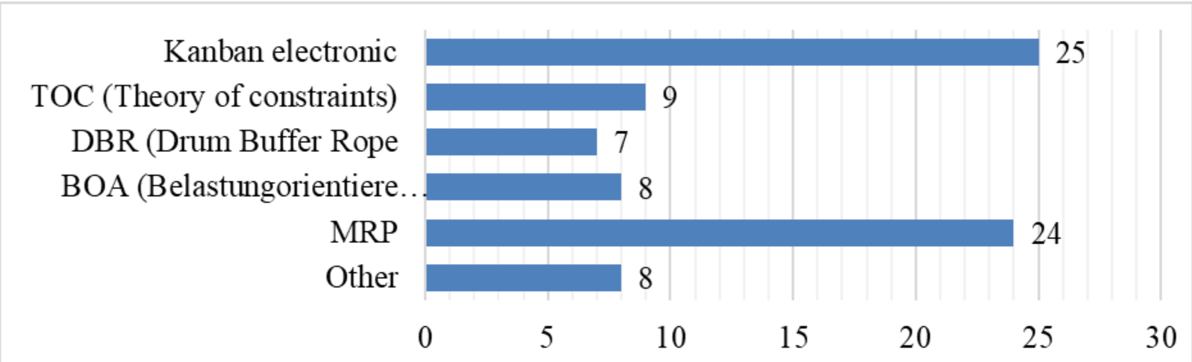

Fig. 5. Use control methods in production [Autor].

The second important issue that is interesting is the technologies used in production. The question was divided into subgroups. The first subgroup is technologies that are used for data collection. It turned out that the most used technology is QR codes [3]. The reason is easy to use and easy coding of information, this code can contain both numerical and textual information. Companies see great potential and interest in using RFID technology for data collection, Fig.6.

Fig.6. Technologies in production (data collection) [Autor].

The second subgroup is technologies that are used for data processing and visualization. It turned out that companies use electronic KPI visualization. The analysis shows that companies plan to integrate IoT technologies, Fig. 7.

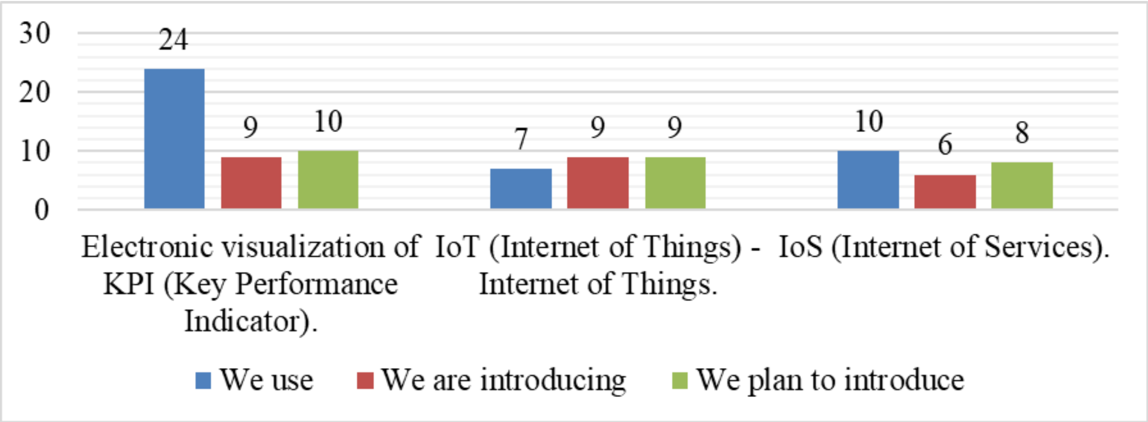

Fig.7. Technologies in production (Data processing tool) [Autor].

The third subgroup is data analysis technology. The most used technology is Cloud computing. There has been great interest in data mining. From the results of the questionnaires, we can identify that companies are already collecting data but do not yet use the required extent of data analysis, data mining to gain a competitive advantage, Fig.8.

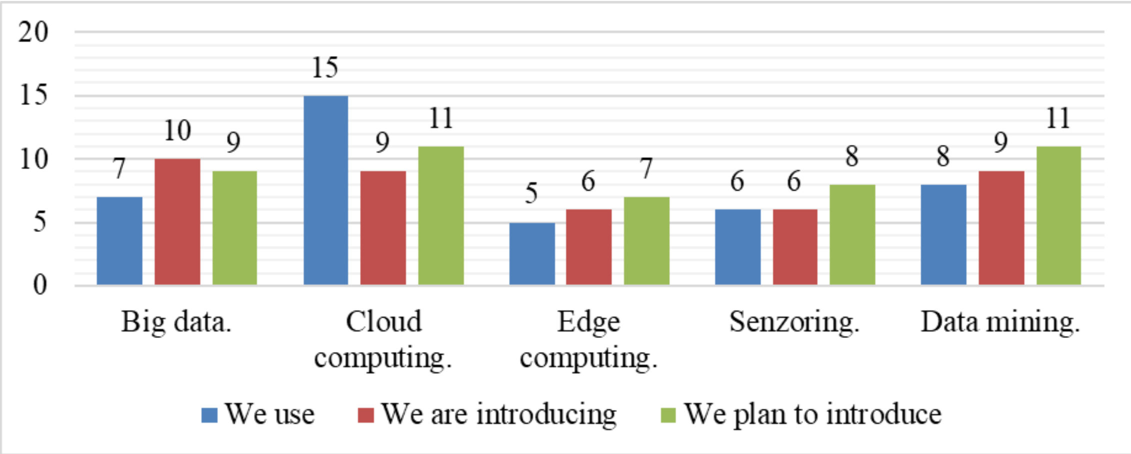

Fig.8. Technologies in production (Data analysis) [Autor].

The constant improvement of sensors leads to an increasing amount of data of various physical nature being obtained from production lines. Therefore, it can be said that data is the most valuable resource in the world today. Efficient data mining and use have become another frontier to support innovation, competitiveness, and economic growth in many sectors. Indeed, advances in computing infrastructure and innovation in data analysis techniques have allowed industry to begin using the knowledge embedded in data analysis to improve value creation.
The results of the questionnaires revealed that the companies have completed the collection phase, the placement of data in the Cloud and are currently planning to implement progressive methods and tools that would help them use the data obtained, [4].

Conclusions

The long-term success of any company depends on satisfying emerging social and market needs. Due to this, every company must strive to respond to these trends with its production systems. In the case of piece production, universal machine tools were needed that were able to produce a wider range of products. However, with the advent of mass production, these facilities were replaced by single-purpose production lines that were able to meet mass constant demand at low production costs and prices. However, over time, the markets became saturated, and demand was no longer constant but was foreseeable. The customer started looking for products that met his requirements at a low price. At that moment, the market ceases to be homogeneous and begins to show a wide range of products. Flexible production systems have begun to be applied to enable companies to meet these needs.
Based on a survey of manufacturing companies, it can be stated that companies use different management systems, different progressive technologies, which is often limited by the level of automation achieved. As a precondition, it is necessary to consider the statement that the level of use of individual technologies subsequently affects the efficiency of process management. Therefore, it is appropriate to analyse in more detail the relationship between the mix of technologies used and their impact on the company's performance.

Acknowledge
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SEMITRAILER TRANSSHIPMENT TECHNOLOGIES IN INTERMODAL TRANSPORT

Peter FRANKOVSKÝ – Ingrid DELYOVÁ– Darina HRONCOVÁ – Peter SIVÁK

Abstract: The efficient use of the logistics network is one of the prerequisites for increasing the economic result, based on the optimal connection and maximum use of its individual elements in order to reduce the time of the transport process, reduce costs and increase productivity with minimum resource requirements. This paper describes a new system for road-to-rail vehicles for railways. This is a description of intermodal technologies transport in the transhipment of these vehicles on rail waggons and their consecutive transportation by rail.

Keywords: SCM, Transport, CargoBeamer.

Introduction

Logistics and SCM (Supply Chain Management) can be used to generate both cost savings and service enhancements. Freight transport is an integral part of SCM, but traditionally it has been treated as a service that is easily available when required by suppliers and distributors. Choosing which mode(s) to use for freight transportation will usually be a function of the volume and value of the freight, the distance to be travelled, the availability of different services, freight rates to be charged and so forth [1].

Road transport is the dominant mode of transport for inland transport. Due mainly to the flexibility, directness and speed that the movement of freight by road offers, when compared to rail, inland waterway or sea transport, it has become the principal freight transport mode, carrying the majority of inland freight [2,3]. It is, however, also the most environmentally damaging mode of transport. Policy makers are thus endeavouring to shift freight from road to more environmentally friendly transport modes, in particular to rail and inland waterway. This is not an easy task, however, as many transport systems are predicated on extensive use of road transport.

Fixed of rail transport cost is high and the variable cost is relatively low. Fixed costs are high due to expensive equipment requirements such as locomotives, wagons, tracks and facilities such as freight terminals. On relative operating characteristics, rail is considered good on speed, dependability and especially capability to move larger quantities of freight [4].

The basic characteristic of rail transport is the transport of goods over long and short distances. The rail transport system is much more reliable and safer compared to other modes of transport. Advantages of rail transport:

- high level of passenger and freight car utilisation,
- high level of high capacity of freight cars and trucks, high environmental friendliness of the mode of transport,
- increased speed of transport of goods, by connecting the producer and the consumer, thus reducing the amount of transhipment work and making transport cheaper,
- large quantities of goods transported,

- high transport speed,
- the possibility of transporting dangerous goods,
- low cost per tonne of goods transported,
- the possibility of combining one transport with another.

Disadvantages of rail transport:

- high initial cost of building railway lines,
- long payback period,
- tied to the timetable of the railway companies,
- use of other transport to deliver goods to the customer [5].

Freight wagons are used for bulk transport of large quantities of goods in specially designed type wagons. Their construction is made in such a way that the material can be quickly loaded and unloaded into the wagon, which leads to its efficient handling.
The world's most widely used wagons are open wagons, used to transport containers that can be easily unloaded and loaded by crane onto freight trains. They are double-axle or triple-axle. They are usually designed for large transport capacities and lower speeds, but there is now a drive to increase the maximum speed allowed by using mechanisms from passenger cars.
A large number of types of freight wagons are divided according to their decisive structural character in accordance with the international classification system. Each type of wagon is characterized by its construction, the method of loading and unloading vehicles, the capacity of transported cars, the possibility of transporting off-road and delivery vehicles [6, 7].

Intermodal transport

The transport of goods from producers to customers requires a high degree of organization and coordination between the different modes of transport. One innovation that has changed the global freight transport landscape is intermodal transport.
As such, intermodal transport is one of the most efficient ways of transporting road trailers, containers and swap bodies, for longer distances. This transport is more environmentally, road, fuel, energy and financially friendly. Intermodal transport is a mode of transport that is carried out using the same means of transport or container and two or more modes of transport. It uses one or the same unit of combined transport without handling its contents during transport. The benefits of this type of transport are the security and savings entailed owing to the fact that the goods are not handed. This type of transport involves goods being grouped into loading units or closed ILUs (containers, swap bodies or semi) to reduce load handling, therefore lessening the possibility of losses, breakage or theft. These units also facilitate their transfer or transshipment to the different means of transport (road, rail, sea, etc.) used to bring them to their final destination [1, 7].
Intramodality ultimately involves further integration and complementarity between different modes of transport, allowing the goods shipment system to be used more efficiently from one point to another.

Semitrailer transshipment technologies in intermodal transport

The transshipment of intermodal semi-trailers and containers can be carried out on two levels within the intermodal transport system between the different modes of transport. It is a vertical and a horizontal plane.

These special transshipment technologies have already been applied and are advanced technological and design solutions, which are mainly developed and then immediately applied as pilot projects for new lines and terminals for combined transport. Different transshipment systems in the vertical and horizontal planes use different systems that allow goods to be transshipped more efficiently [8,9].

Horizontal transshipment is when the transport unit, semi-trailer or container is not lifted off the ground, i.e. the transport unit is still at least partially in contact with the means of transport or the ground. In this transshipment there are technologies such as ModaLohr, CargoBeamer, CargoSpeed and Mobiler [9,10].

CargoSpeed is an innovative semi-trailer transport solution that enables rail freight to operate with a truly balanced and sustainable intermodal transport system.

Technological process of transshipment

The transshipment of goods takes place in terminals designed for this purpose, where the essence is that the track is placed about 1 meter below the road level for a good entry of the tractor-trailer on the wagon floor, Fig. 1.

Fig. 1 Loaded semi-trailer on a rotated surface [8]

ModaLohr is a horizontal reloading technology. This railcar is designed as a low-platform railcar with a turntable platform for inclined passage of the entire road set, truck plus semi-trailer. The technology is mainly aimed at ensuring high reliability and minimum maintenance costs. A complete freight train is coupled to the terminal at a defined position along the approach ramps. The wagon loading area is then lifted by a lifting mechanism and hydraulically rotated 30° with the center platform of the wagon so that the semi-trailer can be either detached or attached to the truck (Fig. 2).

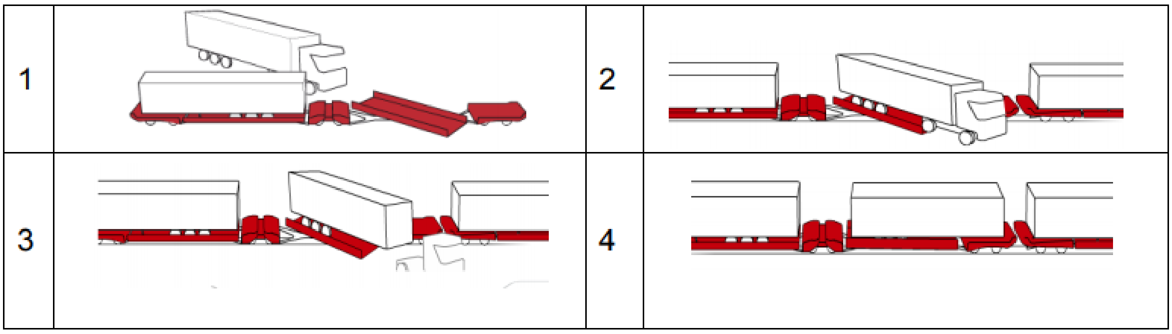

Fig. 2 ModaLohr transhipment procedure [10]

The **CargoBeamer** system differs from conventional methods of loading semi-trailers onto intermodal wagons in that it transports the semi-trailers on large steel pallets which can be pre-loaded without the train being present, and then driven on. Transshipment of the loaded pallets to the wagons is then undertaken using automated transshipment equipment located at purpose-built terminals such as the one in Calais to slide the pallet holding the semi-trailer onto the wagon without cranes.

The horizontal CargoBeamer technology is used for the transshipment of intermodal semi-trailers. It is a new design of railcar chassis that allows horizontal transshipment of semi-trailers using this loading platform (Fig. 3). The freight train in the terminal is docked at a defined location. Subsequently, a process occurs when the loading platform of the rail wagon and the loaded road semi-trailers are slid out. This platform extension is carried out by a lifting device which is below the rail wagon. The loading platform is then moved to the transshipment ramp by means of a roller conveyor [9,10].

Fig. 3 Loading the semi-trailer and subsequent sliding onto the wagon in the terminal [1]

Conclusion

In order to maximise the efficiency of transport using intermodal transport, it is necessary to gain enough knowledge base for the correct selection of wagons and transshipment systems.

Each of the horizontal semi-trailer systems has advantages and disadvantages in something different. When selecting the right system, one must first decide on the goods to be transported and then deal with the issue of the type of transport and the selection of the right wagon. It can be concluded that the most advantageous system for use in transport is CargoSpeed because of its low operating costs and the lack of the need to build a terminal [10]. Conversely, the least favorable systems for transport are those for which a freight terminal has to be provided, with high costs both for operation and for operating staff. All influencing factors must be taken into account for future transport improvements.

Acknowledgement
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VISUALIZATION OF MANAGEMENT INFORMATION SUPPORT

Jaroslava KÁDÁROVÁ – Michaela KOČIŠOVÁ– Laura LACHVAJDEROVÁ–Denisa RYBÁROVÁ

Abstract: The aim of this article is to analyze the impact of color selection in dashboards on management and decision making. The dashboard can be used to add a professional look to color, highlight key indicators or even evoke an emotional response from users, which can result in action. The color value is not only aesthetic but also expresses a certain meaning when visualizing the data. Control panel colors can alert us immediately to critical information, identify data relationships, or alert you to potential issues before they become major constraints. Color is an element that makes data visualization visible. The role of colors is to make the analytical instrument panel attractive, easy to read and use.

Keywords: management, decision making, color, infographic, dashboard

Introduction

According to [1], they express themselves about reporting as a complex system of internal reports and reports, which are key for the management of the company as a whole, but also its individual components. They also claim that the selection, processing, formal editing and distribution of information in the reports is an integral part of reporting. As reported by [2], the author defines reporting as a tool that should serve to provide information that is important for all managers in the company and in the decision-making process. Reporting is divided into external and internal according to its end users. External reporting is defined by [1] as external reports that must be published by each company. At present, these are mainly financial statements, of which the balance sheet, profit and loss statement and notes are an integral part. Internal reporting can take various forms, which depend on the organizational structure of the company and the needs of its managers [1]. Internal reporting is mainly interested in information support of value management of the company's activities.

Based on [3], management reports can be considered a system of providing information important for decision-making processes at various hierarchical levels in the company. He deals in detail with the importance and compilation of management reports in the book Methodological issues of management reporting systems design. Depending on the technology used and the way management reports are used, there are two basic types of management reports:

- **Management dashboards**, which are designed to produce data at regular intervals, with the data being analyzed on a daily basis. The data are most often processed in the form of graphs and tables.
- Scorecards, which are performance charts and make it easier for managers to monitor business progress. They usually display weekly, monthly, quarterly and annual data.

Managerial reports and the reporting system can be defined as a technique of providing relevant information to management, which should be further used in planning, organizing and controlling the company's activities. They describe two views of management reports. According to a closer look, management reports deal with providing internal information about the company in a formal way. From a broader perspective, they argue that management needs a much wider range of information for business management and control. According to them,

the reports cover internal, external, formal, informal, historical, current, future, financial and non-financial data and information. The content page should meet certain criteria, such as uniformity of information provided, information about the environment and competition, and last but not least, the reports must be selective. Insufficient information can mean neglect of some areas of management, and conversely, excessive information causes inefficiency and imbalance of the reporting system.
Although management reports must contain all relevant current information, it is important that the information contained in the reports is key to the company's success in that area. This information must be processed in such a way that users can orientate themselves and quickly judge which information is key and which does not play such an important role for the future of the company. The content of reports must be adapted to their users and the reporting system must be set up in the company so that it can be adapted to each user.

Objective and methodology

The aim of the paper is to analyze the elements of infographics and their influence on managers' decisions. We analyze the impact of color selection in management dashboards on manager management and decision making. With the help of color, it is possible to give the dashboard a professional look, highlight key indicators or even evoke an emotional reaction of users, which results in action. When visualizing data, the color value is not only aesthetic but also expresses a certain meaning. Dashboard colors can instantly alert you to critical information, identify relationships between data, or alert you to potential issues before they become large. Color is a powerful element that makes data visualization visible. The role of colors in the analytical dashboard is to make it attractive, easy to use and easy to read.

Results and discussion

Infographics are a method of visually displaying data, information, or the relationships between them. Through graphs, maps, symbols and illustrations, it enables the fast and clear presentation of data in order to understand them more quickly. Today, infographics are considered to be one of the best ways to interpret more data and information. Businesses usually work with large amounts of data. In order for the numbers to change in knowledge, it is necessary to select the appropriate data and then present them correctly. Four basic types of presentations can be used to present data (Figure 1).

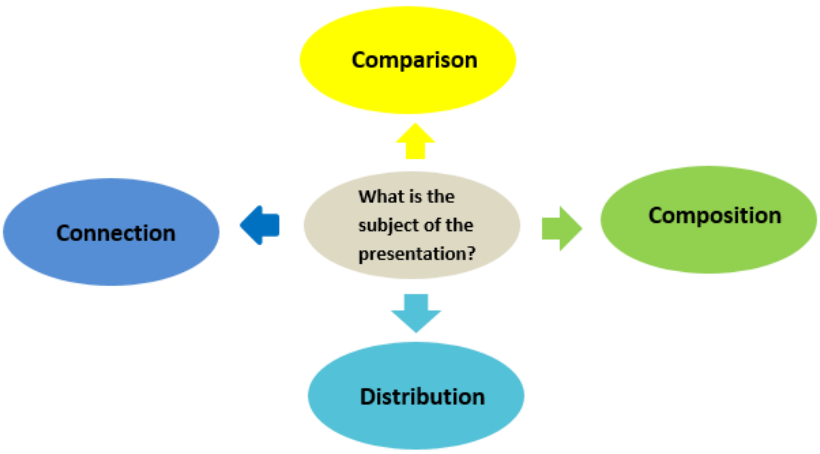

Fig. 1 Types of presentations, Source: own research

The most commonly used types of data analysis are data comparison or composition, which is one of the simpler ways to work with data.

The importance of colors

Marketing has long used colors to influence how we see and perceive the world. The influence of colors depends on the setting of society and on some universal human abilities of perception. Color in data visualization affects the judgment and perception of the audience and can have a very subtle effect or, conversely, be a significant element that everyone focuses on.

The meaning of color and its perception does not apply in general and unconditionally. The perception of the meaning of colors is subjective and to some extent is associated with culture, religion, traditions, geographical and contemporary differences, experiences, and similarities to objects. When compiling managerial reports, it is necessary to respect certain laws of color perception, and especially when it comes to reports compiled in international and transnational companies and companies, where managers and employees from several countries, cultures, religions and continents meet in general. The importance of colors also in terms of clarification of these aspects is elaborated in Table 1.

Tab. 1 Meaning and perception of colors, Source: own research based on [4-5]

Color	Characteristics	Symbolism
White color	The white color symbolizes purity, tenderness, innocence and coldness. White symbolizes high values and ideals. White is often used in modern minimalist design. Its simplicity creates an absolutely timeless impression.	• Peace (flags: Bulgaria, Ireland, Poland, Cyprus, Philippines, Georgia, India, South Korea, Lebanon, Singapore, Syria, Uzbekistan, Dominica, Panama, Peru, Burundi, Djibouti, Lesotho, Nigeria, Equatorial Guinea) • purity (flags: Greece, Philippines, Indonesia, Japan, Singapore, Thailand, Dominica, Cuba, Algeria, Madagascar, Niger, Togo) • freedom (Saint Kitts and Nevis, Suriname), understanding (Ireland), hope (Georgia, Panama, Saint Kitts and Nevis) • unity (South Korea, Gambia, Niger, Sierra Leone) • truth (India) • honor (Japan, Singapore) • happiness (Laos) • good (Laos) • justice (Peru, Suriname) • tolerance (Pakistan) • noble thoughts (Cuba) • law - faith - credibility - honor (Latvia) • snow (Estonia, Finland, San Marino, Canada, Chile, Gambia) • glaciers (Iceland) • rivers (Guyana) • sea surf (Trinidad and Tobago) • understanding between whites and blacks (Botswana, Saint Lucia, Dominica) • Buddhism (Thailand) • Action (Kuwait)
Black color	Black, the darkest color, a symbol of darkness, evil and fear. It is associated with death, mystery,	• Battlefield (Kuwait) • gloomy past (Syria) • foreign domination (Georgia)

	evil, loneliness and sadness. It looks elegant and sublime. We subconsciously perceive the black packaging of products as heavy, unlike white.	• hard life of slaves (Jamaica) • death (Angola) • unity (Bahamas) • force (Trinidad and Tobago) • patience and perseverance (Guyana) • earth (Estonia) • color of black people (Antigua and Barbuda, Barbados, Saint Kitts and Nevis, Botswana, Kenya, Malawi, Uganda, Tanzania, Zambia), Africa (Mozambique)
Yellow color	Yellow is an optimistic, creative color that catches the eye. The yellow color is characterized by a feeling of freedom, hope of energy and humor. Yellow is the color of light, "enlightenment" and then understanding. Yellow is suitable for graphics where it is necessary to show grandeur and respect. Its practical disadvantage is that it does not stand out very well on white. The less rule is sometimes more.	• wealth (Lithuania, Burkina Faso) • Royal Authority (Bhutan, Brunei) • mineral wealth (Jamaica, Bolivia, Brazil, Guyana, Angola, Mozambique, Tanzania, Togo) • golden future (Suriname, Mauritius) • Agriculture (Lithuania) • harvest (Guinea-Bissau) • sunshine (Grenada, Jamaica, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Chad, Gabon, Guinea-Bissau, Cameroon, Mauritius, Uganda, Solomon Islands) • desert (Chad) • savannah (Guinea-Bissau) • beach (Bahamas, Barbados, Saint Lucia) • courage (India) • friendship (Grenada) • cordiality (Saint Vincent and the Grenadines) • self-sacrifice (Suriname, India) • respect for the people (Suriname) • justice (Guinea) • neutrality (Cyprus) • hinduism (India)
Green color	The color green is the color of nature and evokes pleasant feelings such as: peace, harmony, hope, peace, freshness and relaxation. Color is preferred in the food, healthcare and organic businesses.	• nature (Dominica, Grenada, Saint Vincent and the Grenadines, Guyana, Uzbekistan, Burundi, Gambia, Guinea-Bissau, Kenya, Malawi, Niger, Equatorial Guinea, Tanzania) • forests (Lithuania, Gabon, Guinea-Bissau, Cameroon, Mozambique, Nigeria, Zambia, Solomon Islands) • meadows (Kuwait) • mountains (Oman) • sea (Portugal) • rainforest (Brazil) • agriculture (Jamaica, Burkina Faso, Libya, Mauritius, Nigeria, Seychelles, Sierra Leone, Togo) • fertility (Bangladesh, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Bolivia, Suriname) • defense of freedom (Bulgaria) • hope (Portugal, Jamaica, Burkina Faso, Burundi, Guinea-Bissau, Cameroon, Madagascar, Mauritania, Zaire) • abundance (Burkina Faso, Lesotho, Muretania) • progress (Burundi) • faith (India) • knighthood (India) • solidarity (Guinea)

		• Prophet Muhammad and Islam (Azerbaijan, Bangladesh, India, Maldives, Pakistan, Saudi Arabia, Sri Lanka, Algeria, Comoros, Libya, Mauritania) • Catholic Church (Ireland)
Blue color	The blue color symbolizes wealth, sincerity, trust and a sense of security. gives Blue color gives a feeling of seriousness, responsibility, rationality and stability. The light blue color evokes warmth and pleasant feelings, while the dark blue color seems cold and uncomfortable to us. Blue is considered the iciest color. Blue is used to express quality and purity. Blue was once a woman's color of harmony and fidelity, vastness and peace. Today, thanks to children's fashion, we perceive it as a boy's color.	• sky (Estonia, Iceland, Liechtenstein, San Marino, Azerbaijan, India, Kazakhstan, Taiwan, Barbados, Saint Vincent and the Grenadines, Chile, Chad, Somalia) • lakes (Finland) • sea (Greece, India, Bahamas, Barbados, Colombia, Venezuela, Gabon, Mauritius, Equatorial Guinea, Sierra Leone, Tanzania) • rivers (Laos, Chad, Gambia) • rain (Lesotho) • water (Cambodia) • idealism (Philippines) • Judaism (Israel) • hope (Chad)
Red color	Red is an energetic color and increases desire. It is associated with blood as a symbol of life, but also of struggle and death. It symbolizes love, liveliness, energy, danger, blood, anger, sensuality, enthusiasm and passion. Burgundy red represents luxury and elegance. In large areas, it is beneficial in small quantities and can attract attention. But if you overdo it, it can be aggressive and frightening. Red attracts attention and excites action. Red has a physical effect on people, increases heart rate and pressure. Until the 1920s, red together with pink expressed masculinity.	• blood of fallen warriors (Albania, Bulgaria, Lithuania, Latvia, Austria, Armenia, Bangladesh, Kuwait, Laos, Thailand, Canada, Cuba, Chile, Colombia, Peru, Algeria, Chad, Kenya, Malawi, Mauritius, Togo) • struggle for independence (Saint Kitts and Nevis, Burundi, Cameroon, Kenya, Equatorial Guinea, Zambia) • revolution (Portugal, Cambodia, Burkina Faso, Seychelles) • freedom (Azerbaijan, Indonesia, Thailand, Angola, Guinea-Bissau, Madagascar) • bravery (Philippines, Indonesia) • self-sacrifice (Lebanon, Syria) • love (Suriname) • friendship (Singapore) • fraternity (Uganda) • passion (Japan) • suffering (Guinea-Bissau) • dynamics (Antigua and Barbuda) • bravery (Bolivia) • endurance (Suriname) • viability (Uzbekistan) • unity (Grenada, Cameroon) • activity (Guyana) • fire (Liechtenstein) • volcanoes (Iceland) • sun (Gambia) • warmth (Trinidad and Tobago)

	Red is a very dynamic color, it excels, draws attention to itself, it expresses tension, danger.	• evening sky (Denmark) • flowers (Lithuania) • beast (Bolivia) • socialists (Poland, Dominica) • communists (China, Cambodia, Mongolia) • good times (Georgia) • future (Kuwait) • work (Guinea, Guinea-Bissau) • progress (Suriname, Seychelles)

Influence of color on the perception of the content of data provided in the form of graphs:

- Color simplifies complex graphs - Comparing even a small amount of data can be challenging for anyone, especially when looking at different types of lines and scatter plots, which act more like visual chaos as a result. By using contrasting colors, such as blue and orange, for visualizations that compare two sets of data, or a color gradient that is often considered a scale, such as green, yellow, orange, red, things can be simplified and help the audience navigate a large area of data.
- Color affects the overall impression of the data - The choice of colors that make up a particular infographic will depend to a large extent on how the audience should feel. Colors can convey a feeling of peace or create a relaxed atmosphere. They can even evoke impressions such as sophistication, purity and creativity. Using the right colors for a given task is important for managers to feel what they want to suggest by interpreting the data.
- Color adds depth to data - Using the same colors for everything is confusing, boring and uninteresting. Thanks to the use of contrasting colors, gradients and other interesting color combinations, the graphs will protrude from the presentations, attract the attention of managers and give the data a deeper meaning.

Color blindness makes it difficult to distinguish between red and green, so it is recommended to use these colors carefully. In this case, a tool such as Vischeck is used to simulate color blindness so that you can see what the color-blind dashboard user sees when browsing (Figure 2).

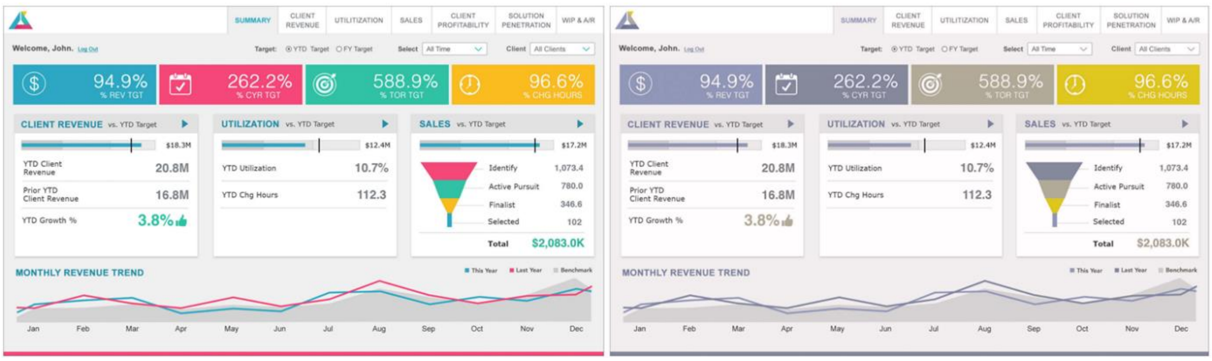

Fig. 2 Dashboard experiment, Source: own reseach based on [6]

When using similar colors, you need to make sure that users or audiences can distinguish between them.

Choosing a suitable graph

Andrew Abela created a graph selection diagram that serves as an algorithm to determine the correct graph for a given data type [7]. Tables are basically the source of all infographics tools. Correlation tables are used to compare the magnitude of the values of indicators and can be used to find the lowest and highest value in the data. They are used to compare current values with past ones to find out what the development of values is increasing or decreasing. The most common questions the tables answer are: "Which products sell best?" And "What is our sales compared to last year?" redistribute the total value of the indicator. Composition graphs show relative value, but some graphs can also be used to show the absolute difference [8]. The difference is between looking at the percentage of the total value and the value of the total. Frequently asked questions are: "What market share does the company have in the region?" Or "In which areas is the budget divided?“.
Distribution tables are used to determine the distribution of quantitative values along the axis from the lowest to the highest [9]. When looking at the shape of the data, the audience can identify characteristics such as range of values, means, shape, and extremes. It can be used to answer questions such as, "How many customers by age group?" Or "How many days on average are payments delayed?"

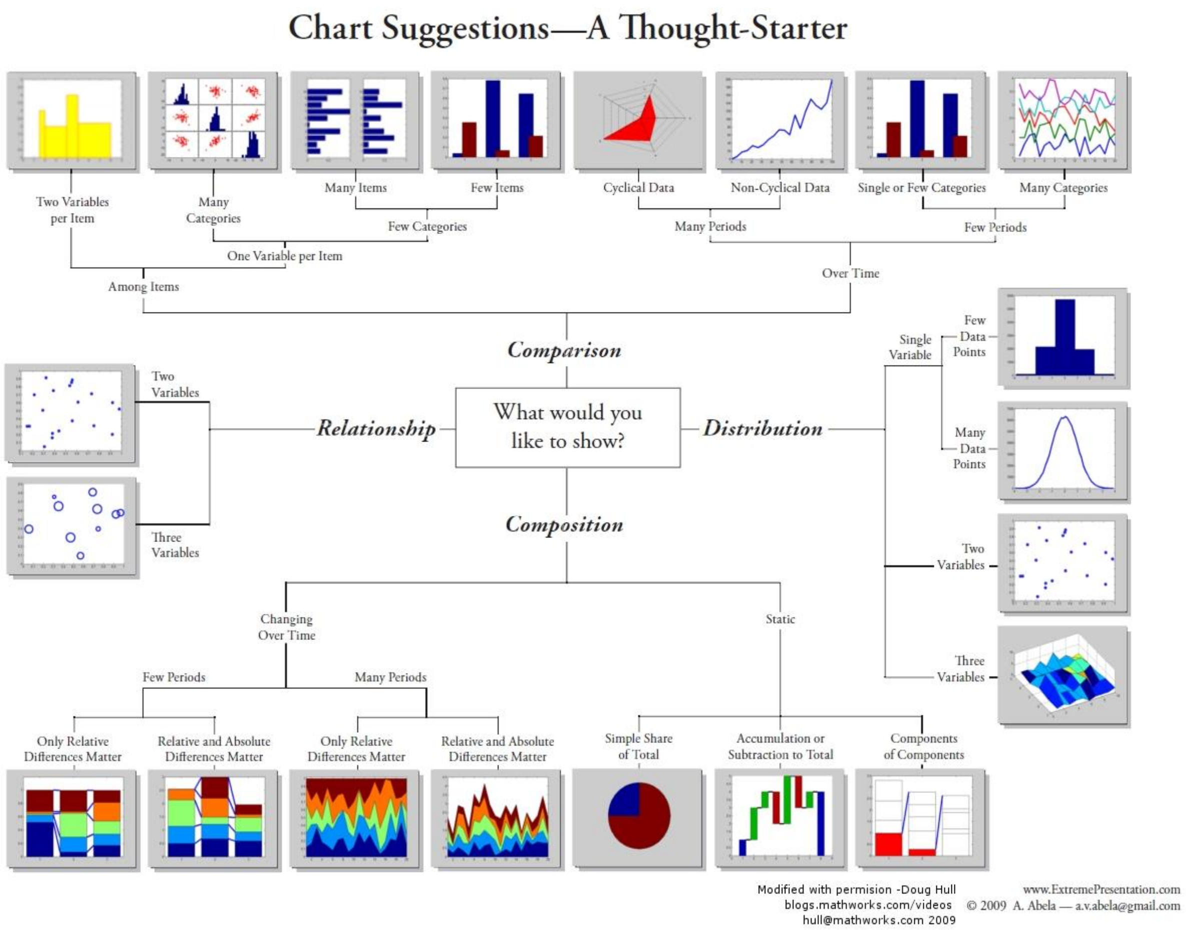

Fig. 3 Aid for selecting a suitable graph, Source: own research based on [6]

Relationship graphs are used to establish relationships between data and can be used to find correlations, extremes, and groupings of data [10]. Common questions are: “There is a correlation between advertising costs and sales. Tables are basically the source of all infographics departments, or "How do costs and revenues vary by region and how does it vary?"

Conclusion

In a data-dominated world, it is more important for businesses to understand and learn how to make the most of the amount of data on offer. Therefore, in conclusion, here are some recommendations suitable for compiling management reports regarding color selection:

- No chart recommends using more than six colors.
- To compare the same value in different time periods, the same color is used with increasing intensity over time.
- Different colors are used for different categories. The most commonly used colors are black, white, red, green, blue and yellow.
- It's a good idea to keep the same color palette or style for all charts in the series and the same axes and labels for similar charts to be consistent and easily comparable.
- The appropriate color contrast can be checked by printing the graphs in shades of gray. If the color differences cannot be clearly distinguished, the hue and saturation of the colors must be changed.
- According to statistics, 7 to 10 percent of men suffer from color vision disorders. When creating graphs, keep in mind that they are legible even for people with color impairments.

Acknowledgement

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MANUFACTURING EXECUTION SYSTEM (MES) AS SOFTWARE FOR VERTICAL INTEGRATION BETWEEN IT OR OT NETWORKS

Michal DIC – Miriam PEKARČÍKOVÁ – Monika BUČKOVÁ – Ján KOPEC

Abstract: This article deals with key element of Industry 4.0, software for vertical integration across manufacturing organizations. Software which allows bi-directional communication and data exchange between IT and OT networks. Competitive environment which faces most of the industrial companies pushes boundaries of MES functionality and provide must have tool for top industry companies. Within business environment we can conceive all activities as an operations set that are linked to computer systems and information management in the network, achieving more efficiency in the flow, in addition, this new industry perception and businesses includes different analytical tools which are useful to support the customer service efficiency improvement.
Keywords: Industry 4.0, manufacturing, vertical integration.

Introduction

Industrial and technological growth, sponsored by the new organizational systems generated by the fourth industrial revolution, require adapt new business management ways in the companies. MES is software that manages and optimizes production and delivers information that enables the optimization of shop floor activities. MES manages the rules, workflow, and information required to execute and document the operational processes to transform raw materials into finished products. The software technology is changing to enable more efficient operations, with real-time information available where needed, digital guidance, workflow enforcement, and documentation for regulatory compliance.

The four main characteristics of industry 4.0/ smart manufacturing

1. Vertical integration of smart production systems – factories are not designed on a standalone basis. There is a need for the networking of smart factories and smart production systems.
2. Horizontal integration through global value chain network - Integration will facilitate the establishment and maintenance of networks that create and add value. The first relationship that comes to mind when we talk of horizontal integration is the one between the business partners and the customers.
3. Through-engineering across the entire value chain - The whole value chain in industry is subjected to what is termed through-engineering, where the complete lifecycle of the product is traced from production to retirement.
4. Acceleration of manufacturing - Business operations, particularly those involved in manufacturing, make use of many technologies, most are not innovative or expensive, and most of them already exist.

In Smart Manufacturing environment, traditional understanding of MES, acting as a centralized monolith between the ERP and shop floor automation don´t necessarily fit with the use of distributed intelligence and the IIoT. This era of systems is coming to their end. It is important to have IIoT connection capabilities within the MES which takes Smart manufacturing to the next level. While sophisticated IIoT platform can provide data aggregation, visualization and analysis, its bottom-up approach means it doesn´t see the wider perspective of manufacturing. Adding an MES solution that is implemented and designed to work within the IIoT environment adds context and end-to-end process connections. This brings enablement of standardization, enforcement of quality processes and clearer visibility of events in supply chain.

Vertical integration

Modern manufacturing requirements direct development, with the main goal of integrating all logical layers within an organization, starting from the field layer (i.e., the production floor). Such integration assists in making strategic and tactical decisions because relevant data can flow transparently and freely up and down among these layers. Key advantage of this kind of integration is that the reaction time of the company can be dramatically reduced, which translates into a competitive advantage in the market.

Picture fig.1 presents vertical and horizontal integration from another viewpoint. In this case, the two ends of the vertical axis are the business side (top) and the production side (bottom). The suppliers(left) and the customers (right) are the two ends of the horizontal axis. For example, ERP is more closely related to the business side, while shopfloor and PLC technologies are nearer to the production side. Supplier relationship management (SRM) supports suppliers, while customer relationship management (CRM) keeps in touch with customers. PLM systems help to manage the processes of the product lifecycle. To meet all requirements of modern manufacturing, it is necessary for digital information to flow as efficiently as possible among all subsystems under controlled conditions. All important user groups in the company, from marketing to purchasing and from the worker to the manager, should have access to the relevant data through the collaborative production management (CPM). The MES occupies a central position, and it is inside in the CPM; thus, logically, it can assist in connecting the other, more “peripheral” systems.

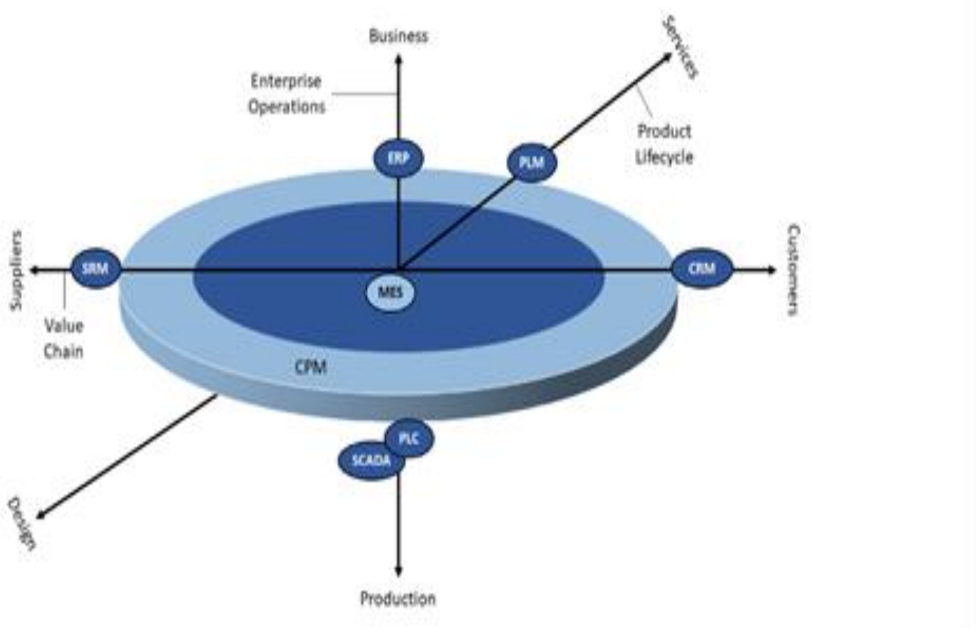

Figure 1 Shows Vertical/Horizonal integration across organization

Industrial and technological growth, sponsored by the new organizational systems generated by modern manufacturing, require adapt new business management ways in the companies. Within the organizational and business area we can conceive all activities as an operations set that are linked to computer systems and information management in the network, achieving more efficiency in the flow, in addition, this new industry perception and businesses includes different analytical tools which are useful to support the customer service efficiency improvement.

IT/OT coverage

The gap between IT and OT systems is starting to close. Companies require enterprise-wide visibility and intelligence from production to make informed, actionable decisions. This means MES must be connected to and integrated into the overall information system and into the supply chain enterprise-wide. MES functionality and capabilities are increasing. There are fewer siloed applications and point and line solutions. While some suppliers embed their own database into their solution, most can integrate and operate among many different types of data sources. In the future, everything will work together seamlessly: people, technology, and things.

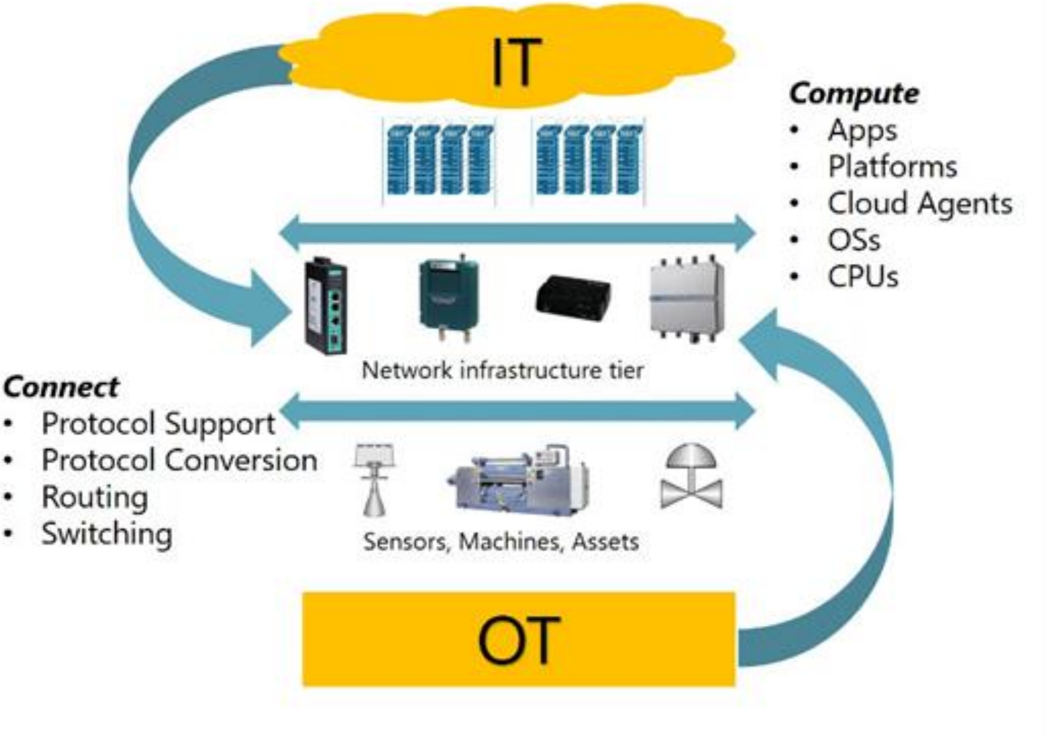

Figure 2 IT / OT coverage

Competition in the next millennium increased emphasis upon time as expressed by speed, quality, service and global focus. Agility is the watchword. Manufacturers are measured by their ability to react quickly to sudden, often unpredictable change in customer demand for their products and services. To compete successfully the manufacturing applications have to be time and activity based and above all should be focused on customer. Today companies must be able to deliver customer specific products with the lead-time of standard, off the shelf products. Make-to-stock and make-to-order types of modes at times have to be selected by the company. Initially, cultural, organizational, operational, and technological constraints slowed the convergence of OT and IT for plant- and field-level automation. But over time, many of these constraints have either faded away or largely been overcome and IT/OT convergence is proceeding at a rapid pace. Examples in place today include:

- Wireless field devices and plant networks.
- Ethernet-at-all-levels.
- Virtualized hardware and applications.
- Cloud computing, software-as-a-service (SaaS), and product-as-a-service (PaaS).
- Advanced simulation and digital twins.
- 3D scanning and additive manufacturing.
- Advanced robotics.
- IIoT-enabled remote asset monitoring.
- Predictive/prescriptive maintenance, and Advanced operational analytics

The above are just some of today’s advanced technologies and solutions being deployed in industrial environments. None would be possible without the convergence of operational and information technologies. In addition, IT/OT convergence is a key enabler for important industrial initiatives such as Industry 4.0.

Manufacturing operations management / manufacturing execution system

MES is designed to fulfill the needs of a broad manufacturing enterprise, by coupling front office accounting with the factory supervisory control systems and products. In addition to linking, MES also closely ties the outputs of these three layers of information systems those residing in the planning functions, such as MRP, execution functions, such as supervisory control software or quality control, and control systems that create the data utilized, so that the enterprise has full access to the separate databases of information that exist within the organization. MES’s functions such as scheduling, resource allocation, process management, quality management, and operation analysis, all operate to “translate” the real-time data occurring on the factory floor into information that is useful from a process control/management standpoint. This further ripples into other adjunct processes such as labor, equipment, and materials management; product tracking; and supportive systems such as quality and documentation.

MES systems help create faultless production processes and help create a consistent view of production data. Other benefits of a successfully implemented MES system are:

- traceability of production,
- ensuring accurate production data,
- reduction of downtime, nonconforming production, shortening of setting times,
- increase overall equipment efficiency (OEE),
- reduction of inventory,

- introduction of paperless production,
- possibility of accurate economic evaluation of production and others.

Real use case experience with manufacturing execution system

The company's expansive portfolio of industrial solutions and components includes hydraulics, motors, controllers, drives, compressors, sensors, switches, pumps, and meters that are designed to drive global advancements in sustainability for energy efficiency, renewables, food supply, and connectivity. This company can be defined as high-volume, high-configurability and high-variation manufacturing company. MES has helped the company's production process by deploying new configuration to its shop floor, minimizing manual intervention, and providing full traceability and product history.

Business challenges

- Demand for more complex and personalized products in condensed time period.
- Adapt new product introduction to shop floor processes.
- Adjust manufacturing line and processes to efficiently handle influx of new products.
- Meet market demand to quickly bring more complex products to market.

The MES template fulfills several key functions, from ERP and automation integration interface to defect logging, NPI product configuration, reporting, order management, traceability, data recording, management of operator and automation instructions, interlocking. MES also increases manufacturing flexibility and efficiently manages a various mix of products. Since deploying MES, company has reduced the number of resources needed to complete a project. With this new solution, the company is much better equipped to handle high-product variation than it was previously. As result can be defined as assure the accuracy of the manufacturing process and possesses the traceability to quickly identify the root cause of any problem and many more.

Results

- Enhanced flexibility of manufacturing processes.
- Increased speed of innovation of new products.
- Leveraged Siemens technology to accelerate digitalization process.
- Elevated product quality and transparency.
- Reduced administrative efforts and costs.

Conclusion

Modern Manufacturing Execution System might be defined as common information system/Backbone for shop floor, not only throughout plant operations, but also across multiple facilities, suppliers and divisions. The key advantage is data consistency, enabling people or teams to work collaboratively and share data. Manufacturing Execution Systems gives traceability of components on required level without any risk of data distortion and providing right information on right place. Information acuired from data collected from shopfloor can navigate companies throught competitive environment. Most of the top industry ranked companies have implemented such a solution due to the reason also described in this article.

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LOCATION DETECTION TECHNOLOGIES AS EXPONENTIAL TOOL OF INDUSTRY 4.0

Marek MIZERÁK – Marek KLIMENT– Miriam PEKARČÍKOVÁ – Ján KOPEC

Abstract: This paper deals with the issue of localization and detection technologies and their use in practice and the subsequent analysis of specific examples of use not only in the premises of manufacturing companies. The paper explains the definition of RTLS technology, as well as its topology or main parts. The use of RTLS localization systems emphasizes the importance of the Industry 4.0 concept in modern manufacturing companies, where nowadays there is an increasing emphasis on process simplification, usability of warehouse space, shortening of times, savings and, last but not least, safety.
Keywords: RTLS, localization system, Industry 4.0.

