STANOVENÍ OPTIMÁLNÍHO POČTU OBSLUH STROJE

DETERMINATION OF OPTIMAL COUNT OF MACHINE OPERATORS

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Abstract

Decreasing or entirely eliminating all kinds of waste within production systems is one of the main goals of today´s industrial companies, especially automotive. Taiichi Ohno firstly categorized all kinds of waste. The contribution attacks one of the most precious resources – time and deals with the issue of planning of workers while operating on injection molding machines. The process of operating on these machines shows several specifics and issues. The contribution represents basically the case study how to streamline whole system and spare significantly headcount.

Key words

Workload, lean, production, automatization, injection molding, Automotive, Industry

Introduction

The project was carried out in an automotive company in the Czech Republic, specifically at the department of injection molding machines. The principle of production process is simple. Semi-automatic machines have its own magazines which are fed by plastics granulate. Plastics granulate is heated up to a certain temperature and melted. As soon as granulate is completely melted it is injected in to the injection molding die where the product gains its final shape [5]. The project deals only with machines, which does not have to be fully operated because the machines are partly or fully automated. Workers only put final products in to the box. In other words operating on these machines includes only products packing [1,2]

The main goal is to create a worker planning algorithm because of fact that there has not been established any algorithm or guidance how to determine the amount of workers operating on a certain group of semi-automatic injection molding machines. Therefore, the foreman who does the worker planning does not precisely know how many workers he needs for production on pre-specified machines.

There were several sub-goals defined within the project. Firstly, to standardize all operations at specified injection molding machines, secondly, to suggest and implement an algorithm to plan work machine operators compatible with current production planning system [4]. The system has to be also described in detail to be easily understandable and could be further developed in the company.

Project solution

The project was specified by the company management very widely. Already out of the initial study were identified several facts which made whole solution much more complicated. Those facts are stated below

- The machines are deployed around two production halls with distances up to 200 meters

- Some of machines are directly connected to the production line (then the worker just checks the machine and do the regular quality inspection)
- The cycle times are between 21 and 52 seconds.
- The multiplicities of the forms are between 1 and 8 products.
- The minimal conveyor capacities are around 5 minutes and the maximal are around an hour
- The activities cannot be fully standardized by Basic MOST because of additionally works which had to be made be due to poor quality (machine settings, old injection dies, etc.)

The solving approach was defined as follows [3]

1. Firstly to identify and categorize all possible activities which must workers perform
2. Then standardize all (by using Basic MOST)
3. Then define all distances between injection molding machines
4. Identify and evaluate conveyor capacities corresponding with production
5. Do the database with all data need to determine algorithm
6. Suggest manual algorithm to determine amount of workers
7. Evaluate algorithm – pilot project
8. Automatize the algorithm

Identification and standardization of operation
All activities that must be carried by the workers were identified. These activities were categorized in two groups. First group represents activities which must be performed during each cycle (Cycle activities). E.g. packing of the final products, visual inspections, additional processing (if necessary) and switching start button. The second group represents activities which do not have to be (or even cannot) be performed during each cycle. Therefore these are performed once a time interval (interval activities). E.g. handling with final products, raw material and empty boxes, quality issues, cleaning of the injection molding form (e.g. by pressure air or steel rod), etc.
All of these activities were standardized by using Basic MOST. Sheet of Basic MOST contains also summation characteristics of interval and cycle operation to be easily usable.

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Definition of all distances between injection molding machines
There were 14 machines selected with average distances of approximately from 20 to 200m. All distances were measured and the transitions times were settled down by using Basic MOST. Distances serve also as the lean tool for evaluation of distance between machines. It clearly shows waste amount caused by too long transfers.

Identification and evaluation of conveyor capacities corresponding with production

There were identified and evaluated capacities of all conveyors connected to the automatically injection molding machines corresponding with specified type of production. It has been defined that capacities of several conveyors are not big enough to plan multi-machine operating. Therefore, cheap and simply solutions which aims to increase the capacity of conveyors were suggested. E.g. change of product stacking, conveyor enlargement, box or slides behind the conveyors or combination of solution showed above.

Not every solution can be implemented for any production. There were defined restrictions such as quality issues and products surface (the product cannot be scratched), ergonomics issues worker friendly environment, economic issues cheap solution, technical and technology issues.

Appropriate capacity of conveyor is crucial for worker planning as will be shown in the following text. Snapshots of operations by machines showed that time of product stocking is shorter than the time of product processing. That simply means that the worker is faster than the machine and therefore his potential is not fully used.

