Abstract

The paper presents a part of lean assembly design tool created for the new Lean laboratory. Whole application created in the excel enables sequentially elaborate main design phases from product analysis to standard work sheet creation. Two presented phases - system characteristic definition and workstation concept design are interconnected together. The result from the first presented module is assembly system lay-out e.g. physical and organizational arrangement and the second module elaborates every workstation in detail.

Key words: lean assembly, Microsoft excel

INTRODUCTION

The concept of Lean Manufacturing is based on the need to identify and eliminate the wastes, which arise in the production process. This concept is of course implemented also in the assembly processes where essentially go about elimination of ineffective movements and manipulation, waiting time, anywhere over-activities, high supply and over-production. The further priority is the transport and product quality, i.e. transport optimization and faulty product elimination. For this purpose can be used lot of methods and tools, which support the Lean Assembly concept, respectively are in this concept used. In assembly it is necessary to solve various problems e.g. assembly sequence which can by very variable and complicated and there also can be used various tools as it is described in [1]. Or divide assembly process at many operations, which must take the same time to be performed due to cycle tact and so on. Lot of these problems can be solved by using special software tools. Some of these software tools can be bought as a complex solution which cover specific assembly planning activities or can be created by yourself e.g. in Microsoft Excel or any other application. Despite the undisputed asset of these software tools sometimes it is very useful to use real conditions which can be achieved at real workstations only. To make experiments and testing various ideas in manual assembly area with considering concept Lean was build a Lean assembly laboratory at the authors workplace.

LEAN MANUAL ASSEMBLY LABORATORY

Lean Assembly laboratory (Fig. 1) is designed to solve the problems of manual assembly of the products respectively sub-assemblies of small and medium complexity with using of the lean production methods and tools. The proposed concept [2] allows to design and implement the manual assembly process by comprehensive way from the product analysis to the assembly at the workstation respectively workstations with using a lot of methods and tools of so called lean concept. Basically the methods and tools are designed so that it is possible:

- to connect the so-called virtual design with the real assembly in the laboratory,
- to apply integrated and interconnected lean assembly methods,
- to apply the each method also individually,
- in the dependence of the accessible data to use variety input types,
- to compare obtained results in the virtual and experimental phase.

Concept of lean manual assembly design toll

The assembly process design begins in the first phase by assembled product analysis. This analysis is possible also in the case that the input is only 3D model of the product. The analysis procedure obtains the product decomposition and analysis of several product parts as well as product subassemblies identification i.e. it is oriented to the product structure. The important part of this analysis is the decision if will be the subassemblies assembled within the, so-called final assembly or not.

The analysis of the assembly operations is a process of assembly operations identification that must be performed. Integral part of this analysis is operation basic classification and identification of
design conditional relations between the operations, which affects to the possible operation sequence variants. In the case of several possible assembly sequences existence is in this phase needful to select one assembly operation sequence. This sequence will be further performed.

In the phase of assembly procedure design is the base performed product analysis and the sequence of assembly operations. The assembly procedure joint together the product structure i.e. parts, components and subassemblies with assembly operations i.e. activities which must be performed and represent this by standardized graphic manner.

In the next procedure it is necessary to identify the system characteristics of the manual assembly workstation respectively workstations as for instance the degree of assembly operation concentration on one worker or expected cycle time. [3] In the case of several assembly workstations it is also necessary at the base of assembly procedure to assign the assembly operations to the separate workstations and in the case that are assembled also the sub-assemblies it is necessary to decide if their assembly will be integrated into the final assembly or not.

In the next part of the procedure it is needful to create workstation respectively workstations layout. In this case is available detailed laboratory 3D model that can be in this still virtual phase used. If is needed other workstation it is possible to proceed so, that the existing workstation will be supplemented or will be created a different one by using of special software respectively configurators as is for instance MTpro or will be designed own new proposal. It also includes arrangement of containers, tools, instruments and other equipments.

This workstation respectively workstations 3D model is the base for the ergonomic analysis that is available in some CAD software. For instance in the Catia software it is possible to realize the RULA posture analysis, push-pull and lift-lower analysis and other.