Introduction

Real Time Location Systems (RTLS) refers to any system that accurately determines the location of an item or person. RTLS is not a specific type of system or technology, but rather a goal that can be achieved with different asset localization and management systems. An important aspect of RTLS is the time at which assets are monitored, and this data can be used in different ways depending on the application. For example, some applications only need timestamps as the asset traverses the area, while other RTLS applications require much more detailed visibility and require constant updating of time data. The ideal real-time location system can accurately locate, track and manage assets, inventory or people and help companies make informed decisions based on the location data collected.

Furthermore, it is possible to say that the RTLS system serves not only to identify the tag, but also to locate it and monitor the movement in real time. The system determines the location using small devices placed on the objects we monitor, active RFID tags. RTLS technology is designed mainly for monitoring and determining the position of objects in the interior or within the exterior (premises of the production company, etc.). RTLS is used in many industries with specific applications such as employee tracking and asset tracking. These applications can be found in the manufacturing and mining industries, but are most important in healthcare.

The accuracy of this system ranges from meters to tens of centimeters, depending on the technology used. We will talk more about the mentioned technologies in the next chapters.

1. Topology of RTLS systems

Each RTLS system uses a certain infrastructure. For the system to run smoothly and properly, the monitored area must be covered by a wireless network so that each tag has a sufficient signal. Each active RFID tag in the network then independently transmits data over that network to a server, where the data is further processed. The position or trajectory of the tag movement is evaluated through the application.

1.1 Definitions according to the infrastructure used

Today, there are a number of RTLS systems that use different frequencies and wireless infrastructures. Therefore, they are divided according to the following parameters:

- ZigBee (2.4 GHz),
- UWB (Ultra Wide Band),
- Wifi (802.11 b / g / n, 2.4GHz).

Proprietary systems - they use special wireless systems for their operation, which are reserved only for the RTLS system. This solution is more reliable because there is no interference or other problems caused by other anodeless devices. Specifically, these are the frequencies 433 MHz, 800/900 MHz and 2.4 GHz.

2. Parts of the RTLS system

All RTLS applications will consist of several basic components: a transponder, a receiver, and software for interpreting the data from each. The complexity of the system, the technology chosen, and the scope of the application will determine the amount of hardware and software needed to create the ideal RTLS.

Each technology used for RTLS uses its own terminology. Here are some general concepts to help you understand the items and their roles in the system in general.

2.1 Transponders

A transponder is connected to an item or person to uniquely identify that item or person. A transponder typically receives a signal from a receiver and responds back with its unique ID, but can also transmit an initial signal if it contains an internal power source.

Depending on the type of technology and the purpose of the application, transponders can be:

- Radio Frequency Identification Tags (RFID)
- Bluetooth beacons
- Smart devices

Fig. 1 RTLS transmitter and receiver

- Wi-Fi tags
- Global Navigation Satellite System (GNSS) / Global Positioning System (GPS) markings
- Ultrasonic markers
- Infrared markers
- Smart devices (depending on mode)

2.2 Receivers

A receiver is hardware with a power source connected to a network that transmits and receives signals from transponders. The receiver then forwards the collected data to end hosts or databases. In some systems, the receiver may be an existing infrastructure, but in others the receivers need to be purchased and integrated into the application environment.

Depending on the type of technology and the goal of the application, the hardware can be:
• Readers
• Position sensors
• Access points
• Receivers
• Beacons (depending on mode)
• Smart devices (depending on mode)

2.2 Software

The software in these systems can vary in complexity, from simple software integrated into the receiver's hardware to multiple software instances, such as localization software, middleware, and application software on the host computer. The software can be combined to create the desired system functionality. Three main types are used in RTLS applications:
• Firmware - software that resides on the hardware
• Software or application software - Software that resides on a back-end computer or server
• Middleware - used to connect firmware and application software

3. RTLS coverage options

RTLS options and reading ranges vary from one technology and setting to another. For example, the system with the longest reading range, GNSS (GPS), can provide the location of an item in real time anywhere in the world, because the receivers are satellites orbiting the Earth. Other technologies with shorter reading ranges, such as UHF passive RFID, can provide placement in a building or zone. The following are the different levels of coverage achievable with RTLS. It is noted that increased granularity can be achieved with each of these coverage options depending on the technology selected, the number of receivers, the labels, or the type of positioning method chosen.

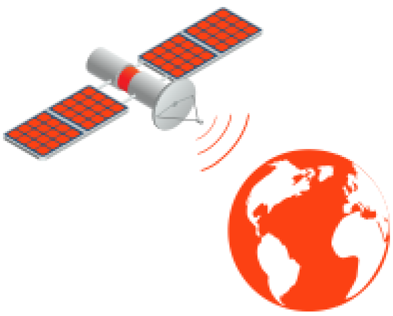

Fig. 1 Illustration of globe capture

Wide Area Coverage - usually refers to the location of an item or person on a global scale using global coordinates.
Example of use: Locating freight containers traveling across the ocean or land with valuable machinery inside buildings.

Fig. 2 Illustration of the location of the building

Local Area Coverage - refers to the location of an item or person in a building or facility that is on the same network.

Example of use: Placement of IT assets in a company building.

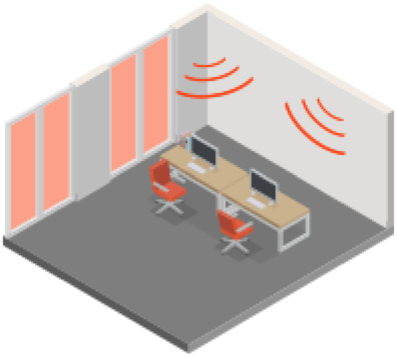

Fig. 3 Illustration of the location of the interior

Zonal coverage - generally refers to the placement of an item or person in a specified zone (i.e., a room, office in a larger area) by setting up hardware at intervals based on reading range and reading barriers.

Example of use: Placement of a high-value oxygen tank in a hospital.

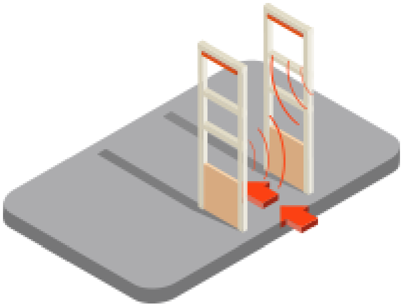

Fig. 4 Illustration of zonal coverage

Throttling points - in general, these are areas that people or people have to go through in order to carry out normal activities (eg doors, corridors, entrances / exits). Usually smaller width to fit the reading areas of certain technologies.

Application example: Determining where in the warehouse the pallet is stored with the products.

Conclusion

The manufacturing companies involved and, in general, the various branches of humanity are subject to constant modernization, which is essential for success. Localization technologies and subsequent digitization using various systems such as RTLS are increasingly recognized. This is due to the results of these systems in the field of locating not only persons but also material things. The application of these systems increases the level of protection of workers' health, saving production time, protection of assets and products and, last but not least, saving corporate finances and the ability to subsequently optimize the use of assets due to improved production. As a result, industrial practice gains more control over everything that happens in production, thus increasing the efficiency and productivity of the business.

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TRENDS IN THE DESIGN OF FACTORIES OF THE FUTURE

Natália BURGANOVÁ - Patrik GRZNÁR - Štefan MOZOL - Marián MATYS

Abstract: Industry 4.0 principles have significantly increased the complexity of the manufacturing environment and presented a slew of new issues. The article deals with the changes and trends in the manufacturing environment, what causes them and what technologies affect them. The main goals of new designs of factories of the future and some of the elements by which adaptive production is achieved are presented. The use of plug and produce architecture, mechatronic systems and sensors and actuators of devices are described.
Keywords: adaptive manufacturing, factory of the future, trends in the manufacturing system

1. Introduction

According to [1], the development of future factories is influenced by two main driving forces:

- Technological development, which includes elements of exponential growth, is achieved mainly by digitization.
- Globalization - offshoring and reshoring, rich versus poor. Changing customer behaviour - local versus global turbulence.

Managing processes is also changing with the Industry 4.0 technologies and the digital transformation of the production and logistics environment. The vision of Industry 4.0 is based on achieving a highly automated and autonomous production environment in which decision-making processes are supported by various technologies based on real-time data analysis. Advances in information technology are a key prerequisite for applying the different perspectives of Industry 4.0. Businesses are under pressure from the market and customers to produce and deliver goods and services as quickly and customized as possible. At the same time, they strive for continuous improvement of their processes, optimization of operating costs and sustainable development.

Global competition and rapidly changing customer requirements are forcing great efforts to change production styles and configurations of production organizations. Traditional centralized production management and step-by-step production planning are not flexible enough to respond to manufacturing changes (such as reduced product batch sizes and increased product complexity and variability) and highly dynamic changes in product requirements. Considerable attention must be paid to reducing production cycles so that companies can respond more quickly to customer desires. In this new range of transformations, corporations worldwide are gradually forced to reorient their manufacturing strategies to expand their market share and integrate adaptive manufacturing into their manufacturing facilities.

At present, it is necessary to focus on the production of tailor-made products. Customers must be involved in all phases of new product development: design, production, assembly and delivery. At the same time, customers demand products with a high degree of functionality, which essentially leads to an incremental increase in product complexity [2].

Customers are becoming more and more demanding:

- the desire for individuality grows in a more oversaturated consumer society in order to differentiate itself from others,
- long delivery times are no longer accepted,
- customers demand better service.

The methods and known processes used are changing significantly due to the exponential growth of technologies. All disciplines, from medicine to government processes, are undergoing a digital transformation, with industry and logistics at the forefront of adapting to new technologies and subsequently implementing them. The graph shows how much each department in Europe has invested in the Internet of Things in 2015 and 2020. The statistics were produced by the [3].

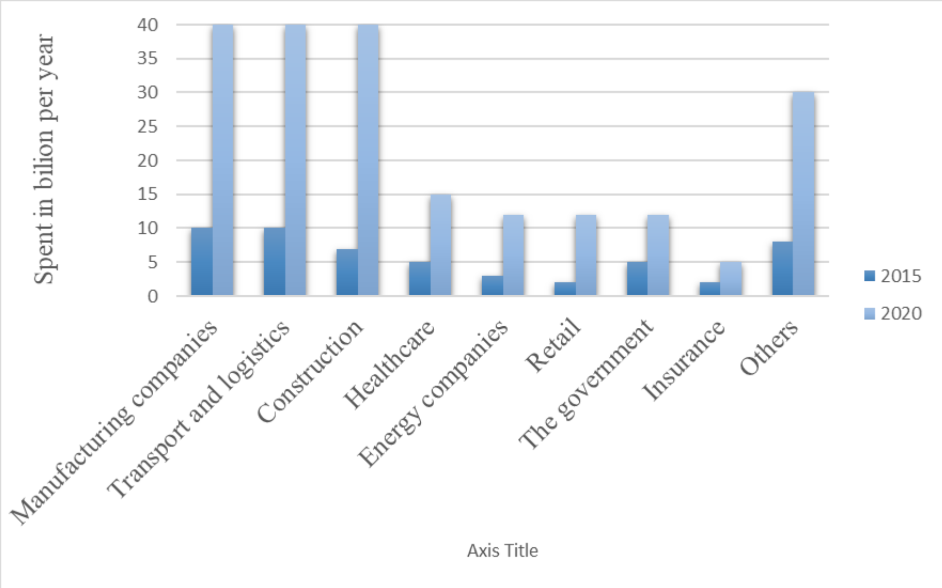

Fig. 3 Comparison of investments in the Internet of Things [3]

New technologies bring benefits such as maximizing productivity, quality and variability of products and services. The added value of products also increases.

2. Trends in the manufacturing system of the future

In addition to making a profit, all new manufacturing concepts strive to meet the primary goal of adaptability. Adaptive manufacturing is the ability to respond flexibly in a production environment to continuous and unexpected changes and is, therefore, a crucial part of manufacturing strategies for the global market [4]. Adaptive manufacturing systems achieve intelligence and adaptive capabilities through the close interaction between mechanics, electronics, control, and software engineering. These systems continuously perform three activities: monitoring the values and trends of the external environment or internal variables, optimizing their goals according to a certain, and adapting their behaviour to achieve the goals. Sophisticated adaptive system control logic is required to support the system. Adaptive functions are achieved by advanced control of production algorithms, estimation of non-directly measurable parameters, planning a set of intelligent sensors, knowledge modelling of processes, and predicting variables.

Adaptive production systems, in addition to changes in management structure and new production systems, require changes in process technologies and the rapid and factual integration of new technologies and new functions. Elements of an adaptive production system are presented to support these changes.

2.1 Plug and produce

If tailor-made products are considered, it is necessary to have a very flexible production environment, which is realized through modularity. It is a methodology to introduce a new manufacturing device into a manufacturing system easily and quickly. It can also remove the device easily from the system. It is designed by the analogy of the Plug & Play concept in the computer world. If you are considering a USB connection for computers, it allows you to connect almost any device immediately and work directly. This is the idea of Plug and Produce technology [5].

2.2 Mechatronic systems

A mechatronic system is a mechanical device controlled by an electronic control unit, currently almost without a program (software). The mechatronic system contains a combination of mechanical, electrical, telecommunication, control and computer technologies.
As we define mechatronics as an area applied to traditional engineering products, a mechatronic system contains several parts. One of them is the working system responsible for all mechanical movements and functions. These do not have to be by themselves, so the working system includes actuators delivering a mechanical dose to the mechanism. They are easy to check back. These three parts - mechanics, actuators and together - form the working system of the mechatronic device. Above it is a controller that issues commands to the actuators based on sensing signals and permission requests. The human interface is used for human interaction with the device [6].

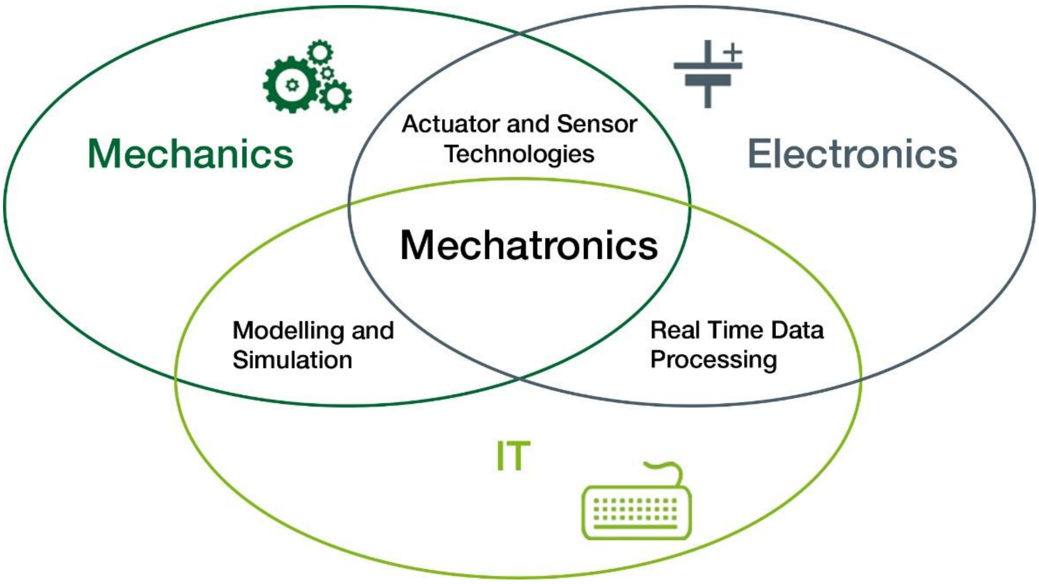

Fig. 4 Mechatronics [7]

2.3 Sensors and actuators of devices

With IoT technologies, data is collected wirelessly through low-energy sensors, small devices that use the IoT network to communicate. The sensors communicate with central systems via common or particular types of wireless connections. They are able to measure various quantities, and their operation is undemanding. Sensors are small devices with low demands on the volume of transmitted data and very high endurance.
Challenge Industry 4.0. is the development of industrial adaptive sensors that can be reconfigured depending on different conditions and requirements. This challenge is related to

the onset of further technological progress in the sense of the Fourth Industrial Revolution, based on cyber-physical systems that are the basis for the Internet of Things.

You can explore predictive maintenance options with analytical techniques by installing sensors and controls for selected production facilities and collecting and evaluating data.

The actuator is a part of the device that converts the information part of the process into a mechanical one based on the control unit's program run. The system can influence its evaluation by actuators on its environment.

Sensors that include a signal processing module are called intelligent sensors. The signal processing module processes the signal directly in the sensor separately from the rest of the system.

The reasons for processing signals directly in the sensor include:

- improvement of required sensor properties,
- signal amplification and subsequent extraction of the required data.

The reason for signal processing already in the sensor is to remove the noise generated during transmission and improve the readability of the output signal [8].

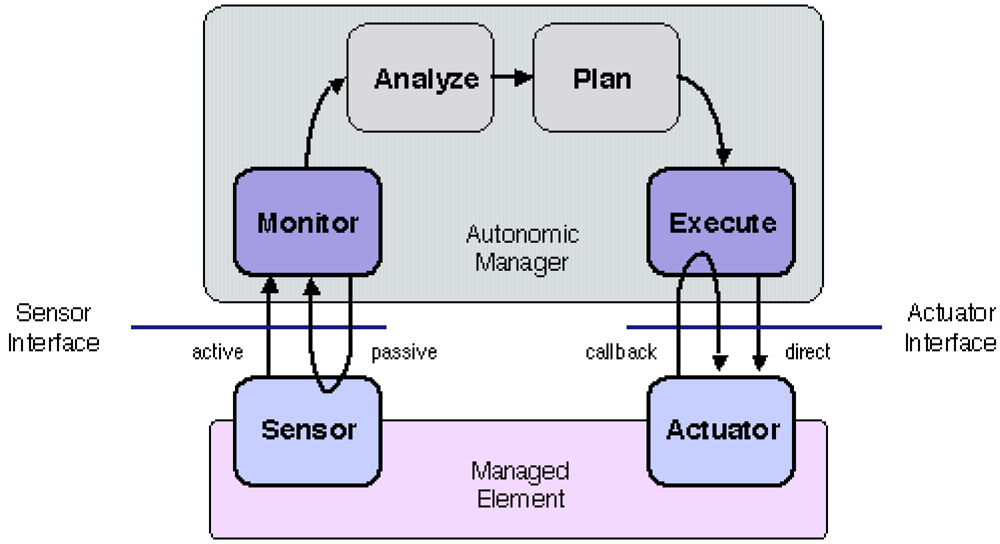

Fig. 5 Sensor and Actuator [9]

3. Conclusion

Changes in management structure and new manufacturing systems, as well as changes in process technologies and the speedy and accurate integration of new technologies and functions, are all examples of adaptive production systems. To facilitate these changes, elements of an adaptive production system are provided. Element such as architecture plug and produce, mechatronics system and sensors with actuators.

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TRENDS IN MARKETING FOR INTERNET SALES AT THE COMPANY

Ivan ANTONIUK – Branislav MIČIETA – Marta KASAJOVÁ – Vladimíra BIŇASOVÁ

Abstract: Online marketing around the world is part of a marketing strategy. Every company located in Slovakia uses elements of marketing. Marketing is an integral part of the success of any business, and choosing the right way to invest in marketing is extremely challenging, as start-ups usually have limited resources and can get into financial trouble much more easily. Nowadays, we are in a pandemic situation. Internet advertising is gaining more and more prominence not only among young start-ups, but also among companies that have not used online marketing at all. The main goal of the article is to propose a marketing strategy in existing internet sales and its verification in real online marketing. The article also contains a design solution for optimizing campaigns that were evaluated as the most powerful from the analysis. Finally, the benefits of the implemented solutions for online marketing in the company are evaluated.
Keywords: Marketing. SEO. Optimalization. E-shop. Online.

Introduction

Search Engine Optimization (SEO) is a set of several techniques for making a website accessible to search engines. The job of SEO is to properly optimize and place a website in the top positions of search results without the need to pay for advertising. In this way, it becomes one of the best and most effective ways of promotion for e-shop owners. SEO optimization is a long-term process in which we try to provide the best possible information for search engines using keywords, title, parameters, short description, more detailed description, filters, photos, photo descriptions, EAN code, PLU code, categories, name add-on, Title in the XML feed and others. (Bubeník, 2004)

Professionally processed SEO optimization is several times better investment compared to half-page advertising in a newspaper, magazine or banner or pay-per-click campaign. This optimization regularly brings new as well as regular customers to the website, and the cost of processing a really high-quality optimization is not as high as the cost of another advertisement. (Císar, 2017). The investment has long-term effects. However, it will take Internet search engines to find that there is quality content on the website and will start prioritizing the display of products / services. It is a long-term investment that can last for several years. (Bučková, 2015), (Fusko, 2018)

For just one fixed payment in a monthly campaign, you can increase traffic several times over your regular monthly CPC payment. On the world wide web, website optimization is the fastest growing form of online advertising for search engine success. (Čuboňová, 2015). The standards define the main methods of measurement:

• Ad Impression: measuring the responses of the ad system for each selected ad in the user's browser, which is filtered by a robot and is recorded during the transfer of advertising material to the user's browser window.

• Clicks: There are several types of click measurement methods.

Advertising pricing can be determined in three different ways:

• CPT - cost per thousand - price per thousand impressions,

• CPA - cost per action (e.g. CPC),
• CPC - cost per click - the cost per click per ad impression.
• Unique Measurements: the number of individual users for a monitored period of time whose activity on the site consists of one or more visits to the site or are recipients of certain content of information sent e.g. via newsletter.
• Visit: one or more downloads of text or graphics from a page, qualified as the content of one page. The textual or graphical content of the page must be displayed in the browser in order for it to be considered a visit.
• Page Impression: measures the server's response to a page request from a user's browser, which are filtered and recorded at the time it is displayed in the browser (Krajčovič, 2017).

When optimizing, it's very important to avoid illegal techniques that search engines often detect. Therefore, it is necessary to use only relevant information in SEO optimization, which is not repeated. After following the optimization procedure, we can increase traffic by 200 - 300% compared to the current state, while the price depends on the result of the SEO test and not on the CPC. The price is usually suggested only after the tests have been performed, as it depends on several factors: competition, type of optimization phrases, etc. (Gabajová, 2019)

Analysis of the current situation

The cooperation was established with two large furniture suppliers marked as A and B, which have more than 7,000 products. With supplier A, the system works fully automatically. They send an XML file that contains all the necessary product information and is displayed directly on my website. These products are also modified for searchability and supplemented with the necessary information, which not provided by the supplier.

In 2019, the average purchase value of the supplier A was about 14,000 € / month, in 2020 I recorded a more significant increase to about 20,000 € / month. At the beginning of 2021, however, I noticed a fivefold increase in demand. On average for the first three months of 2021, my purchase value is € 47,000. We assume that the average value will decrease this year due to the buying trend. The increase in the first quarter is due to investment in Smart Shooting Google advertising and SEO.

In the observed period we can notice that the most important sources are:
• Favi / cpc
• Google / cpc
• Google / organic

The result of this analysis is the identification of the most important resources and their optimization. At Google Ads, I suggest focusing on the most effective Smart Shoping campaign. It is no longer possible to optimize with the Favi search engine. In this campaign, we can only increase the cost-per-click to increase our position in specific products or categories. I also suggest optimizing Google Organic Search, as this resource appears to be a very good one-time investment in the long run.

Proposed solution for a marketing strategy focusing on internet sales
The analysis of the current situation showed that the biggest benefits will be Google / cpc and Google / organic.

In organic search, I had very good results when I was editing products, adding parametric filters, adding the necessary information about products and changing advanced product settings such as: tag title, meta tag description.
At the time I made these changes, the number of visitors to my site coming from organic search was increasing. The number of orders has increased significantly compared to the cost of this adjustment. These changes will also have a positive impact on developments in the coming months, as some of the changes that have been made will only become apparent in the long term. Google will record these changes gradually, and I will get to a higher position in Google. Leading positions will bring more potential customers.

For Google / cpc campaigns, the adjustments made to organic search were also very helpful for Google Ads campaigns. Your smart shop campaign achieved an optimization score of 100%. This value will decrease again over time and the system will provide additional options to supplement the information. It was found that the system works very reliably and adheres to the selected PNO even out of season.
If the customer uses the path through the main or secondary domain, there are no marketing costs for the e-shop. If the customer comes from online search engines or e-shop price comparators, marketing costs arise in the form of CPC (cost per click) - the e-shop pays for the click that takes the customer to the page. Google campaigns work in a similar way, but here you pay for the display of campaigns. However, it is possible to determine the maximum PNO that can be afforded. Organic search doesn't pay per click because Google has served the product based on processed SEO.
For a customer who comes through a Facebook or Favi campaign, the e-shop is also forced to pay CPC and for the display of the advertisement. E-mailing incurs the costs of operating the database and sending e-mails. Whatever method the customer uses will get to the main page, category or to a specific product. Fig. 1 shows the 4P of the company.

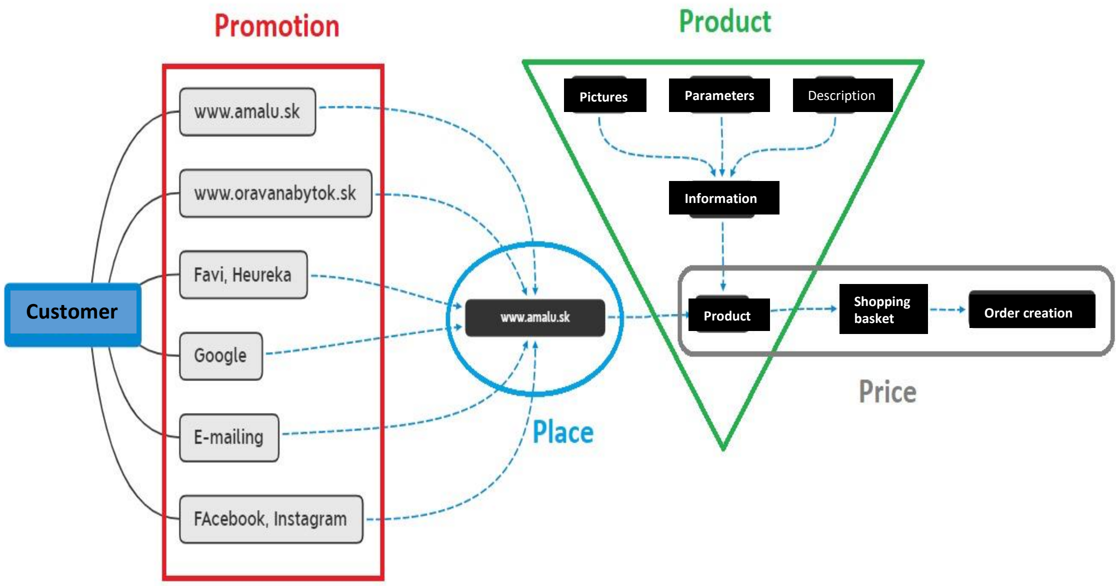

Fig. 1 Model 4P in practice

When the customers are on the website (selected existing company in Slovakia), they can search for products through categories and use filters to facilitate the search. Potential customers are looking for the information they require. If the products do not have sufficient information, the

customer leaves the e-shop. I try to list this information clearly for each product so that the customer can easily find what he is looking for. When a customer puts a product in the shopping cart, it is the first signal that he has a real interest in the product. During the purchasing process, it is very important that nothing disturbs the customer on the site, the process was as easy and short as possible.
After creating the order, transport to the products in the order is created. Every time there is a change in the order, the customer will receive a notification e-mail. After picking up the goods from the supplier, a shipping label will be assigned to the shipments, and I will hand them over to the forwarding company. Within 24 hours, the transport company will deliver the shipment to the delivery address. The customer is always informed about the shipment and the time of delivery by e-mail and SMS. When the courier delivers the shipment, I change the status of the order to delivered and the process ends.

Conclusion

The situation after applying the optimizations is as follows: Google/cpc has reached a value of more than 59% Favi has more than 28% and Google / organic more than 5% (Fig. 2).

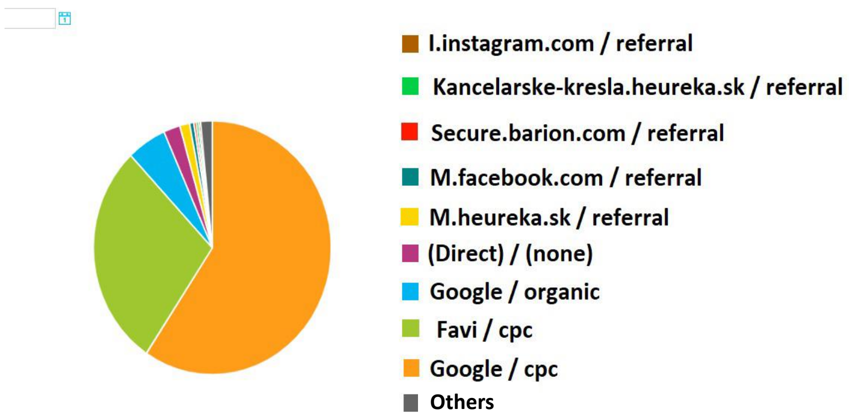

Fig. 2 The situation after applying the optimization

This graph shows visits and revenues for the period from 1.1.2021 to 31.3.2021. After the changes, the values in Google / cpc and Google / organic have been significantly adjusted. With Google / cpc, we can see these changes much faster. The optimization has been implemented to Google / organic are much slower, but I've nevertheless improved. This process is lengthy and we will not see the final results for several months (Fig. 3).

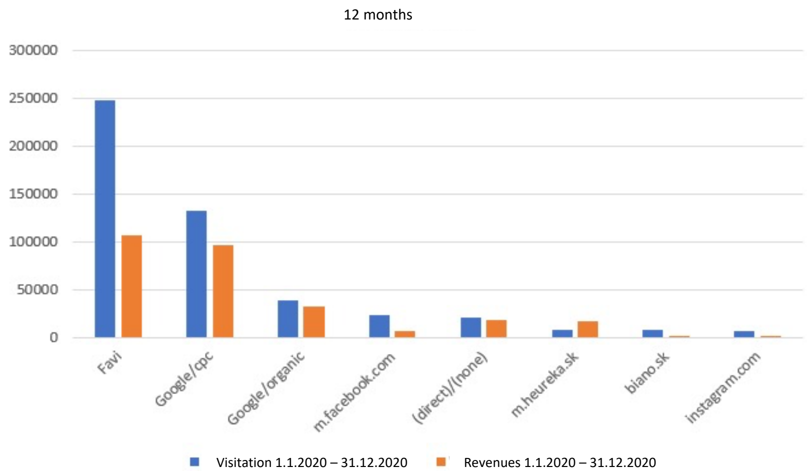

Fig. 3 Visits and revenues year 2021

Table 1 shows the values of revenues and costs in 2020 (12 months) and in 2021 (3 months). With Google / cpc, revenues reached more than € 35,000 in 3 months than in the previous year. With Google / organic revenues also increased.

Tab. 1 Visits and revenues year 2021

Valules	Visitation		Revenues (Eur)	
Dates	1.1.2020 – 31.12.2020	1.1.2021 – 31.3. 2021	1.1.2020 – 31.12.2020	1.1.2021 – 31.3. 2021
Favi	247 796	75 810	106 654,29	39 287,69
Google/cpc	132 169	157 332	96 404,46	133 564,87
Google/organic	38 115	14 211	32 160,47	18 803,62
m. Facebook.com	23 362	1524	6 172, 29	2033,88
(direct)/(none)	20 251	5987	18 465,28	8870,90
m.heureka.sk	8398	3515	16 773,60	6845,78
Biano.sk	7790	0	1 239,75	0
Instagram.com	5982	689	94,10	194,35

In 2021, the company plans to expand our range of products from 7,000 to 20,000 products in Slovakia. We are starting to work with WIP meble, which is a successful company in Poland. In addition to the Slovak market, the company is preparing to enter the Hungarian market. The expected launch of internet sales is 5-6 months 2021. With this step, the company wants to provide services to Hungarian citizens and expand its sales. We plan to provide approximately 10,000 products in this market by the end of this year. Another plan is definitely 3D visualization of products. We have this project ready, but it is not yet active. We are waiting for approval from suppliers and 3D images. The process is extremely costly as well as time-consuming, so we cannot pre-determine the introduction of this innovation. We also want to invest more in online marketing, because it has paid off immensely. Two years ago, we invested a significant amount of money and today we see results. The main marketing benefit is Google ads. In December 2020, we invested around € 7,000 in this project and the plan for 2022 is a monthly investment of € 25,000. Compared to other marketing tools, Google is the best choice for us. The next step forward in 2021 will be Youtube advertising and television advertising.
The topic of online marketing in this work was elaborated on the existing company, which deals with the sale of furniture over the Internet, as many people are starting to use online shopping.

Times have changed and people have adapted to a technique that is advancing incredibly. The main goal of the article was to design a marketing strategy in Internet sales. Applying the design parts significantly increased traffic and optimized the purchasing process. The company's total turnover also increased. The Google / organic optimization also improved other campaigns that I didn't plan to optimize. Optimizing Google / cpc campaigns has significantly increased traffic and revenue, while not increasing the percentage of marketing costs.

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KONCEPT TESTBED AKO RIEŠENIE PROBLEMATIKY INDUSTRY 4.0

Marek MIZERÁK – Peter TREBUŇA – Jozef TROJAN- Tomáš ŠVANTNER

Abstrakt: V dôsledku konkurencie, ziskovosti a neustáleho vytvárania tlaku na nízke ceny musia priemyselné podniky neustále inovovať a zlepšovať svoje produkty, efektivitu výroby a logistiku. Spoločnosti si mnohokrát nemôžu dovoliť robiť pokusy nájsť najlepšie riešenie, keďže výroba musí plynúť nepretržite. Firmám často chýbajú informácie, ktoré potrebujú na správne rozhodnutia, takže každé nesprávne rozhodnutie ich môže vyjsť veľmi draho. TestBed prináša riešenie v podobe unikátneho pracoviska. Tento článok popisuje rôzne schopnosti konceptu testovacieho zariadenia, ktorý pomáha výrobným spoločnostiam riešiť ich problémy.

Kľúčové slová: testbed, digitálne dvojča, digitálna továreň, digitalizácia, digitálne dvojča

Úvod

V mnohých oblastiach života využívame digitalizáciu bez toho, aby sme si to uvedomovali. Čítame elektronické knihy, prechádzame sa po múzeu z pohodlia domova, študujeme v digitálnych knižniciach. Popri podnikových inováciách je digitalizácia jedným z najdôležitejších obchodných trendov pre budúcnosť ekonomiky. Spoločnosti musia držať krok s touto dobou, rozvíjať digitálne stratégie a zamerať sa na kľúčové faktory úspechu digitálnej transformácie. Digitalizácia sa týka podnikov všetkých veľkostí. Na jednej strane firmy potrebujú digitalizovať svoje interné procesy a postupy, na druhej strane potrebujú vyvíjať nové služby a digitálne obchodné modely.

Digitálne dvojča

Digitálne dvojča možno opísať ako inteligentný digitálny obraz skutočného produktu alebo procesu. Ako inovatívna technológia ponúka veľké príležitosti pre priemysel a hospodárstvo, ale predstavuje aj veľké výzvy. Digitálne dvojčatá sú preto vo výskume čoraz dôležitejšie. Ide o virtuálne repliky fyzických zariadení, ktoré možno volať. Využite dátových vedcov a odborníkov na informačné technológie na spustenie simulácií pred vytvorením a nasadením skutočných zariadení. Technológia digitálneho dvojčaťa sa posunula za hranice výroby, do spájania svetov internetu vecí, umelej inteligencie a analýzy údajov. Čím zložitejšie „veci“ sa čoraz viac spájajú so schopnosťou produkovať dáta, digitálny ekvivalent dáva takzvaným dátovým vedcom a ďalším IT profesionálom možnosť optimalizovať nasadenie pre maximálnu efektivitu a vytvárať ďalšie scenáre „čo ak“.

Ide o digitálnu reprezentáciu fyzického objektu alebo systému. Technológia digitálneho dvojčaťa sa tak rozšírila, že zahŕňa veľké položky, ako sú budovy, továrne, mestá a dokonca aj ľudí alebo procesy.

digitálnych dvojčiat, čím sa koncept ďalej rozširuje. Zohľadňuje vstupy z údajov z reálneho sveta o fyzickom objekte alebo systéme a vytvára ich ako predpovede výstupov alebo simulácie toho, ako tieto vstupy ovplyvnia fyzický objekt alebo systém.

Digitálne dvojčatá poskytujú výrobcom a spoločnostiam bezprecedentný pohľad na výkon ich produktov. Digitálne dvojča môže pomôcť identifikovať potenciálne chyby, eliminovať problémy, ktoré sa môžu v budúcnosti vyskytnúť a v konečnom dôsledku zvýšiť spokojnosť používateľov. Pomáha tiež s diferenciáciou a kvalitou produktov spolu s doplnkovými službami. Výrobcovia môžu vidieť, ako používatelia používajú ich produkt po jeho zakúpení, a môžu získať množstvo informácií. To znamená, že údaje možno použiť (ak sú opodstatnené)

na bezpečné odstránenie nežiaducich produktov, funkcií alebo komponentov, čím sa ušetrí čas a peniaze.
V posledných rokoch sa na trhu objavil aj jeden z nápadov digitálneho dvojčaťa v podobe konceptu s názvom TestBed, ktorý je v súčasnosti zameraný na optimalizáciu a simuláciu výrobných procesov. Na príklade je znázornená situácia, kedy výrobný podnik uvažuje o kúpe obrábacích strojov s určitými parametrami a koncept TestBed vďaka simulačným programom dokáže určiť rôzne parametre, ktoré v konečnom dôsledku určia priebeh výroby. Vďaka tomu sa firma môže rozhodnúť, či je pre ňu zariadenie výhodné.

Tesbed 4.0
V dôsledku konkurencie, ziskovosti a tlaku na nízke ceny musia priemyselné podniky neustále inovovať a zlepšovať svoje produkty, efektivitu výroby a logistiku. Spoločnosti si mnohokrát nemôžu dovoliť robiť pokusy nájsť najlepšie riešenie, keďže výroba musí plynúť nepretržite.
Firmám často chýbajú informácie, ktoré potrebujú na správne rozhodnutia, takže každé nesprávne rozhodnutie ich môže vyjsť veľmi draho. TestBed prináša riešenie v podobe unikátneho pracoviska, vybaveného prvotriednymi technológiami, prispôsobeného na simuláciu rôznych variantov riešení, ich následné testovanie a nakoniec vyhodnotenie tých najvhodnejších, či už v rámci jednotlivých procesov alebo komplexne, naprieč celou spoločnosťou. Zahŕňa vývojové a konštrukčné procesy, technickú prípravu výroby, plánovanie výroby, výrobu a samotnú logistiku, ktoré sú vzájomne prepojené v koncepte Industry 4.0. Strojnícka fakulta Technickej univerzity v Košiciach v spolupráci s odborníkmi zo Sova Digital predstavila prvý slovenský TestBed 4.0 zameraný na technológie a procesy Industry 4.0. a digitálna transformácia priemyselných podnikov (obr.1). Vďaka tomu sa dnes dá navrhnúť najvýhodnejšie riešenie, ktoré sa následne aplikuje v danej firme. To eliminuje riziká, šetrí peniaze, čas a ľudí.
TestBed 4.0 je určený pre priemyselné firmy na riešenie ich problémov a výziev, top manažérov na hľadanie príležitostí na nastavenie stratégie Industry 4.0, študentov na spracovanie projektov a záverečných prác či špecialistov na vývoj nových produktov, služieb a riešení. Je to vhodné prostredie aj pre workshopy, školenia či exkurzie, ktoré sa vďaka špecialistom a špičkovému vybaveniu dostanú na novú úroveň.

Obr. 1 Prvý TestBed v SR

TestBed je prínosom pre diskrétny výrobný priemysel, malé, stredné a veľké podniky, univerzity, ich zamestnancov a študentov so záujmom o prax. Pre priemysel rieši metodiku, koncepciu a postup aplikácie Industry 4.0 vytvorenej pre konkrétny priemyselný podnik, návrh, overenie a optimalizáciu nových procesov, pracovísk, liniek a prevádzok pre výrobu a logistiku. Rieši redizajn existujúcich procesov, operatívne plánovanie výroby vrátane priestorových, personálnych a strojových obmedzení, návrh, overovanie a optimalizáciu skladov, technológie a pracovníkov, skladové hospodárstvo, aplikáciou konceptu digitálnych dvojčiat a mnohé ďalšie, viď obr.2.

TestBedy sa vo všeobecnosti používajú na preskúmanie systémových komponentov a interakcií s cieľom získať podrobnejší prehľad o povahe skutočného systému. Sú vyrobené z prototypov a častí skutočných komponentov systému a slúžia na poskytnutie prehľadu o fungovaní prvkov systému (prvkov). Dôležitou vlastnosťou testovacieho zariadenia je, že sa zameriava len na podmnožinu celého systému. Toto je dôležitý aspekt, ktorý chceme študovať, zlepšovať alebo rozvíjať, je to aspekt implementovaný v testovacej miestnosti.

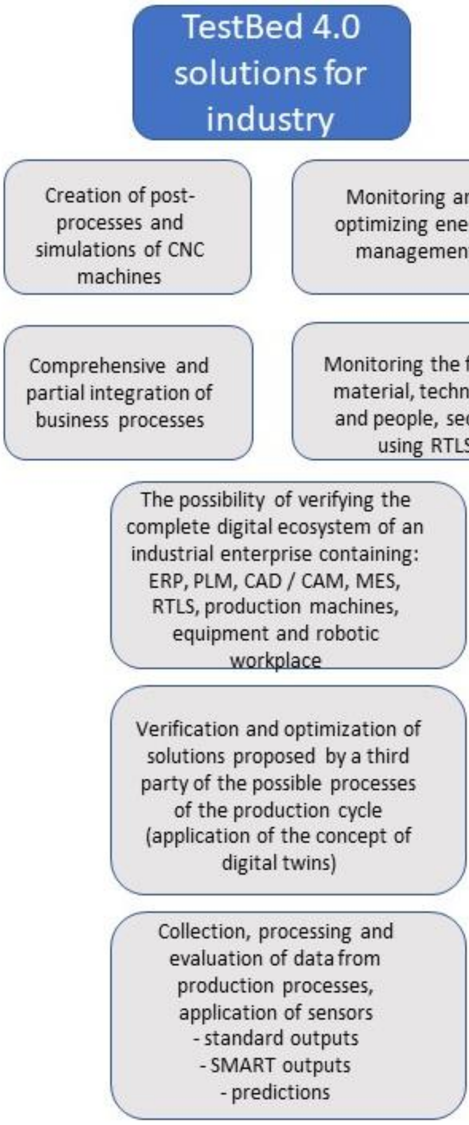
TestBedy sú vybavené najmodernejším hardvérovým a softvérovým prostredím, vďaka ktorému je možné testovať jednotlivé komponenty bez dokonalého systému. Testovacie zariadenie poskytuje prostriedky na zlepšenie pochopenia funkčných požiadaviek a prevádzkového správania systému. Je tiež možné vykonať merania, z ktorých možno odvodiť kvantitatívne výsledky o systéme. Poskytuje integrované prostredie, v ktorom možno vyhodnocovať vzájomné súvislosti riešenia systémových problémov. Nakoniec je schopný vytvoriť prostredie, v ktorom môžu byť rozhodnutia o dizajne založené na teoretických aj empirických štúdiách.

Moderný koncept TestBed pozostáva z troch hlavných komponentov: experimentálneho subsystému, monitorovacieho subsystému a simulačného a stimulačného subsystému. Experimentálny subsystém je zbierka komponentov a prototypov reálneho sveta, ktoré chceme modelovať a experimentovať s nimi. Monitorovací subsystém pozostáva z rozhrania k experimentálnemu systému na získavanie nespracovaných údajov a podporného komponentu na porovnávanie a analýzu zozbieraných informácií.

S týmito prvkami možno experimentovať na základe rôznych systémových stimulov, aplikácií a konfigurácií.

Prinos Testbedu 4.0 pre priemysel

TestBed poskytuje služby pre priemysel, ktoré umožňujú spoločnostiam navrhovať, testovať a optimalizovať riešenia prispôsobené ich potrebám. V laboratórnych podmienkach, veľmi blízkych realite, si pracovisko vytvorí množstvo verzií riešení a následne vyberie to najvhodnejšie. Týmto krokom sa firmy vyhýbajú potenciálnym hrozbám a dokážu rýchlo, efektívne navrhovať, overovať a implementovať inovácie do svojich prevádzok. Veľkou výhodou TestBed 4.0 je odborné zázemie, ktoré po otvorení zastrešuje viac ako 100 špecialistov, z ktorých sa na riešenie každej úlohy zostaví profesionálny tím, ktorý ju dokáže efektívne vyriešiť (obr.4). TestBed 4.0 rieši pre priemysel metodiku, koncepciu a postup aplikácie Industry 4.0, vytvorenú pre špecifický priemyselný podnikový komplex a čiastočnú integráciu podnikových procesov, zber, výmenu, spracovanie a vyhodnocovanie dát pre priemyselné podniky návrh, overovanie a optimalizáciu nových procesov, pracovísk , linky a zariadenia pre výrobu a logistiku redizajn existujúcich procesov, pracovísk, liniek a zariadení pre výrobu a logistiku, operatívne plánovanie výroby vrátane priestorových, personálnych a strojových obmedzení.



Obr. 2 Výhody TestBed 4.0 pre priemysel

Prínos TestBed 4.0 pre študentov

Priemysel zúfalo potrebuje množstvo odborníkov, ktorí sa o Priemysel 4.0 zaujímajú a toto číslo bude v budúcnosti len narastať. Cieľom TestBed 4.0 je spojiť teoretické vzdelávanie s tvorbou praktických skúseností, čím sa zvýšia odborné zručnosti absolventov. TestBed 4.0 poskytuje študentom návštevy s výkladom a prezentáciou princípov a možností Industry 4.0 pre študentov stredných a vysokých škôl, štandardný vzdelávací proces vo forme prednášok a praktických cvičení, riešenie tém ročníkov a záverečných prác prinesených z praxe, participácia na riešení projektov pre prax, participácia na riešení výskumných projektov - univerzitných a praktických projektov.

Záver

Digitalizácia sa stala neoddeliteľnou súčasťou dnešného sveta a sme priamymi svedkami toho, ako odvetvie priemyselného strojárstva dostáva novú podobu. Vďaka digitalizácii vznikol nový rad produktov a služieb, ktoré uľahčujú prácu priemyselným podnikom. Hoci TestBed nemá na Slovensku konkurenciu, už teraz môžeme povedať, že toto testovacie pracovisko bude

nápomocné pri riešení praktických potrieb priemyslu v oblasti Industry 4.0. Vytvorením spolupráce medzi priemyslom a univerzitami a následným zapojením mladých talentovaných študentov do riešenia praktických potrieb praxe bude Industry 4.0 obrovským prínosom pre výskum a vývoj aplikácií.
Prvky konceptu Testbed dnes patria medzi neoddeliteľnú súčasť vytvárania moderného digitálneho podniku. Inovácie a vylepšenia, ktoré testovacie zariadenie prináša, dosahujú pozoruhodné výsledky a v nasledujúcich rokoch sa očakávajú ďalšie vylepšenia.

Poďakovanie
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SPATIAL ARRANGEMENT OF NEW PRODUCTION AREAS

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Abstract: The article focuses on the design of the spatial arrangement of the hall and the production line. Based on the design documentation and the necessary analyses, two variants of the layout were developed. At the same time, due to the identified ergonomic deficiencies, proposals were made for the optimization of individual workplaces. The design of the automation concept leading to better efficiency of the production process, reduction of the number of workers and prevention of exceeding ergonomic and hygienic limits can be considered as a main part of the project.

Keywords: Spatial arrangement, layout, optimization, design

Introduction

The thesis is focused on the design of the newly built premises of the manufacturing company. The design consisted of an analysis of all drawings, logistic processes, material flows, ergonomic conditions and other available data of the client. The aim of the project was a complex design of the layout of the hall and production line.
The research framework provides the following points according to the plan:

- Analysis of available data of the contracting authority.
- Analysis of construction drawings and newly constructed spaces.
- Analysis of the process and production volume.
- Spatial layout (2D documentation, 3D visualization, VR model).
- Internal logistics concept (buffers, handling, material flows).
- Calculation of required capacities.
- Calculation tool for production flow tracking.
- Ergonomic studies at individual workplaces.
- Analysis of potential for automation and design of process automation.
- Cost analysis of the implementation of individual elements.
- Alternative designs for the spatial layout of the hall for 2021/2022.
- Standardisation of workplaces and processes.

Partial or full automation of individual workplaces can also be considered a crucial part of the project. Already at the beginning of the project, the first shortcomings were detected. Imperfect production machines emerged as a problem area. Almost all the machines were designed for batch production and each of them always required at least one worker. This prompted discussion and solutions to the possibility of automation leading to the elimination of the required human resources.

Methodology

The study was carried out according to classical methodologies for the design and creation of the spatial layout of the workplace. In the first phase, an analysis of the input data was carried out and at the same time an analysis of the entire production process. The next step was the creation of optimal variants of the production space forms in 2D and 3D visualization using the visTable software from Plavis GmbH. The entire 3D model was also converted into virtual reality in the Oculus Quest II headset. Furthermore, material flows, product and variant drawings or the MOST methodology (an empirical method based on predetermined times according to the decomposition of motion into sequences) were used.

Discussion

Before starting the project itself, it was necessary to get familiarized with the problem. Initial meetings were first held to provide input and define the required outputs. Everything was continuously discussed, consulted and refined. During the on-site workshop, the outputs were brainstormed together and the final solution was selected, finalised and plotted in the documentation according to the required outputs.

In the first phase of the project, an analysis of the drawings of the spatial design of the new production areas was carried out based on the available data. A 2D and 3D model of the new building was created, as well as models of the machinery and equipment of the production line. On the basis of these, the optimum positioning of the machines could be further worked out due to to the required handling spaces, corridors, safety distances and working procedures.

The next phase was a complete analysis of the production processes within the entire production line and a decision on the products to be produced on the production line. The entire process needed to be analyzed thoroughly and input data defined.

An important part of the study was the calculation of the required buffers between different workplaces. The calculation was carried out using a tool created in MS Excel, which indicated if manipulation between workplaces is automatic or not, the type of product, time consumption, etc.

Ergonomic study of working positions

Ergonomic analyses were carried out on the created models of machines, equipment and workplaces concerning:

- Local muscular load
- Overall physical load
- Working positions – workplace ergonomics

Ergonomic requirements and recommendations are the subject of CSN, ISO and EN norms. Ergonomics is linked to laws, directives and decrees concerning working conditions at work.

The aim of ergonomics is to achieve optimum working conditions in relation to the abilities and limits of the person. Another important objective is the design and optimisation of the working environment, the tools and the activity itself. [2]

With the help of ergonomics, it is possible not only to achieve a significant improvement in production efficiency, but also to promote the health of workers, to ensure safety in the workplace, or to find the best and least fatiguing way to perform the required work.