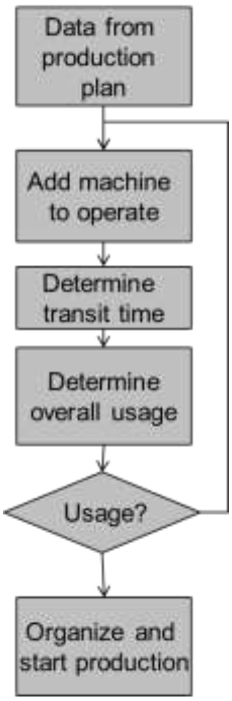
Database with all data need to determine the algorithm

There was created a database with corresponding characteristics for each production and machine. There were measured several characteristics such as: Cycle time, multiplicity of the form, conveyor capacity, operation lengths, duration of quality issues and percentage of workload –usage which shows the amount of workload of selected worker who operates only on one machine. Worth highlighting are lengths of filling and stocking conveyor. Its difference tells us for how long can worker leave the machine.

Manual algorithm to determine the amount of workers

There was suggested preliminary algorithm, its description is stated below in the table 1.

Table 1: Manual algorithm

Algorithm	Description
	Select and insert data coming out of the production plan in to the algorithm
	Select one, two, three of four machines and corresponding material number and assign the to the worker
	Determine transit times between machines (automatically based on selected machines)
	Determine overall usage (composed by sub-usage at each machine and transit times)
	Decision Block tells us how high is the usage? < 50% add machine; 50 – 80% add machine; 80% - 90% aim; > 100% remove machine.

Algorithm evaluation

The algorithm was firstly manually proved. There have been selected two ongoing production which are operated by two workers (each operating at one machine) in the current state. There were chosen specific production first one produced view-parts that means products should not fall on to the ground or even touch each other to avoid the risk of any scratches. The second one produce parts witch significant amount of additional work. The products are stacked on the continuous conveyor (not stepper one which is significantly slower) this fact also increased requirements on operator. The algorithm tells us one worker should be able to handle both machines. Therefore there were organized pilot project which aims to confirm or disprove the whole idea of algorithm.

The first aspects which proved the algorithm especially the time of stacking defined by Basic MOST was comparison between times defined by Basic MOST and measured times in production See table 2.

Table 2: Comparison between times

Description	KM27	KM29
Average stacking time for 5 pcs – defined by observation	33	13,5
Average stacking time for 5 pcs – defined by Basic MOST	31,35	12,2
Difference	1,65	1,3

The second group of aspects was time characteristic belonged to whole working cycle by operating both machines. There were mainly proved three aspects

- Operating times on the both machines
- Transition times between machines
- Times of filling of the conveyor

The table 3 below shows comparison between times measured and times used in algorithm determined by Basic MOST.

Table 3: Pilot evaluation

Average time of operation on the machine 1	
Measured	4:38 min
Basic MOST	4:52 min
Difference	0:15 sec
Average time of operation on the machine 2	
Measured	8:13 min
Basic MOST	5:16 min
Difference	2:57 min
Average transition time	0:25 sec
Transit times Basic MOST	0:28 sec

The pilot showed also several facts which have not been presumed in the primary algorithm and must be further assumed.

- The main requirement can be seen already in table above. The operation time on the second machine must be smaller than the filling of the conveyor on the first machine and analogically with more machines in a group (the sum of times of operation on the machines must be smaller than the smallest time of conveyor filling) otherwise the products start falling on the ground. Therefore machines must be subordinate to the machine with the smallest conveyor capacity.

- Next fact is that the worker would never empty whole conveyor without any significant time losses. Therefore we have to count with smaller conveyor capacity (about 90%)
- The worker needs a signal to be alert to go to the next machine in the sequence.
- Quality issues represent huge time and would disrupt whole operation sequence. Therefore it must proceed by someone else than worker.at the machine.

Algorithm automatization

Automatized algorithm was created in the MS Excel to ensure compatibility with company ERP and production planning system. There were implemented all comments and facts collected by creating operation standards (Basic MOST), questioning knowledge workers and facts coming out of pilot project. It basically copies preliminary algorithm with several fool proof steps. Its interface shows following picture 1.

Picture 1: Algorithm Interface – example of selected production

All what the foreman of the shift must do is to select the machine and corresponding production. The algorithm calculates all other characteristics, shows partial and overall operator workload clearly display and highlight all logical mistakes and overburden of worker. Hence it serves dynamical changing color and graphical tools.

Conclusion

Defined algorithm significantly helped the company with worker planning. The main benefit for the company is the automatized algorithm which provides clear and easy tool for worker planning. There were also standardized all activities performed by the workers, determined distances and transit times between machines, designed and described algorithm for worker planning and suggestions and requirements for its complete implementation were described.

These benefits can be easily monetary expressed. During the algorithm implementation the amount of workers operating semi-automatic injection molding machines has been significantly decreased. The decrease depended on the specific production plans but in average it makes 4 till 5 workers on the semi-automatic machinery.

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Key words

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