The last module in the part of the virtual phase is assembly time calculation by some predetermined motion time systems as MTM - Method Time Measurement. At this data can be defined also the assembly process efficiency factor as a ratio of effective and non-effective times. By assembly procedure or workstation lay-out change can be also changed this efficiency factor. If there are several proposal of the same assembly workstation this factor can be one of the criteria to optimal variant selection.

After ending the virtual phase we can go to the experimental phase. At this stage it is necessary stepwise to realize the assembly in the lean assembly laboratory and also to use several methods. Each of the described method can also be used individually and it is not necessary to realize whole experimental design phase. The first method is to develop a process map which gives detailed instructions to the worker including variants in the case of decision-making situations and also to identify the process type – for instance the dividing into effective or non-effective processes.

In the laboratory is implemented Pick to light system based on sensing of the hand presence in the container with the parts. The integral part of the experimental procedure is definition, setting, using and result data analysis of the pick to light system.

The video analysis is a method which on the base of captured video enables to obtain detailed data about time characteristics of several activities at the workstation. In dependence on applied classification system can be the analysis detail for instance according to MTM or according to assembly operations which can serve as an input for the YAMAZMI diagram.

Time measuring is a standard time measuring at the workstation. The prepared excel module enables to measure and evidence the real time by mouse click.

In the final phase it is possible to crate so-called Standard process worksheet as an output that define as well as detailed assembly procedure and time data and characteristics.

MODULES OF THE LEAN ASSEMBLY DESIGN TOOL

Presented concept of the lean assembly design consists from 16 modules arranged to three main phases mentioned above. The modules workstation 3D model design and ergonomic analysis are elaborated in selected CAD system. The other modules are processed as an Microsoft excel application. Whole excel application was proposed and elaborated under following conditions:

- each excel module can be used separately
- for some modules can be selected various inputs
- the result from one module can be an input for the next one.

Developed modules are in testing use. Two from developed modules offer combination of numerical and graphical functions for simplified system and station layout based on graphical icons. These modules are described below.

Module for system characteristics definition

This module summarize main product characteristics as number of parts in the product, number of product variants, product size,
production volume together with characteristics of the assembly procedure as final product and subassemblies operation sequence, proposed cycle time, assembly operation concentration, etc. These main characteristics affect on the basic assembly workstation or assembly system structure. The excel application enable to summarize and to create some assembly workstation or system variants. Because this excel application is dedicated for the lean laboratory the whole analysis toll are adapted to this conditions.

**Module for workstation lay-out concept creation**

This module for creating of the workstation lay-out combines the parts and subassemblies list obtained from previous analysis with possible technical means which are available. [4] Technical means was drawn in approximately measures as simplified icons. In the excel application was created special drawing template for lay-out concept design. In this way can be created and changed detailed workstation lay-out. The Fig. 2 presents a part of the predefined icons template which can be used by usual way – copy, rotate, move, etc. Workstation lay-out can be quickly created and easy changed without a need to use CAD system. The result lay-out is transparent and corresponds to the real conditions. In the lean assembly laboratory will be used repeatedly. The Fig. 3 illustrates the workstation lay-out design.

**Fig. 2** The template of workstation design in excel – front view

**Fig. 3** Example of assembly workstation lay-out design in top view
CONCLUSION

Results obtained from particular excel applications indicate that this way of assembly workstations and assembly workshops design can be very helpful and productive. Also connection among modules allows to made design process more effective and precise. Because developed modules are in Microsoft excel which is widespread it is easy to distribute and use these modules.

REFERENCES

[1] Suszyński, M., Ciszak, O., Żurek, J., Metodyka ustalania kolejności montażu z użyciem hipergrafu, grafu skierowanego i macierzy stanów, Archives of Mechanical Technology and Automation, 2009, Vol. 29, Nr. 4, Art. 10, ISSN 1233-9709


This contribution is the result of the project VEGA 1/0879/13: Agile, to the market adaptable enterprise systems with high flexible organization structure.