There are three categories of work in terms of adverse effects on the health of the worker: [1]

- 1st Category – there is no probable adverse effect on the health of employees (administrative work)
- 2nd Category –adverse effects on the health of the worker can be expected only in isolated cases
- 3nd Category –work in which hygienic limits are permanently exceeded, therefore it is necessary to use personal protective equipment (PPE), organizational and other protective measures to ensure the protection of human health, as well as work in which occupational diseases or statistically significantly more frequent diseases occur repeatedly, which can be considered as work-related illnesses.

In the case of a workplace classified as category 3, it is necessary to iimplement safety breaks, double the workplace or rotate employees in positions. These problems are also associated with lower production line performance and lower labour productivity.

Limits for the evaluation of workload are part of NV 361/2007 Coll., which sets out the conditions for health protection at work.

Repeated occupation of unfavorable working positions is considered as one of the causes of disability of tendon and muscle structures, joints and spine.

An ergonomic study of working postures was carried out using specialized software. According to this study, the necessary equipment for each workplace was determined in order to achieve optimal results.

Optimization and racionalization of workplaces

Based on the analysis of design documentation and ergonomic study, proposals were made to optimize individual workplaces. A proposal for the optimal working position for inserting products into the basket was created. Then suggestions for equipment ensuring optimal ergonomic, hygienic and safety conditions were made.

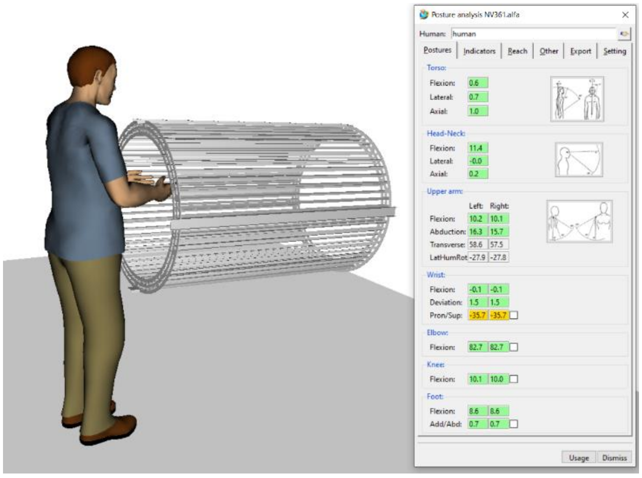


Fig. 1 – Proposal for optimizing the working position for inserting products into basket

As technology advances, human resources performing monotonous, repetitive, difficult and dangerous tasks are increasingly being replaced by industrial robots. Today, the use of industrial robots can be divided into three different groups: manupulation with material, process operations and assembly. In general, companies implement them in production mainly to reduce costs, increase productivity, improve product quality and eliminate tasks that do not meet ergonomic limits. [3]

The introduction of automation has mainly focused on logistics processes at two places of the production line. The concept of automation was supposed to lead to reduction of the amount of workers and the elimination of exceeding ergonomic and hygiene limits.

In the first place, the machine was operated by a robotic arm and the manipulation between machines was provided by a system of automatic conveyors. The exchange of boxes was ensured by a lift system, which enabled the empty boxes to be moved to the required position and exchanged for full boxes.

The second place was designed to reduce ergonomically inappropriate manipulation into and out of the bins, as well as the manipulation with bins on the whole place. The automation of loading and unloading from the bins was provided by two robotic arms. The manipulation with the baskets in the whole place was carried out by a closed conveyor system.

Selection of the final option

As part of the final option processing, two approaches were considered, which differ in the solution of the output from the machine at the particular workplace.

Option 1

The output of the machine is solved by automatic crate exchange and loading of products into the crates by conveyor. The crates are then handled by a pallet truck pulled by a worker to the cooling zone.

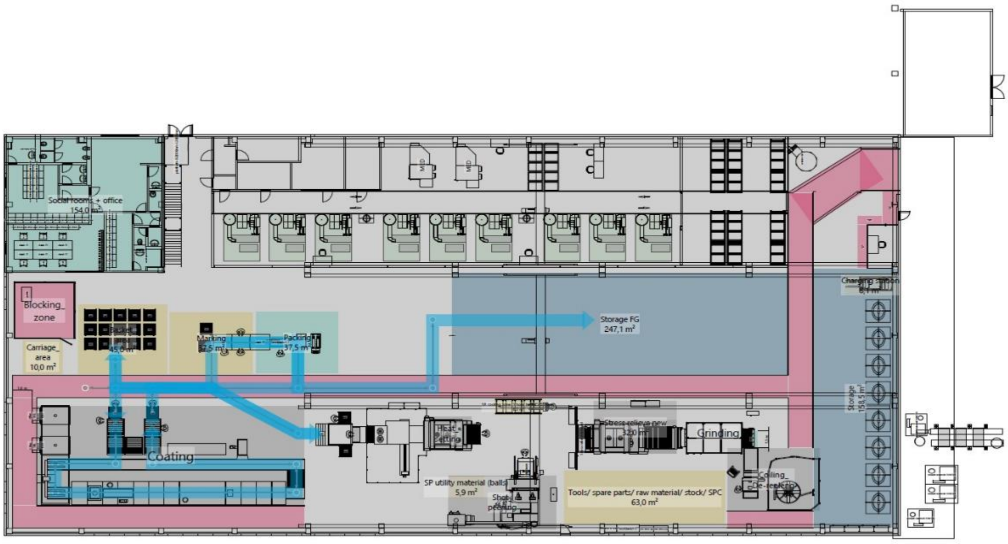
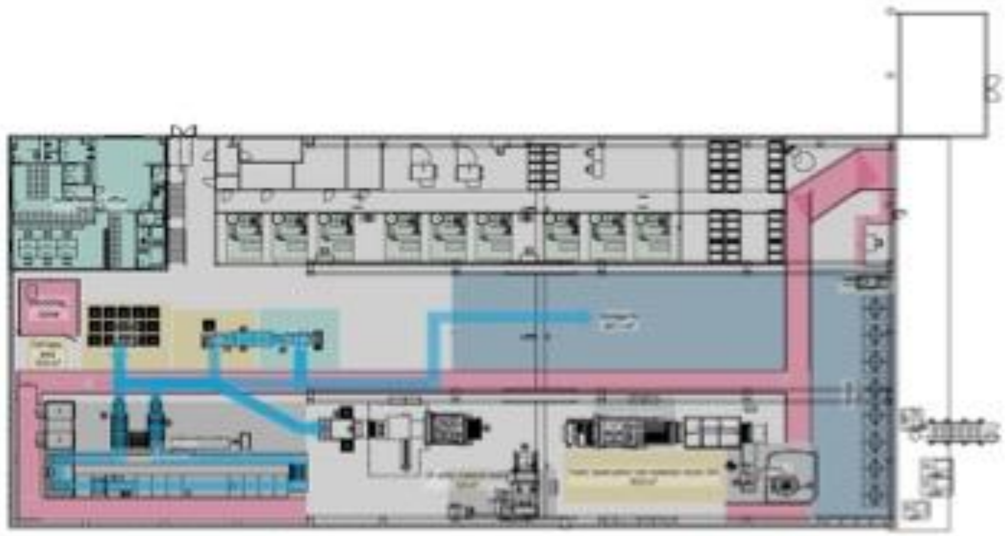


Fig. 2 – Spatial arrangement and material flow – option 1

Option 2

In this case, the cooling of the products at the output of the machine is ensured by cooling tower. Therefore, there is no additional cooling zone in the workplace, due to the direct connection of the cooling tower.



Picture 3 – Spatial arrangement and material flow – option 2

Conclusion

This study was focused on the layout design of newly built spaces. The design consisted of an analysis of all drawing documentation, logistics processes, material flows, ergonomic conditions and other available data of the client.

Within the project, two final options of the spatial arrangement of the newly built hall were completed. To ensure the suitability of the proposed options of the spatial arrangement, the necessary analyzes and ongoing consultations with the client were performed, including a

workshop directly at the workplace. The basis for the most realistic representation of the layout was also the creation of models of machines and equipment of the production line according to the design documentation of the client.
Based on design documentation and ergonomic analysis, proposals for the optimization of individual workplaces were prepared. As the ergonomic analyses revealed shortcomings, a proposal for the optimal working position for placing products in baskets was developed. Proposals were made for equipment to meet optimum ergonomic, hygiene and safety requirements.
The final options of the spatial layout were handed over in the form of 2D documentation, 3D visualization and VR model. Both options take into account the sequence of production operations, workflows, required handling spaces, corridors and safety distances.
The design of the automation concept leading to better efficiency of the production process, reduction of the required number of workers, as well as elimination of ergonomic and hygienic limits can be considered a most important part of the project.

Acknowledgments

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ALTERNATIVE END-OF-LIFE SCENARIOS FOR OBSOLETE MOBILE PHONES IN SLOVAKIA

Juraj ŠEBO

Abstract: In European Union the responsible authorities are searching for schemes for proper collection and treatment of Waste Electrical and Electronic Equipment, as a one of the fastest growing waste streams. In the paper we discuss 3 alternative end-of-life scenarios for obsolete mobile phones identified in Slovakia.

Keywords: mobile phones, end-of-life scenarios, Slovakia.

Introduction

Obsolete mobile phones are part of Waste electrical and electronic equipment (WEEE). This waste stream is currently considered to be one of the fastest growing in the EU, growing at 3-5 % per year [1]. WEEE contains diverse substances that pose considerable environmental and health risks if treated inadequately. On the other hand, the recycling of WEEE offers substantial opportunities in terms of making secondary raw materials available on the market.

Waste legislation in the EU is moving to product take-back. The extended producer responsibility requires also in case of mobile phones the supplier to recover at least a specified minimum proportion of products at the end of their service life. The potential of take-back lies not only in removing hazardous materials, but in reducing impact of processes earlier in the supply chain through re-use or recycling [2].

Take-back systems for obsolete mobile phones could be provided by manufacturers or network service providers as part of their customer service, as part of their corporate environmental responsibility program, for compliance reasons or outsourced to the third-party. Collection methods range from drop-off bins to prepaid envelopes or boxes [3].

Identification of alternative end-of-life scenarios for obsolete mobile phones in Slovakia

According to Slovak practice, we identified 3 currently used alternative end-of-life scenarios for obsolete mobile phones in Slovakia (Figure 1). First scenario is collection of mobile phones by network service operator (T-com, Orange, O2, …) partial disassembly and further treatment by final processor. Second scenario is regular/standard system of collection and treatment of WEEE through municipal collection sites, form which shipping to final processing is conducted. Third scenario is incineration and landfilling. This scenario is conducted in the case when people through away mobile phone to the municipal garbage bin. (Remark: On the Figure 1 is presented also 4th alternative, which is keeping mobile phone by his owner at home. In the text we do not consider this as an end-of-life scenario, since there is no treatment involved.)

Discussion of alternative treatment and logistic processes

The urban strategies in the case of WEEE treatment should be mining for valuable recyclable materials like metals, plastics, glass or others, which are part in most WEEEs. After collection of WEEEs, the city responsible authority/plant has several options how to treat WEEEs. These options are limited by the decision about shredding and disassembly in the first stage. When disassembly is feasible, then we can reach some secondary materials directly in this treatment stage. For example, we separate dangerous part (batteries) from mobile phone in this stage. As showed in Šebo & Fedorčáková [7], also deeper disassembly of mobile phone, if optimized,

could be economically feasible. The question is, if there is build infrastructure (e.g., disassembly plant) for its execution. In the past there were and also today there are some manual disassembly plants for WEEE in Slovakia in operation. Despite this built infrastructure, according to information presented by WEEE recycling companies, prevailing strategy is to separate/disassemble just dangerous substances and then execute shredding. Since these companies are private, we assume this model is economically most feasible in practice. After shredding of the end-of-life products, number of developed sorting/separation technologies and techniques (e.g., vertical vibration separation [4], air table sorting, flotation sorting, hydro-cyclone sorting, electrostatic sorting, near infra-red and optical sorting [5]) could be implemented in this stage of treatment. In case of obsolete mobile phones, well-known pyrometallurgical or hydrometallurgical processes are used for recovery of non-ferrous metals as well as precious metals from printed circuit boards. As concluded by Sarath [6] almost all the materials such as polymers, precious metals as well as other materials like metals, and glass can be effectively recycled from mobile phones at high yields, while recovered materials possess properties almost similar to the corresponding virgin materials.
Another important issue is logistics. According to Cilft & Wright [2], comparing two pilot take -back schemes in UK and Sweden, the UK transport system was found to use, per unit, 60 times the energy required by the “green transport” system used in Sweden. In the UK trials, two methods of collection were taken into account: through telecom operator outlets for transport by lorry, and through the postal returns system. In Sweden, the phones were collected through the “green transport” system, which carries mixed loads of non-perishable goods to minimize the unused capacity of the trucks.

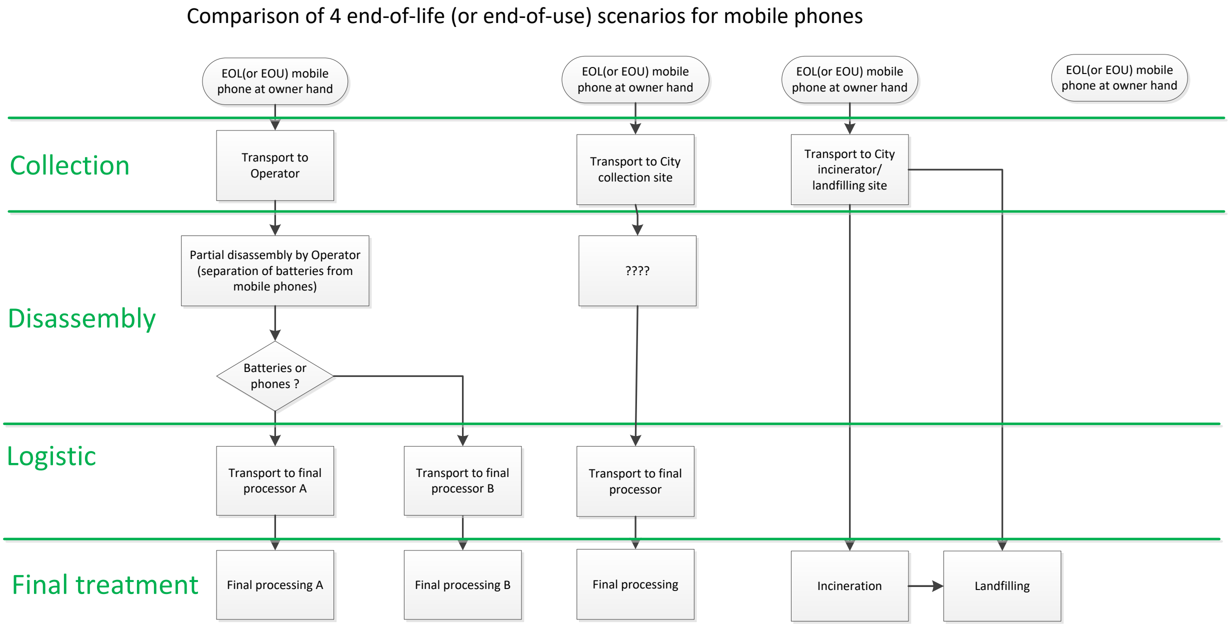

Fig. 1 End-of-life scenarios for obsolete mobile phones in Slovakia (Source: [8])

Conclusion

There are different options when dealing with obsolete mobile phones. We can choose complete manual disassembly, which could be economical feasible in some circumstances, but according to practice the most feasible strategy seems to be to separate dangerous substances (e.g., batteries) from mobile phones and then use pyrometallurgical or hydrometallurgical processes for separation of valuable metals.

Conclusion

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VÝHODY A NEVÝHODY ROBOTICKÉHO STOLNÉHO FUTBALU

Laura LACHVAJDEROVÁ – Jaroslava KÁDÁROVÁ – Tomáš ŠVANTNER – Martin TREBUŇA

Abstrakt: Tento článok sa zameriava na stolný futbal vo všeobecnosti. Poukazuje na chronologický prehľad vyvinutých riešení a ich históriu, na stručný popis fungovania robotického stolného futbalu a v závere na popis výhod a nevýhod riešení. V závere článku sú zhodnotené celkové riešenia a zároveň sú prezentované možné úpravy pre úplnú automatizáciu robotického stolného futbalu v jednotlivých vyvíjaných riešeniach.

Kľúčové slová: robotický stolný futbal, výhody a nevýhody, vyvinuté riešenia

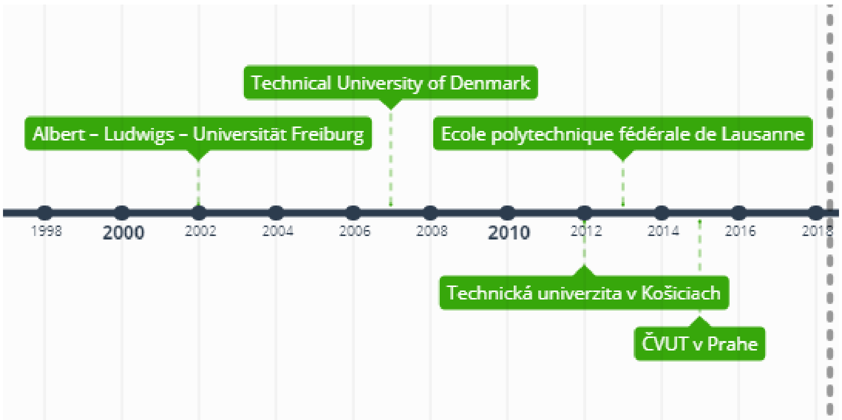
Úvod

Strojné zariadenia sú bežnou súčasťou každodenného života. Zásadný prelom v používaní týchto zariadení však priniesla až priemyselná revolúcia. Reakcie ľudí na zmenu boli rôzne. Niektorí považovali stroje za hrozbu, iní za šancu a možnosť uľahčiť si život. V súčasnosti môžeme hovoriť o podobnej situácii, tentoraz však v súvislosti s inteligentnými strojmi a ich procesmi. Takzvaná všadeprítomná revolúcia nás zavedie tam, kde sa dajú stroje inštalovať naozaj všade, napríklad do ľudského tela, roboti ako pomocníci budú bežnou súčasťou každej domácnosti a nepochybne môžeme povedať, že roboty sa stanú spoločníkmi osamelých ľudí. Nové technológie však neprinášajú len nové výhody a príležitosti, ale prinášajú aj nové náklady a hrozby. Tempo, akým sa začala priemyselná revolúcia, je čoraz nezastaviteľnejšie a budúcnosť sa nám môže zdať ako veľká neznáma. Každý týždeň sa zavádzajú nové inovácie a vynálezy, v dôsledku čoho je potrebné sa v odbore neustále vzdelávať. V súčasnosti sa veľkým trendom stala automatizácia takmer všetkých zariadení a procesov. Tomu sa nevyhla ani najpopulárnejšia oblasť ľudí, ako je zábava a šport.

Stolný futbal, ktorý patrí do kategórie spoločenských hier, rozhodne patrí do skupiny najobľúbenejšej zábavy a zároveň aj športu. Mnoho ľudí si však stále myslí, že to nemá so športom nič spoločné, no v roku 2002 bola táto obľúbená hra uznaná ako profesionálny šport, čo sa potvrdilo založením Medzinárodnej federácie stolného futbalu (ITSF), ktorej hlavným poslaním je propagácia stolného futbalu ako športu a tiež začlenenie medzi olympijské disciplíny v spolupráci s Medzinárodným olympijským výborom a Medzinárodnou športovou federáciou [1].

Vyvinuté riešenia

Za posledných pár rokov táto oblasť v porovnaní s nasledujúcimi rokmi výrazne narástla (obr. 1). Zlepšila sa kvalita, či už v prípade softvérového alebo hardvérového riešenia. Veľká časť riešenia bola vyvinutá na pôde univerzít po celom svete za účelom prípravy záverečných prác na rôznych stupňoch štúdia.



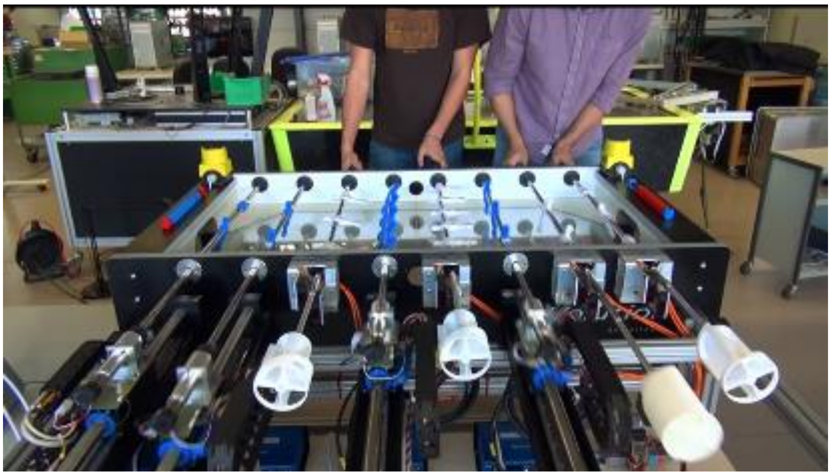
Obr. 1 Časová os vyvinutých riešení RSF, Zdroj: vlastné spracovanie

Jedno z prvých riešení pre robotický stolný futbal (RTF) bolo vyvinuté na univerzite vo Freiburgu v Nemecku. Cieľom hernej stratégie je odfotiť hraciu plochu vysokofrekvenčnou kamerou umiestnenou nad hracou plochou, ktorá sníma polohu lopty a tiež polohu hráčov. Celý cyklus, v ktorom prebieha táto detekcia, trvá 20 milisekúnd. Tento čas zahŕňa spracovanie údajov a spätnú väzbu systému [2]. Nevýhodou umiestnenia kamery nad hracou plochou je však možnosť tienenia lopty počas hry hráča. Tento problém je však vyriešený pridelením poslednej známej pozície lopty najbližšiemu hráčovi v tomto prípade a následným umiestnením všetkých hráčov v poli do základnej pozície ako na začiatku hry. V roku 2005 tento mechanizmus a dizajn upravila spoločnosť Gauselman AG do následnej podoby (obr. 2), kde sa konštruktéri zamerali najmä na bezpečnosť pri manipulácii na ihrisku [3].

Obr. 2 Finálna verzia RSF od Gauselman AG, Zdroj: [3]

RSF skonštruovaný študentmi a učiteľmi na Ecole polytechnique fédérale de Lausanne vo Švajčiarsku možno rozdeliť na dve časti. Prvá verzia pochádza z roku 2013 a vytvorila ju dvojica Martin Savary a Cyril Picard, ktorá sa zamerala najmä na dynamický pohyb osi. Prvý servomotor je umiestnený na osi posuvu, je spojený remeňom s ozubeným kolesom a je tak spojený s pevnou konštrukciou stola. K pásu je pripojená posuvná podpera, na ktorej je umiestnený druhý servomotor. Polohu lopty zisťuje kamera umiestnená v spodnej časti stola [4]. Dvojica dizajnérov sa však pri tomto riešení nesústredila na zisťovanie polohy protivníka. Druhá verzia z roku 2016, skonštruovaná Léo Sibut a Dr. Christophe

Salzmann, bola vylepšená s väčšou rýchlosťou a presnosťou. Táto dvojica ako prvá prišla s riešením detekcie pomocou laserových senzorov a ich herná stratégia bola doplnená o detekciu polohy súpera. Princípom zisťovania polohy osi hry je zisťovanie dvoch vzdialeností. Na konci každej súperovej osi sú plastové rukoväte v tvare slimáka. Predná časť hriadeľa je v jednej rovine s prvým laserovým senzorom. Zistená vzdialenosť sa počas otáčania nemení. V dôsledku otáčania medzi snímačom a rukoväťou sa však vzdialenosť nameraná druhým snímačom mení. Rozdiel medzi týmito vzdialenosťami určuje uhol natočenia, ktorý je možné vypočítať na základe stúpania hriadeľa [5]. Lineárny pohyb je riadený dynamickými motormi s presnosťou menšou ako 1 mm a dokáže generovať zrýchlenie až 9 g, čo znamená, že poskytujú oveľa vyššie rýchlosti, než ľudský hráč. O rotačný pohyb sa stará rotačný servomotor. Detekciu lopty zabezpečuje kamera, ktorá je umiestnená pod hracou plochou stolného futbalu. Kamera detekuje farebnú guľu viditeľnú cez priehľadné ihrisko a dokáže vytvoriť až 300 snímok za sekundu. (obr. 3) Pomocou týchto snímok systém vyhodnotí a spracuje vlastný obraz a pomocou laserov, ktoré zisťujú polohu súpera, systém na základe získaných údajov vyhodnotí najlepší spôsob, ako skórovať do súperovej bránky. [5].



Obr. 3 RSF vytvorený na EPFL, Zdroj: [5]

Z ďalších univerzít, ktoré sa venovali zostrojeniu RSF je Technická univerzita v Dánsku, ktorá oficiálne ukončila vývoj v roku 2007. Projekt bol plne funkčný a pripravený konkurovať ľudskému protivníkovi. Stôl má na jednej strane automatizované všetky štyri osi. Pohon zabezpečujú dva rotačné motory umiestnené na jednej strane stola. Jeden motor zaisťoval lineárny pohyb a druhý motor rotačný pohyb. Na obrázku 4 môžeme vidieť, že celá konštrukcia je masívna a ťažká. Všeobecný princíp riešenia tohto typu RSF je veľmi podobný riešeniu, ktoré uvádza Univerzita vo Freiburgu. Ďalej je to kamera umiestnená nad hracou plochou, ktorá sníma polohu lopty. Kamera použitá v tomto riešení odosiela snímky do počítača rýchlosťou 25 snímok za sekundu. Do tejto doby je už započítaná doba spracovania údajov. Cieľom tohto riešenia bola predovšetkým jednoduchá montáž a demontáž celého systému. Podľa dostupných informácií je celé toto riešenie schopné konkurovať ľudskému protivníkovi [6].

Obr. 4 RSF vyrobený na Technickej univerzite v Dánsku, Zdroj: [6]

Katedra kybernetiky a umelej inteligencie Technickej univerzity v Košiciach (TUKE) sa v rokoch 2012 - 2014 podieľala na výrobe menšej verzie robotického stolného futbalu. Aj keď technické prostriedky na výrobu RSF nie sú lacnou záležitosťou, TUKE poskytla materiál na výrobu a úpravu stolného futbalu len na dve hracie tyče. Model RSF sa nachádza v hlavnej budove TUKE v laboratóriu L9-536 / A (obr. 5). Konštrukcia je veľmi podobná modelu z Dánska. Kamera je umiestnená nad hracou plochou a sníma loptu. Na hracich tyčiach sú umiestnené servomotory, ktoré vykonávajú posuvný a zároveň rotačný pohyb. Celý tento systém je doplnený o počítač, ktorý upravené tyče pomocou algoritmu riadi a posúva tak, aby zabránil súperovi skórovať a zároveň umiestniť loptu do súperovej bránky. Keďže hracia plocha je oveľa menšia ako pôvodná, hra beží veľmi rýchlo [7].

Obr. 5 Model RSF na TUKE, Zdroj: [7]

Výhody a nevýhody vyvinutých riešení

Vyššie uvedené popisy robotického stolného futbalu poukazujú na to, čo je potrebné urobiť pre ich vytvorenie a realizáciu. Všetko má svoje výhody aj nevýhody a určite to platí aj pre spomínané vyvinuté riešenia. Jednou z prvých nevýhod by určite bola záťaž snímacej kamery RSF vo Freiburgu. Rýchlosť, akou kamera spracováva získané zábery klesá kvôli veľkému množstvu prijatých dát. Tým sa znižuje rýchlosť odozvy samotného riadiaceho systému. Dánska technická univerzita nám poskytla veľmi podobné riešenie ako Univerzita vo Freiburgu. Ako jasnú nevýhodu modelov na univerzitách vo Freiburgu a Dánsku by sme určite zaradili kameru umiestnenú nad hracou plochou. Keďže os otáčania má dve polohy, kamera nedokáže rozpoznať, či hráč smeruje nadol alebo nahor. V tomto prípade musí riadiaci systém predpokladať, že pozícia hráča je smerom nadol, čím sa zabráni prihrávke lopty, aj keď v skutočnosti to môže byť naopak, kedy lopta nemá problém prejsť cez hráča (obr. 6).

Obr. 6 Nerozoznateľná poloha hráča a loptičky, Zdroj: [8

EPFL vo Švajčiarsku vyvinula dve riešenia. Kým v prvom riešení sa nezamerali na zisťovanie polohy súpera, v druhom to vylepšili laserovým skenovaním jeho polohy a zvýšili aj rýchlosť a presnosť celého systému. Za veľkú výhodu považujeme umiestnenie kamery pod priehľadným ihriskom, takže nevzniká problém, ktorý bol spomenutý pri modeli univerzity z Dánska. V neposlednom rade model vyrobený na TUKE, ktorý ukazuje, že človek sa vie vynájsť v každej nepriaznivej situácii. Žiakom nebránilo doviesť model do finálnej verzie ani to, že poskytnuté finančné prostriedky neboli ideálne. Hoci ide o model s kamerou umiestnenou nad hracou plochou, v tomto prípade vidíme ako jednoznačnú výhodu odhodlanie študentov zmenšiť hraciu plochu, popasovať sa s návrhom a vývojom algoritmu a najmä prispôsobiť svoje možnosti na to, čo bolo poskytnuté.

Záver

Na základe týchto vyvinutých riešení sme sa dozvedeli ako funguje robotický stolný futbal a popísali sme spôsoby vykonávania automatizácie stolného futbalu, využitie pohonov, riadiacej jednotky a všetkých komponentov, ktoré sú potrebné pre realizáciu robotického stolného futbalu. Uviedli sme niekoľko príkladov vyvinutých riešení, ich nedostatky a naopak ich výhody. Robotizácia a automatizácia sa každým rokom posúvajú míľovými krokmi vpred, preto je z hľadiska výhľadu do budúcnosti potrebné zamerať sa na aktuálne technologické postupy a inovácie v jednotlivých oblastiach. Dôležité je aj zamerať sa na vytvorenie správneho algoritmu, výber správnej riadiacej jednotky a výber správnej kamery. Tempo, ktoré nastolila priemyselná revolúcia, je čoraz viac nezastaviteľnejšie a budúcnosť robotického futbalu v takomto tempe sa nemusí zdať jednostranná kvôli technologickým inováciám, ktoré sa periodicky objavujú v oblasti automatizácie a robotiky.

Poďakovanie
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TRENDS OF ROBOTIZATION IN THE CONTEXT OF INDUSTRY 4.0

David ZENISEK – Tomas BROUM

Abstract: This article focuses on the robotization in industrial companies. It follows up on the fourth industrial revolution and aims to collect and summarize information on robotization. In the first part, it discusses the basic terminology and briefly talks about the history of robots and their types. Next, authors look at the growing market of industrial robots, growth and the trends associated with it. Finally, it concludes the results of the search.

Keywords: Robotization, Robots, Industry 4.0

Introduction

Reports from both the OECD and PwC state that automation, which can take both physical and virtual forms, will be a key driver of the future industrial production. This article will be focusing on automation by means of robots (robotization). Robotization is essential part of Industry 4.0 and strongly influences a large part of work positions in production, productivity, quality and safety. Due to the fast improvement and development in the field of robots, some significant changes in job work or even the disappearance of some positions can be expected. This article will try to summarize collected information on the past and current situation in robotization. [1], [2]

Understanding terms: Robot, Robotics, Robotization

Robotics is a discipline that helps people solve their problems with facilitating work and increasing work productivity, through the use of technical means as a result of mental and intellectual activity of generations of inventors, designers and technicians. Robotics as a scientific and technical discipline is the science of robots, their design, production and applications. It is closely related to electronics, mechanics and software. [3]
The field of robotics includes everything in terms of development, construction, programming and testing of robots. With the advent of the Internet of Things (IoT) and the growth of the use and processing of big data (Big data), the importance of robotics is growing rapidly. [4] [5]
Robotization is basically the implementation and use of robots in workplaces. Workplace robotization is, for example, the replacement of workers who perform manual activities with one or more manipulators, etc. [6]
Oxford English Dictionary states, that robot is a machine - especially a computer programmable one - capable of automatically performing a complex series of actions. [7]
Niku S. B. [8] defines robot as: “An automatic or computer-controlled integrated system capable of autonomous, goal-oriented interaction with the natural environment, according to human instructions. This interaction consists in the perception and recognition of this environment and in the manipulation of objects, or in moving in this environment." This definition undoubtedly includes various robotic systems for a variety of, not just industrial, applications.
The nature of an industrial robot is perhaps best described by the definition ac-cording to prof. PN Beljanina: “An industrial robot is an autonomously operating machine-automat, which is designed to reproduce certain movement and mental functions of man in performing auxiliary and basic production operations without the direct participation of man and which is equipped

for this purpose with some of his abilities (hearing, sight, touch, memory, etc.), the ability of self-learning, self-organization and adaptation, i.e. adaptability to a given environment. " [8]
The IFR (International Federation of Robots) states that there is no single agreed definition of a robot, although all definitions generally include the result of a task that is completed without human intervention. While some definitions require a task to be completed by a physical machine that moves and responds to its environment, other definitions use the term robot in connection with tasks performed by software, with-out physical execution (such as RPA). [9]
ISO Standard 8373 defines a robot as an automatically controlled, reprogrammable multi-purpose manipulator programmable in three or more axes, which can be either fixed or mobile for use in industrial automation applications.

Characteristically, the robots are:
- Reprogrammable: programmed movements or auxiliary functions can be changed without physical changes;
- Multi-purpose: it is possible to adapt robots to another application with physical changes;
- Physical modifications: change of mechanical structure or control system with the exception of changes of programming cassettes, ROM, etc.
- Axes: the direction used to specify the robot's motion is in linear or rotary mode. [10]

According to [3], an industrial robot usually differs from other machines:
- The possibility of adapting to different industrial requirements;
- An effector mounted on a movable arm (the effector is the working body of the robot);
- Memory used to store a sequence of automatically repeatable movements;
- Programmability.

History
To better understand the relationship between automation and robotics, it is worth looking at some data from modern history:
- 1588 - the first production machine - vibrating grain feeder
- 1801 - invention of the first automatic spinning machine
- 1914 - Establishment of the first automatic assembly line at Ford
- 1928 - The first application of vending machines in the automatic assembly of the Smith factory in Milwaukee
- 1938 - Claude E. Shanon lays the foundations for numerically controlled ma-chines
- 1946 - Delivery of the first ENIAC computer to the US government
- 1949 to 1952 - John Pardons developed a machine tool spindle position control system
- 1956 - Establishment of the FUJITSU Fanuc branch for the development of NC controllers
- 1958 - creation of the APT programming language
- 1961 - The American company AMF enters the market with a multi-purpose automatic machine called the industrial robot "VERSETRAN", which acts as a human machine
- 1974 - installation of the first industrial robot in the FANUC factory
- 1984 - creation of CNC systems with graphic programming tools
- 2003 - 20,000 robots are installed in Europe
- 2008 - 200,000 robots are installed worldwide
- 2009 - Universal Robots sells the first collaborative robot
- 2015 - Fanuc installs 400,000 robots worldwide and Yaskawa and ABB Robotics 300,000 robots worldwide. [11], [12], [13]

Types of robots

The IFR states that there are a number of differences between types of collaborative robots in terms of compliance with standards and the extent of robot contact with workers in cooperating applications and ensuring safety. In general, however, they are industrial robots that are specifically designed to work with people in a shared environment. The most common variants are coexistence and sequential cooperation. [9]

According to LEE, robots can be distinguished according to the level of robotic application:

- Conventional - the robot is located in the protection zone and operator access is prevented,
- Coexistence - the operator of another workplace is allowed to enter the working space of the robot,
- Cooperation - the operator and the robot work at the same workplace, but without mutual cooperation,
- Collaboration - direct cooperation of the operator with the cobot. [15]

Trends in Robotization

Sales - The industrial robot market has been growing at a record pace of around 19% per year since 2012/13 and is expected to continue to grow in double digits at least until 2021. The IFR estimates that the total market for industrial robotic systems was al-ready $ 48 billion in 2017. Of this revenue, the robot itself accounts for about 30% of revenue, accessories for about 25%, and service (including auxiliary hardware, software, and programming and installation) for the remaining 45%. The industrial robotics market recorded record sales of 381,000 units in 2017 and currently has a base of about 2.1 million units installed worldwide. [9]

According to Market Research Reports, the global industrial robotics market is expected to reach $ 42.29 billion for robotic machines by 2026 and $ 138.03 billion for robotic systems, representing a compound annual rate of 2019-2026 growth rate (CAGR) of 11.57% and 12.59%. The annual shipment is expected to have a CAGR of 17.09% during the same period and will increase to more than 1.51 million in 2026.

Based on Loup Ventures' 2017 estimate, the ratio of worldwide sales of conventional and collaborative industrial robots can be seen in **Tab. 1 Industrial robotics outlook by Loup Ventures, IFR [17]**.

Tab. 2 Industrial robotics outlook by Loup Ventures, IFR [17]

INDUSTRIAL ROBOTICS OUTLOOK

	2015	2016	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E	2015 -2025 CAGR
Traditional Industrial Robots												
Units Sold	250,073	288,834	335,048	388,655	446,954	509,527	575,766	644,858	709,344	780,278	858,306	**13.1%**
ASPs	$43,969	$41,771	$39,473	$37,105	$35,250	$33,840	$32,571	$31,431	$30,409	$29,497	$28,686	**-4.2%**
Market Value (B)	$11.00	$12.06	$13.23	$14.42	$15.75	$17.24	$18.75	$20.27	$21.57	$23.02	$24.62	**8.4%**
Collaborative Industrial Robots												
Units Sold	3,675	8,950	22,745	47,030	83,183	131,654	183,856	239,012	299,840	368,402	434,404	**61.2%**
ASPs	$28,435	$29,170	$29,950	$29,311	$27,939	$26,754	$25,563	$24,320	$23,193	$22,145	$21,206	**-2.9%**
Market Value (B)	$0.10	$0.26	$0.68	$1.38	$2.32	$3.52	$4.70	$5.81	$6.95	$8.16	$9.21	**56.5%**
Total Units Sold	**253,748**	**297,784**	**357,793**	**435,685**	**530,136**	**641,182**	**759,621**	**883,870**	**1,009,184**	**1,148,680**	**1,292,710**	**17.7%**
Y/Y	*15.0%*	*17.4%*	*20.2%*	*21.8%*	*21.7%*	*20.9%*	*18.5%*	*16.4%*	*14.2%*	*13.8%*	*12.5%*	
Total Mkt Value (B)	**$11.1**	**$12.3**	**$13.9**	**$15.8**	**$18.1**	**$20.8**	**$23.5**	**$26.1**	**$28.5**	**$31.2**	**$33.8**	**11.8%**
Y/Y	*9.0%*	*11.0%*	*12.8%*	*13.6%*	*14.4%*	*14.9%*	*12.9%*	*11.2%*	*9.4%*	*9.3%*	*8.5%*	

Source: Loup Ventures, International Federation of Robotics

In 2016, the vast majority of conventional industrial robots accounted for the total sales. In the future, analysts expect even more significant growth in cobots, about 61% each year. In 2025, approximately 434,000 collaborative robots are expected to be sold, accounting for almost half of total sales. Outlook of industrial robots according to Loup Ventures shows that the reason for the expansion of cobots into production is mainly their relatively low purchase price, which is around 30,000 USD without additional costs, in contrast to conventional robots, whose price is around $ 100,000 including programming costs. This high price is often increased by investments in protective measures to ensure the safety of the workplace. This is not necessary in the case of collaborative robots, as cobots have integrated safety features that prevent collision situations. [16], [17]

Growth - The growth of robots has been driven mainly by the following trends:

• Price reductions - smaller and cheaper robotic applications are in high demand. Finally, lower robot production costs (e.g. by increasing production in lower-cost regions) lead to lower prices (more than a 50% decrease in average robotics costs since 1990),

• Growing variety of models - Since the first microprocessor-controlled electric five-axis robot in 1974, the robot portfolio has expanded to more than 300 models to-day. What's more, robots have not only grown larger and can handle heavier loads (due to the exponential increase in possible load from 6 kg to 1,000 kg), but they also have more axes and require fewer controls, as in some cases where more than 30 axes are possible. synchronize with one controller,

• Greater technical capabilities - higher accuracy, for example, enables new applications (e.g. in the manufacture of electronics) and safer use (e.g. operations in which a person works closely with a machine that previously could not be automated). Mobility is another technical advance that opens up the field of intralogistics automation to robotics applications,

• Rising labor costs - given that labor costs are rising not only in industrialized countries (e.g. in the US by a 24% increase in production labor costs since 1990), but also in traditional countries providing cheap labor force like China or India, the return on robotics becomes even more attractive. The significant increase in wage costs alone is due not only to the growing shortage of people / workers and skills, but al-so to the costs associated with turnover, as it is no longer uncommon for people to move from one job to another,

• Accessible talent - While robotic engineers were once rare and costly professionals, people with the skills needed to design, install, operate, and maintain robotic manufacturing systems are becoming more accessible,

• Easy integration - thanks to advances in information technology, software development techniques and network technologies, the assembly, installation and maintenance of robots is faster and cheaper than before.

These trends, as well as their impact on the growth of the robotic sector, are expected to continue. [17], [18], [19], [20], [21]

According to IFR, the price of industrial robots has fallen by 60% in 2017 to $ 27,074 since 2017. It is expected that in 2025 the average price will be around 16% of the price of 2005. It can therefore be stated that the price of industrial robots is and will be declining. [17]

According to the survey of yearly sales of robots by industries, conducted by IFR, the most important customer of robots is the automotive industry, which in 2017 saw an extraordinary increase to 125,700 robots production. However, the highest in-crease belongs to the electronics industry, which increased its robot sales by an incredible 33% (116 thousand robots) compared to 2016. Engineering industry had 44 thousand, Chemical industry had 21 thousand and Food industry just 10 thousand sold robots in 2017. [17]

Asian countries, especially China, are at the forefront of the robotic revolution in every way. China exceeded all expectations in 2017 with 58% year-on-year growth in robot supplies; the

local companies installed a total of 138 thousand robots. This represents almost 36% of world robot production in 2017. In the ranking, China is followed by Japan (46 thousand pieces), South Korea (40 thousand pieces), the USA (33 thousand pieces) and Germany (22 thousand pieces).). These TOP 5 countries represent 72% of the demand for worldwide robot production. [17]
It is also worth noting that in a 2018 McKinsey survey, most respondents (82 out of 85), when asked about the main reason for investing in robotics and automation answered cost reductions. Following were quality improvement (55), Increase productivity through R&A and improved capabilities of robots (technology driven). [18]

Research Methodology
Presented literature review related to the topic of actual trends in robotization is based mainly on analysis. Analysis belongs to the area of logic methods of scientific re-search. According to [19]: “Analysis is the process of factual or mental division of the totality (objects, phenomena) to the parts. The analysis makes it possible to reveal various aspects and properties of phenomena and processes, their structure, stages, contradictory tendencies, etc. The analysis makes it possible to separate the essential from the insubstantial, to distinguish permanent relationships from casual ones. When analyzing, we proceed logically with a "top-down" system.”
The analysis was used in the form of a critical literature research of literary and internet sources related to the robotization. Afterwards the results of the analysis were summarized.
Synthesis was used for the summarization. It also belongs to the area of logic methods of scientific research. Gray [22] defines the synthesis as: “Synthesis means to proceed from part to whole. Allows you to recognize the object as a totality. It is a connection of knowledge gained through an analytical approach.”
The outputs of the synthesis were afterwards presented in the results chapter of the paper.

Results
The basic part of robotics, robotization and robot was defined in the research part of robotization, although in the case of the term robot the terminology is not fixed. However, the search showed that robotics can be understood as a part of automation, which deals exclusively with the application of physical robots. Based on the search, it can also be said that robots differ from manipulators mainly in their versatility and reprogrammability. Robots also have different levels of application - conventional, coexistence, cooperation and collaboration. Today, the most common is coexistence or cooperation.
The trend search showed that the number of robots and the amount of annual sales are growing from year to year and are forecast to continue to grow, while the price of robots is gradually declining. The variety of models, applications, and technical skills of robots is growing. In addition, the available talent (the number of people able to program robots) increases and the overall integration of robotic solutions is facilitated. The most common robots are classic industrial robots, but collaborative robots are growing in popularity, especially in industry and engineering. Finally, a literature search shows that there are a number of reasons for robotics, such as reducing costs, increasing quality, increasing safety in the workplace, or even increasing performance.

Conclusion
The term robot was firstly used one hundred years ago in the drama R.U.R. After one hundred years, many conditions changed and developed. It is for sure not the end of development in

rapidly growing area as robotization is. The trends in robotization shows its optimistic future and further expansion. Even current Covid-19 situation can be impulse to implement more robots to reduce the human contact.

The main concentration of the paper is on trends in robotics, showing for example the increase amount of industrial robots, prediction of their cost reduction and the main drivers triggering investment in robotics and automation solution.

The main benefit of the paper is to share the information and its summarization. It can be helpful and time saving for other researchers within similar area of research. Other benefit is to contribute to popularization of the interesting topic that robotization is.

The paper set the foundation for future research activities. The future research is planned to be concentrated in the area of productivity and investment analysis in connection to robotization. The plan is to specify all the important aspects that can have influence on the mentioned topics and create the new methodology concentrated on investment evaluation of robotic solutions in industrial companies.

Acknowledgment

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USE OF VIRTUAL REALITY IN ASSEMBLY PROCESSES

Juraj KOVÁČ – Vladimír RUDY

Abstract: The article deals with the use of virtual reality in assembly processes. Defines basic concepts regarding assembly and virtual reality. The individual chapters of the article list and describe the hardware and software resources needed to implement the assembly simulation in virtual reality. The specific VR software Pixyz Review is also described in more detail, where its functions and a specific example of component assembly are listed.

Keywords: Assembly, virtual reality VR softvare.

Introduction

Assembly is a set of various activities, which are used to create a functional unit from individual components (machine, equipment, etc.). This is usually the last stage of production, followed by functional tests and commissioning. It decisively affects not only the quality and reliability of products, but also the ongoing production time, labor productivity and efficiency of the entire production system. Assembly is a very laborious and expensive operation with a high proportion of manual labor. Assembly costs make it possible to reduce compliance with the principles of construction technology, especially the use of standardized, resp. unified components, the simplest possible ways of joining components. [3] Virtual reality in assembly has its place and recognition in terms of training and practice of individual tasks that need to be practiced and mastered. VR can be used both in the design of assembly workplaces, as well as in the planning of the assembly procedure of a specific product and in the assembly simulation. [1]

Fig. 1 Virtual assembly

1. Virtual reality

Virtual reality is a breakthrough technology that, through computer technology and software, allows people to enter three-dimensional (3D) visualized and simulated worlds. Virtual reality is characterized by the ability to provide interactivity and "immersivity" in a single user environment. It is an artificially created computer-generated environment that is perceived by humans as a credible imitation of real reality. The created visual experience is provided to the user by suitable 3D display means. In more complex cases, the experience can be enriched by other systems that affect the senses such as touch, hearing and smell. The very quality of the demonstrated reality is directly dependent on the technical software and hardware equipment. The interaction between the user and the used software is mediated not only by the workstation and standard devices for its operation, but also by other expanding means such as. a suit that captures individual movements, 3D glasses showing the impression of three-dimensionality, devices simulating touch and multi-channel sound reproduction. [2]

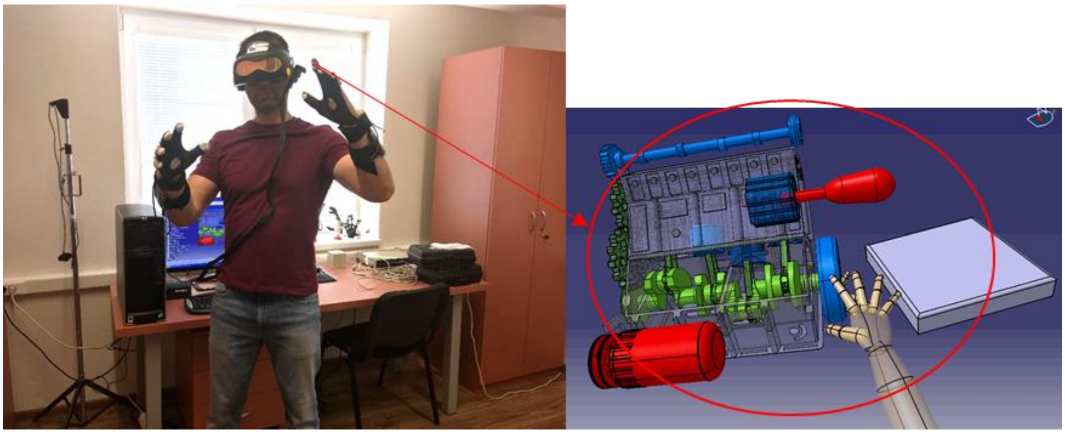


Fig.1 Working in virtual reality using data gloves

The systems provide users with the illusion that they are in a simulated environment, called a virtual world, virtual scene, or virtual environment. It is created by software and hardware means that simulate real scenes of the real but also unreal world in dimensional, color and design reality.

2. Virtual reality and assembly

As part of the product assembly simulation, the service technician uses an intelligent auxiliary system, which consists of a head display of data gloves resp. VR controllers that simulate human hands. Using the above technical means, the technician performs the assembly simulation and trains the individual assembly tasks. To this end, it is necessary to create a digital manual for each operation, which includes the relevant operations and procedures. The system ensures that the service technician performs this work correctly and ergonomically. Errors are monitored and displayed and corrective action is required.

Obr. 2 Prostriedky virtuálnej reality

The benefit of using virtual reality in the assembly of products or machines is the acquisition of the procedure of work at individual ends, which must be performed within the actual assembly of the machine or product. The functionality of the work process as a whole is checked after each operation performed during the entire time of working with the model. Tests and simulations thus help to detect errors and deficiencies that would only become apparent during the physical assembly of a real machine or product and would require retrospective, time-consuming and cost-effective changes. This is a significant benefit of state-of-the-art technology over the classical method. The condition is the integration of virtual technologies with other CAD systems. The use of virtual technology has been made possible mainly by innovative changes and, in particular, by the progress made in hardware, software and information technologies and imaging technology. Advanced reprography and presentation technology integrated with interactive software systems enables a new trend of work today.

3. Software equipment

As part of the assembly simulation in virtual reality, software equipment in the form of CAD systems is required, which enables the modeling of a virtual model of a part or product for assembly simulation. The product model must be created as a set of individual parts that can be assembled in virtual reality.
For the virtual assembly itself, there are several software products on the market that allow the simulation of assembly in VR. For example, as CMC Vewr software, VR Skech, Techviz, Pixyz Review, etc. They work either as a stand-alone program or as a subroutine for one of the CAD systems.
An interesting VR software is the aforementioned Pixyz Review. It allows you to easily import a wide range of models from CAD systems such as. Catia, SolidWorks, Inventor, CREO in the form of a step file and simulated assembly operations in virtual reality. Software allows you to improve and accelerate workflows, reduce product development time, and simulate assembly and disassembly procedures.

Fig. 3 VRyz Pixyz Software Review [5]

Imported 3D models can be edited using the tools included in the Pixyz Review VR software and offered. It is possible to adjust their dimensions and assign a specific color or material to the model. It is possible to set the degrees of freedom of the model during manipulation, display the section plane, measure the distance of movement and much more. It is possible to insert a virtual environment created by a 360 camera into the project.

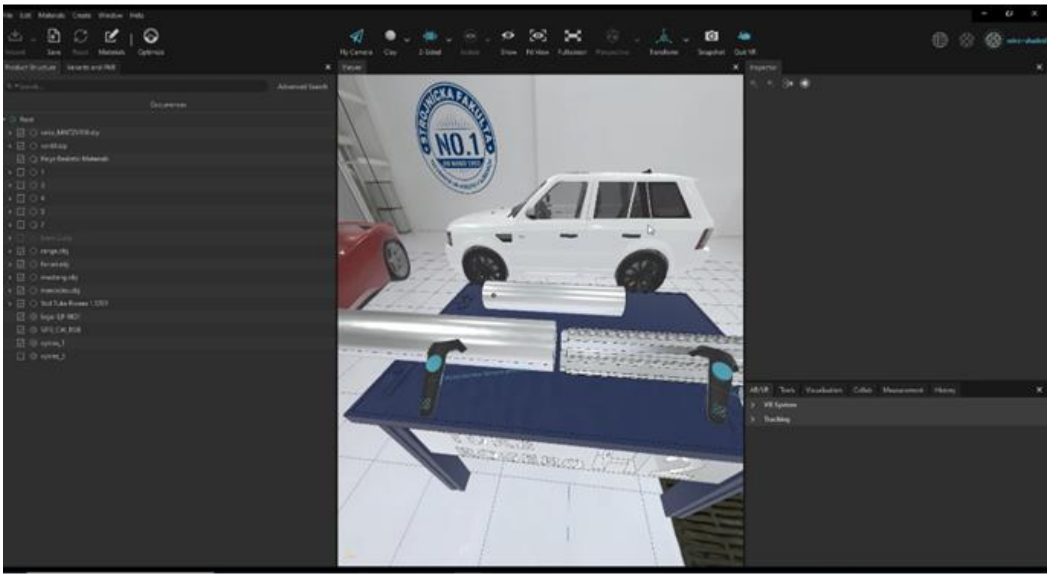
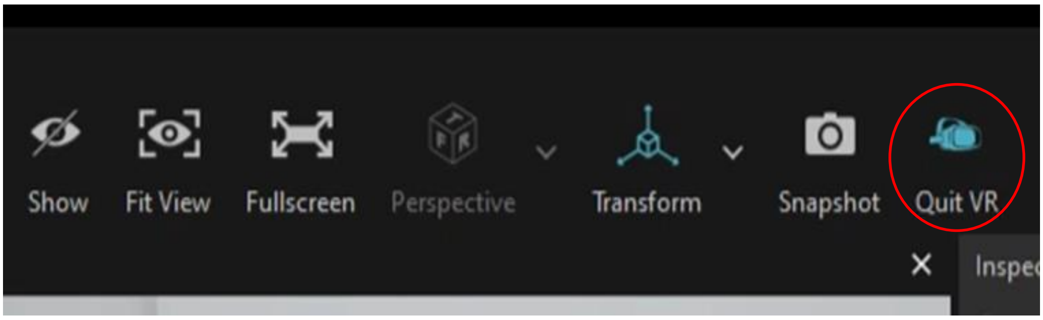


Fig.4 Virtual scene of product assembly in Pixyz Review

The software supports most virtual reality hardware resources such as:

- HTC Vive
- HTC Vive Pro
- Oculus Rift
- Oculus Rift S
- Oculus Quest (using Oculus Link beta)
- Windows Mixed Reality devices (Lenovo Acer, HP) [4]

The transition to the Virtual Environment is realized by means of the icon on the top sheet of the software control panel and the settings of the respective VR head set. Fig.5:



Obr. 5 Panel nástrojov Pixyz Review

Conclusion

Virtual reality has its place in various industries. It clearly includes the assembly of products, where it allows you to simulate assembly operations and learn the procedures and instructions for assembly of specific products. It allows you to gain specific practice and save costs and time by not requiring a physical model of the product, but everything takes place in a virtual environment.

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APVV-17-0258 Digital engineering elements application in innovation and optimization of production flows.

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INDUSTRIAL ROBOTICS SIMULATION DESIGN PLANNING

Ján KOPEC – Miriam PEKARČÍKOVÁ – Martin TREBUŇA – Jozef TROJAN

Abstract: This paper presents Industrial Robotics Simulation Design Planning, which is based on SolidWorks Application Programming Interface (API) to offer an intuitive and convertible environment for designing and simulating robotized tasks. The core idea is to integrate features of mechanical CAD and robotics CAD into the same platform to facilitate the development process through the designed Graphical User Interface (GUI) which permits user friendly interaction. The platform includes various 3D models that are essential for developing any robotized task and offers possibility to integrate new models in simulation. Robotic manipulator library is one such example which contains several types of serial arms with different combinations of revolute and prismatic joints. The platform provides most important steps such as defining the task, CAD learning of the end-effector's trajectory, checking the manipulator's reachability to perform a task, simulating the motion and finally validating the manipulator's trajectory to avoid possible collisions.

Keywords: Industrial manipulators, Robotics simulation, CAD, SolidWorks

Introduction

The need of robotic manipulators in industrial sector has raised requirements related to the development of robotized tasks. These requirements take place throughout the development phases of the task. Recent advancements in industrial automation have stipulated the need to simulate and control industrial robotized tasks in a more systematic and efficient way. Moreover, developing and programming robotized task in the conventional manner such as using teaching pendant is a cumbersome and time consuming task in general, requiring highly expert operators. This may be a critical constraint for many small and some medium-sized manufacturing companies in setting-up robotic manipulators in their facilities. Thus novel, advanced and more intuitive techniques to develop and program the robotized tasks are required. This has motivated engineers to develop tools that help users to carry out robotic tasks, which may require automatic path planning and determination of collision-free path. Additionally, the simulation tools offer potential benefits in terms of reduction in time consumption and ease in the whole process of development of robotized task.

Definition of PLM

CAD model databases such as SolidWorks API have been widely investigated to define and simulate a manipulator's trajectory in various industrial applications. SolidWorks API last offers the feature to calculate the task parameters based on a virtual 3D model of the real robotic cell. Moreover, modifications and redefinition of these parameters are easily possible with a user-friendly integration with SolidWorks. We used a Product Lifecycle Management (PLM) software SolidWorks to develop series of steps that allow user for define simulate and validate a given industrial task. The main blocks of the proposed platform that allows engineers to design, plan and optimize the industrial tasks in the same environment, without the need to export all models from the design environment to the simulation environment [1].

Important steps in Fig. 1 listed below:

1. Task definition based on knowledge of the real cell.
2. CAD learning based on the virtual 3D model.
3. Accessibility verification of the task and calculations of placement and orientation zones.
4. Time optimization of the task.
5. Graphical simulation and validation of the task [2]

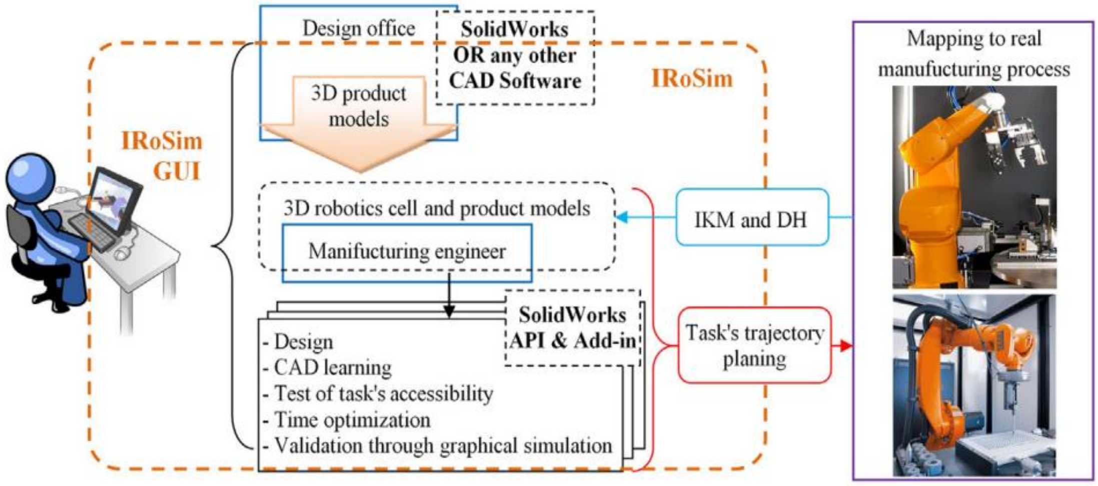

Figure 6 Offline-CAD programming schema

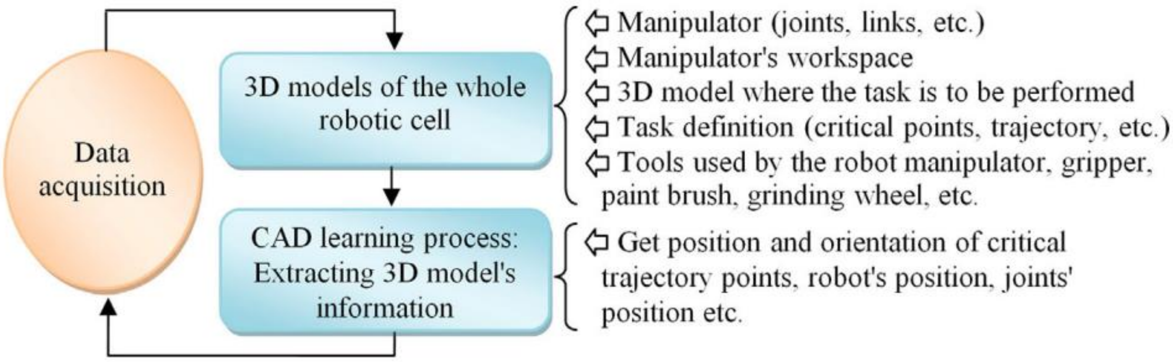

Figure 7 Illustrative schema of the data acquisition process

CAD robotics package

- **Data acquisition:** The key underlying concept behind robotics offline programming is data acquisition. In our approach, this is based on a virtual representation of physical model of the robotized cell. A 3D virtual model is developed, followed by application of an algorithm for CAD learning to extract useful information from the virtual environments as illustrated in Fig. 2. This gives definition of the task and delimits some constraints between the robotic manipulator and the task [3] [5]

- **3D modeling of robot and environment:** 3D modeling: 3D modeling of the robotic cell can be based on a volume and/or surface like CAD components. This can include the robots' libraries, end-effectors, 3D model of the task and objects of the remaining environment. For instance, a robot's WorkSpace (WS) modeled by volume has more geometrical information than the one modeled by surface. However, auxiliary 3D objects may be modeled by surface for specific needs. 3D objects that construct the cell are very similar with the real ones. It is worth to note that a realistic representation of these objects in the present work offers more accuracy compared with primitives modeling given in. Fig. 3(a) shows a snapshot of robotized cell modeled in SolidWorks. Three main represented objects include the robot manipulator, the corresponding WS and the 3D model of the task. 3D modeling of the manipulator must allow possible kinematic joints representation of the corresponding links subject to certain numerical constraints. In SolidWorks, the 3D models are generated as Part or Assembly files, however these can also be easily imported from other format such as ParaSolid, EGS, and CATIA. Task definition: Robotic task can be represented as a 2D/3D set of points to be visited by the manipulator's end-effector. We distinguished two kinds of trajectories; Point-to-Points (P2P) and Continuous. P2P trajectory may include spot welding and drilling tasks while arc-welding, laser cutting, painting, polishing etc. are examples of later trajectory. Fig. 3(a) and (b) illustrates two tasks corresponding to the mentioned kinds of trajectories. Robotics library: The proposed platform includes a set of robot manipulators including Staubli and KUKA KR6–2. 3D models of these manipulators have been integrated and assembled into SolidWorks. It is worth to mention that the proposed platform is open for new manipulator models. Moreover, the developed robotics library contains several other 3D models that are needed to run given simulation scenarios. These include five spot welding tools, two conveyors, three tables, two drilling tools, a drying machine, two grippers and a painting basin. For the sake of brevity, some of these models are illustrated in Fig. 4 [4] [5].

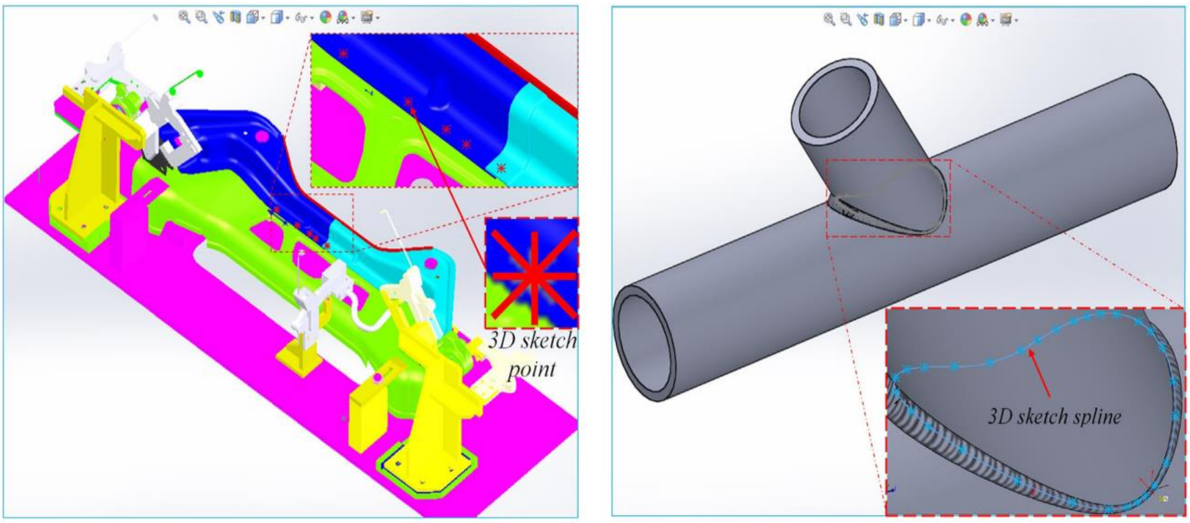

Figure 8 Tasks defined in SolidWorks, (a) a car's chassis as P2P trajectory and (b) two tubes welded together as continuous trajectory

- **Knowledgeware and Visual Basic Application (VBA):** Knowledgeware technologies include set of programs or components that contain knowledge embedded into the CAD model. These technologies are key of the contemporary PLM systems. Automation of activities can be done in many PLM systems, such as CATIA, SolidWorks, and AutoCAD by using a tool like Microsoft Visual Basic (VB) common controls. In that sense, knowledge embedded in VB macros can be used to manipulate the models (assembly and kinematics) [2] [3].

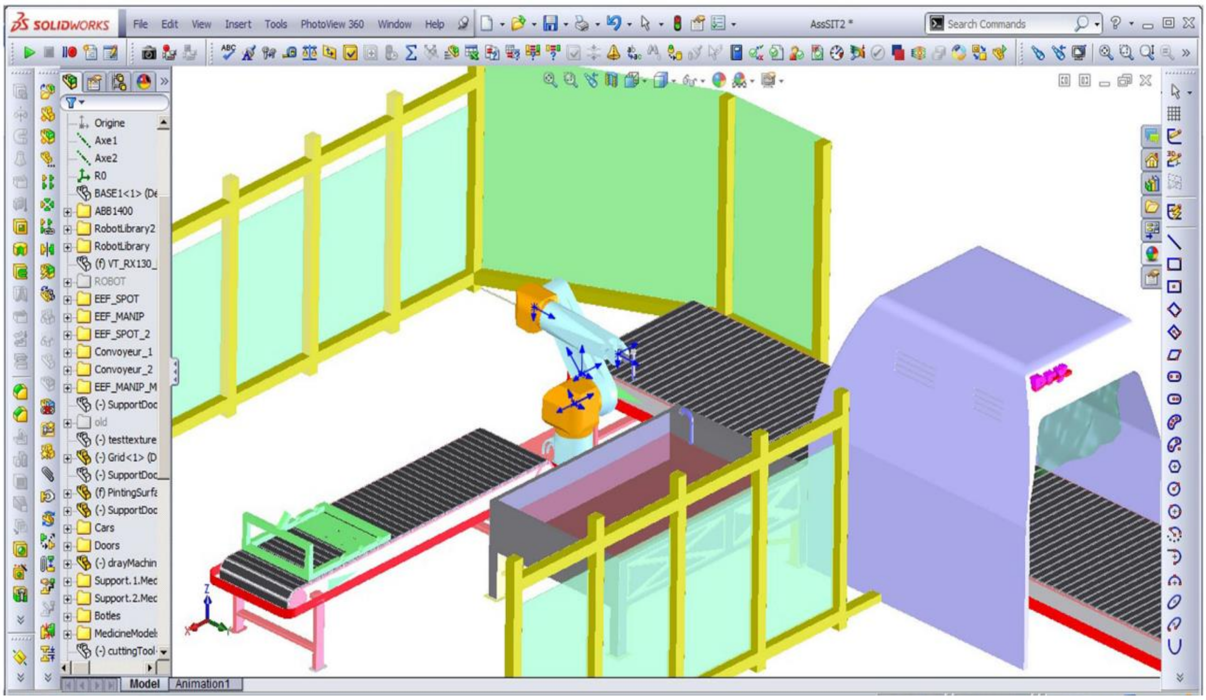

Figure 9 3D models of some objects in IRoSim robotics library showing a robot manipulator, five spot welding tools, two conveyors, three tables, two drilling tools, a drying machine, two grippers, and a painting basin

Simulation

The values of placement and orientation zones are found to be very small and can be neglected. This implies that during the optimization process, the placement and orientation parameters are not considered. Moreover, the order of visiting points is fixed because of the highly constrained task, where we have only one sequence (e.g., doors are given in orders). For instance, the manipulator grasps the support from the first conveyor and puts it on the second one, then starts transporting the first door (Fig. 5(a)), paints it in the basin (Fig. 5(b)) and then places it on the second support (green color model) (Fig. 5(c)). This operation will be repeated for all other doors and finally the manipulator transports the last support after drying the painted doors in the drying machine. Grasping, painting and putting the last door on the second conveyor are respectively shown in Fig. 5(a)–(c). It is important to confirm that the detected obstacles during the simulation have been resolved by adding intermediate points in the trajectory of the robotic manipulator. [3] [4]

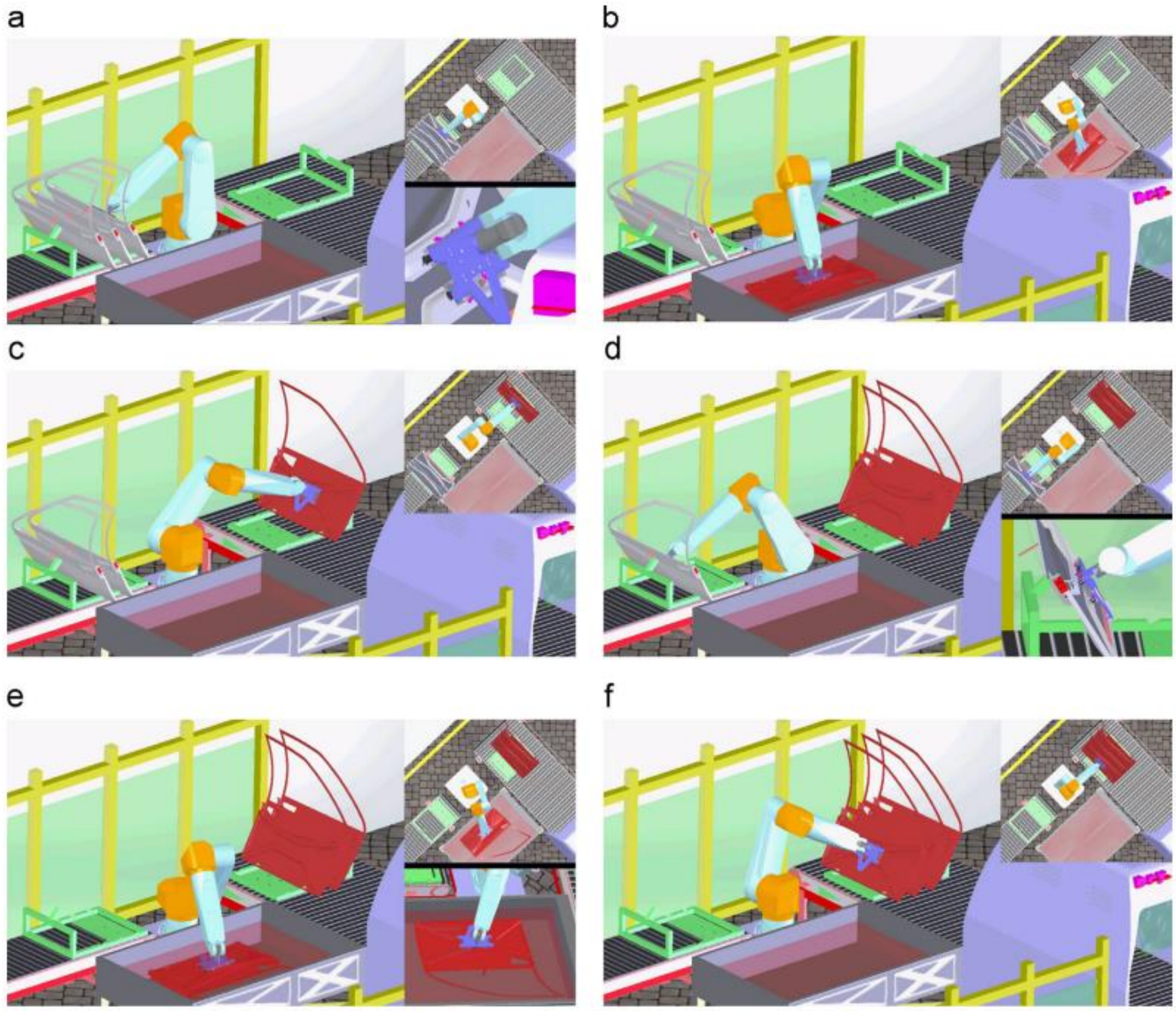

Figure 10 Simulation

Conclusion

In this paper, we presented software IRoSim (Industrial Robotics Simulation Design Planning and Optimization) platform which is based on several steps that are, in total, connected and vital to define, optimize, simulate and validate industrial tasks. Through many known steps, a user is able to define and simulate a given task and then map it to the real site. This allows cost-effective solution to the problems related with time optimization and collision avoidance. The definition step can be performed in a Part or Assembly docs. Therefore, the designed GUI of the proposed platform offers many utilities that can cope with several industrial tasks including but not limited to drilling, painting, spot welding, pick and place and other object manipulation tasks. Moreover, the proposed platform is fully integrated with SolidWorks GUI which further enhances its efficacy. We showed two main industrial tasks to prove the claimed capabilities of the proposed platform. Spot welding task was performed on a car's body that was developed entirely in SolidWorks.

Acknowledgements

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IMMERSIVE VIRTUAL TRAINING AND ITS EFFECT ON A USER'S WELL-BEING

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Abstract: Virtual reality (VR) offers many possibilities, but it is important to not forget about possible shortcomings. It is a relatively new technology, therefore, the exact effects on the human body are not completely known. This article presents a small study focusing on identifying the main sources of discomfort during immersive VR reality usage. The study consisted of 2 sessions of VR application playthrough – the immersive virtual training and a VR game. The participants played both applications for a set amount of time and then undergo a short interview regarding their experiences. The study identified five main problems affecting the comfort of the player which are visualized in the presented article.

Keywords: Virtual reality, virtual reality games, health, virtual reality issues.

Introduction

Virtual reality (VR) offers a new immersive approach to education [1]. Simulating real problems without negatively impacting the real world is not only an effective but also a safer solution [2]. However, as VR becomes more popular, the questions regarding its impact on the human's body need to be addressed [3]. The full VR immersion requires various hardware components, from headsets to various sensors and controllers. Most of them are worn by the user to secure the full movement capabilities in the VR environment. Moreover, wearing a VR headset means that the user perceives the display set right before their eyes. The VR sessions can often last for a long time, which poses risk to many aspects of the user's well-being. Addressing those problems can be crucial for the further adaption of VR into many industries. This article presents a small study that examined the effects of playing VR applications and wearing or wearing VR hardware on a small sample of volunteers.

Methodology

The core of this small study is two VR applications. The first VR application is an immersive virtual training created at the Department of Industrial Engineering, Faculty of Mechanical Engineering at the University of Žilina [1]. The second application is a state of the art VR game created by Valve Corporation – Half-Life: Alyx. A group of people (15 people) played these two applications and then participated in an interview regarding their experience.

The study took place between April 2021 and July 2021. In the first stage, volunteers were introduced to both games and tried VR headset (introduction session). They were free to explore both applications for 30 minutes to learn the controls and get familiar with a virtual world. The day after, they would undergo the test. Firstly, they played the immersive virtual training for 30 minutes. After a half an hour long break, they played the second game for 60 minutes. Shortly after finishing both games, a small interview was held. This interview contained these questions:

- Have you tried immersive virtual reality before?
- Have you felt some kind of discomfort during the test?
- What type of discomfort did you feel?
- What events in both games were the source of discomfort?

The interview was conducted in face-to-face form and answers were written down for the analysis. Details of the small study are included in the table below (Tab. 1).

Tab. 3 Study details [authors]

Number of participants	15
Age range	25-60
Sex Ratio	7F:8M
VR hardware used	1x HTC Vive Pro
Study content	**Duration**
Introduction session	30 minutes
24 hours break	
Test 1.1 (Virtual training)	30 minutes
30 minutes break	
Test 1.2 (Half-Life: Alyx)	60 minutes
Interview	10 minutes

It is worth noting that the size of the participant sample is small. Therefore, the amount of obtained data are not enough to evaluate possible hypotheses. However, the goal of this study is to serve as a pointer for future studies. The main objective is to identify, which issues are most prevalent during VR sessions and should be focused on in the future.

Results

After the introduction session, participants played both games for a set amount of time. The introduction session was focused on first time VR users, because the first experience may be the most uncomfortable one, therefore, every participant should have at least minimal experience with VR before the test. The majority of the participants (87%) did not experience immersive virtual reality before, therefore, the introduction session was their first time using the VR headset. During the test, 93% of participants experienced discomfort caused by various sources (Fig. 1).

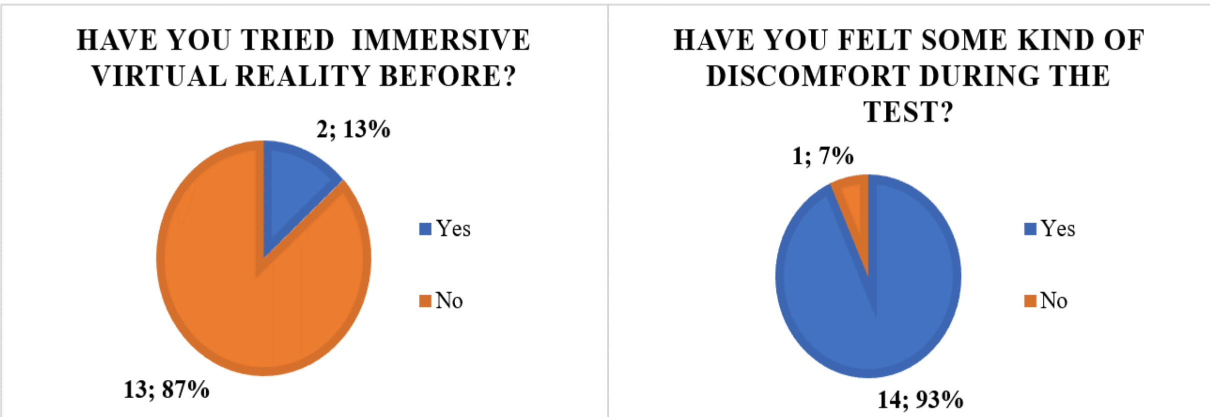

Fig. 21 VR experience and discomfort result [authors]

The source of discomfort may vary and can be caused by various factors. Therefore, the last two questions focused on identifying the cause. During the interview, participants would describe their negative experiences while using VR hardware. Although described differently, the participants stated five problems in total, which are shown in Fig. 2. Participants could state multiple problems per one person.

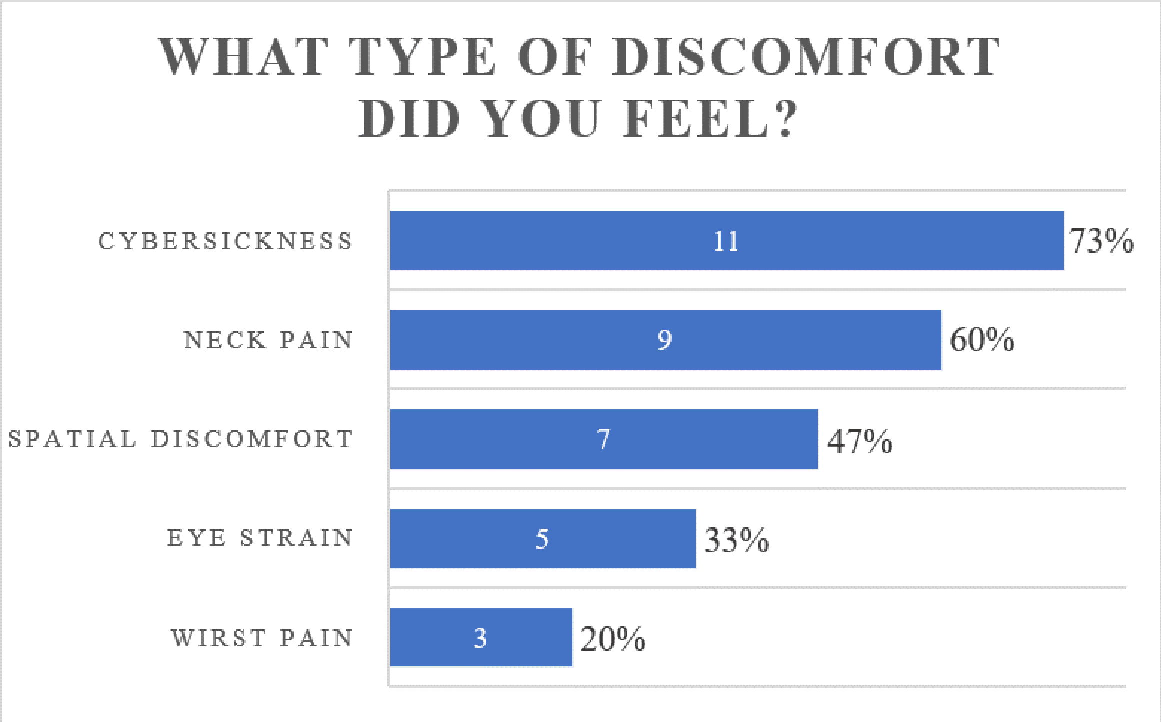

Fig. 22 Sources of discomfort [authors]

The most prevalent problem was the cybersickness reported by roughly 73% of participants. This is caused by inconsistency of signals between the inner ear’s vestibular sense of motion and what eyes are seeing [4]. The second most reported problem was the neck pain reported by 60% of participants. In third place (roughly 47%) was spatial discomfort, which represents a fear of bumping into an object in real life while in a virtual world. Participants stated that they could not fully immerse themselves into the game because they did not feel confident to move freely across the room with their sight in the different world. The last two problems were eye strain and wrist pain reported by roughly 33% a 22% of participants respectively. Five reported problems can be divided into two categories. One affects the physical shape of the body, while the other affects mental comfort.

The last part of the interview questioned the events that potentially caused the discomfort. In the case of the most prevalent problem, the main source of cybersickness were fast and uncontrollable movements. Frequently, participants would bump into the stationary sensors of the VR hardware, confusing position sensors resulting in an unexpected nauseous movement inside the VR application. The other potential sources of cybersickness were the planned movements not controlled by a player (such as elevator or train ride). The second most reported problem (neck pain) was likely caused by the weight of the device and prolonged use of the VR hardware. The participant reported that they felt neck pain near the end of the sessions. Prolonged use of the VR hardware is problematic and other reported problems (eye strain and wrist pain) are also likely caused by it. On the other hand, the third most chosen problem (spatial discomfort) was reported at the very start of the sessions, as participants were not fully used to the feeling of VR immersion. They stated that the feelings of spatial discomfort were slowly fading after the longer usage of the device.

Conclusion

The presented small study consisted of 15 people playing two different VR applications (virtual training and VR game). In an interview after the session, participants stated the main sources of discomfort during their playthrough. The two most common problems were cybersickness and neck pain reported by roughly 73% and 60% of participants respectively. Followed by spatial discomfort, eye strain and wrist pain. The cybersickness and the neck pain seem to be the most likely to occur during the usage of immersive VR hardware. Therefore, they will be the point of interest in the potential following studies focusing on the user’s well-begin in the virtual world. However, the sample size of participants will be increased. The main goal of this study was to identify the most common problems connected to the usage of VR hardware regarding the user’s health and well-being. Fig. 3 shows the screenshots from the used VR application. The left side shows immersive virtual training created at the Department of Industrial Engineering, Faculty of Mechanical Engineering at the University of Žilina. The right side shows the VR game Half-Life: Alyx created by Valve Corporation.

Fig. 23 VR applications screenshots [screenshots taken by the author]

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PREPARATION OF 3D MODELS FOR INDUSTRIAL VIRTUAL APPLICATION

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Abstract: The article focuses on the creation, preparation and optimization of 3D models that are further used for virtual reality. Most industries use CAD software in which companies create models of their products, machines, halls. These models are very demanding, often elaborated in every detail, and some CAD programs are not supported by the development environment. This article gives an overview of which programs are optimal for implementation in VR, what are their suitable settings and in which format to export the models.

Keywords: Virtual reality, CAD, 3D models, polygons, rendering

Introduction

The main topic of this article is Optimizing 3D Models for Virtual Reality. In general, 3D models can be divided into two basic groups: models created by CAD software and models created by alternative modelling software. The first group is characterized by a high creation effort, since it must contain all the components that a real model has in it. These models are almost unusable for virtual reality as their complexity is highly challenging to render in software for creating and editing VR applications. This is because the applications render all the components that the model has inside it, even though these components are not visible through the various shells and covers. The second group consists of models created in alternative modeling programs such as Blender, SketchUp, 3Ds Max, or Maya. In these programs, models are created in a different way, in particular by creating only the visible content, not the functional elements of the model. These models are thus adapted for further use and modification, which makes it possible to implement these models (especially due to their simplicity) in virtual reality applications. Most of these programs have the ability to modify basic model properties such as appearance, functionality and mobility. These basic modifications include, for example, texturing, animation, rendering, etc.

Thus, the aim of this research was to optimize the process of converting 3D models from CAD software to programs involved in creating virtual reality applications. The main reason for this is the use of industrial models for virtual training, which is mainly used to simplify the process of training employees. This eliminates the need to stop the line to train new employees, but everything can be done directly in VR. Another use of these models in virtual reality can be in workplace design, where the entire workplace is designed in 3D. This workplace is then transferred into virtual reality and can then be modified according to the flaws found directly in the created application. In this way, there is no need to stop the production floor with new workstations and then gradually modify them, but this entire process can be carried out directly in VR. Another advantage of creating a workplace in VR is the possibility of optimizing this workplace based on ergonomic analysis, which can also be carried out directly in virtual reality applications, mainly thanks to the combination of virtual reality glasses and sensors from different suits, which can be automatically linked to these applications.

CAD Software

This chapter describes the most common CAD software and its options for importing and exporting 3D models. It serves as a base for understanding modeling in these software and also for understanding the basics of format conversions.

What is CAD – Computer aided design? It is a large area of IT that covers a wide range of design activities. Simply put, it is the use of advanced graphic design programs instead of a drawing board. CAD applications always contain graphical, geometric, mathematical, and engineering tools for drawing flat drawings and modeling real world objects and processes. The more advanced ones deal with calculations, analysis, and control of systems (manufacturing, equipment). The field of computer visualization is also a close relative, as virtual 3D designs are often presented to clients in the form of photorealistic visualizations.

CAD software can be divided in two main groups which are 2D and 3D software. 3D CAD software are focused on surface or volumetric. [1]

Specialized CAD software are used for:

- Mechanical engineering - CAM (computer-aided manufacturing), CAE (computer-aided engineering),
- Construction and architecture - AEC (Architecture-Engineering-Construction), BIM (Building Information Model), CAAD (Computer-aided architectural design),
- Piping systems and building services,
- Linear and transport structures,
- Facility Management (FM)
- Electrical engineering - PCB (Printed Circuit Boards), EDA (Electronic design automation),
- Urban planning and geography - GIS (Geographic Information Systems).

The best-known CAD software are:

- Autodesk Inventor,
- SolidWorks,
- Catia
- NX,
- Fusion 360,
- AutoCAD,
- CorelCAD,
- Solid Edge. [2]

To investigate the complexity of the exported 3D model, the following programs were chosen: Autodesk Inventor 2019, Catia V5R20, SolidWorks 20/21 and NX12, as these are the programs most encountered in industrial companies.

Optimalization of 3D models

The next part of this article describes the optimization of 3D models, where it was necessary to test the complexity of models created by various CAD programs for programs that deal with the development of applications for VR. This complexity is determined by the number of polygons that are the basis for calculating the visual aspect of the model. According to the number of polygons, different quality 3D models can be created. Models that have few polygons are called low-poly and are not of high quality. However, these models are very friendly for creating VR applications. They are not very computationally intensive and therefore a powerful computing system is not needed, but a computer or even a mobile phone is enough. On the other hand, high-poly models that have a large number of polygons are of high quality and this is reflected in the required performance of the device that plays these models. For filmmaking,

these models are the cornerstone and therefore a high-performance computer or computing station is needed to convert such high-quality models with rendering to film.
The actual research that deals with the number of polygons of a given modeled part focuses on the CAD design programs that are the basis of any designer. However, these programs are not very friendly for conversion into applications that are used for example for virtual 2D and 3D tutorials, or directly for applications created in virtual reality. That is why it is necessary to test the complexity of the models that are created in the different CAD programs.
The basic CAD programs encountered in different companies were chosen for the research. The same model with the same dimensions was created in these programs. The model was then exported into a uniform format that can be imported into Blender, which is used for the creation of 3D models and in which it is possible to determine the complexity of the model in terms of polygons.
The procedure of this research was therefore as follows:

1. Creation of a uniform model with the same dimensions in different CAD programs.
2. Exporting the models to .stl or .obj (some programs have a choice of model quality - all options were chosen for this option)
3. Import models into Blender and find out the number of polygons
4. Comparison of exported file sizes

When creating the model in the mentioned programs, a big emphasis was placed on creating rounded surfaces, which are usually the most demanding and contain the most polygons when exporting, because these programs use a different algorithm for calculating these surfaces than the programs for creating applications and it is therefore easier to convert these models into 3D form.
The following figure shows the 3D model that was chosen as the default:

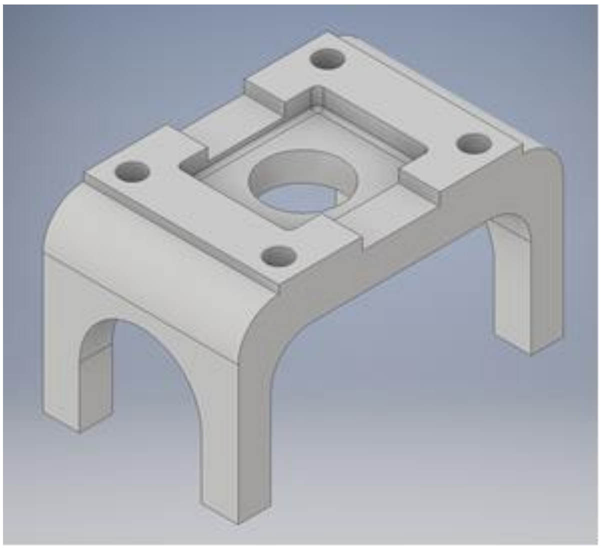

Fig. 4 3D model for research

This model with the same dimensions was created in all selected CAD programs. The model was built from the same material, but the visualization differs in the various programs. A comparison of the visualization of these models in these programs is shown in the following figures:

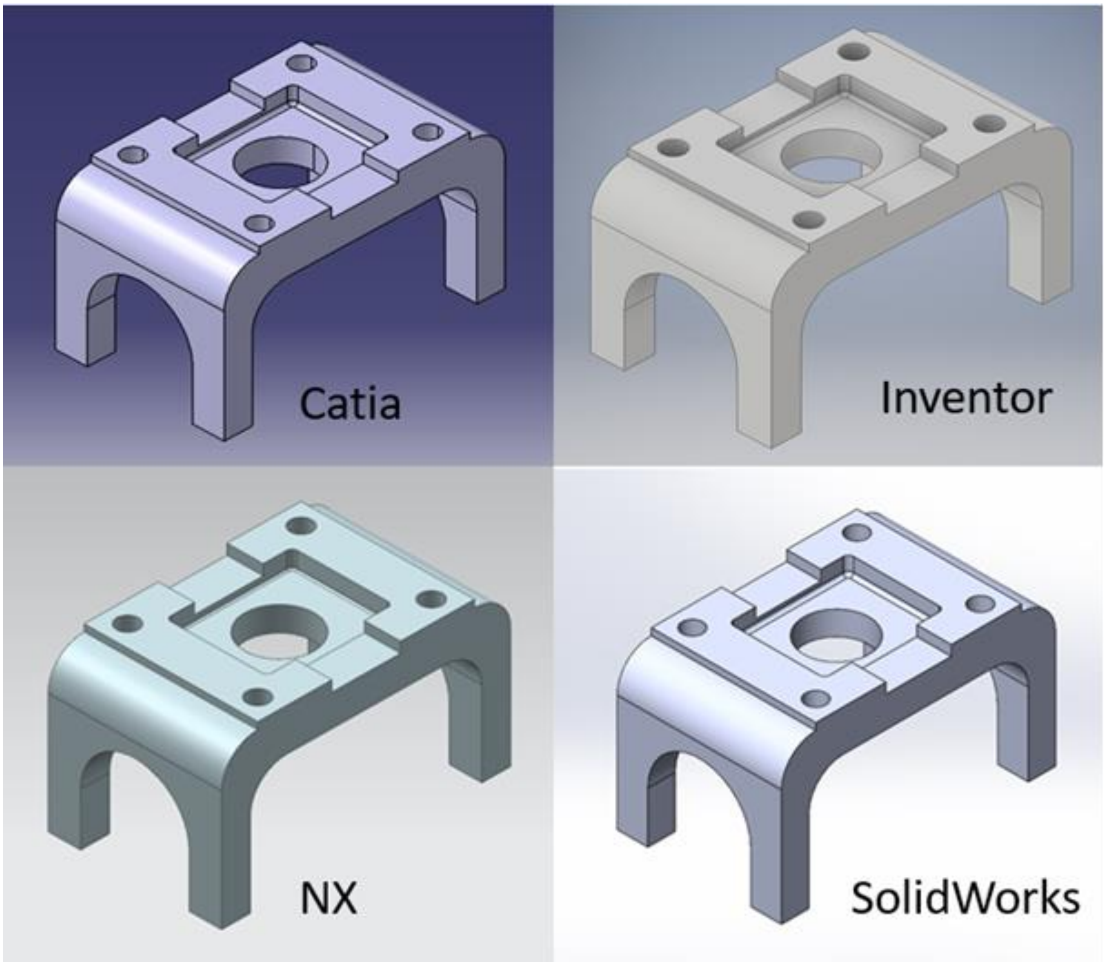

Fig. 5 All CAD models

These models were exported to a format supported by Blender. After the export, it was already possible to find out the size of the model. These sizes are the basis for determining the complexity of the model but are not sufficiently indicative of the complexity in terms of the number of polygons.

Tab. 2 Comparing model sizes

CAD	File size
Catia	315 kB
Inventor	234 kB
NX	346 kB
SolidWorks	183 kB

The table above shows that the largest model is created by NX, while the smallest is from SolidWorks. However, as already mentioned, the size may not be indicative of the complexity of the 3D model, but it is one of the basic parameters for choosing the appropriate program for creating these models.
After exporting the models to.stl format and finding their sizes, it was necessary to import these models into Blender. Here, these models had different visualizations, which differed mainly due to the number of polygons that render the model.

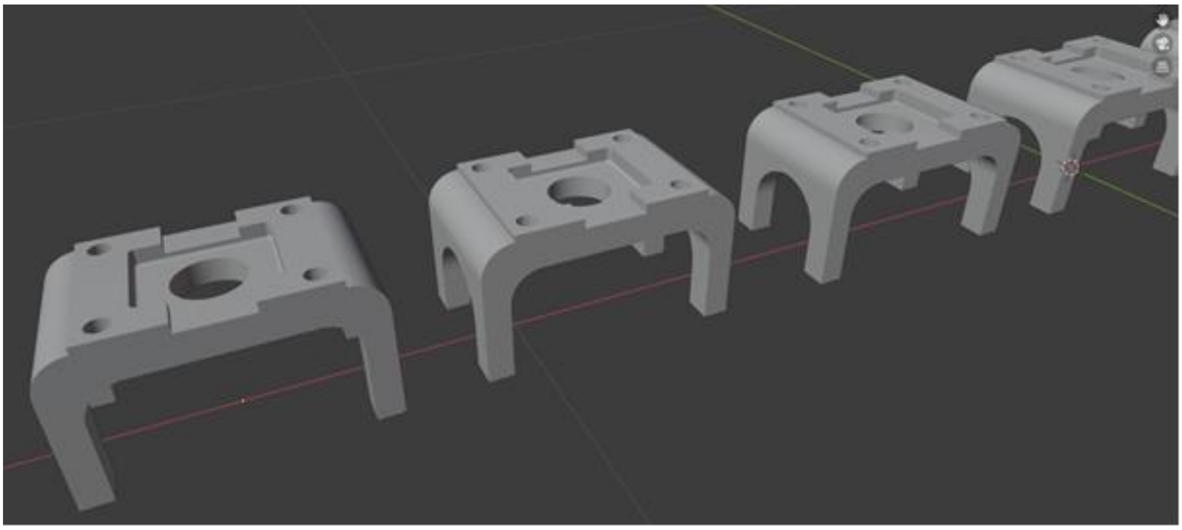

Fig. 6 Rendering models in Blender

In the image above, you can see the difference in the rendering of the models in Blender, where some models did not look rounded, which is caused by the smaller number of polygons.

Result

As already mentioned, the most important part for the research was to find out the number of polygons (triangles), vertices and edges of each model, as these values tell whether the 3D model can be implemented in a virtual reality application. A comparison of these models in terms of these parameters is shown in the following table.

Tab. 3 Comparison of model properties

CAD	Vertices	Edges	Triangles
Catia	541	1 647	1 098
Inventor – Low	594	1 806	1 204
Inventor – High	2 498	7 518	5 012
NX	993	3 003	2 002
SolidWorks – Low	428	1 308	872
SolidWorks – High	1 117	3 375	2 250

From this table, we can see that SolidWorks is the most suitable program for creating 3D models suitable for implementation in industrial applications such as 2D, 3D and VR tutorials, with its Low version of the model having a value of 872 polygons. For the use of SolidWorks, it was observed that this program can be purchased in 3 commercial and 3 educational versions, and the trial license of this CAD program is for 2 weeks. Another suitable program is Catia, but it is a bit more complex and is more suitable for engineers than for beginners who want to model in CAD programs. For beginners, the program Inventor is more suitable and can be obtained for free as a student.

However, when choosing the most suitable CAD program, it was also necessary to consider the possibilities of exporting in different formats, as each format is converted differently to the other program and therefore the visual aspect may be different. After several experiments, it was found that the most suitable format for exporting 3D models from CAD programs is the .obj format, which can easily render a rounded edge with fewer polygons. Therefore, a compromise had to be chosen between a program that creates a model with the fewest polygons and a program that can export the .obj format. Since neither of the Catia and SolidWorks software can do this, Autodesk Inventor was chosen as the most suitable CAD program for creating 3D models for virtual reality model modification applications. [3]

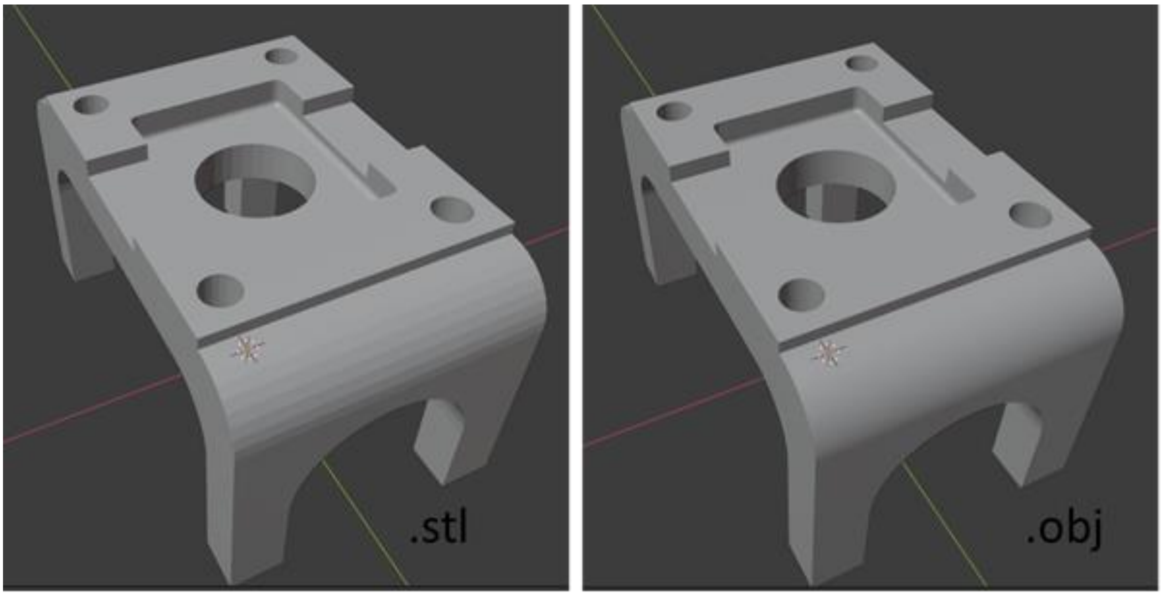

Fig. 7 Difference between formats

Conclusion

This paper analyzed the complexity of 3D models created in various CAD software exported for virtual reality model creation programs. The analysis revealed variations in the number of polygons when exported from different CAD software. In this aspect, SolidWorks came out as the most suitable program for creating 3D models for virtual reality applications, which had only 872 polygons when the low-quality model was set. However, since this model in .stl format could not render rounded edges well, it was necessary to find an optimal solution for creating 3D models in CAD that had a better visual quality. For this reason, several other formats were exported that are compatible with programs for creating VR applications. The most suitable format was found to be .obj, which can be imported into many other programs. This format can be exported by Autodesk Inventor, which showed 1204 polygons when exporting the created model at a lower model quality setting. Therefore, Inventor was chosen as the optimal CAD software for creating 3D models, especially in terms of the ratio of polygon count vs. rendering quality in VR modelling programs.

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ANALYSIS OF INNOVATIVE APPROACHES OF GENERATION Z IN THE CONTEXT OF THE CONCEPT INDUSTRY 4.0

Lucia GRAJZOVÁ – Mária HALADOVÁ – Miloš ČAMBÁL

Abstract: The presented paper deals with the analysis of innovative approaches of generation Z in the field of Industry 4.0. The aim of the authors is to find out the contribution of the youngest generation in the field of information technologies, digitization of processes or data processing. The arrival of generation Z can be defined as the year of birth 1995 to 2010. It is specified by personality, motivation and other characteristics. This generation requires to be technologically active and the understanding of new technologies becomes intuitive and develops from childhood. Generation Z becomes the first generation that does not adapt to technological progress, but takes it as part of life. In recent years, technological advances are evolving in parallel with the Fourth Industrial Revolution, which has become the most debated concept. There may be solutions to the problem of constantly achieving competitiveness, developing innovative approaches or increasing productivity.

Keywords: generation Z, Industry 4.0, work skills and knowledge, innovative approaches

Introduction

Many jobs for which people have been educated and trained have changed significantly and their configuration is determined by the emergence of new digital technologies. In some industrial areas and beyond, artificial intelligence now fulfills specific roles and forces employees in these sectors to exercise different, unique and human abilities. Generation Z is currently entering the labor market and is beginning to contribute to the country's GDP. Young people have their first experience with the requirements of the labor market for digital literacy and require an effective transition from student to working life. The Fourth Industrial Revolution in the way companies, technology and people interact, work and life are likely to be more transformative than any previous industrial revolution we have seen so far. The breadth and depth of the impact of this 4th revolution will quickly penetrate almost every sector. At the heart of today's industrial revolution is the idea that the current pace of expansion will be driven by engineering - specifically computer and software engineering. The new economic paradigm is based on the development of technology. However, it is not clear whether this development has lasted only since the transformation of human resources or whether the development of human resources has brought about fundamental changes at the technical level. One of the goals of the authors of this paper is to identify how the rapid development of development will adapt to the youngest generation of employees and what innovative approaches it has brought to the Industry 4.0 concept.

Theoretical background

The age range of the Z generation varies considerably from author to author, and this information can be found in several professional literature. Table No. 1 shows chronologically examples of different ranges of years of birth of Generation Z, together with a professional article and author.

Table 1: Generation Z birth years range (own research 2020)

GENERATION Z	
Years of birth	**Author and his publication**
1990 and later	Wiktorowicz et al., Pokolenia na rynku práce (2016)
1990 - 1999	Half R., Ready for Generation Z (2015)
1993 - 2012	White J.E., Meet Generation Z (2017)
1993 - 2002	Turner A.R., Generation Z: technology’s po-tential impact in social interest of contemporary youth (2013)

Generation Z is generations that work in both the real and virtual worlds. Young people simply switch between these two worlds, they do not separate the virtual experience from the real. They transfer these habits into their work environment (Tracy, Hoefel 2018). A positive consequence of this circumstance is the fact that the young generation can easily obtain, manage, and disseminate the necessary information (Sabadka 2015). Generation Z is the most distant generation so far. From childhood, they are guided to education and are motivated to stay in schools for as long as possible. Industrial companies respond to this fact and come to schools, so we intend to find talent and help them develop. Many young people use these opportunities to gain practical experience during their studies (Cagáňová et al. 2017). Generation Z has an innate comfort in the virtual world. As consumer has always had more options on the market. The only limit to their expectations of innovation may be their youth.

What is Industry 4.0?

The world has been through three industrial revolutions that started in 1976 until 2010. Industry 4.0 is a future manufacturing paradigm that improves manufacturing system efficiency and performance (Brettel, Friederichsen, Keller, & Rosenberg, 2014). According to Schwab (2016), we are facing the brink of a technological revolution that will fundamentally change the way we live, work, and interact. Industry 4.0 focuses on digitization, optimization and customization of production; automation and adaptation; human machine interaction; value-added services and businesses and automatic data exchange and communication (Posada et al., 2015; Roblek et al., 2016). This transformation will be unlike anything ever experienced by mankind before as it is characterized by a combination of technologies that blurred the lines between the physical sphere, digital and biology. Industry 4.0 represents the technological evolution from embedded systems to cyber-physical systems. The intelligent factory is built on the following technologies show in Figure No. 1:

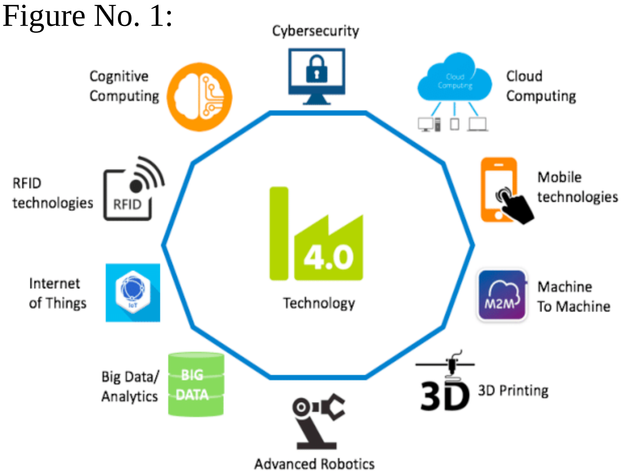


Figure 11: Technologies for Industry 4.0

Is Generation Z really a generation of digital wizards that are able to intuitively navigate code. Despite the lack of studies examining the relationship between Industry 4.0 and Generation Z, these concepts are believed to be interconnected. Generation Z's skills will be increasingly determined by their ability to work with smart and intelligent technologies. Today, industry leaders have a unique opportunity to understand, adapt and take advantage of the technical dependence of Generation Z. Recognizing this new way of interacting with technology as a paradigm shift will help leaders better connect generations in the workplace and beyond.

Methodology

To identify the relationship between Generation Z and Industry 4.0, we chose a questionnaire survey, which also revealed to what extent does Generation Z use innovative approaches in the concept of Industry 4.0.

The main goal of our research

The aim of this paper is to determine whether Generation Z enters the innovative approaches used in Industry 4.0.

Research questions

RQ1: Generation Z employees have theoretical knowledge about Industry 4.0?

RQ2: Are Generation Z employees involved in innovative approaches of information technology, process digitization or data processing?

We further investigated these through a questionnaire survey in industrial enterprises in Slovakia. The basic file of medium and large industrial enterprises in Slovakia was set at 1462 enterprises (Table No. 2). Of the total number of medium and large enterprises (3614) in the Slovak Republic, industrial enterprises make up **40,45 %** (1462).

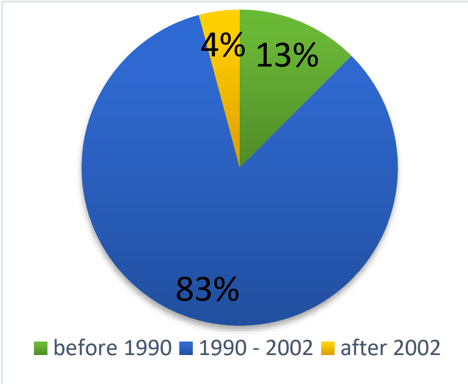
Table 2: Determining the base file (DATA cube and SK NACE)

Business category	Number of employees	Number of enterprises	Industrial enterprises
Micro and small businesses	> 49	318 353	-
Medium ponds	50-249	2 943	1 109
Large companies	250 <	671	353
=	-	321 967	**1 462**

Distribution was selected via Google Form - Questionnaire, 1200 E-mails were sent to medium and large industrial organizations in Slovakia. In order to maximize the effective return of the questionnaire survey, we selected an internal database of industrial companies that work closely with MTF STU. This method of distribution was determined mainly for the pandemic situation in Slovakia due to the SARS-CoV-2 pandemic and also for time efficiency. Data collection took place during the time horizon: 09.08.2021 to 13.09.2021. After the gradual processing of the questionnaires and the exclusion of incomplete questionnaires, 480 questionnaires were usable. Which represents an **32,83 %** return on the questionnaire data collection. The research aimed to determine whether Generation Z enters the innovative approaches used in Industry 4.0.

Results

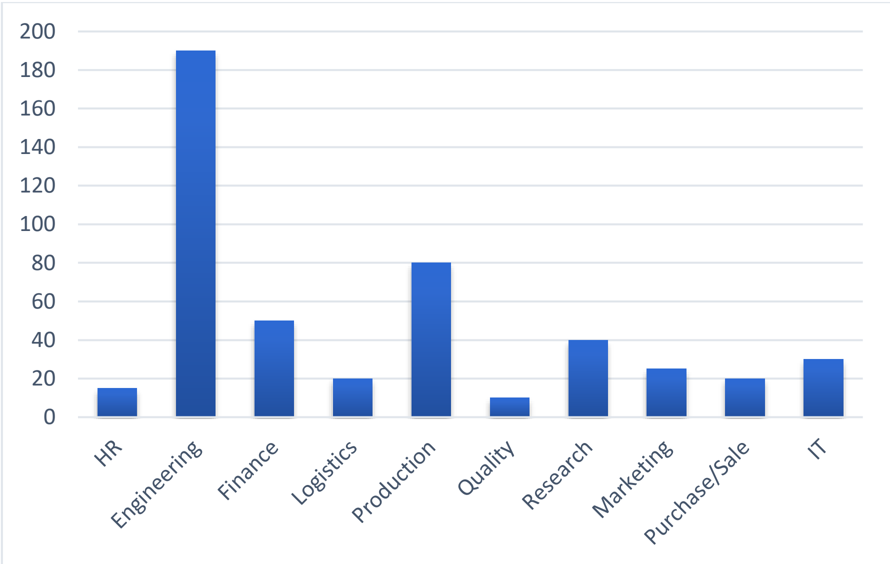
From the questionnaire survey, which was distributed among medium and large industrial enterprises in Slovakia, we filled out a questionnaire of 480 respondents, of whom the questionnaire was returned to us exactly 50% of women and 50% of men. In the following question No. 2 *"Indicate the range of years of birth:"* we ascertained the respondents' belonging to a specific generation.



Graph 1: Percentage of generations (own processing, 2021)

The most numerous generation that participated in the questionnaire survey is Generation Z, which represents **83 %** of the respondents. The remaining 17% represent Generation BB, X, Y (13%) and Generation after 2002 (4%) like we can see Gprah No. 1.

In other question, we found out the job classification of respondents.

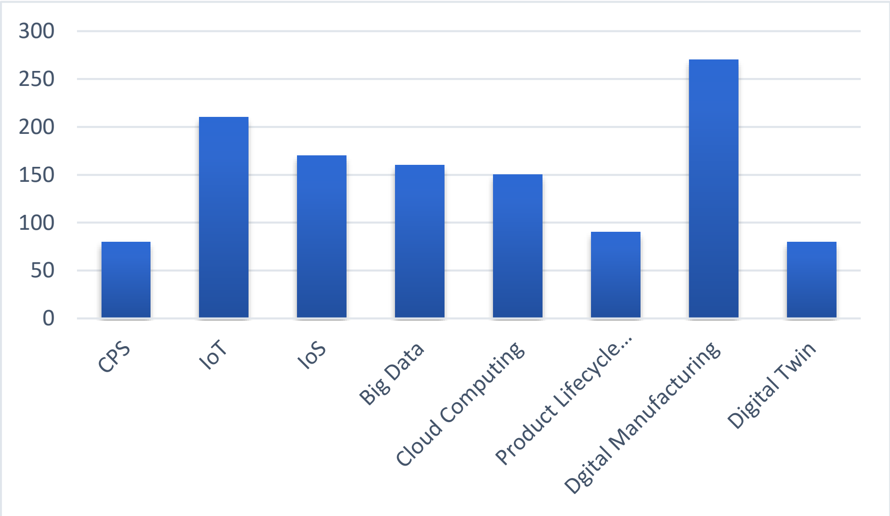


Graph 2: Job classification of respondents (own processing, 2021)

As can be seen from Graph No. 2, the largest representation was in the field of engineering and production, which represents approximately **56 % of respondents.** The remaining respondents work in Finance (10,4%), Research (8,3%), IT (6,2%), Marketing (5,2%), Buy/Sell (4,2%), HR (3,1%) and the smallest representation of Quality (2,1%).

One of the unexpected facts was the result of question No. 4 *„Do you encounter the term Industry 4.0 in your work focus?"* More than half of **57 %** of 274 respondents in medium and large industrial enterprises in Slovakia do not encounter the term Industry 4.0 in their work focus.

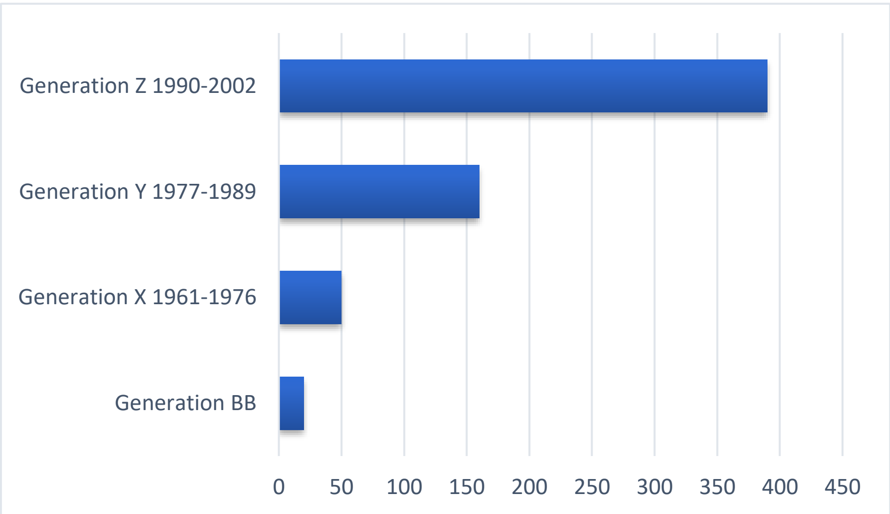
Furthermore, we surveyed the respondents with theoretical knowledge in the field of Industry 4.0. With this question, we directly verified **research question 1 „Generation Z employees have theoretical knowledge about Industry 4.0? ”**



Graph 3: Respondents' theoretical knowledge of Industry 4.0 (own processing, 2021)

From Graph No. 3 we can see that the respondents have the widest knowledge in the field of Digital Manufacturing up to **56,25 %.** Just behind this area, respondents hold relatively the same knowledge of IoT (43,8%), IoS (35,4%), Big Data (33,3%) and Cloud Computing (31,3%). At the bottom of the rankings is knowledge of Product Lifecycle Management Systems (18,8%), CPS (16,7%) and Digital Twin (16,7%).

The most important question of research was to find out which of the generations of innovation activities are involved in this process.



Graph 4: Representation of generations in innovation processes (own processing, 2021)

As can be seen from Graph No. 4 The clear winner of the generation's involvement in the innovation process for medium and large industrial enterprises in Slovakia is Generation Z. Out of the total number of respondents, up to 390 respondents mentioned this possibility.

Equally important for us was the finding from the last question of the questionnaire survey, *„Do you feel that the Z generations contribute significantly to the innovation activities in your company?"* This question was a verification of **research question 2 „Are Generation Z employees involved in innovative approaches of information technology, process digitization or data processing? “**

The research shows that the respondents were clear on this question, **78 % (375)** of the answers were directed to the possibility that Generation Z contributes significantly to the innovation activities in the company.

From the above analysis, it is possible to record a large impact and compatibility of Generation Z in the field of Industry 4.0 in medium and large industrial enterprises in Slovakia. The future of industrial enterprises can be ensured by Generation Z with its innovative approaches and activities that will lead to competitiveness in the market.

Discussion

Based on the evaluation of the results of the research analysis, we identified that Generation Z is actually entering into innovative processes in industrial companies in Slovakia in the context of Industry 4.0. This statement was made to us through a questionnaire survey. Generation Z is and will be of great benefit to these companies in the near future, as it has the broadest scope of knowledge about the technologies of the fourth industrial revolution. However, the disproportion occurs in the fact that more than half of the addressed industrial companies do not encounter the concept of Industry 4.0 in the daily work focus.

For industrial companies, there is the **Concept of Intelligent Industry in Slovakia**, which is under the auspices of the Ministry of Economy of the Slovak Republic, where the priority of industry is the introduction of automation and digital production, digitization of control systems and the use of communication networks to ensure interoperability and flexibility of business processes. The implementation of Industry 4.0 technology will be a key element if Slovakia introduces measures to improve the readiness of Slovakia's digital infrastructure, institutional performance, research, development, and innovation. Slovak industrial enterprises need improvement, which they can help and use to their advantage best practices and lessons learned from the process of implementation and fulfillment of strategies in other EU member states (Ministry of Economy of the Slovak Republic, 2021).

Research on the Industry4^{UM} **Level of Digital Transformation Survey in Industry** from 2020 reveals shortcomings and stagnation in the digitization of industrial enterprises. The survey revealed that the implementation of Industry 4.0 in industrial enterprises with Slovak capital was lagging. Compared to 2019, the number of companies already implementing Industry 4.0 is stagnant. In an annual comparison, it fell from 40% in 2019 to 35% in 2020 (Industry4^{UM}, 2020).

The authors believe that Slovak industrial companies will have to change the current paradigm of thinking and move towards the possibilities offered by Industry 4.0 technologies. Human capital in the form of Generation Z is ready for the possibilities of transformation of the intelligent industry. However, it is not enough for these generations to contribute to innovative practices and thus ensure innovative activities in companies, because the most important factor is missing, the implementation of industry 4.0. company.

Conclusion

In this paper, we examine whether Generation Z is entering innovative approaches used in Industry 4.0 in several medium and large industrial enterprises in Slovakia. For this purpose, we conducted a questionnaire survey based on questions in the field of generations and Industry 4.0 in 1 200 industrial enterprises in Slovakia. The information gathered was analyzed and answered the authors' research questions. The implications of our study contribute to theory and practice. Based on the output of this article, it may follow that the authors have achieved the set goal. Innovative changes are currently affected by the COVID-19 pandemic more than before, in order to stay competitive. For measures that are not yet possible, further research activities that are planned for the future and will be further interpreted and published. The authors unequivocally confirm that Generation Z will be the generation that will be the driving force for industrial companies in the field of innovative approaches in the context of Industry 4.0. In Slovakia, Industry 4.0 mainly deals with scientific and academic issues, but also industrial companies will eventually take this concept for stabilization, future development and maintaining competitiveness.

Acknowledgement

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WORKING TIME MONITORING IN THE DIGITAL AGE

Peter MALEGA

Abstract: This paper deals with the actual problem in the era of Covid-19, monitoring of working time. This problem arises from the necessity to use different tools for monitoring the work of employees, which work at Home Office and there are many different positive, but also negative effects, which can increase, but also decrease the productivity of work. It is clear that not every employee can work at Home Office, but there are also professions, in which assumptions are that employees will work at Home Office in the future permanently. In this time, we can use some modern tools that can effective monitor the productivity of work, such as Time Doctor and Trello.

Keywords: working time, digital age, Time Doctor, Trello, Covid-19

Introduction

As most companies closed their classic stores for a certain time due to the Covid-19 pandemic and employees were forced to start working at Home Office, companies faced major challenges and economic indicators deteriorated significantly in most of these companies. Today (not least during the Covid-19 pandemic), managers are discovering the necessity and importance of using the time tracking application at Home Office for employees. [3, 7, 14]

The operation of companies in market conditions involves the development and implementation of an economic mechanism that ensures increasing of efficiency at all levels of management and areas of activity. [2] One of the main elements of such a mechanism is the implementation of the application for recording the working hours of employees in the company, as well as business processes, which not only reflect functional and information activities, but also significantly affect them.

Monitoring and recording of working time

Working time is considered the time during which the employees, according to the working, respective collective agreements and internal labor regulations are obliged to be at the workplace and to fulfill their work duties. [1]

The question is: Why we have to monitor and record working time? Working time monitoring allows managers to resolve several issues [10]:

- check the arrival time to work so that we can identify employees, who are late,
- check the employee's timely return after lunch and attendance at the workplace,
- determine the time of work completion,
- identify those who do not fulfil working time according to standards,
- divide paid working time periods into hours actually worked, holidays, sick leave, downtime caused by the employer, etc.

The employer is interested not only in the timely entry of employees into the workplace, but also in the productivity of the team. Productivity is directly related to what the employee does in the workplace. [5, 9]

The employee will not have enough time to complete the duties if he spends time on social networks, chatting with friends, watching messages, reading books or surfing the Internet.

Methods for monitoring, recording and evaluating staff time have evolved over time, and despite of this fact the organizations have adopted the traditional approach. For example, one responsible person records arrival time to work and leaving work and systematically prepares reports for the manager. Another option is to introduce the position of administrator to the staff, who will be in the same room with colleagues or in a separate office and will control the continuity of the work process. Another way is to keep personal records, independently monitor the work and record working time. The method helps to evaluate the work performed from the point of view of the performers and develops independence. A better known method is to set up an access control system using ID cards or fingerprint sensors. Information about each employee is stored in a file and is available for viewing at any time. [4, 6]
Methods of checking employees' working time include recording:

- tasks completed between turning the computer on and off,
- telephone conversations with clients, partners and suppliers,
- screenshots of the desktop during the working day using specialized IT solutions,
- the contents of corporate correspondence, including e-mail correspondence,
- presence on the workplace during working time with camera surveillance.

Remote working time monitoring

The current situation in the world associated with the Covid-19 pandemic requires modern solutions in the field of business management. In the time that almost the entire world was in quarantine, people in companies have been forced to move to work in the form of Home Office. Special programs make it possible to monitor employees' working time during quarantine. Automated systems record information, analyze and generate reports. The market currently offers a wide range of automated time management systems for staff focused on different users with different budgets. The automated system allows:

- keep records about start and end of the work of each employee, respective about the reasons for the absence,
- generate reports for the company as a whole, for individual departments or specific employees in the required context,
- create optimal work plans for the team,
- integrate data with other information systems used by the company.

Records about working time have to be kept in each company, regardless of the schedule adopted. Time management techniques increase productivity, employee discipline and reduce costs. We can introduce e.g. a simple system for scheduling tasks – Google sheets. Google Spreadsheets includes the following tools:

- creation of the tables and edition of the existing tables,
- setting up access to the spreadsheet archive and work on each file simultaneously with friends and colleagues,
- offline access,
- formatting cells, entering and sorting data, viewing graphs, inserting formulas, searching and replacing,
- user changes are saved automatically,

- support for a large number of different add-ons that significantly expand the functionality of Google spreadsheets,
- built-in script editor, which also enable to expand the possibilities, especially for integration with other applications.

The scheme of operation of all systems is approximately the same. A small program called "Agent" is installed on employees' computers. The agent collects information about user actions on the computer. The amount of information collected is different for each program. The Agent then sends the information to the server or stores it on the employee's computer. A dedicated server is certainly more comfortable, because it enables to generate reports and display information much faster, even when the employee's computer is turned off. Finally, the manager or supervisor can use a browser to view the information collected. This can be report analysis, monitoring of online streams from employee monitors, violation analysis, etc.

People in successful companies often plan in their diaries or use applications and services. For example, many people choose Google Calendar (Fig. 1).

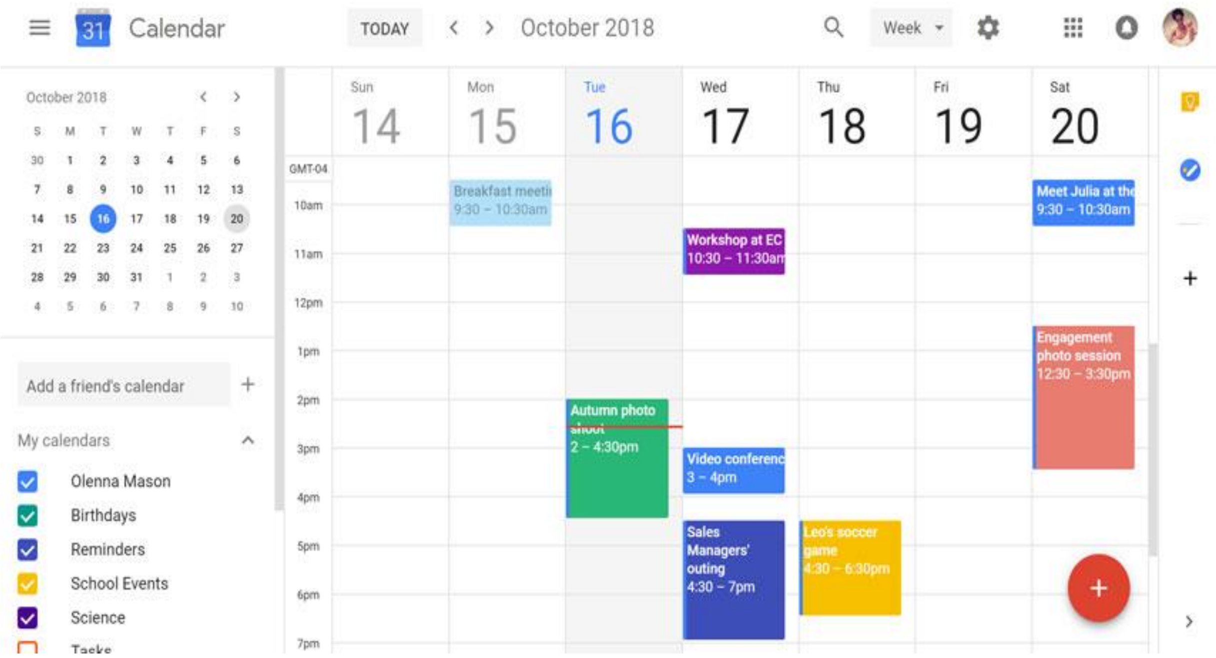

Fig. 1 Google calendar [8]

For many managers can be an important finding that 90% of office employees use the Internet for personal purposes during their working time as follows:

- 29% read newspapers,
- 27% "surfs" on information portals,
- 20% communicate via social networks and Messenger,
- 19% download files unrelated to professional activity
- 5% of men and women visit dating sites.

In principle, it is impossible to find an employee who would not use working time for personal interests, such as drinking tea and smoking breaks, talking to colleagues, phoning relatives and friends, playing computer games, reading books, solving household problems, etc. However, the main absorber of working time is, of course, the Internet. It takes it from 30 minutes to three hours a day as they communicate on social networks, shop online, read or download e-books, play, read blogs, and look for work. The result is reduced efficiency of employees, respectively deadlines and projects that were not completed on time.

Before implementing any control tool, it is very important to perform information work, i.e. explain to people what results can be achieved, prepare a documentation base, if it is possible, about the implementation of software products. The benefits of usage can be summarized as follows:

- monitoring the work of all company employees for only 10-20 minutes a day,
- control of remote employees,
- quick notifications online, by email and mobile phone,
- increasing the productivity of employees and company as a whole.

Programs for monitoring the working time of the employees are also useful in other ways, as they motivate employees to work more efficiently. There are possibilities as follows:

- identification of unserious subordinates,
- improvement of the work discipline level.

The disadvantages of usage are the following:

- demotivation,
- totalitarian regime.

Time Doctor – modern tool for monitoring the working time

Time Doctor is a powerful attendance software focused on productivity and daily task management. Time Doctor not only monitors the work of employees, but also provides a schedule of how much time is devoted to a specific projects. The application is configured to monitor work in real time, unlike the usual "guessing" of the number of hours devoted to the task. [12]

Working time control is set up in the way that real-time data are displayed in the same second. Time Doctor provides a large number of options at once [12]:

- creation of screenshots to monitor employee work,
- Time reports (by programs, websites, tasks, and other areas),
- Payroll accounting, work with Paypal and Payoneer,
- API for cooperation with other services,
- working time control – timer,
- distraction warning tools,
- website and application monitoring.

The software can be easy integrated into most managerial tools including JIRA, Asana, Basecamp, Basecamp2, Trello, GitHub, Evernote, Freshbooks, Pivotal Tracker, Freshdesk, Podio, Readmine and more. Time Doctor's pricing policy is that free access to this feature is provided for 14 days. The price for each employee is $ 9.99 per month.

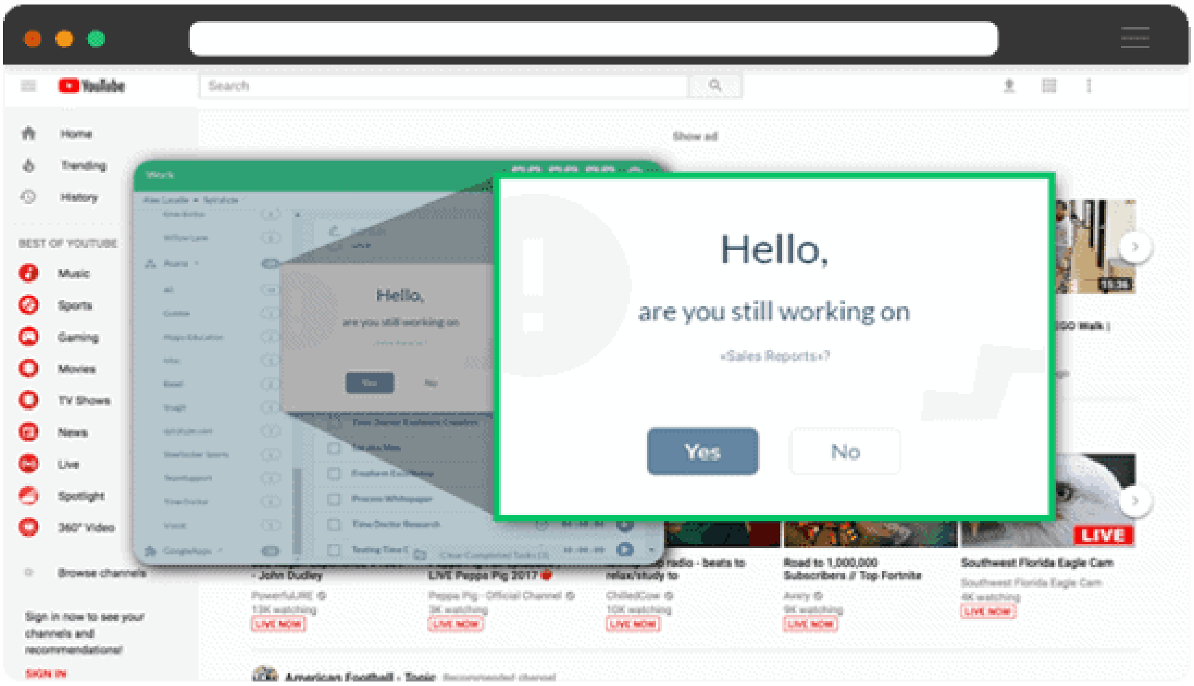

Fig. 2 Warning in Time Doctor [12]

There is a system for determining the URLs of the pages on which the employee is working, as well as a system for detecting inactivity. If the webpage is not in the white list, a pop-up window will appear with the question if the employee continues to work on the assigned project. This will allow them to return to work if they have stopped there and e.g. started using Facebook or watching videos on Youtube. In Fig. 2 is an example of the warning, when employee incorrectly use the working time In Fig. 13 is a screenshot of Time Doctor program in the company that already used this software.

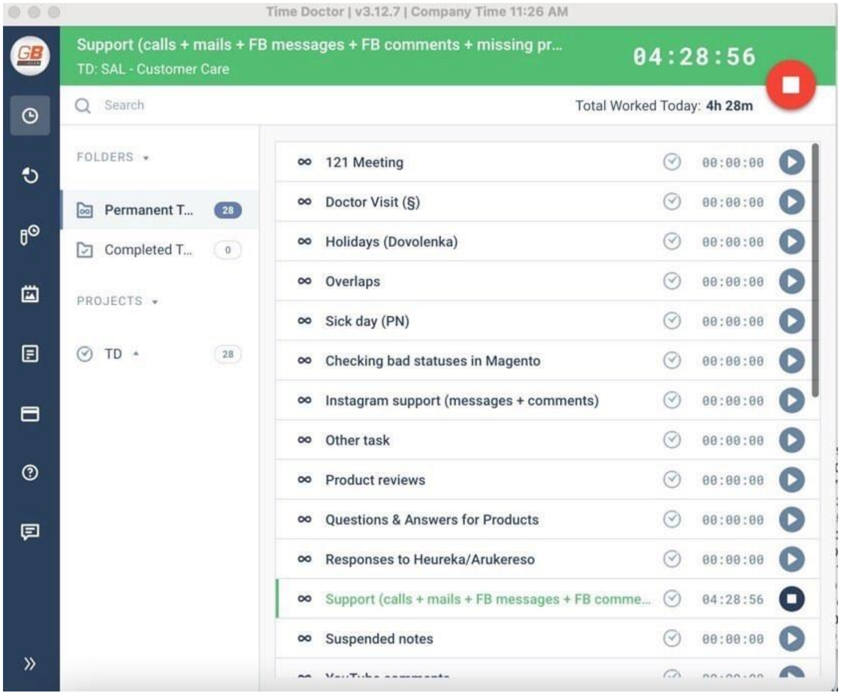

Fig. 3 Example of Time Doctor usage [12]

After the work start times, work intervals, responsible persons are set, company can start to use Time Docotr. Fig. 4 shows the employee's working time, including time worked on various devices (computer, mobile phone, tablet, etc.), non-productive time, and the program compiles a ranking from the most visited pages.

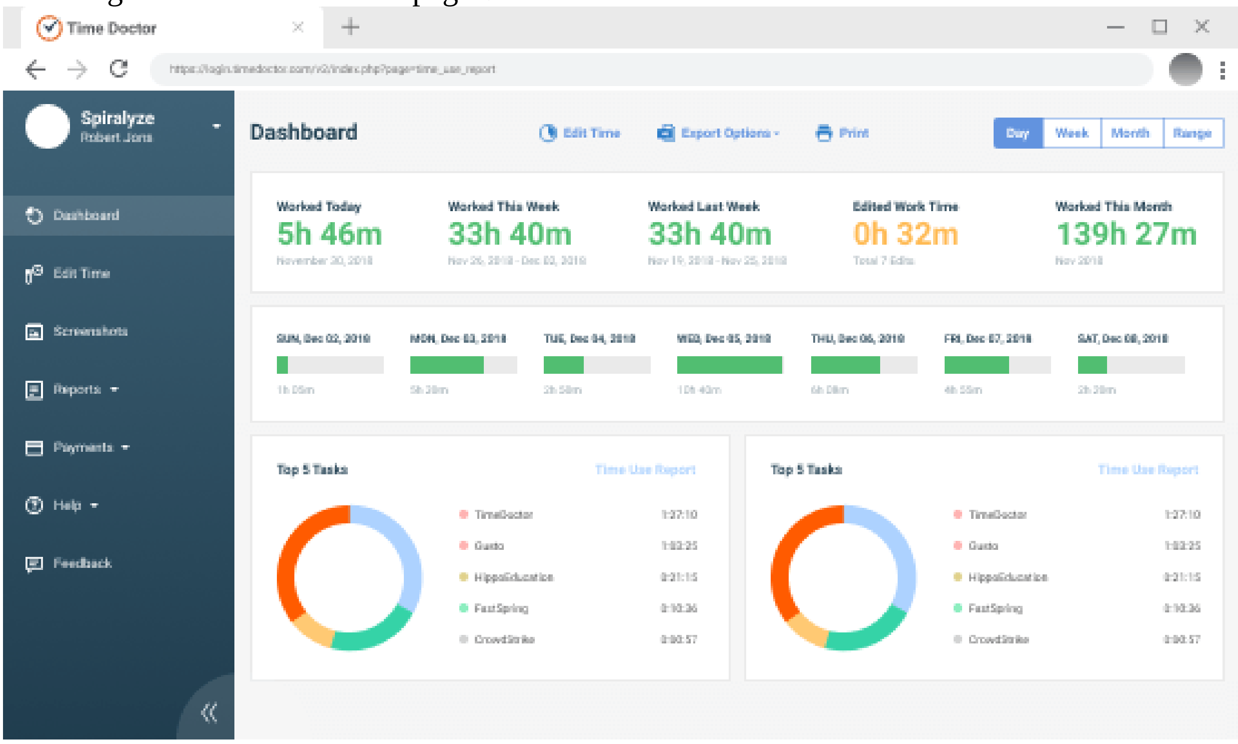

Fig. 4 Employee's working time in Time Doctor [12]

Trello – support platform for Time Doctor

Trello is a collaboration tool that organizes your projects into boards. In one glance, Trello tells you what is being worked on, who is working on what, and where something is in a process. You can imagine a white board, filled with lists of sticky notes, with each note as a task for you and your team – this is Trello.

If you want to use Trello, you have to register an account with this program. It is best to sign up for a Trello account by synchronizing with your Google Account. To do this, it is best to create a separate (enterprise) Google Account first.

Members are added to the team by sending an email invitation. For all added members, "ChangePermissions" is set to "Normal". This gives a team member the right to view, create, delete and edit the team board and its elements, but does not give the right to change any settings. The added participant must confirm their connection to the team ("Joinboars") by clicking on the link in "Trello" in order to become a normal member of the team. In Fig. 5. is a screenshot of the "Trello" program after registration, specifically in the implementation phase.

A separate board is added for each team. The "Team" message board mode means that all managers working in this organization will be involved. There is also a "Private" mode, which means a "Face to Face" conversation between employees. Whiteboards can be created for specific members of the organization and for all staff in general.

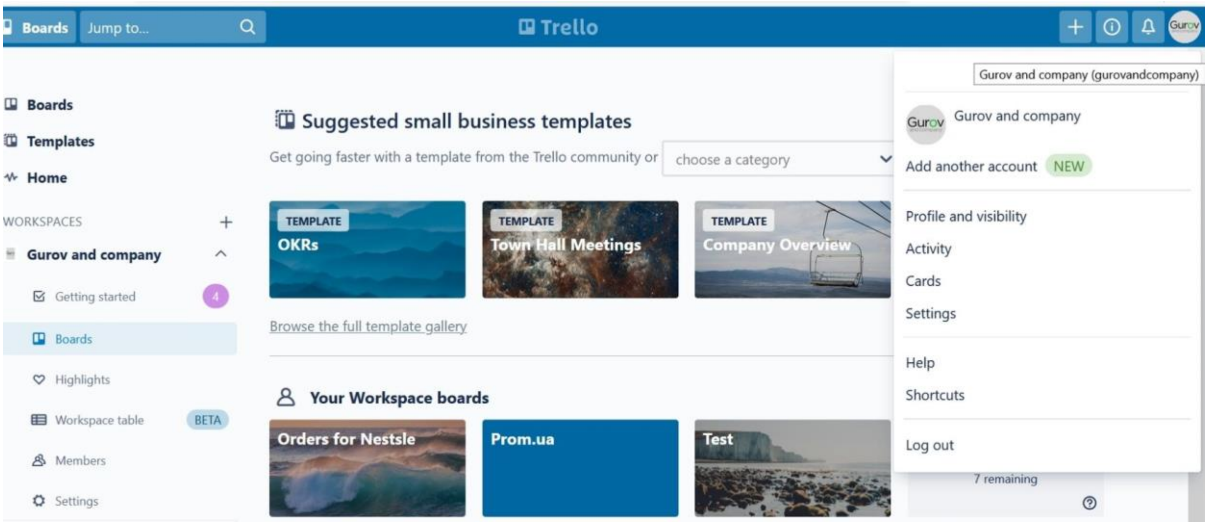

Fig. 5 Account in Trello [13]

Into public boards in Trello, every employee has an access, which means that the tasks will be written here in general, i.e. for everyone. It will be specifically such as e.g. events, photos, meetings, etc. In these public boards, the lists will be created with the following names: "Backlog", "Design", "To-Do", "Doing". As it can be seen in Fig. 6, photos or screenshots can also be uploaded to the cards. In Fig. 6 we can also see that the upcoming events and tasks of the company that have to be fulfilled within a certain time frame are explained on this board.

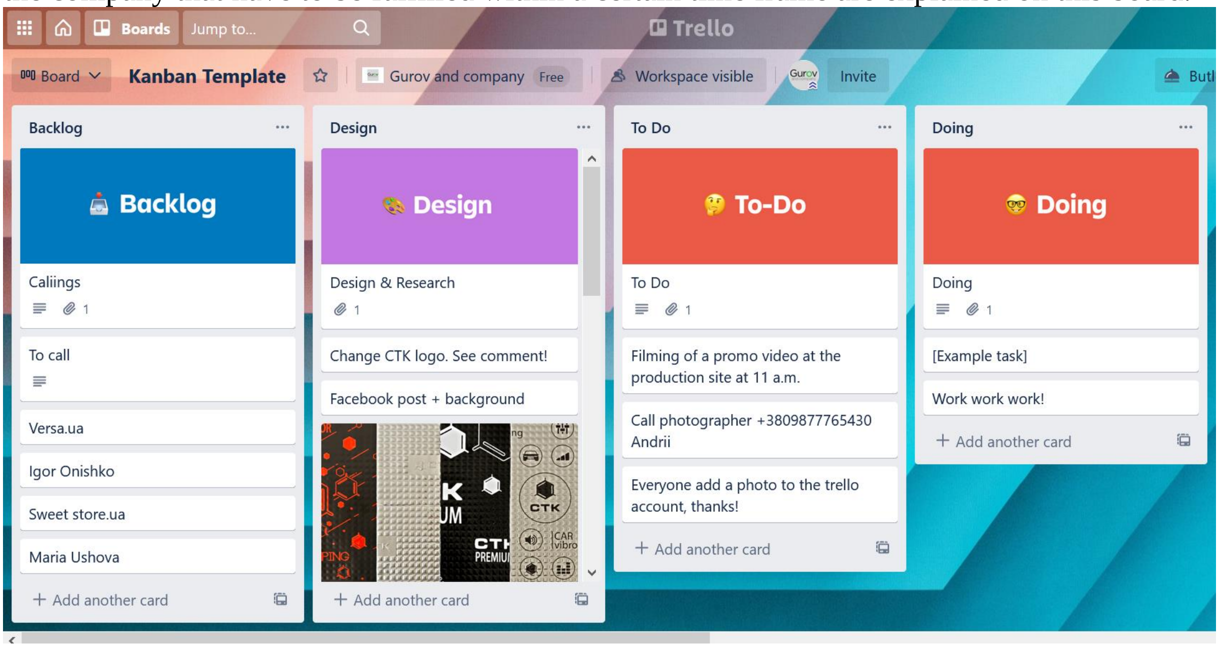

Fig. 6 Public board in Trello [13]

If you create the public board for specific staff, such as managers, only the certain person and manager who will create plans and tasks will have access to the board. The program also allows you to move items and select completed tasks or postpone them to the next time, if something has not been completed. If the task is completed during the working day, the corresponding card is transferred to the list "Completed". This list is checked by the responsible manager. The example of such a "moving" is shown in Fig. 7.

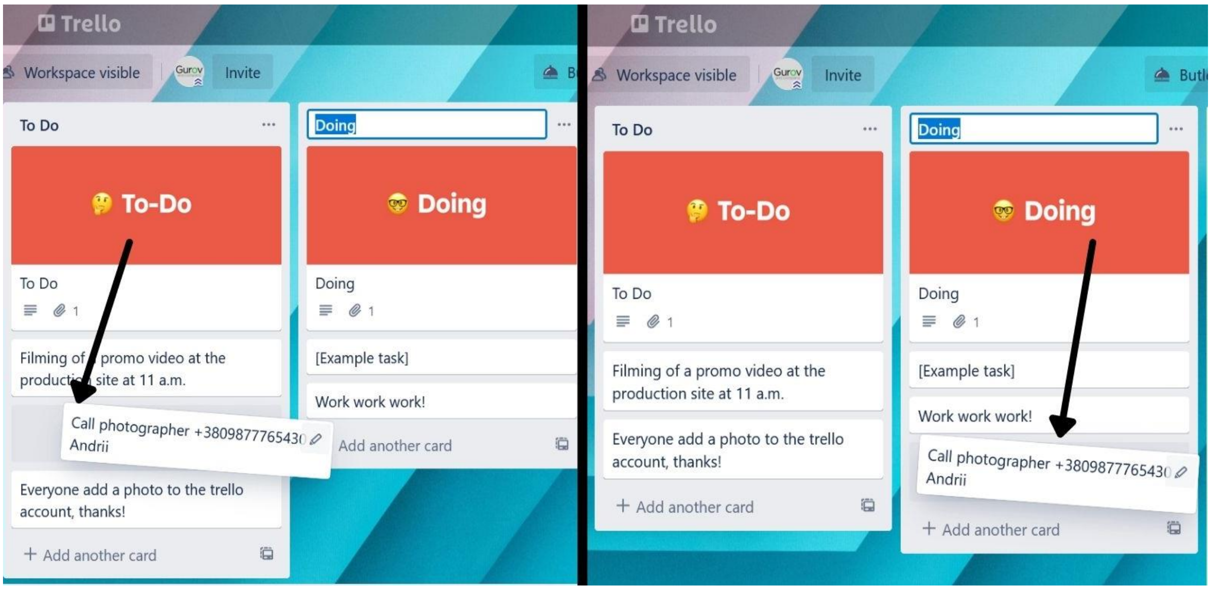

Fig. 7 Moving a card from the "To to" list to the "Doing" list in Trello [13]

Implementation of Time Doctor and Trello from the economic point of view

If we can calculate the costs for implementation of Time Doctor and Trello in for example medium enterprise with 50 employees, it is necessary to prepare project (time schedule) with the phases that are necessary for successful implementation. In Tab. 1 is the calculation of costs on such a project.

Tab. 1 Calculation of costs for implementation of Time Doctor and Trello in medium enterprise with 50 employees [8]

Task	Costs	Implementation time
Approval of program requirements	53 €	12 days
Comparison, collection of feedback from other companies, which already use these programs	108 €	19 days
Introductory presentation of the program for managers	68 €	1 days
Object study, testing	206 €	7 days
Secondary presentation of the program to employees	68 €	3 days
Purchase of license for Time Doctor for one year	5 000 €	-
Purchase of license for Trello for one year	5 000 €	-
Employee training	200 €	4 days

Implementation	230 €	7 days

The implementation of Time Doctor and Trello will increase the level of work of employees, speed up the work with documents and reports, which will enable the company to compile and complete tasks on time and increase overall efficiency. The Time Doctor license costs $ 120 per employee per year. The Trello license also costs $ 120 per year per employee. This usage also includes Messenger. Fig. 8 shows the development of return on investment for 6 years.

Fig. 8 Development of return on investment for 6 years [8]

Conclusion

As remote working becomes a new standard for many workers, there is no doubt that many employers are trying to ensure that their employees enjoy full working days. Companies are likely to be investing in and deploying digital technologies for tracking employee performance much more than before the pandemic. When it comes to tracking what employees are doing, there is a balance to be struck between the legitimate business interests of the employer and employees' right to privacy. [10, 11]

Time Doctor and Trello are very good tools for control of the working time in these days, when a lot of people work in the form of Home Office, because they ensure that efficiency of the working process will be at the same level or higher than in “normal” time.

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STATUS OF THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN SMALL AND MEDIUM-SIZED ENTERPRISES IN SLOVAKIA

Jaroslava JANEKOVA

Abstract: The article provides an analysis of the development of small and medium-sized enterprises in Slovakia, focused on a specific area - indicators of the use of information and communication technologies. The analysis is carried out for the years 2017 to 2020 with an emphasis on the number of employed IT specialists, use of the internet, creation of own website, online sales, use of cloud computing and big data in SMEs.

Keywords: Small and medium-sized enterprises, information and communication technologies, internet, online sales, cloud computing.

Introduction

The development of small and medium-sized enterprises is one of the basic preconditions for the healthy economic development of the country. In Slovakia, small and medium-sized enterprises (SMEs) play an important role in job creation and regional development. Of the total number of business entities, they make up 99.9 %, of which 97 % are micro-enterprises. More than three quarters of SMEs operate in services, construction and industry. Since 2010, the performance of SMEs in Slovakia has been increasing. In 2019, SMEs recorded a positive development, but their results reached the lowest growth in the last three years, which was caused by a slowdown in the growth rate of the Slovak economy. In 2020, SMEs had to cope with the effects of a coronavirus pandemic.

The performance of SMEs is assessed using economic indicators (sales, gross production, value added, labor productivity, profit before tax, ...), employment indicators, the level of foreign trade, high-tech indicators, the state of use of digital technologies and the level of research and development. A more detailed analysis focused on indicators that map the state of use of information and communication technologies in Slovakia is the content of this article.

Information and communication technologies and SMEs

Information on the use of information and communication technologies in Slovak companies is drawn from the data of the Statistical Office of the Slovak Republic, the Slovak Business Agency and Eurostat. The data are focused on the number of employed IT specialists, use of the Internet, creation of own website, online sales, use of cloud computing and big data in SMEs.

According to the Statistical Office of the Slovak Republic, in 2020 the percentage of enterprises that employ IT specialists increased by 0.9 p.p., i.e. at 16.8 %. Up to 76.8 % of large companies, 35.7 % of medium-sized companies and 9.7 % of small companies employed IT specialists. A more detailed view of the share of enterprises employing IT specialists according to selected economic activities (according to SK NACE Rev. 2) is provided in Fig. 1. ICT related activities are provided by three quarters of SMEs through external suppliers, large enterprises up to 84.4 %.

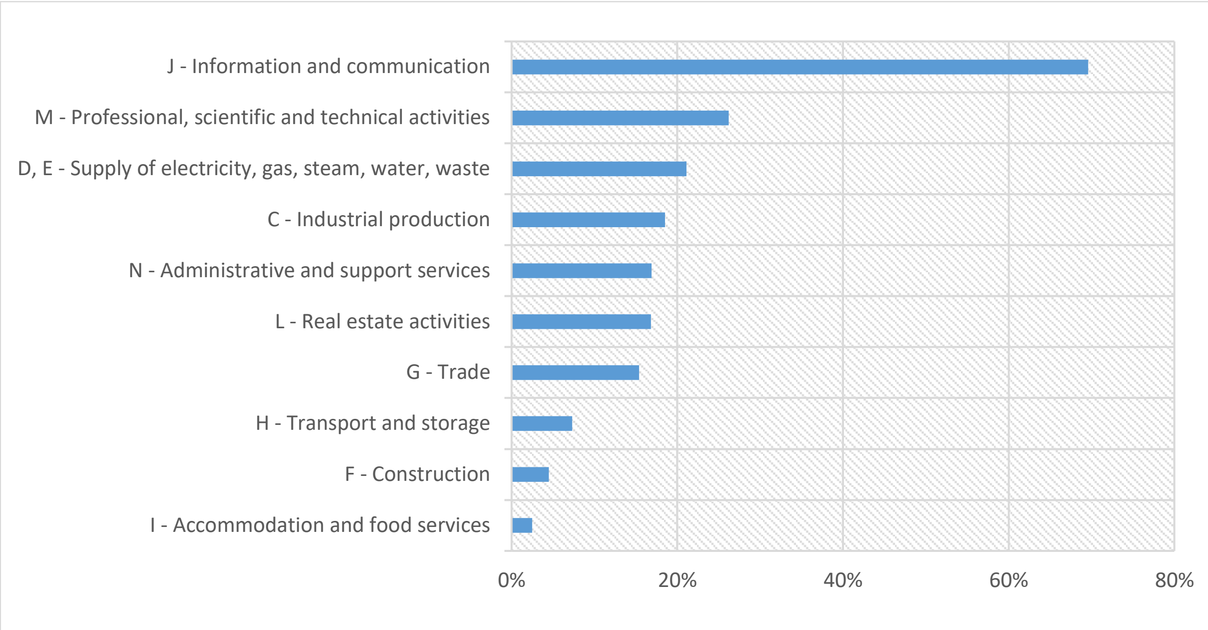

Figure 1 Share of enterprises employing IT specialists by selected economic activities in 2020
Source: Own processing according to the Statistical Office of the Slovak Republic

In 2020, 95.9 % of companies declared the availability of the Internet. Most of them are active in the repair of computers and communication equipment; wholesale and retail trade or real estate activities. According to the size of the company, 99.7 % of large companies, 97.1 % of medium-sized companies and 95.5 % of small enterprises have access to the Internet.

The gradual increase in the share of companies with their own website can be assessed as positive. In 2020, 79.0 % of companies with an Internet connection had their own website. Compared to 2019, their share increased by 2.7 p.p. (Fig. 2).

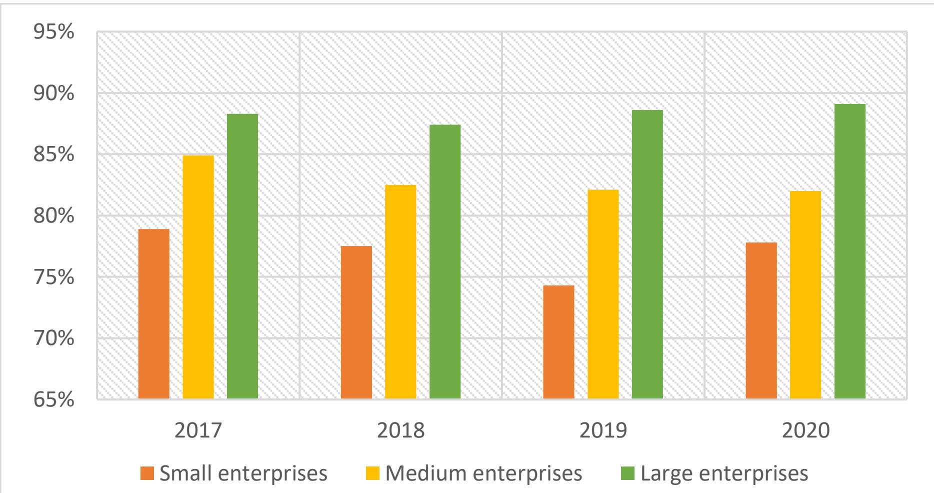

Figure 2 Share of companies with their own website in 2017 -2020
Source: Own processing according to the Statistical Office of the Slovak Republic

The website was available to 77.8 % of small enterprises (an increase of 3.5 percentage points compared to 2019) and 82.0 % of medium-sized enterprises (a decrease of 0.1 percentage points compared to 2019) with an Internet connection. In the category of large enterprises, 89.1 % of business entities with an Internet connection had set up their own website (an increase of 0.5 percentage points compared to 2019). As many as 90.2 % of small and medium-sized enterprises use their website to describe goods or services, or presentation of catalogs and price lists. Almost a third (31.6 %) of small and a quarter (26.8 %) of medium-sized enterprises with a website use the option of ordering or booking goods and services online.

The use of cloud services is increasing among companies. During 2020, more than a quarter (26.6 %) of all companies used them. In terms of enterprise size, cloud services were used by half (50.8 %) of large enterprises (their share increased by 9.5 p.p. compared to 2018), 34.3 % of medium-sized enterprises (increase by 7.3 p.p.) and 23.7 % of small enterprises (increase by 4 p.p.). These services were mostly used by enterprises with the main activity in the sectors of information and communication (48.0 %), or professional, scientific and technical activities (41.3 %). This was followed by real estate activities (35.9 %) and administrative and support service activities (34.2 %).

Businesses use cloud services for various purposes (Fig. 3). As many as 85.0 % of businesses purchased cloud services for e-mail. Compared to 2018, this share increased by 1.6 p.p., most significantly in the category of medium-sized enterprises by 9.0 p.p. Almost two thirds (64.3 %) of companies use cloud computing services for office software. The use of the Internet for this purpose increased by 4.7 p.p. compared to 2018, in medium-sized enterprises by 17.4 p.p. and in small enterprises by 0.9 p.p. The share of businesses using cloud services is also increasing dynamically due to the need to store files. In 2020, it was already 61.4 % of companies. The expansion of cloud services in the corporate environment is also due to the more intensive use of the cloud in the area of hosting corporate databases. Compared to 2017, their share increased by 6.9 p. p.

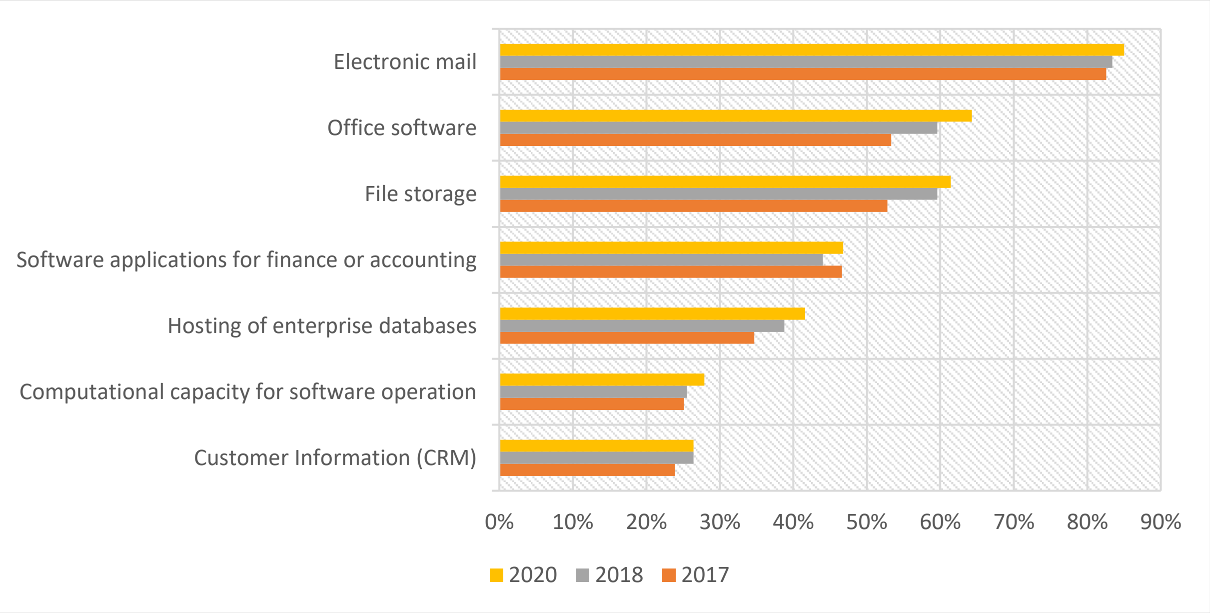

Figure 3 Use of cloud computing services in 2017 -2020
Source: Own processing according to the Statistical Office of the Slovak Republic

Only 5.6 % of companies in Slovakia, 4.6 % of small and 7.7 % of medium-sized companies used big data and their analysis in 2020. Higher intensity of work with big data was recorded in case of large companies (16.7 %). We thus lag significantly behind the EU-27 average

(13.0 %). Businesses most often analyzed data generated from social media (47.7 %), geolocation data from the use of portable devices (46.5 %) and data from their own smart devices or sensors (38.1 %).

In 2019, the share of companies selling products and services online (Fig. 4) grew with the size category of the company. Sales of products and services through electronic sales were realized by 18.3 % of small enterprises (year-on-year increase by 6.0 p.p.) and 24.9 % of medium-sized enterprises (growth by 2.3 p.p.). Online sales are mostly used by large companies (42.3 %). E-commerce was mostly used by companies in the field of repair of computers and communication equipment (55.0 %), trade (33.0 %) and accommodation and food services (27.9 %).

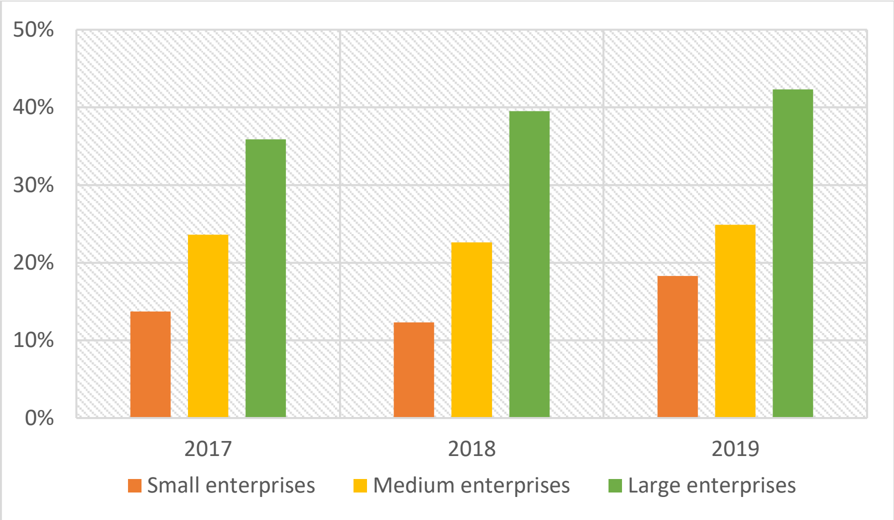

Figure 4 Share of companies selling online in 2017 - 2019
Source: Own processing according to the Statistical Office of the Slovak Republic

According to Eurostat data from 2020, the share of Slovak SMEs (10 - 249) selling their products or services online is at the level of 20.0 %. Compared to other EU countries, Slovakia is at the level of the EU-27 average. Online sales are mostly used by SMEs in Denmark and Ireland (38.0 % each) and Sweden (34.0 %). Within the V4 countries, the Czech Republic achieved the highest share, namely 30.0 %. Poland and Hungary have the same share of 16.0 % and lag slightly behind the EU average. Over the past decade, the share of Slovak SMEs with online sales has increased by 4.0 percentage points.

Conclusion

The performance of small and medium-sized enterprises in the coming period will depend on the development of the epidemiological situation, the effects of the third wave of the pandemic and the extent of anti-pandemic measures taken. The Slovak economy can reach its pre-crisis level by the end of 2021, but the negative effects of the sectors affected by the crisis will most likely be reflected also in the period following after its end.

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DIGITISATION IN MANUFACTURING PROCESSES IN SMES

Miroslav FUSKO – Martin GAŠO – Monika BUČKOVÁ – Katarína ŠTAFFENOVÁ

Abstract: The main topic of the submitted paper is a view of digitisation in Small and Medium-Sized Enterprises (SMEs) and few essential features of impact on factory competitiveness. Today’s factories have become more flexible than ever too complex modern market turbulence. The importance of new disrupting technologies and innovations is most significant for SMEs. Modern concepts of production systems require vertical and horizontal integration of all participants in the production process.
Keywords: digitisation, industrial engineering, transformation, SME, manufacturing processes.

Introduction

Many leaders in the industry and automotive say that the digital transformation will significantly impact the future of manufacturing. Furthermore, it has already begun. Manufacturing is undergoing a digital transformation; the use of technology to improve factory results (productivity, technical KPI, cash flow); driven by smart technologies and connected devices. In the factories, digitisation can include the back office and supply chain applications, factory automation, data analytics, sensors implementation and more. The digital evolution (in some factories is a revolution) can disrupt every part of the factories. It is an excellent match for manufacturing with opportunities to increase efficiency, productivity, and accuracy in the industry. Result from this transformation is new type of factories, called smart factories. These type of factories will be key for building next concept of future factories, called intelligent factories. [1 - 3]

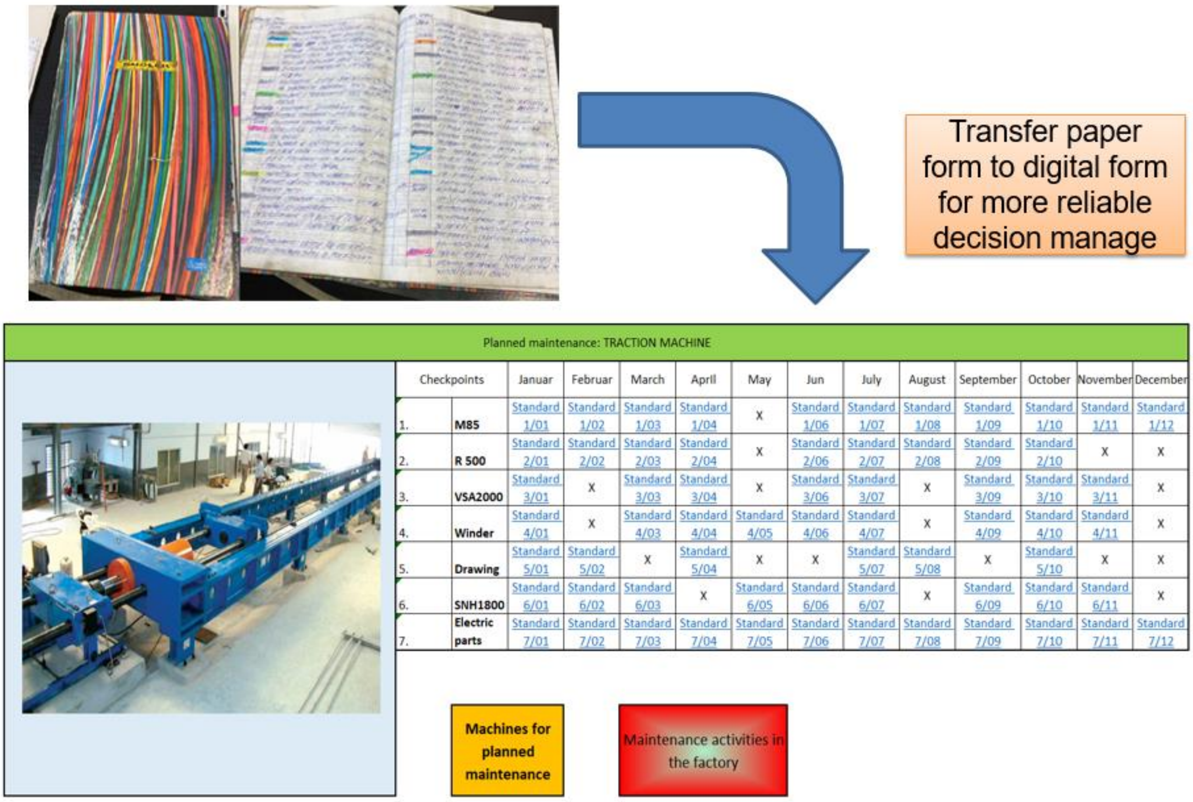
It is possible to say that the smart factory concept is a concept deriving from IIoT (Industrial Internet of Things). That envisages manufacturing processes as a fully automatised and intelligent network of systems that enables facilities, machines, and logistics chains to be managed without human intervention. Moreover, a smart factory is an environment where disruptive technologies co-exist thanks to the exchange of data between production tools and machines and all elements in the production technology chain. As the name suggests, a smart factory is a factory environment that is highly digitised. It is a place where the systems are interconnected, and data is exchanged about each aspect of production in real-time. This communication flows quickly and seamlessly between the various systems, and the manufacturing processes happen automatically without any human intervention. A fundamental feature of smart factories is data. When data flows through systems to achieve connected operations, the environment in the factory as a whole can learn and adapt to the changing requirements of the market. [4, 5]

Digitisation like an essential factor for SMEs

If there is one critical metric in a production environment, it is OEE (Overall Equipment Efficiency). The metric measures how efficient a manufacturing operation is used compared to how efficient it could be. The average OEE is at the level of 60 - 70%. Today's world-class OEE is around 85%. It means that even the most efficient factories today lose 15% of their time on value-free activities such as machine conversions, stops, maintenance and the production of faulty products. The cash equivalent of increasing OEE by one percentage point is huge for each factory. It means plenty of room for future smart and intelligent factories to move closer to OEE at 100%.

Nowadays, despite the expansion of digitisation, numerous factories still use documentation in paper form. However, this form has many difficulties compared to digital forms. In some countries, digitisation is mandatory, and fines can be imposed for non-compliance with the regulation on digital documentation. Digitisation of manufacturing processes is a fundamental part of factories of the future. With the many digital standards of technical service activities, employees would have all the necessary information in one place (e.g. Cloud). They could navigate in it and help them reduce downtime on machines and equipment. Standards serve as a guide for personnel to perform inaccuracies, reducing inaccuracies and undesirable situations. When implementing digitisation in SMEs, it is relevant if the factories first try to manage their processes, manage documents and estimate the gathered information via MS Office combined with ICT (information and communication technologies). The impact of digitisation is potential to see in many features in factories. [6] For SME will be the following areas essential for their coming future competitiveness:

- **Improves efficiency** - smart factories bridge the gap between control systems and their on-premises implementation by bringing physical and digital systems together. It means that the smart factories blend control systems, data systems, and physical systems to decrease time lags in the manufacturing processes. [7] In turn, this leads to tremendous efficiency, productivity and better utilisation of usable sources. Smart factories can create output at a tremendous rate compared to traditional industries, and that also within the shortest possible time. For SMEs is very useful to use digital content for manage processes in factories.



Planned maintenance: TRACTION MACHINE													
Checkpoints		Januar	Februar	March	April	May	Jun	July	August	September	October	November	December
1.	M85	Standard 1/01	Standard 1/02	Standard 1/03	Standard 1/04	X	Standard 1/06	Standard 1/07	Standard 1/08	Standard 1/09	Standard 1/10	Standard 1/11	Standard 1/12
2.	R 500	Standard 2/01	Standard 2/02	Standard 2/03	Standard 2/04	X	Standard 2/06	Standard 2/07	Standard 2/08	Standard 2/09	Standard 2/10	X	X
3.	VSA2000	Standard 3/01	X	Standard 3/03	Standard 3/04	X	Standard 3/06	Standard 3/07	X	Standard 3/09	Standard 3/10	Standard 3/11	X
4.	Winder	Standard 4/01	X	Standard 4/03	Standard 4/04	Standard 4/05	Standard 4/06	Standard 4/07	X	Standard 4/09	Standard 4/10	Standard 4/11	X
5.	Drawing	Standard 5/01	Standard 5/02	X	Standard 5/04	X	X	Standard 5/07	Standard 5/08	X	Standard 5/10	X	X
6.	SNH1800	Standard 6/01	Standard 6/02	Standard 6/03	X	Standard 6/05	Standard 6/06	Standard 6/07	X	Standard 6/09	Standard 6/10	Standard 6/11	X
7.	Electric parts	Standard 7/01	Standard 7/02	Standard 7/03	Standard 7/04	Standard 7/05	Standard 7/06	Standard 7/07	Standard 7/08	Standard 7/09	Standard 7/10	Standard 7/11	Standard 7/12

Fig. 1 Data substitution from paper form to digital form

- **Optimises factory assets -** smart factories optimise different assets and help each factory get the most out of them. It helps to identify the performance and location of your people, equipment, and resources in real-time so you can make the essential inventory changes on the fly. Also, it helps each factory tap into the synergy of all these resources working together to gain a significant advantage in productivity and revenue.
- **Predictive maintenance** - Predictive Maintenance in Industry 4.0 (Predictive Maintenance 4.0) prevents asset failure by investigating production data to classify patterns and predict issues before they happen (Fig. 2). Until now, factory managers and workers on the shop floor carried out scheduled maintenance and regularly repaired machine parts to prevent downtime. In addition to consuming unnecessary resources and managing productivity losses, half of all preventive maintenance activities are inefficient. Therefore, it is not a surprise that Predictive Maintenance has quickly emerged as a leading Industry 4.0 use case for manufacturers and asset managers. Implementing Industrial Internet of Things technologies to monitor asset health, optimise maintenance schedules, and gaining real-time alerts to operational risks, allows manufacturers to lower service costs, maximise uptime, and improve production throughput. [8]

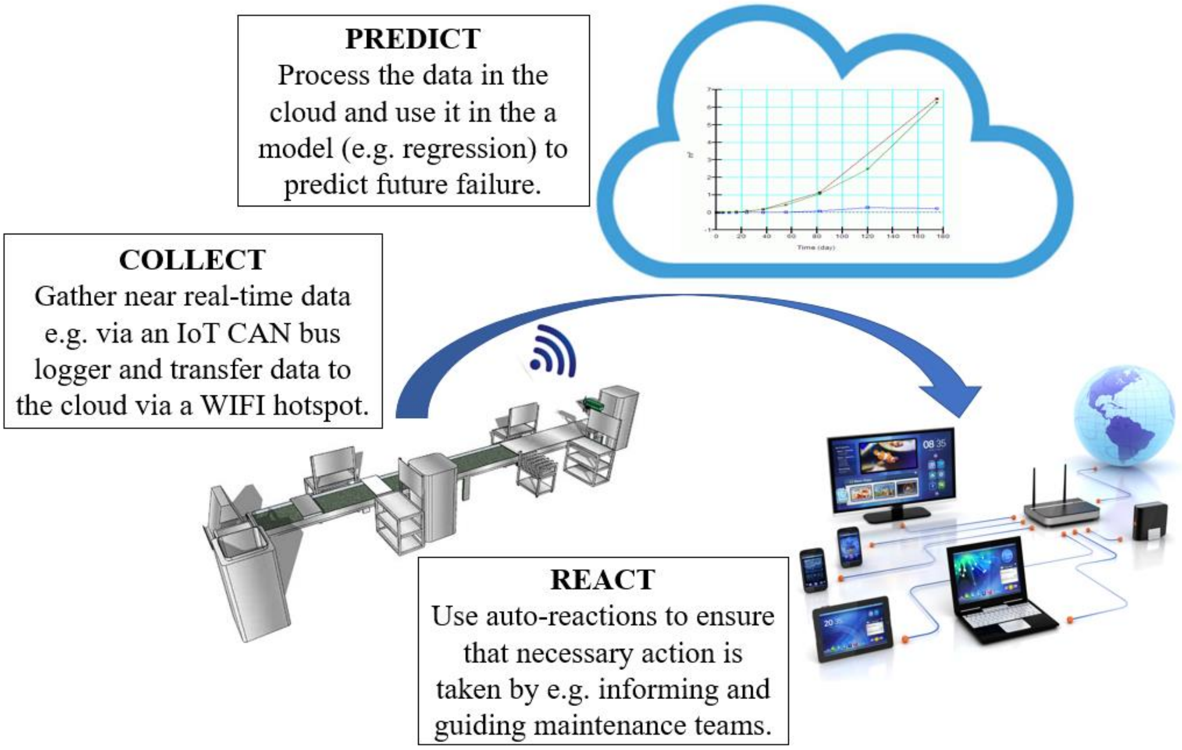


Fig. 2 Concept of Predictive Maintenance 4.0

Predictive Maintenance 4.0 has come a long way since the ’90s. Over the past decade, the IIoT (Industrial Internet of Things) and the evolution of analysing sensor information have pushed many factories to look at new ideas to gather information to understand machine health.

- **Safety, security and sustainability of processes** - the smart factory can also give real benefits around labour conditions and environmental sustainability (Fig. 3). The types of operational efficiencies that a smart factory can provide may result in a smaller environmental step than a traditional manufacturing process, with greater environmental sustainability overall. More comprehensive process autonomy may provide the more limited potential for human error, including industrial accidents that cause injury. The smart factory’s relative self-sufficiency will likely replace specific roles that require monotonous and fatiguing projects.

Fig. 3 Simplified model of operator decision making in future manufacturing processes [9]

Nevertheless, the role of the workers on the shop floor in a smart factory may take on greater levels of decision making and on-the-spot discretion, which can lead to more excellent job satisfaction and a decrease in turnover.

- **Factory of the Future** - When creating a Factory of the Future, it is necessary to implement the concept of Digital Twin and Factory Twin. The Digital Twin represents the digital model of the physical system, object, etc. The Digital Twin concept was initially used to create a digital copy of the product. However, it was later found that the concept could be used in all areas of industry, whether it was designing a new product prototype, creating a digital twin product, production machine, production line, or even creating a Digital Twin of the entire manufacturing business. The Factory Twin concept is an extension of the Digital Twin. As mentioned in the previous chapter, the Digital Twin initially originated to create a digital twin product. Nevertheless, Factory Twin is a concept that deals with the design of manufacturing and logistics systems with the help of a digital twin. The whole concept consists of three essential parts, respectively, words. The difference between a digital business and a Digital Twin is adding a virtual world to the natural and digital world. This is the fundamental difference between the two concepts. [10] The Factory Twin, therefore, consists of the digital, real and virtual worlds. At the same time, such a factory should focus on the application of a maintenance prediction program and implement technical diagnostics devices, smart sensors, connect devices using the Internet of Things and mobile applications in maintenance, and create a digital twin for maintenance management to provide a reliable, intelligent digital maintenance system. The first step is to ensure their interconnection and transfer gather information from the devices from manual paper checks to automated collection systems (Fig. 4), which improves the data quality and eliminates quantity and time. Monitoring equipment from the centre or anywhere in production using the Internet of Things expands the number and variety of parameters that can be monitored and used to ensure regular monitoring of the mechanical condition of equipment, operational reliability, downtime costs due to machine failures.

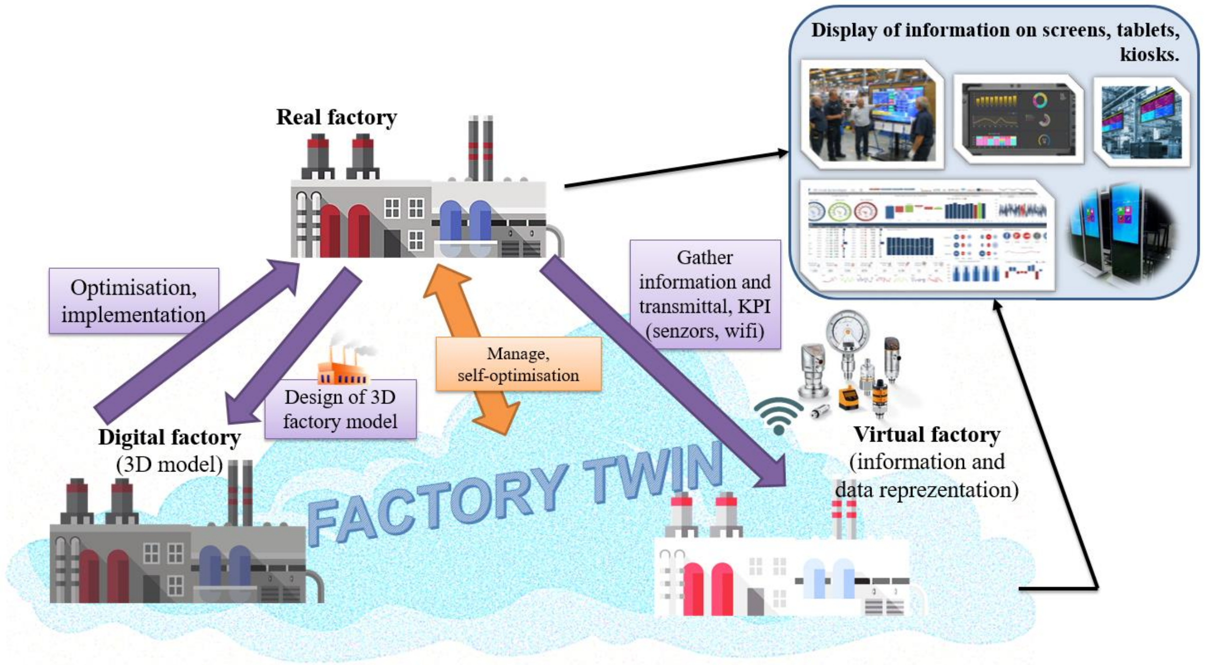


Fig. 4 Concept of digital twin in the Factory of the Future

It is the digitisation of all data describing the status of the device. All necessary information from the production process is collected and evaluated in real-time. The collected data will create a comprehensive picture of the product, equipment and production process. Much data is obtained, which will lead to faster and better management of maintenance processes.

Conclusion

The article gave insight how digitisation disrupts the established processes in small and medium-sized enterprises (SMEs). **Digitisation plays a critical factor in innovation strategy in SMEs.** This disruption will be caused by workers using innovative and disruptive technologies to extend their skills, increase safety, and streamline work activities across all factory processes. As the industry continues to move towards digitisation, automation and robotics, many of the activities that are now manual today will be changed or disappear. The Factory of the Future solution is dedicated to manufacturers who would like to leverage the potential of their resources, crew skills and time to obtain competitive advantages. It is true that taking up the idea of Factory 4.0 and bringing it to life requires investment, effort and strategy. Digitisation is not the end of the story of digital transformation as we move to Industry 4.0. Nevertheless, it is a significant start for continued improvement. Once processes are digitised, other technologies like machine learning, augmented intelligence, Industrial Internet of Things, digital twin and factory twin, and a comprehensive, complete product lifecycle can emerge. However, we have to take the first step and put down our pens.

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HODNOTENIE ETICKEJ KREDIBILITY VO VÝROBNÝCH PODNIKOCH SR

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Abstract: Medzi dôležité determinanty ovplyvňujúce podnikovú kultúru patrí miera rizikovosti predmetu podnikania. Podnikateľské subjekty musia byť v prvom rade schopné rýchlo reagovať na potreby externého, ale aj interného prostredia, byť v úzkom vzťahu so zákazníkom, podporovať vnútornú podnikateľskú aktivitu, snažiť sa o budovanie želaného spôsobu správania sa a konania všetkých zainteresovaných strán. Cieľom príspevku je na základe analýzy a uskutočneného výskumu identifikovať možné riziká etickej kredibility vo vybraných výrobných podnikoch pôsobiacich na Slovensku a následne poukázať na možnosti, opatrenia, pre elimináciu vzniku rizík etickej kredibility a tým dosiahnutie zvýšenie dôveryhodnosti a spoľahlivosti výrobných podnikov..

Keywords: etická kredibilita, riziká, podniková kultúra, etika, výrobné podniky

Úvod

Kvalitatívne spoločenské zmeny, ktoré nastali v novom tisícročí sú charakteristické predovšetkým globalizáciou a multikulturalizmom, ale aj internacionalizáciou ekonomických procesov. Uvedené zmeny si vynucujú aj nový prístup k tvorbe netradičných podnikových prístupov, ktoré by podnikateľské subjekty mali viesť k zlepšovaniu ich hospodárskych výsledkov a tým im zabezpečovali aj konkurenčnú výhodu. Podniková kultúra ako nositeľ eticko - morálnych noriem a zásad, vstupuje do tohto procesu, ako nespochybniteľný faktor úspechu podniku v konkurenčnom boji, ktorý nadobúda globálnu platformu.

Podnikanie a konkurencia sú činnosti, ktoré uskutočňujú, riadia a ich výsledky v podobe produktov a služieb využívajú ľudia ako spotrebitelia. Medzi spotrebiteľom a výrobcom, spotrebiteľom a podnikateľom, podnikateľmi navzájom existujú rôzne vzťahy. Tieto vzťahy majú charakter spätnej väzby. Tak, ako ich nemožno vtesnať do prísne nalinkovaných väzieb, naprogramovať každého jedinca do podoby šachovej figúrky, nemožno ich ani nechať bokom. A tak prichádzame k tomu, že popri vyslovene ekonomickej stránke podnikania, t. j. orientácii na zisk, existuje ešte niečo, čo súvisí práve s dlhodobou orientáciou úspešnosti podnikateľa, firmy, a tou je etika ako súčasť podnikania.

Podnikateľská etika v praxi sa odohráva na štyroch úrovniach, ktorými sú globálna, spoločenská, organizačná a individuálna úroveň. Toto členenie je kľúčové pri aplikácii podnikateľskej etiky do praxe, pretože poukazuje na to, že za aplikáciu etiky do hospodárstva zodpovedajú rôzne subjekty. Etika a jej dodržiavanie v manažmente môže prispieť k vybudovaniu dôvery a zvýšeniu úrovne medziľudských vzťahov. Má tak svoj podiel i na výkone konkurenčnej schopnosti a na celkových dosahovaných výsledkoch. Zároveň funguje ako regulátor napätia medzi rozdielnymi ekonomickými a sociálnymi záujmami podnikateľských subjektov a spoločnosti. Podniky nemôžu diktovať spoločnosti svoje hodnoty, ale samy musia rešpektovať hodnoty spoločnosti [1].

Predmetom článku je monitoring rizík etickej kredibility výrobných podnikov strojárskeho zamerania, ktoré podnikajú na Slovensku. Pojem etická kredibilita označuje dôveryhodnosť a spoľahlivosť ľudí v podniku z hľadiska ich správania. Vytváranie aspektov dôveryhodnosti a spoľahlivosti umožňuje podnikom lepšie sa presadiť v spoločenskom prostredí a všetci aktéri, ktorí sa o to usilujú, majú väčšiu šancu, že budú na trhu uznávaní a akceptovaní. Sú ale podniky, ktoré nemajú zavedenú dostatočnú etiku, z čoho môžu nastať mnohé riziká. Etická kredibilita je v podnikoch veľmi dôležitá. Bez nej by podniky nemohli správne fungovať a prosperovať. Hlavným cieľom nášho výskumu je navrhnúť postup alebo opatrenia pre minimalizovanie rizík etickej kredibility v analyzovaných výrobných podnikoch. Článok je súčasťou riešenia výskumného projektu APPV -17-0400 „Posilňovanie etického prostredia na Slovensku (inštitucionálne postupy, aktéri, riziká, stratégie“).

Teoretické východiská

Pojem kredibilita znamená dôveryhodnosť alebo spoľahlivosť. Vytváranie dôveryhodnosti akéhokoľvek subjektu umožňuje lepšie sa presadiť v širšom spoločenskom prostredí. Všetci aktéri, ktorí usilujú o budovanie dôveryhodnosti sú si vedomí toho, že dôveryhodnosť znamená byť akceptovaný, uznaný, preferovaný. Je to zároveň uznanie zákazníka, občana, stakeholderov, verejného záujmu a spoločenského blaha. Je taktiež dôležité, aby bola podporená nielen individuálnou etickou ambíciou, ale ako systémová forma etickej podpory. Vnímať ju v komplexných dimenziách a dopadoch je dôležitá podmienka jej uznania [2]. Medzi dôležité determinanty ovplyvňujúce podnikovú kultúru patrí miera rizikovosti predmetu podnikania. Mierou rizikovosti predmetu podnikania rozumieme intenzitu ohrozenia ďalšej prosperity podniku jedným neúspechom v niektorej z ďalších aktivít podniku [1]. V súčasnosti stále prebiehajúci proces ekonomickej transformácie vytvára také podmienky pre činnosť organizácií, ktoré si vyžadujú nielen výrazné zvýšenie efektívnosti ich činnosti, ale aj zlepšenie uspokojovania potrieb zákazníkov, čo vyvoláva potrebu radikálnych zmien, ktoré sa majú týkať najmä spôsobu reakcie podnikateľských subjektov na ich vnútorné či vonkajšie prostredie. Firmy musia byť dnes v prvom rade schopné rýchlo reagovať na potreby externého, ale aj interného prostredia, byť v úzkom vzťahu so zákazníkom, podporovať vnútornú podnikateľskú aktivitu, snažiť sa o budovanie želaného spôsobu správania a konania všetkých zúčastnených [2].

Sme presvedčení o tom, že akákoľvek forma vytvárania dôveryhodnosti môže mať zmysel, ak je založená na etickom zámere. Je tiež dôležité, aby bola podporovaná nielen individuálnymi etickými ambíciami, ale aj ako systémová forma etickej podpory. Jeho vnímanie v komplexných dimenziách a dopadoch je dôležitou podmienkou jeho rozpoznania [3, 4]. Etická kredibilita je založená na etických hodnotách, ktoré možno tiež nazvať etickými zásadami. Etické princípy obsahujú charakteristiky a hodnoty, ktoré si väčšina ľudí spája s etickým správaním. Podniková kultúra a jej etické hodnoty sú priamo určené správaním a konaním manažérov, ktorí im majú ísť príkladom. Experti na organizačnú etiku [4, 5, 6] písali o profesionálnom etickom prístupe, akým je napríklad systematické zavádzanie etiky do organizačného prostredia vo firmách vychádzať z uváženého a citlivého prístupu. vyvinuté etické programy. Videli významný prínos etického programu v predchádzaní neetickému správaniu a vytváraní pozitívnej povesti v kombinácii s dôveryhodnosťou a dobrou vôľou. Balúnová [7] sa zaoberala významom etickej dôveryhodnosti v podnikaní. Uviedla, že etická dôveryhodnosť je dnes dôležitým faktorom ekonomickej prestíže a obchodného úspechu a profesionálna pomoc pri vytváraní etickej politiky sa považuje za dôležitú súčasť budovania dôveryhodnosti a dobrej povesti inštitúcií. Použila dôveryhodnosť a povesť ako synonymá. Podľa Balúnovej [7] a Simanovej a Gejdoša [8] miera dôveryhodnosti závisí od toho, do akej miery sa spoločnosť dokáže vysporiadať so záležitosťami, ktoré nemôže ovplyvniť - vonkajšími udalosťami, zlyhaním konkurencie alebo zlým riadením dodávateľského reťazca. Všetky tieto faktory poškodzujú hodnotu reputácie a vnímania manažmentu. Z uvedených dôvodov podniky musia venovať náležitú pozornosť budovaniu reputácie dôveryhodnosti, ktorá je správnou cestou k úspechu [7].

Výskumno – analytické prístupy hodnotenia kredibility podnikov

Hlavným zameraním článku je identifikovanie a analýza rizík etickej kredibility vo výrobných podnikoch pôsobiacich na území Slovenska. Pre realizáciu výskumu bol vytvorený online dotazník, ktorý bol distribuovaný vybraným podnikom prostredníctvom internetu.

Dotazník je výskumný nástroj, vďaka ktorému je možné rýchlo a jednoducho získať údaje od veľkého počtu respondentov. Pre ciele nášho výskumu bol online dotazník vhodnou výskumnou metódou. Veľká pozornosť bola kladená formulácii otázok pre získanie relevantných odpovedí. Na začiatku kreovania dotazníka boli určené základné kritériá hodnotenia a otázky vedúce k získaniu informácií o výrobných podnikoch – respondentoch prieskumu. V štruktúre dotazníka boli prvé tri otázky určené pre anonymné zistenie informácií o zúčastnených respondentoch (podnikoch):

1. Počet zamestnancov podniku
2. Zameranie podniku
3. Percentuálne zastúpenie žien v podniku

Podniky boli podľa počtu zamestnancov rozdelené na mikropodniky (do 9 zamestnancov), malé podniky (10 až 49 zamestnancov), stredné podniky (50 až 249 zamestnancov) a veľké podniky (250 a viac zamestnancov). V druhom kroku sme si určili, ktoré podniky a s akým zameraním budú súčasťou našej analýzy. Vybrali sme 3 hlavné zamerania z technickej oblasti a to:

- Výroba strojov a zariadení
- Výroba a spracovanie kovov
- Výroba a spracovanie dreva

Vo výskumnej časti dotazníka bolo koncipovaných 6 otázok pre hodnotenie etickej kredibility podnikov. Pre náš výskum boli hodnotenými parametrami:

1. zavedenie etického kódexu v podniku,
2. dodržiavanie etických princípov,
3. existencia kompetentných zamestnancov v podniku pre riešenie problémov, názorov a návrhov zamestnancov,
4. zavedenie systému manažérstva kvality,
5. existencia systému hodnotenia rizík procesov,
6. spôsoby informovania zamestnancov o identifikovaných rizikách.

Uvedené základné výskumné otázky boli v dotazníku doplnené možnosťou otvorených odpovedí, kde sme sa respondentov pýtali na spôsob realizácie danej oblasti, na konkrétne dodržiavané etické riziká alebo na najčastejšie sa vyskytujúce riziká.

Elektronický online dotazník bol vytvorený v aplikácii MS Office 365 Forms. Postup rozsevu dotazníka spočíval v tom, že po selekcii podnikov so skúmaným zameraním cez databázu ec.europa.eu bol link na vypracovanie dotazníka zaslaný na kontaktný e-mail podniku z databázy. Dotazník sme rozposlali 430 výrobným podnikom pôsobiacim na Slovensku. Čas na posielanie odpovedí bol stanovený na 4 týždne. V priebehu stanovenej doby sa vrátilo 132 odpovedí, tzn. návratnosť dotazníka bola 30,7 %.

Výsledky analýzy respondentov

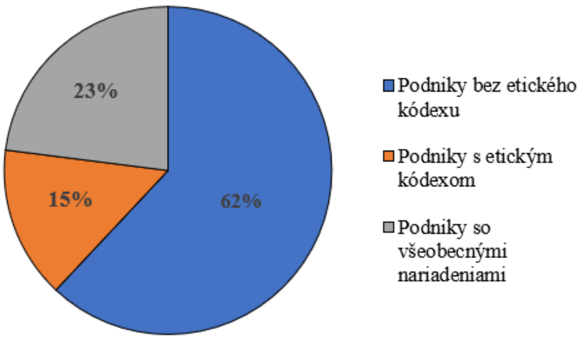
Na základe analýzy výsledkov dotazníkového prieskumu sme o anonymných respondentoch zistili nasledujúce údaje:

1. mikropodniky - 3, malé podniky - 50, stredné podniky - 67 a veľké podniky - 12.
2. podniky podľa zamerania: výroba strojov a zariadení - 31, výroba a spracovanie kovov - 72, výroba a spracovanie dreva – 29.
3. priemerné zastúpenie žien v analyzovaných výrobných podnikoch je 11,3 %.

Z pohľadu cieľov výskumu zameraných na etiku podnikania pokladáme za základnú otázku to, či má podnik vypracovaný etický kódex. Ďalšou otázkou je, keď podnik nemá etický kódex, podľa akých etických pravidiel sa riadi. V dotazníku boli vytvorené tri kategórie hodnotenia:

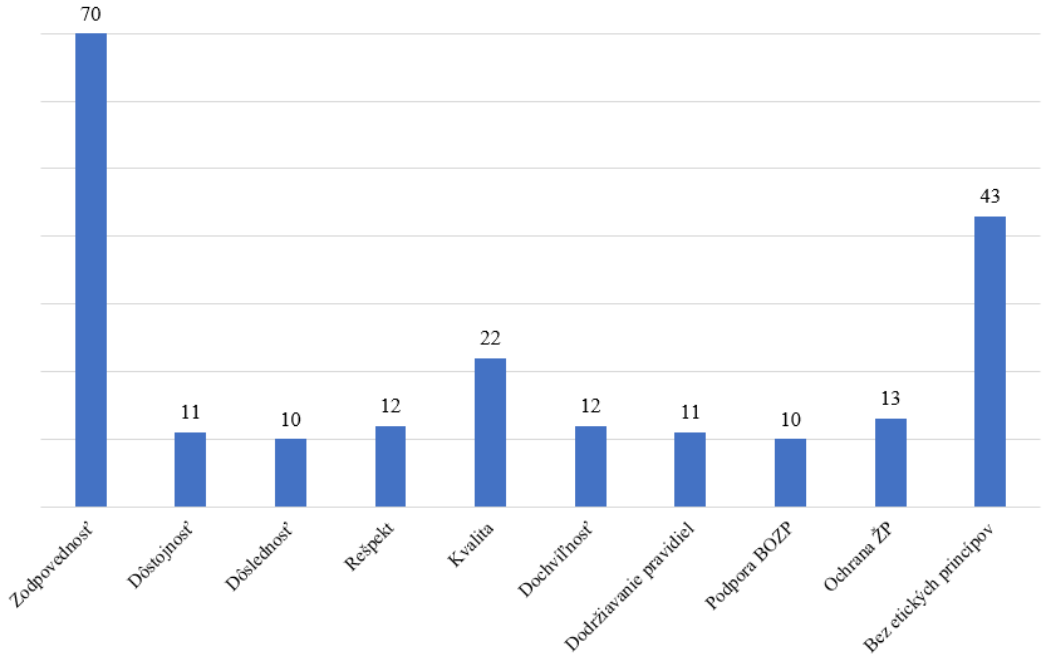
1. podnik, ktorý má vypracovaný etický kódex,
2. podnik, ktorý nemá vypracovaný etický kódex a pravidlá etického správania nerieši v žiadnej podnikovej smernic,
3. podnik so všeobecnými smernicami, v ktorých sú zakomponované pravidlá etického správania.

Vyhodnotenie existencie etického kódexu na základe uvedených kategórií je uvedená na obr. 1. Z výsledku analýzy je zrejmé, že prevažnú väčšinu, až 62 %, tvoria podniky, ktoré nemajú vypracovaný žiadny etický kódex a pravidlá etického správania neriešia v žiadnej podnikovej smernici. Z hľadiska etickej kredibility výrobných podnikov z oblasti výroby a spracovania kovov môžeme konštatovať, že 43 % z tejto kategórie podnikov má zavedený etický kódex alebo všeobecné nariadenia a 57 % uvádza, že pracuje na základe etických princípov aj bez uvedenia v podnikových dokumentoch. Čo sa týka výrobných podnikov z oblasti výroby a spracovania dreva, tak môžeme konštatovať, že 33 % zavedený má etický kódex. U podnikov z oblasti výroby strojov a zariadení sme zistili, že 33 % má zavedený etický kódex a 66 % z nich si myslí, pracuje na základe etických princípov aj bez ich zakomponovania v podnikových dokumentoch.



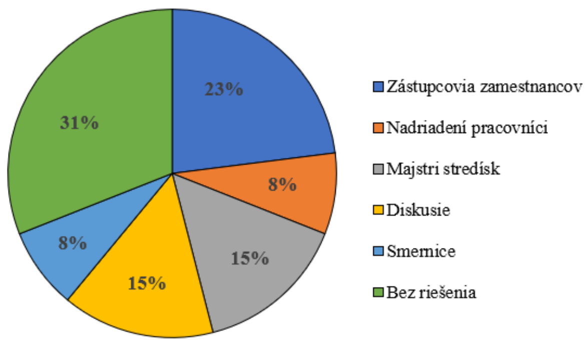
Obr. 1 Vyhodnotenie existencie etického kódexu v podnikoch

V ďalšej analýze sme sa zamerali na to, aké konkrétne etické princípy podniky uznávajú. Respondenti mohli označiť viac možností. Výsledky analýzy sú zobrazené v stĺpcovom grafe na obr. 2.



Obr. 2 Vyhodnotenie konkrétnych uznávaných etických princípov v podnikoch

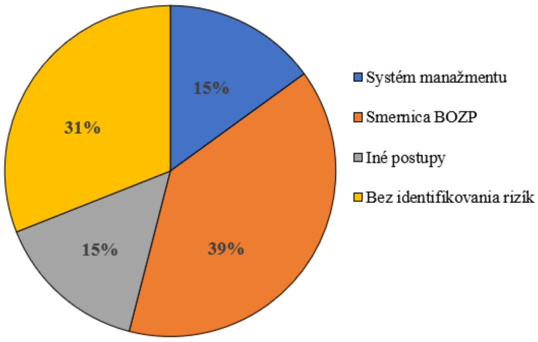
Z hľadiska fungovania a manažmentu interpersonálnych vzťahov sme zisťovali, na koho sa môžu zamestnanci podnikov obrátiť v prípade riešenia ich problémov, alebo komu môžu komunikovať názory a návrhy. Výsledky výskumu sme percentuálne zhodnotili v koláčovom grafe uvedenom na obr. 3.



Obr. 3 Okruh ľudí a oblastí pre riešenie problémov, názorov a návrhov zamestnancov

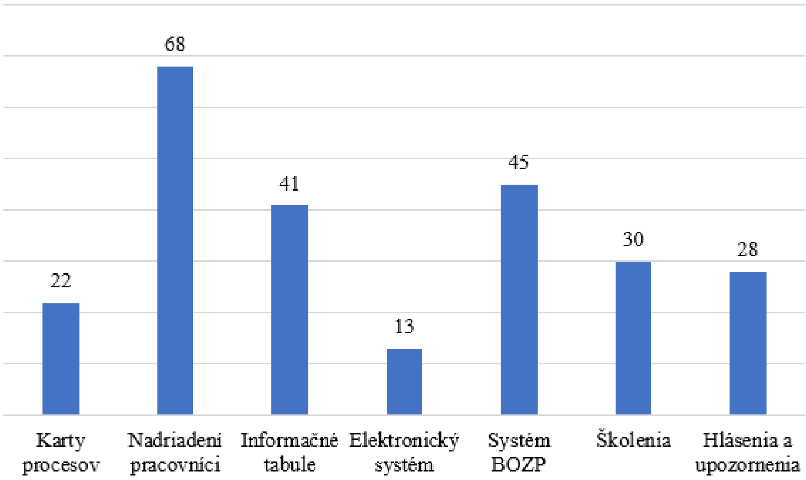
Z výsledkov zobrazených na obr. 3 je zrejmé, že až 31 % zamestnancov nekomunikuje svoje problémy a návrhy s inými kolegami, pretože zrejme nevnímajú nikoho v podniku, na koho by sa mohli obrátiť. V početnosti komunikujúcich kolegov sú najviac zastúpení zástupcovia zamestnancov (23 %), ďalej nasledujú priami nadriadení, majstri stredísk (15 %) a potom sú to diskusie medzi kolegami navzájom (15 %).

Nasledujúca časť výskumu sa týkala hodnotenia rizík a informovanosti o rizikách. Na obr. 4 sú percentuálne zosumarizované odpovede na spôsob identifikovania rizík procesov v podnikoch. V výsledkov vyplýva, že najčastejšie sú riziká hodnotené v rámci smerníc BOZP. Je zarážajúce, že až 31 % podnikov uvádza, že nemajú identifikované riziká, resp. respondenti o tejto skutočnosti nie sú informovaní.



Obr. 4 Spôsob identifikovania rizík procesov

Z hľadiska informovanosti o rizikách procesov (obr. 5) boli najčastejším komunikačným kanálom nadriadení zamestnanci (60 odpovedí), ďalej nasledovali informačné tabule a BOZP (40 odpovedí). Respondenti si mohli vybrať z viacerých možností.



Obr. 5 Forma informovania o rizikách procesov

Z hľadiska etickej kredibility boli pre náš výskum dôležitými parametrami etický kódex, etické princípy, riešene problémov, názorov a návrhov zamestnancov a v neposlednom rade aj procesné riadenie, identifikácia rizík procesov a informovanie zamestnancov o možných rizikách. Z hľadiska etickej kredibility výrobných podnikov (respondentov) pracujúcich v oblasti výroby strojov a zariadení konštatujeme , že 33% nami oslovených podnikov má zavedený etický kódex a 66% pracuje na základe etických princípoch. Všetci respondenti deklarujú, že majú ľudí pre riešenie problémov zamestnancov, pričom 66 % podnikov má identifikované riziká procesov a každý respondent má zavedený aspoň jeden spôsob informovania o možných rizikách procesoch.

Výrobné podniky pôsobiace v oblasti výroby a spracovania kovov uviedli, že 43% má zavedený etický kódex, alebo všeobecné nariadenia v oblasti etiky, 57% podnikov pracuje na základe etických princípoch. Z oslovených respondentov má 71 % identifikované riziká procesov a uvedené percento má okruh zamestnancov na riešenie problémov a prijímanie názorov a návrhov zamestnancov. Výrobné podniky pracujúce v oblasti výroby a spracovania dreva uviedli, že 33% má zavedený etický kódex, pričom všetci respondenti uviedli, že pracujú na základe etických princípoch, ale tiež uviedli, že nemajú okruh zamestnancov, ktorí by riešili problémy, návrhy zamestnancov. Identifikované riziká procesov má 33%respondentov pracujúcich v uvedenej oblasti.

Návrh algoritmu krokov posilňovania etického prostredia podnikoch
Každý podnik si od začiatku svojej existencie postupne formuje svoju jedinečnú podnikovú kultúru. Správne vytvorená podniková kultúra má zadefinované všeobecne platné predpisy, príkazy a priania, ktoré konkrétne činnosti v podniku prikazujú alebo zakazujú. Pre zlepšenie stability, rozvoja a medziľudských vzťahov by mal podnik pracovať na základe etických princípov. Z hľadiska etiky sú najdôležitejšie princípy: úcta, dôstojnosť, jedinečnosť, zodpovednosť a solidarita. Podnik, ktorý pracuje na základe aspoň dvoch z uvedených princípov, výrazne zvyšuje svoju dôveryhodnosť voči zákazníkom. Etický kódex je súčasťou podnikovej kultúry. Slúži ako nástroj riadenia ľudí a v stratégii manažmentu by nemal chýbať. Každý podnik by mal mať pevne stanovené pravidlá, interné smernice a postupy. Základným prínosom zavedenia systému manažérstva kvality je spokojnosť zamestnancov a spokojnosť externých zákazníkov, posilnenie vnútornej infraštruktúry podniku, zvýšenie konkurencieschopnosti, ako aj dôveryhodnosti a spoľahlivosti podniku. Identifikovanie rizík procesov má za cieľ, akým rizikám a do akej miery je výrobný proces vystavený. Optimálnym spôsob ako identifikovať a následne znížiť riziká je vytvorenie tzv. karty procesu. Vzťahy medzi zamestnávateľom a zamestnancami sú veľmi dôležitou súčasťou podniku. Úlohou zamestnávateľa je vytvorenie pracovného prostredia, v ktorom sa budú cítiť zamestnanci potrební a správne oceňovaní. V prípade nedodržiavania etiky a morálky na pracovisku by mal výrobný podnik mať jasne stanovené vypracované zásady a postupy ako riešiť vzniknuté situácie. V prípade, že zamestnanec je svedkom nežiadúcej situácie, môže sa obrátiť na zamestnanca povereného takéto etické a morálne problémy riešiť. Každý podnik by mal mať zamestnanca povereného na riešenie etických problémov na pracovisku alebo v podniku. Môže sa jednať priamo o zamestnanca, ktorý bude riešiť len etické problémy, poprípade to môže byť zamestnanec z niektorých vedúcich pozícií, ktorý bude oboznámený s postupom riešenia nežiadúcich situácií vzniknutých na pracovisku alebo podniku. Motivácia predstavuje proces psychologického naštartovania k zvýšenému výkonu. Ku zvýšeniu spoľahlivosti a dôveryhodnosti zamestnancov v podniku môže dopomôcť práve motivácia. Preto je nesmierne dôležité motivovať zamestnancov ku zvyšovaniu svojho výkonu. Zvýšenie výkonu zamestnancov podniku následne znamená aj zvyšovanie prosperity a uplatniteľnosti podniku na trhu. A v neposlednom rade, každý podnik by mal zabezpečiť kontinuálne vzdelávanie a preškolenie zamestnancov o oblasti etiky.

Zavedením nami navrhovaného algoritmu krokov do výrobných podnikov sa etické prostredie posilní a podnik bude mať jasne stanovené pravidlá a zásady. Zamestnanci budú oboznámení o zmenách a nariadeniach, ktoré sú na jednotlivých pracoviskách zavedené. Takto oboznámení zamestnanci budú lepšie dodržiavať pracovnú morálku, minimalizujú sa problémy a porušovanie etických zásad na pracovisku a uľahčí sa riešenie vzniknutých nežiadúcich situácií. Zavedením spomínaného algoritmu môže dôjsť aj k eliminácii rizík jednotlivých procesov vo výrobných podnikoch.

Záver
V uskutočnenom výskume sme analyzovali parametre etickej kredibility. Za parametre etickej kredibility považujeme: etický kódex, etické princípy, riešenie problémov, názorov a návrhov zamestnancov, systém manažérstva kvality, identifikovanie rizík procesov a informovanie zamestnancov o možných rizikách. Do oblasti systému manažérstva kvality môžeme zaradiť výrobné procesy, vyrábané produkty a ich kvalitu, riadenie zdrojov, vzťahy medzi

dodávateľom a odberateľom, riadenie rizík, plnenie požiadaviek zákazníkov a spokojnosť zákazníkov. Spoločným parametrom oblasti etickej kredibility a manažérstva kvality sú riziká procesov, ktorým je potrebné sa neustále venovať a minimalizovať ich, resp. odstraňovať. Ako vyplynulo z výsledkov nášho výskumu a celkového zhrnutia odpovedí respondentov konštatujeme, že len 28 výrobných podnikov má zavedené všetky dôležité parametre etickej kredibility, čo môžeme označiť za ich vysokú spoľahlivosť a dôveryhodnosť, čo je však z celkového počtu respondentov nízky počet. Vychádzajúc z výsledkov nášho výskumu výrobných podnikoch pôsobiacich na Slovensku sme dospeli k záveru, ako je možné zvýšiť spoľahlivosť a dôveryhodnosť podnikov.

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Autori chcú vyjadriť poďakovanie agentúre APPV za podporu projektu APPV-17-0400 „Posilnenie etického prostredia na Slovensku (inštitucionálne postupy, aktéri, riziká, stratégie)“. Tento článok bol vytvorený ako súčasť uvedeného projektu.

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PERFORMANCE ANALYSIS OF SMES IN THE EU BASED ON EMPIRICAL STUDIES

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Abstract: All over the world, innovation is considered to be a key tool for the competitiveness of small and medium-sized enterprises (SMEs). Small businesses, where processes and products do not contain any innovations, risk losing customers and thus become uncompetitive. The adoption of information technology has ensured a competitive and dynamic economy across Europe. Most of the literature shows that several empirical studies have been conducted on barriers to innovation in SMEs. The aim of this article is to identify these barriers to innovation that limit innovation performance in SMEs. This scientific output uses document analysis and a qualitative approach for completion in the literature in its methodology. Scientific articles from databases such as WoS, Scopus and Google Scholar were used, which led to the analysis of documents using keywords related to the topic. The above results of the analysis suggest that the key factors hindering the innovation performance of SMEs are insufficiently qualified staff, insufficient funding, very poor technology uptake and strong competition between businesses. A view of some of the main obstacles and impacts on the European economy will provide a theoretical implication. The results of the study may be beneficial for the leadership of SMEs seeking to embrace innovation across the EU region.

Keywords: Performance, SMEs, Innovation barriers

Introduction

Newly established small and medium-sized enterprises (SMEs) appear under the constant threat of great transformation from large competitors [1]. Digitization and globalization are considered to be the main drivers of change in the SME sectors. Recently, SMEs have been facing competition in the market and this is one of the reasons why they need to accept the need for innovation. Therefore, most companies have created new procedures, processes or established research departments (R&D) to explore new ideas and technologies. The vast majority of SMEs involved in financial services have improved their services and the products they provide to the general public through digitization. It has improved customer perception and satisfaction since the 1990s. Many more online and offline services and products have been made available because of innovation. Nevertheless, new players, which mainly offer better services and products online, have adopted new intelligent technologies (eg SMEs involved in the production of footwear). Nowadays, smart shoes have different functions, such as inserts that can act as Bluetooth-enabled devices and can help track activities through a smartphone app that allows clients to track their fitness. [2]. This current trend used by shoe manufacturers will generate greater output with the same set of input. The newer design of shoes is manufactured with this smart technology to meet customer needs, this will ensure customer satisfaction and enhances business profitability which is relevant for microeconomics. Xiaomi, Nike and Armour are of course larger firms. Innovation takes full effect when a new technology is applied in the firm where it has been developed. The full benefit of innovation can be realized when it spreads across the economy and benefits firms at large. Europe has been the birthplace of innovation and there has been a continuous boost of innovative capacity in the European region [3]. Many researchers have asserted the barriers, challenges, and obstacles for effective innovation within newly established SME firms that have been reviewed in recent literature [4].

However, the growing literature in the field of innovation barriers mostly focuses on disruptive innovations within the public service sector [5]. Less is known about the barriers that focus strongly on obstacles related to the product of SME firms and R&D in manufacturing firms. This is very relevant since companies are constantly challenged by new laws aimed at stabilizing the market and competitiveness. Besides, enabled by modern technologies and new entrants to the market to offer new and improved services and products. This compels SMEs to employ technology and offer new competitive services. Unlike other financial service sectors, most manufacturing SMEs do not have an R&D and are primarily focused on the improvement of products and services. This implies that SMEs involved in manufacturing need to inject more funds, create structures and build new R&D to enable successful innovation [6]. Consequently, successfully implementing changes will require subsystems and is connected with devasting organizational change effects [7].

In this paper, we assessed some of the key barriers to the improvement of potentially disruptive and radical innovations within SMEs in the manufacturing sector. The main focus is on both internal and external barriers to innovation for us to have a clear firm dynamic. First, we assess some traditional obstacles to SME innovation based on reviewed literature. Second, we assess some external barriers through empirical studies conducted in recent literature.

Literature review

Recent societal and policy debate on SMEs innovation among manufacturing firms lacks empirical studies on both internal and external barriers to innovation. Most studies focus on consumer adoption barriers or the cultural influence that resulted in barriers connected with innovation [8] [9]. Most of the literature focused on the impact of innovation on the market and customer's perception or the funding of innovation and its impact on the firm's growth. Hence, empirical assessment of both internal and external barriers experienced by SMEs firms to adopt and launch effective innovation is absent.

The Organization for Economic Co-operation and Development (OECD) has grouped innovation into four types namely: process, product, marketing, and organizational innovation. For the sake of this research, the concentration will be on process and product innovation [10]. The result of product innovation is the introduction of improved goods or services regarding special components and their importance. Product innovation is a result of consumer demand without also neglecting the supply factor because both factors are the main drivers of this type of innovation. Modern technology, consumer preference, and the short life cycle of the product have ensured keen competition among SMEs to innovate worldwide. The method of producing new products or services improves as a result of process innovation. The process used in creating the product can be new or improved upon the already existing product. According to [11], the theory of creative destruction suggests that firms involved in innovative activities have a competitive edge to replace non-innovative firms. Innovation is key to economic growth and ensures the development of SMEs. Theoretically, SME innovation is expected to boost firm economic performance. Nonetheless, empirical study results have always contradicted innovation studies. That is, several studies indicate that innovation does not spring better performance.

Many studies have looked at process innovation compared to product innovation. Based on [12] who discovered that investment in R&D and firm size were the key determinants of product and process innovation for SMEs in Italy. They also concluded on empirical evidence on the link between innovation and productivity. Product innovation has been discovered to be more superior to process innovation according to many authors. Many authors assert that the introduction of a new product has a strong and positive impact on the income of SME

employees and creates employment opportunities whilst process innovation's main goal is to reduce the cost of production. Some other scientists suggest that firm-specific demand varies in terms of technical efficiency, which is the dominant factor in determining whether a firm will survive and have a positive influence on measured productivity. Product innovation relates to firm-specific demand whilst process innovation affects technical efficiency. According to [13], the authors indicated that product innovation seeks to be dominating factor of labor productivity whilst process innovation is statistically insignificant and economically irrelevant. As reported by [14], they discovered that product innovation affects productivity but not process innovation. Studying innovation seeks to explain why some SMEs innovate rapidly than others by identifying various factors that help in their innovation. However, there have been major challenges identifying the successful determinants of a firm's innovation worldwide (De Brentani et al, 2010). Although there have been several issues connected with some of the factors contributing to the high performance of firms, many studies fail to provide a more integrated framework in the field of innovation. This is as a result of higher expectations on the part of SMEs to provide good satisfaction to customers and achieve better revenue for firms due to several actors like networking with an external institution which includes academic universities, companies, and the general public in the area of operation coupled with organizational policies. Such forms of collaboration provide a clearer picture of SME's innovation activities. According to [15], a research model on innovation was proposed for the comprehensive framework during a constant review and analysis of various studies conducted on innovation. In general, the various factors can be classified as internal and external factors influencing SME's innovation performance. Among the internal factors are the size & age of the enterprise, human resources & human resources practices, business networks, occupational health & safety precautions, product, process, organizational, marketing innovation, leadership and planning, family ownership, and intellectual property. Although most of the reviewed articles analyze the different aspects of an organization's internal and external factors to contribute to the performance of SMEs, other authors also consider macroeconomic factors to be critical to the general success of SMEs.
Many of these studies have developed different models to access firms' level of innovation performance with the structural equation model, multiple equations, and a decision-based model [16], [17], [18]. Similar studies were conducted on societal & environmental responsibilities which increase business performance through "green practices" [17]. All the literature reviewed factored SME's performance at the microeconomic level, but a detailed understanding could be explained by studying the firm's performance at the macroeconomic level. Studying at the macroeconomic level has more advantages since it will factor all the determinants of SME innovation into account. SMEs innovation performance can be taken in three dimensions: the number of SMEs involved the number of employees working for the firms and the added value for firms. According to [19], where the authors analyze the influence of macroeconomic indicators on SMEs growth in the Czech Republic and their results developed a concave relationship between growth and unemployment which was a positive relationship between economic growth and development of firms whiles finance use to support the SMEs sector had no significant influence.

Innovation barriers
Many firms have adopted diverse ways in other to facilitate innovation such as the stage-gate model proposed by [20]. These authors grouped the innovation process into several stages which help firms to meet their innovation goals through new products and services with the help of modern technology with minimal errors. Nevertheless, SMEs such as those involved in

manufacturing and service who failed to adopt modern technology such as the use of point of sale (POS) devices are considered not be innovative. Several obstacles tend to hamper the process innovation of non-innovative manufacturing and service providers [21]. According to [22], several factors hinder innovation and tend to be different throughout the firm's innovation process.
To successfully implement and adopt innovation depends on both internal and external aspects of the firm. For instance, a company may explore and adopt new technologies through research and development which allows for new ideas that lead to product development. Both internal and external barriers to a firm's innovation performance can determine whether the firm will succeed or not. Identifying the barriers to innovation performance will help determine firms that are directly or indirectly influenced by modern technology. The most recent internal innovation barriers according to [23] are the firm's strategy, organizational architecture, leadership, how research is conducted, and incentives given to employees. Conversely, the most mentioned external barriers are the adoption of smart technology, keen competition on the market, and market dynamics [24]. According to [25], innovation barriers are grouped into traditional internal barriers such as lack of competent employees, restrictive mindset, and organization not willing to change its structure whilst customer resistance, ecosystem dynamics,

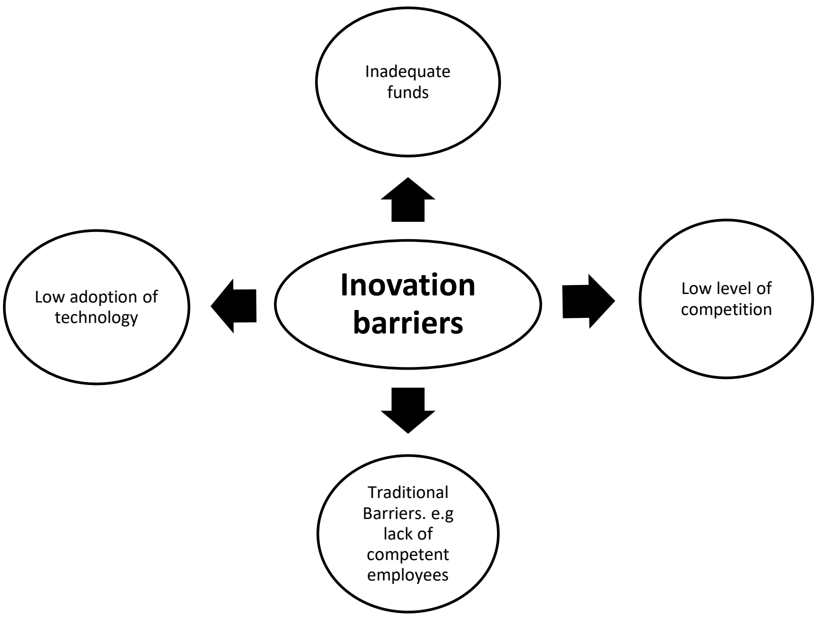

Fig. 12 Conceptual framework, Source: Own research

and technological troubles are all traditional external barriers.

The identification of obstacles to SME innovation can contribute massively to the innovative culture of SME firms which encourages new ideas. On a national level, it is very relevant to identify and remove some barriers to promote innovation based on competition and to avoid the probability of failing during innovation [26]. Conversely, from an innovation management point of view, it is very vital to identify the barriers to SMEs innovation to promote economic pay-offs innovation-related efforts [27].

Methodology

To execute the objective of this study, a qualitative method was adopted by the researchers. The main aim of this paper was achieved through the adoption of document analysis. Document analysis involves the use of printed and online materials for reviewing and evaluate needed documents to conclude [28]. Document analysis which is the scope of the study has advantages such as no interviews with individuals and easy access to many documents. Document analysis has been used recently by researchers and scholars [29]. The main source of information for this paper relied on keywords search from the Scopus, WoS, and Google scholar databases. To achieve the objective of this paper, some articles between 1990 to 2020 connected to the topic were reviewed by Google scholar, WoS, and Scopus using the relevant keywords search associated with the topic such as barriers to SMEs innovation performance in Europe, obstacles to innovation, and hindrance to innovation outcomes. Out of the numerous literatures downloaded from the specified databases, thirty-five of the articles were subsequently used to execute the aim of this study. All articles downloaded from the database were published in English. Some relevant information was accessed from secondary sources as part of the methodology regarding the topic as well as some theories. Also, most literature showed a positive usage of document analysis to provide adequate information for this paper [30].

Although Innovation in larger firms tend to be rapid than in smaller firms, SMEs are less bureaucratic and are more willing to take risk than larger firms. An attempt to promote innovation comes from the internal decisions of management. First, it contributes to the enrichment of understanding SMEs in Europe. Innovation contributes specific knowledge concerning the financing of SMEs in the selected EU countries. This study will pave way for a more academic and practical inquiry into SME development activities within firms. The research work intends to provide a model for theory and practice for managers of SMEs.

In terms of applied contribution to knowledge, it will help in economic growth by assisting governments and policymakers in establishing an environment that will contribute to entrepreneurship and regional development. The outcome of the research is going to be used as a guideline to the government which will facilitate technology transfer and helps commercialize research activities. That is, it will give direction for further research as there is more room for improvement.

Conclusion

The articles we examined show that SMEs are better involved in technological innovation, as this has been a major constraint on their innovation in all areas. For SMEs, government policies, regulation and innovation have both positive and negative effects on business performance. In such a case, it will either support or discourage individual government policies and improve the innovative performance of SMEs. It is government policies that have been the main factor limiting technological innovation in SMEs, but it is not an important factor in innovation in SMEs.

Every organization wants to overcome competitive constraints with its information flow. However, insufficient market information is an obstacle for the SME industry to embrace technological innovation. Whether they want to or not, SMEs need to work with R&D companies to offer new designs and help promote service and product innovation. But if these companies are properly involved in R&D, adding value to an existing product and creating new ideas will be easier. Insufficient R&D is, therefore, one of the main problems facing the SME sector and, after all, it has contributed to a lack of consumer information.

SMEs that are involved in innovation may have the necessary skills and resources, as a result of which they need huge funds to manage and own existing resources. Without this funding, SMEs will not be able to adapt to technological innovation due to the high costs that have become a major obstacle for the sector. Finance has still been and will be a major economic impetus for businesses and that is why without finance they cannot accept new innovations and technologies. For SMEs, therefore, an insufficient fund is a major obstacle. Also, organizational activities cannot be achieved without the participation of competent employees. However, SMEs do not have sufficient human resources to achieve the required goal. In order for new technologies to be adopted, it is necessary to employ new qualified, competent employees. That is why the lack of qualified staff is considered a living factor in the performance of SME innovation.

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IMPACT OF THE DEVELOPMENT OF DIGITIZATION ON WORKERS

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Abstract: This article provides information about the impact of the development of digitization and technologies on workers. The aim of this article is to present possible problems of workers with the adoption of new technologies and increasing their knowledge and skills so that new technologies and software can control. This article also gives readers answers to how computer simulation can help solve problems with unstable situations of a number of workers in the workplace. The proposed steps of the simulation project will help create other scenarios, which will help reduce the impact in the event of a risk situation.

Keywords: Workers, Digitization, Computer Simulation

Simulation

The word simulation comes from the Latin word simulō - to imitate, while this word expresses the process of simulation of a certain event, process, and work of an object, etc., with the help of computer technology. The basis of the simulation is the creation of a simulation model approaching reality. Computer simulation is one of the effective tools to support training, education and decision-making at all company levels. An essential task of computer simulation and digitization of processes and documents, in general, is not only to improve, clarify selected production and logistics processes, but also to improve working conditions of employees, or readiness of workers to perform their work in the operation, so that they do it correctly, safely and without high physical load.

Workers are the most important part of any industrial society. Modern technologies and the development of software solutions enable a combination of software solution tools and technologies to simulate the movement of workers in the plant. In combination with wearable sensors, such solutions allow the system to first simulate and evaluate how workers in a given production, logistics, warehouse can work and then determine the optimal location of production equipment and machinery to maintain optimal employee working conditions. For example, the Tecnomatix Plant Simulation software solution, which is used at the Department of Industrial Engineering, allows us to simulate the work of workers performing various tasks in production and logistics, such as moving material, performing production operations, repairing machines, setting up machines, etc. When simulating workers' work, it is possible to use several objects and settings so that workers in the simulation move or perform activities as in reality. It is important to make sure that the new workplace will prevent unnecessary resource waste, but also create a safe working environment for employees [5].

Advantages of using simulation to simulate the work of workers, e.g.:

- Creating a complex and real environment in a 2D / 3D environment.
- Possibility to simulate the real way and direction of a worker walking around the workplace.
- The creation of a computer simulation does not interrupt the work of the worker in a real environment, so, it is safe and does not burden the minds of workers.
- The dynamics of the computer simulation environment will show the possibilities of work performance, walking directions and choose the most advantageous routes or ways of

performing work, e.g. maintenance activities.
- Simulations and experiments focused on workplace innovations - development of new trends and change of workplaces, verification of new procedures, etc.

Disadvantages of using computer simulation:
- Financial demands - high costs of purchasing computers, hardware and software.
- Time consuming - creating a complex 3D simulation model or 3D scans may take several Months if 3D models are not available.
- Data collection - is necessary to obtain additional data necessary for the proper operation simulation model, e.g. width aisle length, aisle directions, walking speed employee, priorities at work, etc.
- Staff training - the evaluation of the results of simulation runs can be affected workers work, and wrong decisions can ultimately cause workers' health or psychological problems.

Workers and digitization in the future

Various types of production and robotic systems are already characterized by the ability and properties to process any type of components, parts with predetermined production procedures and customer requirements. However, a necessary feature of modern production systems is flexibility and thus the ability to adapt to unexpected changes in plans or production operations. The new generation of production systems is therefore primarily about production systems that are intelligent and flexible affect the work of workers. Concerns and potential problems that already affect the work of workers include, for example:
- Lack of understanding of the behaviour of these digital technologies.
- Insufficient dissemination of accurate and quality information between company levels.
- Insufficient knowledge of staff in statistics, mathematics and incomplete evaluation of business models.
- Rapid development of technologies and their effort to adapt causes companies low return on investment.
- Not enough awareness of the current state of machinery, equipment, technological equipment, etc.
- Lack of tools for application development and software solutions, costly purchase of licenses and software.
- Attitudes of employees - Careful holding employees for several years common practices that refuse to change, etc.

As mentioned in the introduction to this article, it is necessary to start preparing workers for the gradual emergence of new digital opportunities that are offered to businesses. Intelligent manufacturing and smart products, their development already includes a wide range of various other options, including, for example, sensor integration, integration of a new generation of artificial intelligence technologies, advanced manufacturing technologies (e.g. hybrid production systems), lean manufacturing, digital manufacturing, agile production, networked manufacturing, cloud manufacturing, intelligent manufacturing, and more. However, the too rapid advancement of selected technologies causes companies to face many problems in practice in promoting intelligent technologies into production, but also among workers, specifically by developing their technical skills and emotional intelligence.

An example of supporting the development of workers' technical skills is Amazon [1], which is committed to helping at least 29 million people around the world improve their skills through free Cloud Computing training to keep up with technological and software advances and, above all, not be afraid of these technologies, disillusionment, alarm messages, etc. In order to further development the technical skills of employees, it is necessary to find out the real state of their experience, and it may not be at the level they present. The skills that employees will need to acquire in the future include for example [8]:

- Creation of protocols for new versions of software/hardware.
- Creation of new digital content usable in the factory (for example, 3D models of manufacturing, tools for using augmented reality and so on).
- The creation of a computer simulation does not interrupt the work of the worker in a real environment, so, it is safe and does not burden the minds of workers.
- Developing digital security, cyber forensic tools (such as Network Miner, Encrypted Disk Detector, Autopsy, etc.) and other techniques.
- Development of digital communication in factories (for example, by using Mobile Employee Communication Apps).
- Use advanced problem-solving computational techniques (for example, software for a risk impact assessment on operations).
- Integration of various digital tools to improve customer choice of products over the Internet (e.g. in the form of Face-Scanning).
- Integration of digital tools into products and handling units, e.g. sensors on pallets, etc.
- Developing knowledge of data mining (e.g. in the form of predictive algorithms).
- Developing knowledge in the field of machine learning, statistical data evaluation, etc.

Based on the statistical report from the 2020 year, issued in the year 2021, by the MHI Annual Industry Report, we can say how the company will invest in the technologies over the next three years [6]. For example, in Fig. 1, it is possible to see a result graph of the responses of 1000 supply chain and manufacturing leaders to find out which technologies they want to focus on after the pandemic.

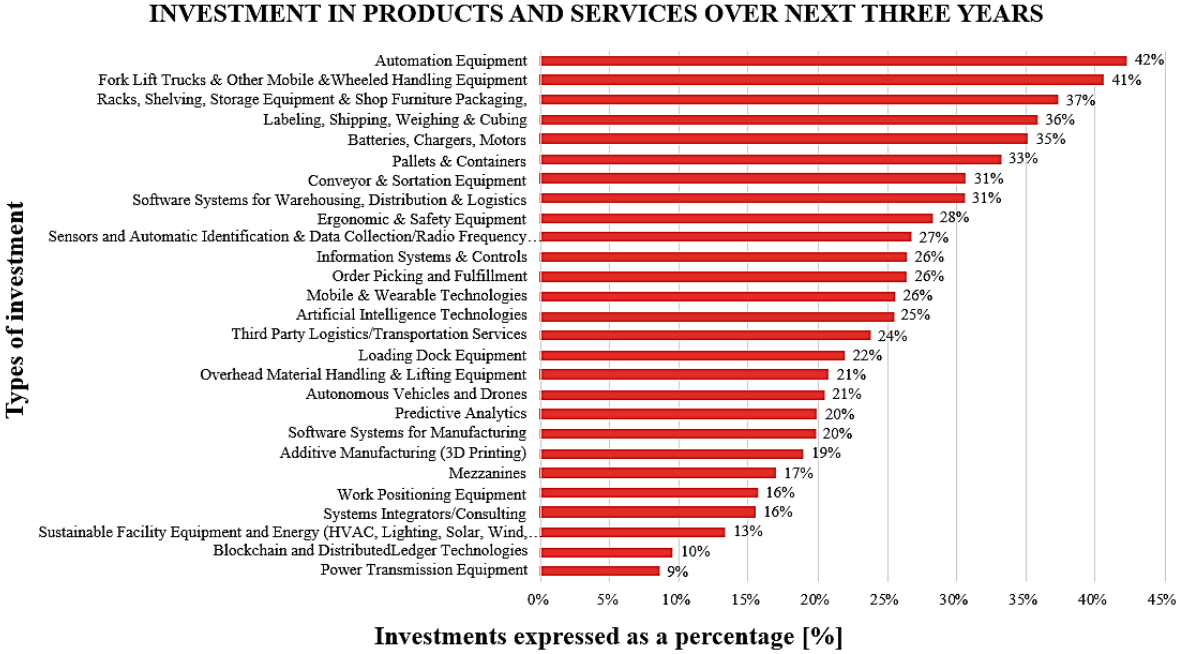

Fig. 1 Graph of investment in products and services (MHI Annual Industry Report, 2020)

Based on the results of a survey conducted by the MHI organization over the next three years, the companies will focus on automation technologies, robotics, warehouse equipment and mobile devices, development of ergonomics and software solutions, sensors and information technologies, also for wearable technologies. Therefore, it is necessary to gradually focus on teaching workers to understand digitization and new technologies so that they are not afraid of these technologies and can work with them.

Simulation project

As described above, it can be seen that the development of knowledge will be a key point for the further growth of workers' knowledge development and the growth of industries and technologies. From the point of view of the use of computer simulation, it is important, as already mentioned, that its results and possibilities of its use must be sufficiently well understood and interpreted. Methods of computer simulation give the possibility of estimation the expected throughput and usability of the system and all elements that are included into the system [2]. Such a development can also affect the way the simulation project is created and steps.

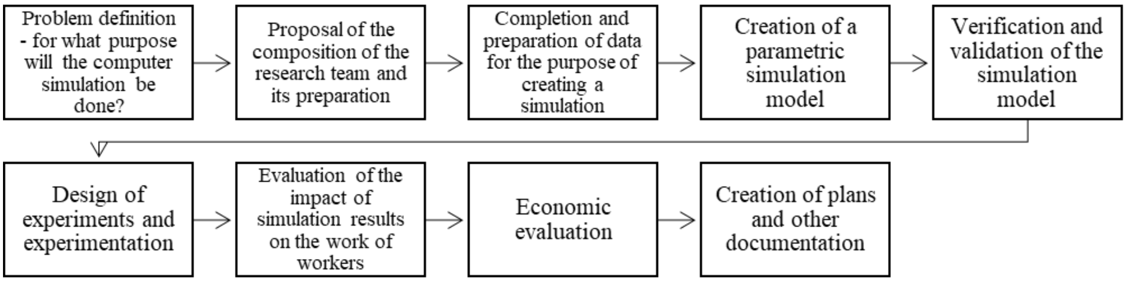

Fig. 2 Proposed steps of simulation project (Author: Monika Bučková)

Fig. 2 shows the steps of the simulation project, which already incorporates the possibility of preparing a solution team and ways to evaluate the results of simulation of workers' work.

Description of the above steps:

- *Step 1: Defining the problem and setting the goal* - In this step, it is necessary to determine the problem that needs to be solved with the help of simulations. For example, use of the worker is not sufficient, shortening the paths when picking goods, improving the method of picking goods, improving maintenance processes, improving assembly processes, and then also warehousing and logistics processes, etc.

- *Step 2: Proposal of the composition of the solution team and its preparation* – During the solution of such a simulation project, it is appropriate if employees from different company levels are involved in its solution, not only the manager and the creator of the simulation. The presence of these workers is important if the problem is to be addressed in-depth, as they bring knowledge, experience, ideas, and suggestions for improvement or just have information on how workers behave in the workplace. In this step, you can also use training using virtual reality.

- *Step 3: Data collection* - This step can be performed even before creating the parametric simulation model because it is necessary to obtain information about employees and the workplace, which can then be time-consuming to collect and evaluate. These steps of data collection include various types of measurements, imaging, creation of time studies, etc. Between the data can be include, e.g. proposal of the number of workers at the workplace, work shifts, break times, working hours, routes of movement of workers, waiting for the operator to order, speed of their movement, performance, etc. For the needs of simulation of the selected process, it is necessary to add detailed information about the selected process (e.g. workplace location, dimensions, taking into account ergonomics, production process, assembly plans, etc.), handling equipment (e.g. a number of handling equipment, speed, charging method, method of storing semi-finished products, etc.), or method of planning (e.g. use of ERP or SAP software), etc.

- *Step 4: Creation of a parametric simulation model* - By parameterizing a simulation model, it is possible, e.g. change data values from a clear dialogue box or enter data into a table created by simulation software or users.

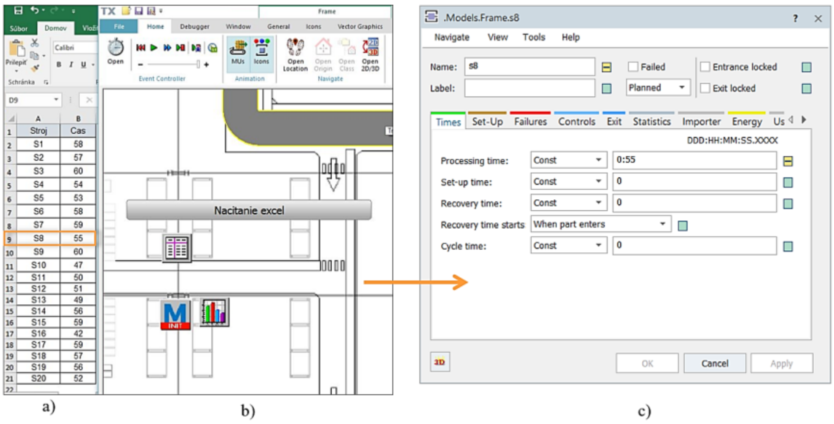

Fig. 3 Connection of Ms Excel and Tecnomatix Plant Simulation software (Author: Monika Bučková)

The example of a model shown in Fig. 3 a) is parametrically set to retrieve data from tables created in MS Excel. We could retrieve statistical data from the simulation model by directly linking variables cells or by using a macro control button to ensure that data is retrieved into the desired cells in the MS Excel workbook. In Fig. 3 b) it is possible to see also a macro called "Načítavanie excel (Loading excel)" by pressing the macro will start the data loading command from the table from MS Excel, after which the data from the table will be overwritten, in the setting table of machines – Fig. 3 c).

- *Step 5: Simulation model verification and validation* - During the verification process, it is possible to verify that the computer model is in line with the objectives for which it was created and that its results are sufficient to make decisions about assessing the impact of risk on business processes. The validation step helps to compare the actual data with the model's outputs if the company has such data [4].

- *Step 6: Proposal of experiments and experimentation* - If the risks from the previous steps of the methodology are known and what consequences they can have on the processes, it will speed up and streamline the process of creating and modifying the simulation model. It is thus possible to design experiments of the type, e.g. how the different number of workers in the workplace will affect the performance of the production system, how many workers are needed to service the warehouse, how will the assembly process be affected by an unexpected order with high priority, etc.

For making a large number of experiments, it is possible to use, for example, the Experiment Manager (Fig. 4) tool in the Tecnomatix Plant Simulation software. It is helpful also for quick evaluate a large number of experiments as part of the risk assessment. By using the results of this tool, it is possible to evaluate various risk situations concerning workers. For example, an optimal number of workers in the workplace - is it possible to predict what happens when one of the workers does not come to work for various reasons; this decision on the number of workers is important with a view of considering the introduction of multi-machine operation or determining whether one worker will operate each machine in order to avoid overloading the workers.

Fig. 4 Experiment Manager table and 3D model in Tecnomatix Plant Simulation software (Author: Monika Bučková)

- *Step 7: Evaluating the impact of simulation results on employee work* - As mentioned, computer simulation results can influence managers' decisions. By modifying workplaces or shortening routes for picking goods, etc., it is possible to improve the working conditions of employees and reduce their fatigue and exhaustion. Computer simulations and experiments can help managers see how the system behaves when the number of employees is lower, how many products they are able to produce, how maintenance is performed, technical service with different numbers of employees with other priorities, and so on.

- *Step 8: Economic evaluation* - The final report from the simulation must contain a detailed description of the created simulation model together with all its elements and settings, evaluation of input data collection, results of simulation runs, conclusions from verification and validation, proposals for corrective measures, etc.

Conclusion

Megatrends growing at an ever-increasing pace along with technological and software developments. Application of different types of innovations and Industry 4.0 implementation supports evolution systems in which interaction, and even integration, achieves business independence elements [3]. For example, they help to create and accelerate the development of information technologies (Internet of Things, Cloud Computing, etc.), digital factories, modular systems, e-learning systems, etc. As described in the article, these technologies also increase their complexity in the form of the need for knowledge and the correct interpretation of knowledge. Also, companies and organizations such as MHI monitor events and developments in companies; they monitor what technologies companies will be interested in and which way they will go. That is why it is necessary to increase the knowledge level of employees and improve working conditions at workplaces. Using digital enterprise tools such as computer simulation, it is also possible to reveal the risks such as a pandemic, fluctuations, dangerous working conditions, high physical burden on workers. It is impossible to solve them by computer simulation, but it is possible to experiment with different situations and then choose and consider variants of how to respond to these situations with the help of statistical results. All types of processes and products will be modified and developed in the future, and these activities should be aided by new information technologies to achieve a competitive advantage [7]. Of course, not every worker will work, e.g. work with computer simulation, because it is financially demanding, but it is appropriate for employees to increase their knowledge in the field of basic software solutions and information technology such as the Internet of Things or Cloud Computing. The impact of digitization on employees is addressed at the Department of Industrial Engineering from several perspectives, not only in terms of ergonomics and statistics but also in terms of improving maintenance processes and technical service.

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EFFECT OF DIGITALIZATION ON THE ACCOUNTING OF COMPANIES

Alžbeta SUHÁNYIOVÁ – Ladislav SUHÁNYI

Abstract:
Digitalization can make business processes significantly more efficient in all areas, be it production processes, online sales, and routine business activities, including administration. The field of accounting has been also touched by the digitalization, which is why the aim of the paper is to examine the effect of digitalization on the accounting of companies with regard to their future, in the Slovak Republic. The current (up to now) development of digitalization in the field of accounting is examined, with an emphasis on the impact of the currently proposed amendment to the Act on Accounting, specifying the digitization of accounting documents, such as e-invoices. The methods of observation, comparison, description, deduction, and interpretation of results have been used to investigate the research problem. Based on the performed qualitative research, it can be concluded that the digitization of accounting documents brings benefits to companies in the form of simplification and streamlining of accounting work, communication with business partners as well as with the government authorities in detecting fraudulent conduct of companies. The digitalization of accounting also brings a structural change in the functions of accounting and in companies providing accounting services.

Keywords: digitalization, digitization, accounting, e-invoice

Introduction

Digitalization is one of the European Union's top priorities. The European Parliament is involved in shaping new legislation that will strengthen Europe's capacity in the area of digital technologies and that will bring new opportunities to both citizens and businesses. Digitalization plays an important role in all European Union policies. Digital solutions bring great opportunities and are very important in rebuilding the economy after the crisis caused by the COVID-19 pandemic and consolidating our position in the world economy and in building a sustainable future. The Digital Europe 2021-2027 program was approved by the European Parliament in April 2021 (European Commission 2021). It is the Union's first-ever financial instrument to bring technology closer to citizens and businesses. The European Economic Recovery Plan calls on Member States to spend at least 20% of the € 672.5 billion total budget on digitization (European Parliament 2021).

According to the Encyclopaedia of Knowledge (2021), digitization is the conversion of information from an analogue form (analogue signal, for example electrical voltage, sound, pressure) to a numerical (= digital) form, usually into a computer file. These usually include scanning and converting graphic shapes into digital shapes (usually using a scanner), scanning and converting fonts into digital shapes (usually using a scanner and OCR software), scanning and transferring the dimensions of three-dimensional objects into digital shapes (usually using 3D scanners), digitization of sound, or film digitization.

It is necessary to distinguish between the words digitization and digitalization. As told, digitization means converting data, documents, and processes from analogue to digital. While digitalization means transforming business processes by leveraging digital technologies, ultimately resulting in opportunities for efficiencies and increased revenue.

The current global crisis has confirmed that many businesses have unfortunately not yet been ready for digitalization. Digitalization can make businesses much more efficient in all areas, be it production processes, online sales and day-to-day business activities, including administration. Digitalization has also affected the business area, specifically accounting.

Digitization and the accounting

In essence, accounting is the most comprehensive economic information system that accurately and reliably records and provides economic information about the business entity. It is a relatively closed and internally organized information system that provides information in monetary terms about the economic activity of the company and about the result of this activity, in other words it provides information on assets, equity, liabilities, revenues, costs and profit or loss (Suhányiová 2019).

During the accounting period, accounting records are processed, which are defined in the Article 31 of the Act on Accounting no. 431/2002 Coll. as amended (for example: accounting documents, accounting books – ledgers, financial statements, etc.). The current Act on Accounting puts the paper form and the electronic form of the accounting record on the same level.

Thus, in general, we can say that digital accounting is the processing of accounting information about the company's activities in monetary terms using tools that allow data processing of this information without the paper form of accounting records. Basically, what is changing is the form of processing accounting information, but not the essence of accounting itself.

Digital accounting records

Automation and digitization make life easier for entrepreneurs, enable easier communication with business partners, and with the state, and speed up processes. The digital reporting system was the first to be introduced in Europe in 2002.

Today, we live in an era of electronic invoices (hereinafter referred to as e-invoices), which are the best example of the impact of digitization on the accounting profession. This will make invoicing faster, more enjoyable, and smoother than ever before, while bringing another turnaround in the lives of accounting service providers. According to Blažejová (2021), looking at the V4 countries, Hungary introduced the obligation to record transactions ‘in real time’ in January 2021, which applies to almost all invoices in the country. The companies with high-risk products (such as food, as well as transport companies that transport goods) are obliged to register in the electronic system. Hungary supports e-invoicing by being able to track goods ‘in real time’ by sending electronic invoices to customers together with a hashtag code. Poland is introducing e-invoices in two phases. The first, voluntary, should be launched now in October 2021 and the second mandatory phase will begin in 2023. Within the European countries, the e-invoicing system is already launched in Albania, Spain, Serbia, Greece, Portugal and Italy. Countries that plan to launch a similar system in the coming years include Denmark (2022), France (2023), and Norway (2022). Slovakia and Germany are among the countries that are considering the introduction of a digital invoicing system and have also submitted draft legislation.

After reviewing the proposed Slovak legislative background, we can state that the accounting record – so the e-invoice as well – must meet three basic requirements (proposed change in the Article 31 (3) to (6) of the Act on Accounting). Must be ensured the: authenticity of origin, integrity of content and the legibility of the accounting record from the moment it is made or

from the moment it is received or made available until the end of the archiving period, and this obligation shall also apply to the transfer of the accounting record to another person.
The authenticity of the origin of the accounting record is ensured if the company
- Which is the contractor, being able to prove that the accepted accounting record is originally from the contractor,
- Which is the recipient, being able to prove that the accepted accounting record is originally from the contractor.

For example, if the supplier issues an e-invoice, he proves the assurance of the authenticity of the origin by posting the invoice in the accounting records.
The integrity of the content of the accounting record is ensured if there is no change in the content of the facts that are recorded in the accounting record due the sending or making available of the accounting record or the transformation of the accounting record in the company.
The accounting record must be *legible to the human eye*. The most common form of sending e-invoices is sending them by e-mail communication in PDF format, which fully meet the requirement of human readability. E-invoices in the form of structured messages, such as XML or EDI messages, are not considered legible to the human eye in their original format. They can only be considered readable after they have been converted to a format that is legible by the human eye.
The authenticity of the origin, the integrity of the content and the legibility of the accounting records can be ensured by the company in one of the following ways or in a combination of them (Kolembus 2021):
- By the signature record of the responsible person (handwritten signature, qualified electronic signature or similar verifiable signature record replacing the handwritten signature in electronic form, which allows unambiguous provable identification of the person who made the signature record),
- By electronic data exchange (exchange of structured messages between computers or computer applications, in which various electronic formats of accounting records are processed, which go through the process of verification, coordination, approval and bookkeeping without any possibility of human intervention in the content of the accounting record),
- By the internal control system of the accounting records (identification of the persons responsible for the control of the process of processing the accounting records, while the control must be sufficient to prove the fact recorded in the accounting records),
- By other means ensuring the authenticity, reliability, and integrity of the accounting records.

At present, many companies prefer to send invoices and related documents in electronic form. However, their processing is carried out by ‘rewriting’ the data by the accountant into the accounting information system, i.e. they are not loaded into the system automatically. We also encounter the fact that companies use this electronic method of delivery of invoices, but they still print these invoices for archiving in paper form. This may be related to a certain historical inertia, but also to the current wording of the Act on Accounting in the Article 31(3), which gives the possibility to make a transfer from paper to electronic form, and vice versa. However, we consider the printing and subsequent archiving of electronically delivered documents in paper form as a thing of the past, because it is possible to ensure the authenticity of accounting records in various technical ways, either by storing backups and electronic copies of accounting documents in several places (offline on media such as external disks, CDs, or eventually online

on the clouds) and, if necessary, these documents can be printed and easily submitted in paper form.
Let us recall that in accordance with the Act on Archives and Registries no. 395/2002 Coll. the period of archiving accounting documents for accounting records is 10 years, annual payslips must be archived for 50 years and personal files of employees for 70 years.

The explanatory memorandum to the amendment to the Act on Accounting (LP/2021/256), the planned validity of which will be from 1 January 2022, states the following in relation to the proposed Articles 31 to 33: *If an entity keeps and archives accounting records in electronic form, it is required to submit them to authorized persons in such a form*.
Article 33 sets out the method of transformation of the accounting record – change of form from paper to electronic or vice versa. We see a positive shift to practical reality here, when the above-mentioned explanatory memorandum states: *An alternative is proposed to the guaranteed conversion, which can be used to change the paper form of the accounting record to electronic*. The aim of the proposed alternative is to carry out such a transformation, the result of which is in the maximum possible conformity – including visual conformity – with the original (with the accounting record in paper form). If the proposed scanning requirements are met, where the output is a scan (image) saved in a file format with raster graphics (for example, an image saved in .pdf, .png, .jpg, .tiff format), such an accounting record will be considered verifiable and will not be require the presentation of the accounting record in its original paper form.
According to Serinová (2021), the above-mentioned approach is extremely practical, especially from the point of view of archiving documents from the electronic checkout till (receipt from the cash register), because the print quality of some printers is not sufficient for archiving purposes and after a year the print fades. Only a high-quality scan of the document as soon as possible after its receipt will help here.
The second advantage of the prepared amendment of the Act on Accounting is the elimination of sending invoices by post, or their additional printing for the purpose of archiving and proving the conformity of paper and electronic form.

Accounting in a cloud storage

There are also software solutions that enable the transfer of information from paper form to the accounting system by scanning an accounting document, thus simplifying the work with documents, and streamlining accounting. If it is established in the company that all paper documents are converted to digital form, for example by scanning, it is possible for the accountant to access them through shared access via the cloud, where these documents are stored.

What is a cloud? We can compare the cloud to a virtual space through which users create, share and manipulate a huge amount of information of various types. These are on-demand computing resources that a user or a company has access to over the Internet. The data is stored on cloud servers, which are located around the world in data centres on physical servers and are managed by their provider. Customers can run their software on them for a fee, use their computing power or their storage to store own data. When choosing a cloud storage, it is very difficult to be familiar with the options offered. According to the DigitalPortal.sk (2021) the best options are Mega, Dropbox, One Drive, Google Drive and Amazon Cloud.

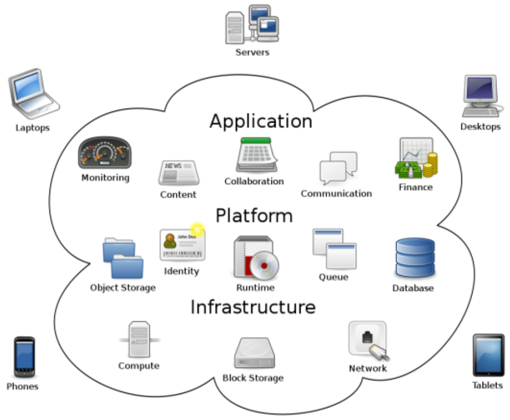

Fig. 1 Illustration of the operation of cloud computing

By two-way communication, it is possible for the owner of the company, assistant, accountant, warehouse worker and other users to have access to the documents at any time and from any place in the world. Access to the accounting system can be handled remotely as long as the accounting system is kept in the cloud.
According to Serinová (2021), these are the advantages of cloud accounting:

- Internet access is sufficient for access to accounting,
- It is possible to use a computer, tablet or phone,
- Simple substitution of the accounting officer,
- No need to buy own server,
- The data is archived in the cloud, in case of loss, damage or theft of the computer or other technical equipment the data will be not lost,
- It is not necessary to update the accounting program, it is always working with the updated version.

The disadvantages of cloud accounting are as follows:

- We need the internet to access the accounting,
- The data are not stored outside the network on the local computer, in case of cancellation of the cloud storage it can be complicated to access the data.

Software companies that provide solutions for the transition of accounting to the cloud pay great attention to the data security of their clients, in addition, it is always possible to make a backup of the accounting system outside the network, or to download the backup to a local computer.
If a company will use cloud accounting in the future, it is appropriate to deal with this method of accounting in the internal guidance for the accounting system so that it will be possible to clearly identify who is responsible for which part of the process and it is necessary to process the protection and treatment of access rights and passwords, and the method of circulation of documents electronically. The transition to paperless accounting in the future or putting the electronic and paper accounting records on the same level brings a great chance for the transition to fully digital accounting. Each of the mentioned processes is one of the elements of digital accounting, which may eventually become quite common in the future, and then a comprehensive system of digital accounting will be created.

Conclusions

None of the currently valid laws, nor the forthcoming amendment to the Act on Accounting in the Slovak Republic, states out exactly what digital accounting actually is, what elements it has, what it is characterized by and how it should work. Perhaps a project called ‘e-invoices’ that is being prepared will bring at least a partial solution. According to public consultations and information published so far on the website of the Ministry of Finance of the Slovak Republic (2021), the preliminary plan for the introduction of e-invoices in Slovakia is early 2022. The first stage should include the Business-to-Government transactions, where the public sector is in the position of customer. Subsequently, there will be space to test the technical solutions. In the next stage will be introduced the obligation to send the e-invoice and the data for Business-to-Business transactions and for the Business-to-Consumer transactions also. The latest date to start the full operation of this system should be January 2023. As there is currently no more detailed information, everything will depend on technical preparations, requirements, and deadlines set by the state.

An e-invoice would help the business sector to simplify administration and would also help the state to detect tax fraud from next year. An e-invoice together with an electronic checkout till (electronic cash register) could also become the main tool of the Ministry of Finance in the fight against tax evasion, not only in VAT but also in income tax. It is questionable whether the current form of Statement of VAT sufficiently helps to detect fraud, as the data are obtained by the tax controllers late and in several cases they are no longer able to recover the tax.

The future of digital accounting will be a joint work of man and machine. We must not run away from digitalization, automation, artificial intelligence, we must face them. Just as punch card billing machines have been replaced by computers and laptops, these devices will be replaced by more modern and innovative technologies. We can say with certainty that we are on the threshold of change. The vision is still unknown, but we see the direction.

In our opinion, one of the results of digitalization will be a structural change in the main functions of providing accounting services, in which the emphasis will be on consulting services instead of bookkeeping. Structural changes, or let's say digitalisation, will certainly create new players in the market for the provision of accounting services as well. In addition to the existing suppliers of accounting software and ERP development companies, there will also appear large new players from other markets, whose solutions can accelerate the digital development and transition.

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ANALYSIS AND SUBSEQUENT INCREASE OF EFFICIENCY OF THE SELECTED PRODUCTION PROCESS WITH THE HELP OF SIMULATION TOOLS

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Abstract: The aim of this paper is to improve the efficiency of the production process in a manufacturing company by applying the TX Plant Simulation module. The work was processed in a company that deals with the import, processing of raw materials, production of products, storage and sale of finished products with added value. A simulation was created using software from Siemens, from which the outputs were used for data processing and analysis. We then compare the simulation outputs with the actual data that we know and find out the accuracy of the process settings in the simulation model. Based on this analysis, we will proceed to the design of a solution in a simulation environment. From the obtained data, bottlenecks were identified, which slow down production, technological and shipping processes. The design part of the work is focused on the elimination of selected bottlenecks in the process of production, shipping and material flows.

Keywords: manufacturing process, efficiency improvement, simulation, models, Tecnomatix Plant Simulation

Introduction

In today's globalized world, we have many opportunities to make our work easier, to improve our work environment and to innovate our surroundings by implementing new technologies that can make our individual processes in society more efficient. In order to implement efficiency improvements in a manufacturing company, it is necessary to have technological and technical possibilities at their disposal, which can be used to implement innovative tendencies to achieve the set goals. One of these elements is the product from Siemens, which launched the TX Plant Simulation software. This software product provides a myriad of modeling options and flexibility that we will work to bring closer to the manufacturing process and material flows. At the same time, it offers us real and high-quality outputs for processing the analysis.

Production process information adapted to Tecnomatix Plant Simulation

To present the entire production process, it is first necessary to divide it into individual sections, in which we will point out the links to individual procedures and material transitions throughout the production process. First of all, we need to schematically display all components of the entire production process, so that we can implement the data into the Tecnomatix Plant Simulation program and then create a simulation. This production process starts with the purchase of the raw material and goes through various stages in which the raw material is converted into finished products.

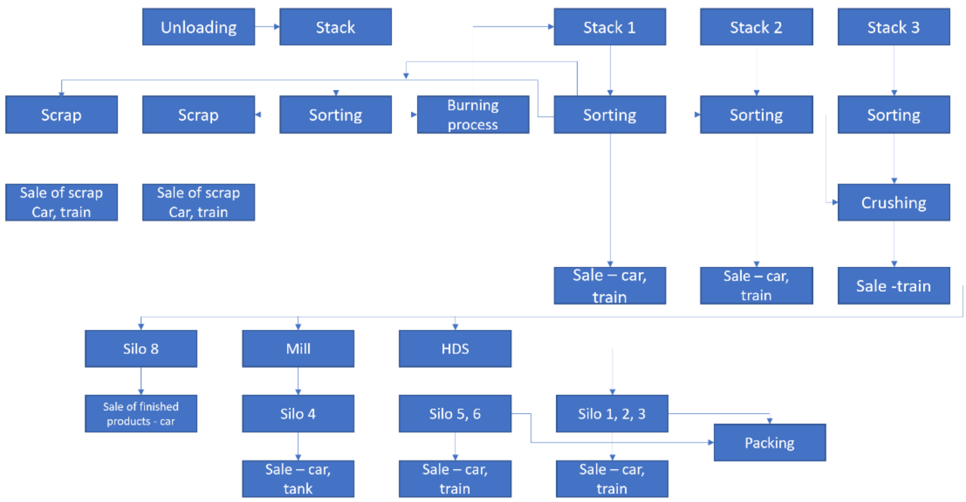

Fig. 24 Production process diagram

The condition for creating a simulation is the analysis of individual activities and the creation of an overview of performance, capacity and time required for individual operations. To process this data, we need to know the exact capacity of the equipment for the time they spend at each workplace. To express the data on individual devices, we use Tab. 1, in which the values will be expressed, which we then recalculate for the purpose of simulation.

Tab. 4 Production processes

Name of the device	Capacitance performance t/min.
Vibrating trough feeder 1	0:30
Vibrating trough feeder 2	0:30
Vibrating trough feeder 3	0:30
Vibrating sorter 1	2:30
Vibrating sorter 2	2:30
Merz shaft furnace 1	3:45
Merz shaft furnace 2	3:45
Feeder of Drum 1	3:00
Feeder of Drum 2	3:00
Crusher	1:30
Vibrating screen 3	1:30
Vibrating screen 4	1:30
Vibrating screen 5	1:30
Hammer crusher	1:30
Hydra-Soothing bath	8:30
Hydrate lime mill	9:00
Mixing	1:10
Mill	9:00
Control HDS	1:00
Packing HDS	2:30
Control of ground lime	1:00
Packing of ground lime	2:30
Aditive mixture	3:00
Mill	2:45
Pallet loading	1:30
Foiling	0:30
Shrink furnace	0:45

At the moment when we know the input data and connections between individual processes (Fig.1, Tab.1, Tab. 2) I can proceed to the implementation and creation of a simulation model. We will then compare this model and its outputs with the outputs we have at our disposal and determine the degree of accuracy of the simulation compared to the actual state in the production process.

Tab. 5 Average inputs to production

	Limestone unloading Car/train		Production - furnace	Expedition Car/train	Expedition - car	Expedition HDS - train	Expedition Train/HDS	Expedition Car/HDS packing	Ground lime expedition - train	Expedition lime with additive - Car	Expedition palet of HDS – Car/trian
Total production	22500	2105,09	9725	309,64	4425,53	4153,63	25,68	225,70	1168,68	463,24	3389,51
24 hour average	750	324,17	324,17	10,32	147,52	138,45	0,86	7,52	38,96	15,44	112,98

The simulation model is created using the Tecnomatix Plant Simulation tool (Fig.2)

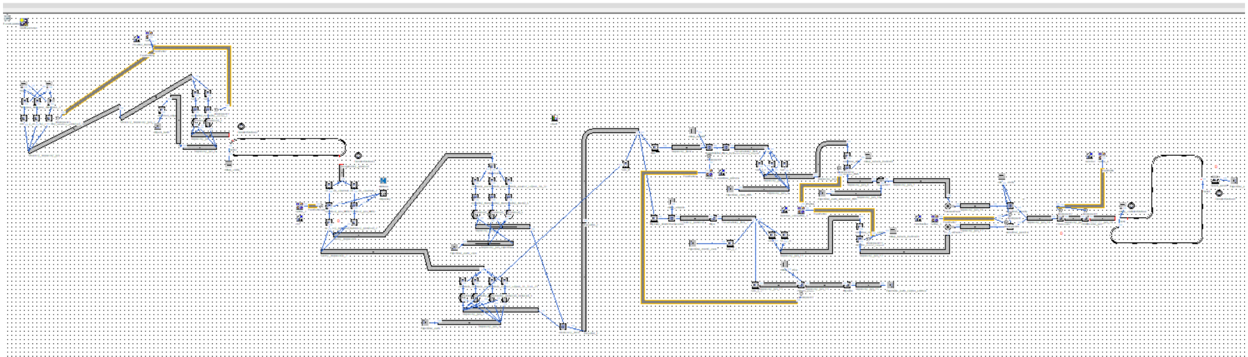

Fig. 25 Simulation model of the production process

For data analysis, we need to have data to such an extent and in such a volume that they are sufficient for further processing and can generate output from this data. For the correctness of the data, we have selected data from a period of one calendar month, which in our case represents 720 hours. From the investigated simulation, the Technmatix Plant Simulation program generated a report, which we have shown in Tab. 3.

Tab. 6 Simulation report before efficiency

Simulation time: 30:00:00:00.0000

Cumulated Statistics of the Parts which the Drain Deleted

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Odpad_Auto	Vápenec_1_triedenie	3:03.8002	1066	1	87.41%	12.59%	0.00%	0.00%	
Expedícia_auto_vlak	Kusové_vápno	18:36.9549	313	0	99.06%	0.94%	0.00%	0.00%	
Expedícia_auto	Vypálené_vápno	3:14:07:02.9391	4253	6	0.06%	0.29%	99.65%	0.06%	
Expedícia_vlak_HDS	Mleté_hydratované_vápno	32.0000	4316	6	0.00%	100.00%	0.00%	0.00%	
Expedícia_auto_zabalené_HDS	Zabalený_HDS	2:52.8000	24	0	86.81%	13.19%	0.00%	86.81%	
Expedícia_mleté_vlak	Mleté_vápno	8.0000	240	0	0.00%	100.00%	0.00%	0.00%	
Expedícia_auto_vápno_aditíva	Vápno_s_aditívami	6:00.0450	1199	2	95.83%	4.17%	0.00%	45.87%	
Expedícia_auto_vlak_palety	Naložená_paleta_HDS	1:37:27.6977	456	1	98.32%	1.68%	0.00%	2.82%	
Expedícia_auto_vlak_palety	Naložená_paleta_Mleté	15:12.7653	3357	5	92.77%	7.23%	0.00%	18.08%	

In the simulation, we compared the data from the individual processes with the real data from the production and determined the degree of accuracy of the simulation data.

Tab. 7 Percentage difference between simulation and real state

	Production - furnace	Expedition Car/train	Expediton - car	Expedition HDS - train	Expedition Train/HDS	Expedition Car/HDS packing	Expedition lime with additive - Car	Expedition palet of HDS – Car/trian
Real data	9725	309,64	4425,53	4153,63	225,68	25,70	463,24	3389,51
Simulation data	9967	313,0	4253	4316,0	240	24	456,0	3357,0
Percentage comparison	-2,49%	-1,09%	3,90%	-3,91%	-6,34%	6,54%	1,56%	0,96%

The data in Table 4 represent the values obtained from the simulation, which was set at 30 days, which represents 720 hours, in order to obtain relevant data usable for comparison with real data. We compared the data generated from the simulation with the data provided to us by the company for processing this work.
Based on the data in Tab. 4 and we worked to compare the data of the real and simulation state of production and shipping, which shows that the simulation model of the production process we managed to simulate with the deviations that are permissible in our case, as it is customer-oriented production. This fact is justified by the fact that the production in the company takes place in the continuous operation of the production plant, but the shipments of material depend on the requirements of customers. Negative numbers show us the percentage expression, by how much we exceed the outputs obtained from the simulation compared to the real values of production and shipping. These deviations will not represent large deviations in the next part of the work. Positive values show the opposite situation, ie by what percentage they exceed the real production and shipping data compared to the simulation ones. When we add these deviation data and make an arithmetic mean of them, we obtain a total deviation of -0.38%.

From all the data obtained from the simulation and the data provided by the company, we can quite accurately identify bottlenecks in the production process. From the data obtained from the simulation, we determined the following places where technological bottlenecks arise. By this term we mean the slowdown of production processes.

We perceive the material flow between the first sorting and the firing process as the first bottleneck. We believe that the transport of material between operations is ensured by an outdated transport system, while its operation is, from our point of view, inefficient in several respects:

1. To ensure the constant operation of the equipment, we need the manpower that must be present when operating this transport system.

2. The transport system can be fatal, resulting in production downtime and high losses for the company due to the fact that the intermediate storage tanks above the kiln have a limited capacity with a holding time in them of approximately one hour of operation.

3. From an energy point of view, this is not a suitable way of transporting raw materials between operations, as this transport system can transport the required amount of material but consumes a large amount of energy. Hammer crusher, where the produced lime is complied with for further processing. In the simulation, it is observable that material from seven forces, with a

total capacity of 5,280 tons, enters the hammer crusher. The hammer crusher can process one ton of material in 1 minute and 30 seconds. After filling the tanks, the hammer crusher blocks or restricts the production process. It would be necessary to replace this crusher with a more powerful and modern crusher, which would contribute to streamlining the entire production process. The second alternative could be to add an identical type of shredder for parallel processing. This would increase the production volume.

Other bottlenecks according to are the vibrating screens 1 and 2, which ensure the initial sorting of the limestone before the actual processing. The above-mentioned sorters sort limestone so that the raw material of the required quality, purity and required dimensions enters the production. Based on previous analyzes and simulation results, we can conclude that replacing these screens with more powerful or efficient screens would ensure continuity of the production process and increase efficiency in limestone processing.

Proposal for improving the efficiency of the production process

To create a streamlined simulation, we need to define which production processes will be subject to streamlining. Based on the analytical part of the work and the bottlenecks listed in it, we need to find equipment that will be suitable for removing bottlenecks. We have a large number of catalogs available in print or online. In these catalogs we can find a vibrating screen and hammer crusher that will meet the technical and technological requirements. After selecting the appropriate equipment, we determine the necessary parameters for setting up the processes to match the technical side for this project. We implement the input information into the simulation in order to achieve the highest possible degree of accuracy of the results. This will achieve the correct simulation outputs that will be generated for us in the final simulation report.

We have selected the following equipment, which should help streamline the production process. We then verify these statements using simulation.

Selected devices:

- LIWELL screen - This screen model is designed for difficult to sort material in all operating conditions.

- Hammer crusher KMR 1220 - which is designed for fine and medium crushing of soft and medium hard materials, such as limestone, quicklime, black coal or lignite.

Subsequently, we can move on to the simulation itself, in which we implement the processes of the hammer crusher and vibrating screen according to the information obtained from the catalogs. Also in the simulation, we will replace the existing obsolete transport system, which we will ensure by transporting the material with an inclined conveyor belt. With such changes in the production process, we would like to make the entire production process more efficient, i. j. from the production of lime to the dispatch of value-added lime, as well as the partial to complete elimination of bottlenecks in the production process.

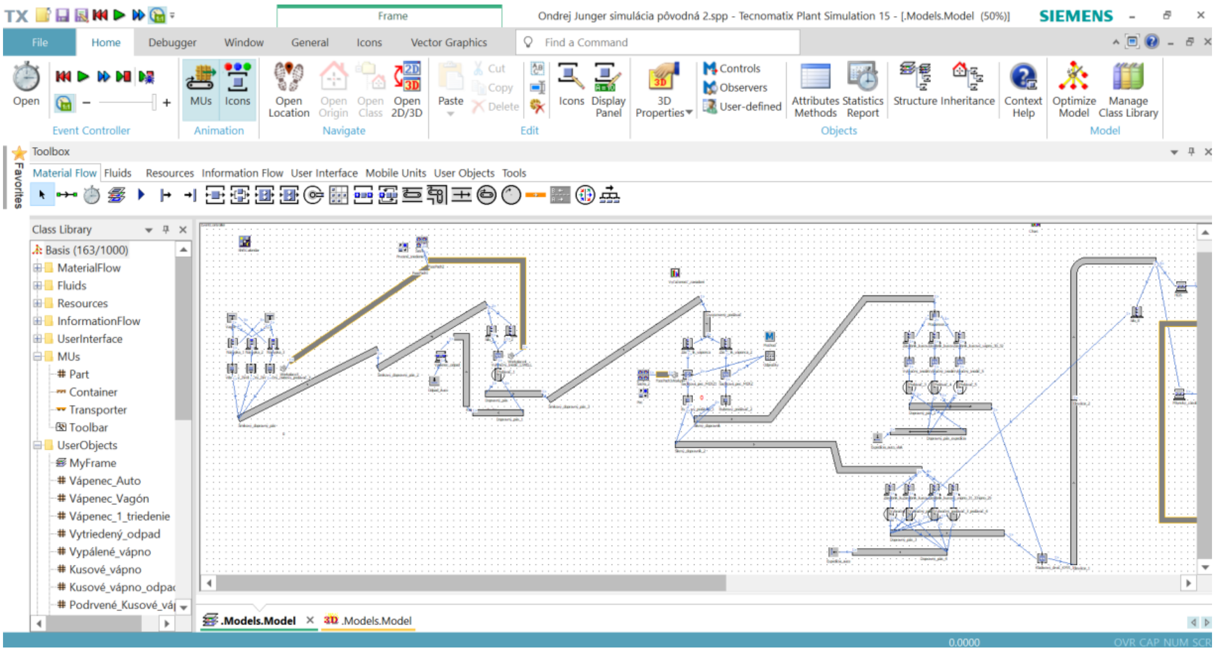

Fig. 26 Simulation in Tecnomatix Plant Simulation after streamlining

After the implementation of all changes, we will check the correctness of the settings of the streamlined simulation and compare the simulation report with the previous simulation and then perform its comparison with the real state of production and shipping. To check the correctness of the removal of bottlenecks, we created a graph of equipment utilization in the Tecnomatix Plant Simulation program.

Tab. 8 Simulation report after streamlining

Simulation time: 30:00:00:00.0000

Cumulated Statistics of the Parts which the Drain Deleted									
Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Odpad_Auto	Vápenec_1_triedenie	2:04.6839	1181	2	81.31%	18.69%	0.00%	0.00%	
Expedícia_auto_vlak	Kusové_vápno	16:11.8407	739	1	98.92%	1.08%	0.00%	0.00%	
Expedícia_auto	Vypálené_vápno	2:08:05:09.6984	4756	7	0.09%	0.03%	99.88%	0.09%	
Expedícia_vlak_HDS	Mleté_hydratované_vápno	32.0000	4857	7	0.00%	100.00%	0.00%	0.00%	
Expedícia_auto_zabalené_HDS	Zabalený_HDS	2:52.8000	27	0	86.81%	13.19%	0.00%	86.81%	
Expedícia_mleté_vlak	Mleté_vápno	8.0000	270	0	0.00%	100.00%	0.00%	0.00%	
Expedícia_auto_vápno_aditíva	Vápno_s_aditívami	6:00.0400	1349	2	95.83%	4.17%	0.00%	45.87%	
Expedícia_auto_vlak_palety	Naložená_paleta_HDS	1:27:30.0052	513	1	97.52%	2.48%	0.00%	3.14%	
Expedícia_auto_vlak_palety	Naložená_paleta_Mleté	13:47.0437	3778	5	92.02%	7.98%	0.00%	19.95%	

For clarity of data, it is necessary to create a simple and well-arranged system, from which we can read and compare data from the original simulation, streamlined simulation and the real state of production and shipping (Tab. 6).

	Manufacture of furnaces	Expedition - car / train	Expedition - car	Expedition HDS - train	Expedition packing HDS - Car	Ground lime expedition - Train	Expedition lime with additive - Car	Expedition palet of HDS – Car/trian
Real data	9725	309,6	4425,5	4153,6	25,7	225,7	463,2	3389,51
Simulation data	9967	313	4253	4316	24	240	456	3357

Simulation after improved efficiency	11519	739	4756	4857	27	270	513	3778

From these values we can read that the equipment designed by us contributed to the increase of production parameters, which sufficiently eliminated the identified bottlenecks in the production process. After comparing the data, it turns out that after replacing the equipment, we could, on a theoretical level, increase production by 18.45% and shipping by 15.02%.

Conclusion

In order to achieve better results in the production and shipping process, solutions must still be sought that will help to improve the efficiency of processes and thus to eliminate problematic parts in technological flows, but also on production facilities. In our case, we have achieved the required elimination of bottlenecks in production by replacing obsolete technological equipment with more technologically advanced and equipment operating with higher efficiency. We achieved this effect by exchanging several components in the process, after analyzing and identifying problem areas from the original simulation. After evaluating the simulation, we decided to innovate the outdated sorting and transport technology for a more modern and efficient one at the first bottleneck identified, thus achieving the set goals. First of all, we achieved a reduction in the number of employees needed to operate the original equipment, which allowed us to use these employees as an auxiliary workforce in the shipping process. At the same time, we have ensured a lower failure rate of the equipment, due to the fact that the new equipment does not need such demanding and regular maintenance compared to the original equipment that it can remain in continuous operation. The new equipment guarantees us the availability of parts for at least ten years. By replacing the equipment, we have ensured a more flexible supply of limestone to the shaft furnace and the time required for the operation of the equipment between individual cycles has also been reduced. The replacement of these devices also ensured higher productivity of the shaft furnace, from the point of view of replenishing the input raw material into the firing process. This eliminated the problems of lack of material in the intermediate storage tank for furnace operation.

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VYUŽITIE ADITÍVNYCH TECHNOLÓGII PRI VÝROBE 3D MODELOV A ICH IMPLEMENTÁCIA DO SIMULAČNÉHO PROSTREDIA

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Abstrakt: Digitálne prostredie sa stalo v dnešnej dobe nevyhnutnosťou pre fungovanie všetkých podnikových procesov. Táto éra vplýva ako na výrobné tak aj nevýrobné sféry podnikových procesov. Nie je novinkou uplatňovanie 3D modelov pri výrobe či prezentácii výrobkov na rôznych trhoch. Pokiaľ chce byť spoločnosť konkurencie schopná musí sa v súčasnosti čo najviac priblížiť zákazníkovi. Digitalizácia je prostriedkom aj v tejto oblasti. Za pomoci digitálneho prostredia môže predávajúci pri rozhovore s kupujúcim veľmi rýchlo v digitálnom prostredí vytvoriť výrobok podľa jeho predstáv, ktorý je zároveň objednávkou do výroby. Príspevok je orientovaný do oblasti tvorby 3D modelov ako produktov tak zariadení na ktorých tieto produkty a ich časti vznikajú. Tieto modely budú následne použité v dvoch oblastiach v rámci modelovania podnikových procesov. Modely sa vo svojej zmenšenej podobe a mierke vytlačia za pomoci 3D tlače. Druhým využitím bude ich implementácia do simulačného prostredia, pre spracovanie čo najvierohodnejšieho modelu výroby, na ktorom bude možné vykonávať transformácie a upravovať ho do čo najefektívnejšej podoby.

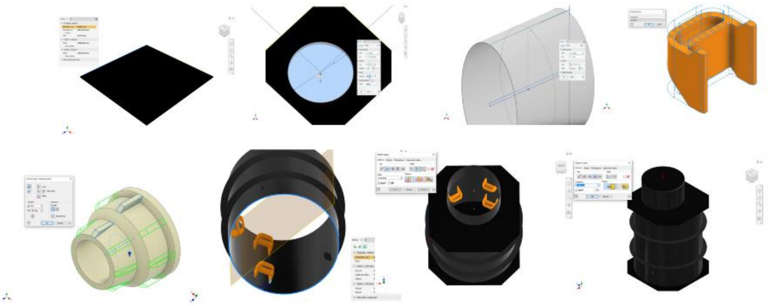
Kľúčové slová: 3D model, 3D tlačiareň, aditívne technológie, simulácie

Úvod

Tento príspevok a jeho téma sa zaoberá simuláciou výrobného procesu v štandardnom výrobnom priemyselnom podniku. V danej práci bolo predovšetkým ako jedným z prvých krokov dôkladne pochopiť materiálový a informačný tok výrobného procesu. Tieto vstupné zozbierané údaje skúmaného výrobného procesu poslúžili k vytvoreniu jeho digitálnej formy. Následne bol konkrétny výrobný proces namodelovaný prostredníctvom využitia 3D prostredia modelovacieho programu Autodesk Inventor. Išlo o všetky entity, ktoré svojím pôsobením zasahovali do tvorby finálneho produktu. Následne sa v ďalšej časti sústreďuje práca k tvorbe simulácie v rozhraní simulačného programu Tecnomatix Plant Simulation spoločnosti Siemens. Kde všetky tieto vstupné zozbierané údaje a počítačom vymodelované 3D objekty boli použité k tvorbe dokonalej replík výrobného procesu v digitálnej podobe. Poslednú časť tohto príspevku predstavuje tvorba tohto výrobného procesu v forme zmenšenej makety využitím technológie 3D tlače a za pomoci aditívnych technológii. Kedy sa všetky 3D modely implementované do simulácie vytlačili prostredníctvom tejto technológie, a pomocou nich sa vytvoril zmenšený model tejto výrobnej haly.

Tvorba modelov pre simuláciu a následnú 3D tlač

Pred tvorbou samotnej simulácie výrobného procesu sme si pomocou počítačového softwaru Autodesk Inventor vytvorili jednotlivé 3D modely súčiastok, polotovarov a zostáv daného výrobného procesu vodomernej šachty. Počas všetkých prác spojených s 3D modelovaním sme zachovali maximálnu autentickosť výsledného produktu z pohľadu materiálov, vzhľadu, rozmerov a výrobného postupu. Pri vytváraní modelov je nevyhnutné na začiatku definovanie materiálu, hrúbky materiálu. Následne sa vytvorili 2D náčrty jednotlivých častí, ktoré sa postupne pretvárali do 3D formátu. Takýmto spôsobom sme si vytvorili jednotlivé diely hotového výrobku, ktorý bude prechádzať transformačným procesom, následne zobrazeným za pomoci simulácie (Obr.1).



Obr. 7 Model produktu a jeho tvorba za pomoci CAD softvéru

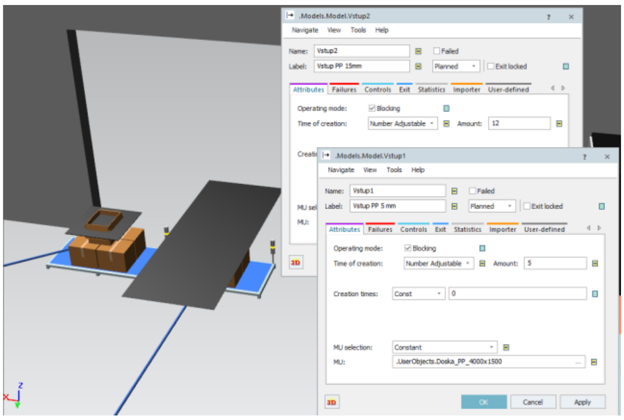
Tvorba simulačného modelu v prostredí TX Plant Simulation

Pre tvorbu simulačného modelu musíme poznať niekoľko základných parametrov výrobného procesu produktu (Tab. 1).

Tab. 9 Základné parameter pre tvorbu simulácie

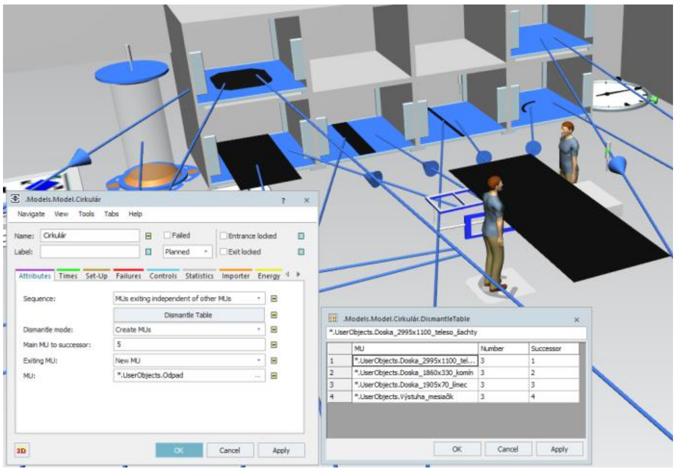
Dĺžka pracovnej zmeny	8 hodín
Počet pracovníkov v linke	10 ľudí
Množstvo vstupov	2
Množstvo výstupov	1
Počet pracovných staníc	13
Počet zásobníkov	10
Počet produktov za zmenu	5 ks

Na začiatku výrobného procesu, ako aj celej simulácie sú 2 vstupy materiálu, ktorými sú 2 druhy polypropylénových dosiek (Obr. 2).



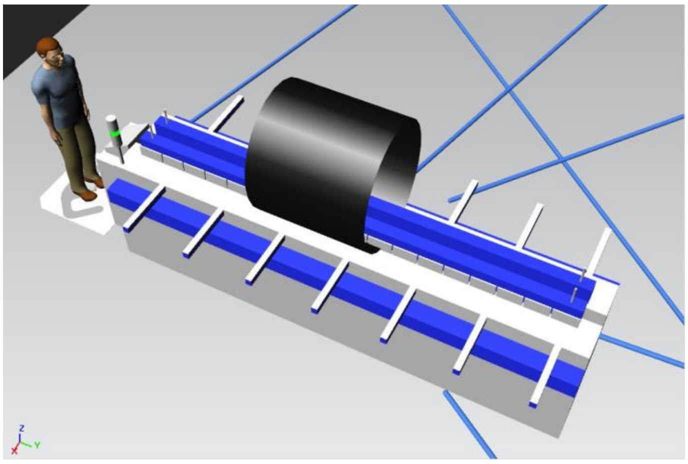
Obr. 8 Vstup materiálu do simulácie

Ďalším krokom v procese výroby je rezanie materiálu na cirkulári. V simulácii môžeme vidieť dvoch pracovníkov obsluhujúcich process rezania vstupného materiálu (Obr. 4).



Obr. 9 proces rezania vstupného materiálu

Nasledujúcou pracovnou pozíciou je pracovisko ohýbania polotovarov plastových dosiek do rotačného tvaru telesa. Toto pracovisko reprezentuje zváračka SP3000CNC. Vstupným materiálom tohto pracoviska je zdroj 3 zásobníkov (Bufferov), ktoré nám naplnilo predošle pracovisko – cirkulár, narezanými doskami. Pracovný cyklus ohybu jedného materiálu bol zvolený na konštantnú hodnotu 20 minút (Obr 4). Toto pracovisko obsluhuje jeden pracovník.



Obr. 10 Ohýbanie materiálu vo výrobnom procese

Materiál pokračuje v transformačnom procese až do poslednej fázy, vytvorenia celkového produktu. Celková podoba simulácie v prostredí softvéru Tecnomtix Plant Simulation je na Obr. 5

Obr. 11 Simulácie celého výrobného procesu v 3D zobrazení

Výroba fyzických modelov za pomoci aditívnych technológii

Pri tvorbe modelu pracoviska výrobnej haly bolo nutné si stanoviť niekoľko bodov:

- Zmenšená maketa výrobnej haly v mierke 1:20,
- Samotný objekt haly vyrobený ručne pomocou plastových profilov,
- Všetky objekty vnútorného výrobného procesu vyrobené prostredníctvom technológie 3D tlače.

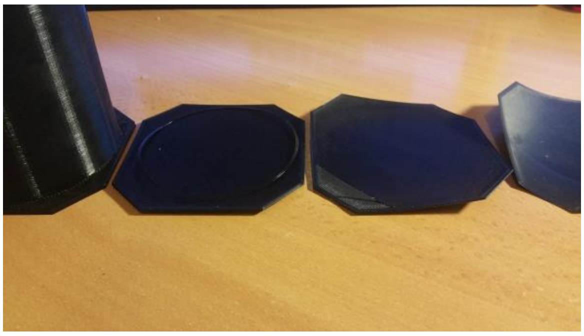
Samotná tvorba modelu výrobnej haly pritom spočiatku vznikla ako vizualizácia jednotlivých vytvorených 3D modelov a 3D modelov zostáv pre naplánovanie si rozloženia layoutu výrobného pracoviska. Tento krok predstavoval naplánovanie si postupu pre nadchádzajúcu 3D tlač a tvorbu, aby boli samotné pracoviská vzájomne správne od seba vzdialené s dostatočným priestorom vôkol seba a pritom nadväzovali schematicky podľa vypracovanej simulácie výrobného procesu a vzhľadovo podľa predlohy reálnej výrobnej haly.

Samotná 3D tlač modelov objektov využitých na pracovisku prebiehala na 3D tlačiarni Anycubic Chiron (Obr. 6). Táto 3D tlačiareň využíva pri tlači technológiu FDM, kedy sa zo vstupného plastového vlákna (filamentu priemeru 1,75 mm) pomocou malého extrúdera a pohybom hlavy tlačiarne s extrúderom v osiach XY a následne po vrstvách v smere osi Z vytvára plastový výtlačok. Maximálne rozmery, ktoré je schopná tlačiareň vytlačiť sú 400x400x450 mm (X,Y,Z). U celého priebehu tlače bola využitá tryska extrúdera priemeru 0,4 mm a rýchlosť tlače od 50 až do 100 mm/s. Ako materiál pre tvorbu tlače boli použité filamenty materiálu PLA. K odmasťovaniu povrchov podložky bol použitý čistiaci prípravok Tangit KS Cleaner.

Obr. 12 3D tlačiareň Anycubic Chiron

Naše všetky 3D objekty vymodelované v programu Autodesk Inventor boli postupne exportované vo vysokom rozlíšení do formátu .STL, ktorý používa tlačiareň. Ako ďalší doplňujúci použitý počítačový software bol Ultimaker Cura. Pomocou tohto softwaru bolo dosiahnuté optimálneho rozloženia tlačených 3D objektov na podložku 3D tlačiarne. Tento software taktiež disponuje možnosťou rozdelenia časti 3D objektov tlačených súborov tak, aby nedošlo pri ich tlačení k zborteniu alebo iným deformáciám vplyvom gravitácie.

Prvým 3D objektom použitým k tlači, bol model vodomernej šachty v mierke 1:10. Pomocou tohto modelu prebiehala kalibrácia podložky. Po kalibrácií podložky sa opakovaným tlačením tohto modelu hľadali takto aj optimálne rýchlosti pohybu tlačovej hlavy a teploty podložky, aby nedošlo k rôznym deformáciám výtlačku počas celého procesu tlačenia. V rámci tohto procesu vznikali aj rôzne nepodarky výtlačkov až po dobu, kedy sa tlačiareň podarilo vyladiť na optimálne parametre, ktoré boli následne využité pri tlači všetkých ostatných modelov.

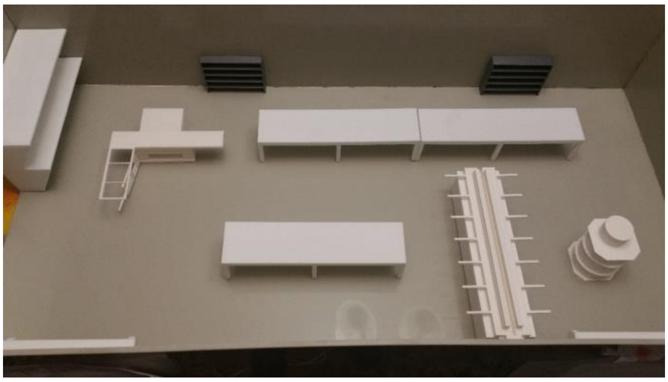


Obr. 13 Prehľad fáz nepodarkov počas postupného ladenia nastavení 3D tlačiarne

Postupne boli vytlačené všetky objekty (Obr.8), ktoré sa predtým využili v 3D simulácii do fyzickej podoby. Po správnom vyladení parametrov tlače už nedochádzalo k tlači nepodarkov a postupne sa podarilo vytlačiť všetky namodelované súčasti ako haly, tak aj častí hotového produktu.

Obr. 14 Tlač modelu zváračky

Celkovo bol vytvorený celý fyzický model výrobnej haly viditeľný na obrázku 9.



Obr. 15 Pohľad zhora na rozloženie modelu výrobnej haly

Záver

Príspevok poukazuje na interdisciplinaritu odboru priemyselného inžinierstva. Ako je viditeľné je využitá oblasť modelovania a tvorby 3D modelov, ktoré sú bezprostredne prepojené do oblasti simulácie a následne tieto modely boli vytlačené na 3D tlačiarni a za pomoci aditívnych technológii sa vytvoril zmenšený model celej prevádzky, ktorá bola predmetom príspevku. Simulačný model je ďalej možné premietnuť za pomoci súčasných technológii do virtuálnej a zmiešanej reality. Nová verzia softvéru Tecnomatix Plant Simulation ponúka možnosť virtuálnej prehliadky po doinštalovaní aplikácii spojených s fungovaním prostriedku na premietanie a ovládanie vo virtuálnom prostredí.

Poďakovanie

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THE RELATIONSHIP BETWEEN INTEREST RATE CHANGES AND STOCK RETURNS – EVIDENCE FROM THE GERMAN STOCK MARKET

Jakob ROHNER - Martin UZIK - Sebastian BLOCK

Abstract: In most industrialized nations, sustained demographic shifts, global excess savings, and a slowdown in productivity development have contributed to a global decrease in real interest rates over the previous 20 years. Coupled with accelerating inflationary developments, individuals need to invest in equity markets to maintain the buying power of their funds. Missing insights regarding the influence of this new macroeconomic environment on stock markets and varying results by scholars create a starting point for further analysis. To better understand the relationship between interest rate changes and stock returns the author regresses the changes of the closing price of the DAX30 index on the changes of a 10-year German government bond yield between 2000 and 2020.
The results contrast with the findings found throughout academic literature and indicate that the broadly accepted notion of a negative correlation between interest rate changes and stock returns is not valid for all economic regions.
Keywords: Low-interest rate environment, Stock markets, OLS regression analysis

Introduction

The global macroeconomic environment has evolved dramatically in recent decades, posing considerable challenges to monetary policymaking. In most industrialized nations, sustained demographic shifts, global excess savings, and a slowdown in productivity development have contributed to a global decrease in real interest rates over the previous 20 years. (Laubach & William, 2003; Holsten, Laubach, & Williams, 2017).
This development has enormous implications for individuals, especially in Germany, who have been holding large amounts of money in interest-bearing assets whose profitability has been hit hard due to accelerating inflation rates. To counter that development private individuals, need to find a way to earn a return on their funds. However, with an investment into interest-bearing assets with adequate returns becoming hard to come by, Bell (2020) and Panwar & Aggarwal (2018) conclude that more volatile investments seem to be the only alternative.
This being the reality for most individuals, the value of insights regarding the potential influence of the current interest rate environment on stock markets is substantial. Accordingly, this research aims to investigate the relationship between interest rate changes and stock returns.

Literature Review

General Association between Interest Rates and Stock Markets

Given its crucial importance in several major areas of finance, including asset allocation, risk management, risk diversification, and monetary policy transmission, the relationship between interest rate changes and stock returns is an unquestionably relevant topic in the financial literature (Benigno, 2016). The first channel through which interest rates influence stock returns is portfolio rebalancing (Benigno, 2016). For example, as yields of bonds decline, investors may start to shift their funds into the stock market in search of higher returns, thereby increasing demand and thus stock prices. The reverse effect holds as well. Secondly, interest rates also influence the discount rate used in standard equity valuation models like the NPV-calculations, directly affecting share prices (Chen & Hu, 2015; Benigno, 2016). Thirdly, interest rate fluctuations change companies’ capital cost, most notably those with high leverage, thus influencing expected future cash flows (Benigno, 2016). Fourth, the demand of heavily indebted consumers will also be affected and potentially decrease corporate profits and hence share prices.

Implications of Interest Rate Changes on Stock Markets

Two separate analyses by Modigliani (1971) and Mishkin (1977) find an overwhelming number of studies that indicate a negative relationship between interest rate and stock returns. Following their results, a decrease in interest rate leads to an inflow of capital into the stock market and increased expected returns. On the other hand, an increase in interest rates causes the complete opposite – cash outflow of the equity market and an increase in savings. Further studies by Pearce and Roley (1985) and Hafer (1986) conclude that equity prices and the discount rate have a negative coefficient confirming previous research results.

Spiro (1990) analyzed the impact of interest rate changes on stock price volatility. His findings show a clear dependence of the movements of stock prices, in particular, the S&P 500 index, to fundamental economic variables – the GNP and the real interest rate. The latter, according to Spiro (1990), “is responsible for most of the excessive short-term volatility of stock price indexes” (p. 68). At the same time, he states that no one would predict precise turning points in the development of the interest rate. Fundamental analysis may provide an expected average value which may be used for predicting broad trends in stock prices.

Other scholars, including Mukherjee and Naka (1995), focused their evaluations on the relationship between long-term interest rates and stock returns and concluded that long-term interest rates especially have negative implications for the stock market. These findings were confirmed by Zhou (1996), who used regression analysis for his investigation into a potential connection between interest rates and stock market returns. He was also able to prove a significant impact on stock returns, especially for longer periods. Furthermore, Zhou’s results show that long-term interest rates explain a major part of the variation in price dividend ratios and hint towards a connection between stock markets’ high volatility and long-term bond yields. According to Zhou, the high volatility may be a direct result of changing predictions regarding discount rates.

Another scholar who dealt with the matter was Lee (1997), who conducted a three-year rolling regression to analyze the relationship between the short-term interest rate and the stock market. His findings changed relative to the timeframe that was investigated. He recognized a change from a significantly negative relationship to no relationship and eventually even a positive although insignificant relationship in his chosen timeframe. Accordingly, no clear connection or pattern was discovered.

Harasty and Roulet (2000) conducted a more wide-ranging analysis of 17 developed countries. Their results proved a correlation between stock prices and the long-term interest rate, among other factors in each country. Except for the correlation analysis of Italy, where the short-term interest rate was used due to data availability, the negative correlation between the two variables could be proven.

Zordan (2005) executed a historical analysis of the relationship between stock prices and the interest rate. The inverse correlation may be observed back into the 1880s and more prominently following the Second World War. From the late 1940s to the 1960s, while the inflation and interest rates were both low and stable, stocks could perform well. The phenomenon has been observable throughout history and puts a stronger emphasis on its importance and meaningfulness.

Benigno (2016) has conducted one of the most wide-ranging analyses regarding the relationship between interest rate changes and stock market returns for European countries. The findings indicate “considerable heterogeneity across countries regarding the stock market-interest rate nexus” (p.12). The reasons mentioned include “the level of indebtedness of the economy, the relative weight of the sectors most interest-rate sensitive” (p.12), and the resulting interest rate sensitivity. The results indicated a weak but positive relationship between interest ratechanges and stock returns for more developed countries in Europe.
Eldomiaty, Saeed, and Hammamm (2020) set out to analyze the effect of the inflation rate and theinterest rate on stock prices. They used quarterly data of non-financial firms for the DJIA30 and
the NASDAQ100 from 1999 through 2016 to analyze the effect. Their empirical findings reveal a
“significant association, in terms of cointegration and causality” (Eldomiaty, Saeed, and Hammamm (2020), p.157) between stock prices and changes in stock prices due to real interest rates and inflation rates. However, their findings contradict their previously analyzed literature. The empirical results indicate a negative coefficient between the inflation rate and the stock price but a significant positive correlation between the stock price and the interest rate. This result contradicts most findings of similar studies.
Concluding, early research in this area found a strong negative association between interest rate changes and stock returns in both financial and non-financial firms (compare further studies by (Flannery & James, 1984), (Dinenis & Staikouras, 1998), (Lynge & Zumwalt, 1980), (Prasad & Rajan, 1995), and (Sweeney & Warga, 1986)). However, following the analysis by Benigno (2016) Eldomiaty, Saeed, and Hammam (2020) regarding various studies covering the research topic and especially referring to Lee (1997), and more recent studies from Czaja, Scholz, and Wilkens (2009), Korkeamäki (2011), and Reilly, Wright and Johnson (2007) concluded that the relationship between interest rates and stock returns changes over time. The significance of their relationship may vary over time as well. Lee’s (1997) results have shown that “stock returns are becoming increasingly insensitive to risk-free rates” (p. 151). This development creates a starting point for future research. An empirical analysis of more current interest rate developments and their implications for the stock market may be used to investigate this development.

Empirical Analysis

An analysis will be conducted by regressing the changes of the adjusted closing price of the DAX30 index on the changes of a 10-year German government bond yield between 2000 and 2020. The choice of a 10-year government bond as a proxy for the interest rate has become increasingly popular following Bruner et al. (1993), and recent studies by Ballester, Ferrer & González (2011), Elyasiani & Mansur (1998), Faff, Hodgson & Kremmer (2005), and Oertmann, Rendu & Zimmermann (2000). The data is derived from Refinitiv DataStream.
The first logarithmic difference of two consecutive data points is used to calculate both stock returns and interest rate changes. For the 10-year government bond of Germany, a constant of one has been added to the yield to enable the use of the natural log as the yield level enters the negative realm. This is in line with other previous research conducted by Al Mukit (2013), Uddin & Alam (2007), and Benigno (2016).
The daily returns/changes are calculated from the daily closing prices as follows:
$R_t = ln\ (P_t / P_{t-1})$
where,
R_t = market return at period t;

P_t = price at period t;
P_{t-1}= the price index at period t-1
ln = natural log.

Empirical Results

Tab. 1 Regression Results DAX30 Index: 2000-2020

Model	*Coefficient*	*t-Stat*	*R^2*	*F-value*	*Significance F*
Constant	0.0003%	1.39	0,11***	690.66	0.00
Interest Rate Changes	12.18%***	26.28			

Note. *Results are significant at 0.1 *, 0.05 ** and 0.01 *** levels.*

The results, as depicted in Table 1, show a statistically significant positive relationship between the stock returns of the DAX30 index in Germany and the yield changes of a 10-year German government bond. Interest Rate changes predicted stock returns, R^2 = .11, $F(1, 5399) = 690.66$, $p < .001$ By studying the positive coefficient and the R^2 value, one is quick to notice the positive relationship, which states that for every unit increase in interest rate, the DAX30 index is, on average, going to gain 12.18%. The opposite holds as well, with a decrease in interest rates causing a drop of 12.18% on average. The relationship between the two variables is significant at an R^2 value of 0.11, indicating that changes in interest rate may explain 11% of changes of the DAX30 index.

Interpretation of Results

The empirical results contrast with the commonly found notion in the widely available academic literature. The positive coefficient of the regression analysis for the DAX30 states that an increase in interest rates favors the development of stock returns in the long term. The relationship, however, also implies that if there was a decrease in interest rates, stock markets are on average losing value. Moreover, the gathered results confirm previous analysis by scholars, such as Benigno (2016), who analyzed the connection among other countries between Germany and a ten-year government bond yield. The scholar’s findings indicated a small but statistically significant positive correlation between the two variables. What does such a relationship imply? It means that Germany’s economy represented by the largest public companies is less interest-rate sensitive than the literature would suggest. Following the analysis of other European countries by Benigno (2016) of European Countries such as Greece, Spain, Italy, or Ireland that were more severely hit by the European Sovereign crisis, the importance of the factor of a country’s indebtedness level becomes more pronounced. The previously mentioned countries were far more interest-rate sensitive and showed more expected results as described in the literature. Likewise, other scholars investigating less developed countries gained similar results, e.g., (Jefferis & Okeahalam, 2000), (Arango, Gonzalez, & Posada, 2002), (Uddin & Alam, 2007), (Teitey, 2019), (Al Mukit, 2013), and (Amarasinghe, 2015). Furthermore, the number of interest-rate-sensitive sectors within the analyzed index plays a crucial role in understanding the relationship (Benigno, 2016).

Statistical Significance Versus Economic Significance

After interpreting the results from a statistical standpoint, it needs to be considered what real-life implications are derived from the results. First, it needs to be noted that the explanatory power of the regression with the DAX30 index is at 11%, meaning that several other factors apart from interest rate changes influence the index returns. Additionally, the derived coefficient states that for the index between 2000 and 2020, a one percent increase in interest rates causes a rise of 12,18%. A more than 10% change would be an extreme movement for a diversified index such as the DAX30. To understand whether those are meaningful insights that are applicable in real life, they need to be put in relation to the actual interest rate changes observed in the respective period. With the average change per day as displayed within the following figure being rather small, the author suggests looking at the maximum values of each period to derive the magnitude of possible daily deviations, which may be then used by multiplying them with the coefficient to derive the greatest possible changes in stock returns caused by interest rate volatility. The calculation is conducted as follows:

Maximum daily stock reaction = *C* * maximum daily change observed at t_x * 100
Average daily stock reaction = *C* * average daily change observed at t_x * 100
where,
C = Coefficient of variable

Tab. 2 **DAX30 – Test for Economic Significance of Regression Results: Yearly Analysis**

period	*coefficient*	*aver. daily deviation in yield*	*aver. daily stock reaction*	*max. daily change in yield*	*max. stock reaction*
2020	14.63%***	-0.0015%	-0.022%	0.20%	2.97%
2019	7.63%***	-0.0017%	-0.013%	0.10%	0.77%
2018	7.90%***	-0.0007%	-0.006%	0.11%	0.89%
2017	4.37%***	0.0008%	0.004%	0.12%	0.54%
2016	8.73%***	-0.0016%	-0.014%	0.14%	1.19%
2015	6.68%***	0.0004%	0.002%	0.20%	1.34%
2014	13.35%***	-0.0054%	-0.072%	0.08%	1.08%
2013	3.71%***	0.0024%	0.009%	0.13%	0.50%
2012	13.14%***	-0.0020%	-0.026%	0.15%	1.94%
2011	19.43%***	-0.0043%	-0.084%	-0.29%	-5.61%
2010	14.57%***	-0.0017%	-0.024%	0.16%	2.38%
2009	15.21%***	0.0017%	0.025%	-0.29%	-4.39%
2008	11.80%***	-0.0054%	-0.064%	0.20%	2.40%
2007	1.14%	0.0016%	0.002%	0.11%	0.13%
2006	-0.50%	0.0025%	-0.001%	0.10%	-0.05%
2005	-0.06%	-0.0014%	0.000%	0.11%	-0.01%
2004	0.01%	-0.0023%	0.000%	0.12%	0.00%
2003	21.26%***	0.0004%	0.008%	0.19%	3.96%
2002	37.80%***	-0.0030%	-0.112%	0.11%	4.12%
2001	13.66%***	0.0005%	0.007%	0.21%	2.82%
2000	2.02%	-0.0022%	-0.005%	0.12%	0.24%

Note. *Results are significant at 0.1 *, 0.05 ** and 0.01 *** levels.*

As Table 2 summarizes for the DAX30 index, the results from the regression analysis have a limited economic significance. When considering the observed daily changes in interest rates between 2000 and 2020, one is quick to notice that only minor changes may be observed on average. The effect of these changes on the index following the derived coefficient from the regression analysis is minor. However, when studying the maximum relative changes, a more pronounced effect may be noted. Given the huge difference between average changes and extreme outliers, the likelihood of those extreme values appearing is rather small. Accordingly, on a yearly basis, one must conclude that the obtained values have little economic significance. The deduced low economic significance suggests that the direct effects of interest rate changes are significant but do not happen regularly in a magnitude big enough to have serious implications. Coupled with an explanatory power of the interest rate changes of 11% for the DAX30 index, interest rate changes are one of many factors that need to be monitored but not the deciding one for Germany.

Discussion of Research Approach & Further Research

A profound literature review and an empirical analysis were conducted to answer the research question of how interest rates affect stock returns. The type of analysis chosen - OLS - is a suitable method for researching the linear connection between two variables. However, other scholars have noted that when OLS analyses attempt to push beyond the mean value or toward the extremes of a data set, it loses some of its value. The complexity of the relationship between interest rates and stock returns has specific characteristics that may be difficult to study using OLS techniques (Benigno, 2016).

Other scholars have frequently applied the selected model, as demonstrated throughout the literature analysis (Al Mukit, 2013; Benigno, 2016; Uddin & Alam, 2007). However, the findings for Germany are not congruent with the results for other economic regions such as developing countries. This emphasizes understanding the dependencies of each economic region. As Nasseh and Strauss (2000) argued for the dependence of other countries in Europe on Germany's economic developments, a similar scenario may be thought of for Germany. As an export nation, the dependence on other countries' economic conditions like the United States or the Republic of China may also be influential and worth analyzing.

Furthermore, it would be interesting to understand how the effect of another interest rate – stock market combination behaves over a longer period. Especially, the countries which have higher indebtedness levels would be interesting to analyze. In that process, one may also investigate the indebtedness level of a country where the interest rate changes become more significant compared to less indebted countries like Germany.

Concluding Remarks

While confirming the findings of other scholars regarding the economic region of Germany, the results contrast with the broader results found throughout academic literature. The results have shown that the broadly accepted notion of a negative correlation between interest rate changes and stock returns is not valid for all economic regions. As other scholars have mentioned, the indebtedness of a country, for instance, or the overwhelmingly represented sector within the evaluated stock index of the respective region are factors to consider in this model.

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