Identification of bottlenecks and analysis of the state before applying lean management

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Abstract. The analysis of the production process from the time operations point of view is very important method use in Lean management to improve the whole process. In this paper we describe example of this type analysis on the example of industrial organization from automotive industry. The aim of presented paper is to identify the bottleneck in the production process and to analyse operations times in the production process. On the basis of the carried out preliminary analysis it was stated that the lack of proper organization of the place and time of work, lack of proper preparation in terms of content and equipment, lack of proper work standards, and what unfortunately in the case of the RZ machine are very important factors of losses.

1 Theoretical introduction

The problem analysed in this paper concentrate on analysis of the production process to identify the bottlenecks and to analyse the state of the process. This problem is very important from industrial organization point of view, because bottlenecks are very dangerous from production time point of view. We need to identify them and next analyse all the process with the times of operation. The next stage could be to use lean management methods to reduce this time [1]. For example the SMEAD method can be useful in this situation.

The aim of presented paper is to identify the bottleneck in the production process and to analyse operations times in the production process. The SMED analysis will be presented in another paper.

The paper was prepared as a result of project 13/030/BK_18/0039 Development of intelligent production methods as well as work and life environments in the context of production engineering challenges.

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According to Cambridge English dictionary we can define the bottleneck term as a problem that delays progress [2]. Other definitions of this term are for example as follows:

- department, facility, machine, or resource already working at its full capacity and which, therefore, cannot handle any additional demand placed on it. Also called critical resource, a bottleneck limits the throughput of associated resources [3],
- bottleneck in production is a point where an operation meets or exceeds the capacity of the facility. In other words, the factory or department can't produce enough units fast enough to keep the rest of the production schedule or other daily operations flowing at the same rate [4].

According to the theory of constraints (TOC), the central task of an effective production management is to find and eliminate the impact of a bottleneck in a company [5]. We can divide the production management into three types from the occurrence of the bottleneck point of view [6]:

- management in a situation with no bottleneck in the production process,
- management in a situation with one bottleneck in the production process,
- management in a situation with many bottlenecks in the production process.

The absence of bottlenecks in the production process means that the production productivity is enough to achieve forecast sales. If one bottleneck occurs, it needs to be determined whether there is only one production process or whether alternative production processes are possible. Contribution margin analysis for individual combinations of products and processes is a useful tool in this case. If it turns out that there are several parallel bottlenecks in the production process, the decision becomes more complex. In such an event, solutions to these problems should be founded with the use of linear programming methods [7].

The Theory of Constraits (TOC) is an organizational methodology of change that focuses on improving profit. The basic premise of a TOC is that each organization has at least one limitation, one factor not allowing more than anything to be the purpose of the organization. This is usually a profit [8, 9].

TOC focuses on process constraints, production organization and also on „Bottlenecks" in different production products. However, the TOC does not focus exclusively on production constraints. Factors such as market demand are taken into account, or the ability to turn this demand into an on-demand sales force. So not only production, but also distribution, finance and accounting, sales and marketing, and HR (human resources) are taken into account [10-13].

After solving the problem, the system capacity limits increase, but this does not mean that they become infinite, because most often, another resource becomes a new cause of further limitations. It is worth pointing out that the proper implementation of the various steps of the TOC cycle will make the existing constraints an opportunity for enterprise development. The key to the success of an enterprise is to understand what limitations exist in its system. We should in this case ask some question. At the strategic level, which limits the creation of exceptional value for our customers? And at operational level, which limits the flow velocity increase? The term „constraint" has in common everyday negative connotations. However, the Theory of Constraints suggests a different perspective. The limitation of the system is, in fact, the point of leverage of the whole system. Once the goals of the system are well defined, understanding its limitations is key to building a game plan - strategies and tactics that guide us to achieve the goal [14-24].

2 Identification an characteristic of bottleneck

After the initial substantive preparation, a brainstorming tool was used to develop a checklist before introducing the SMED method. This list was intended to illustrate the actual state of the situation and to present all aspects to which the team should pay attention during the visit to the production hall during changeover. After making the checklist, the team equipped with a video camera went to the production line and hall and proceeded to the re-documenting and all operations carried out during the change. The culmination of this stage was the development of a preliminary division of duties and a detailed determination of the project's objective.

On the base of this analysis and discussion of the team the main bottleneck was identified in the research. It was reduction of the changeover time to 18 minutes. All the times values in this paper were multiplied by a constant factor.

The characteristic of the process identified as a bottleneck was subsequently made. The analysed production process takes place at the pipe production department. The specification of this line, depending on the reference produced, may require the use of a maximum of seven machines. On of this machines is so called RZ - is responsible for more complex calibration operations, such as the creation of outlets (exhaust system ends).

The necessity of using so many machines requires very good organizational preparation before it starts. Also communication and experience from the rudders and foremen is needed. However, the analysis of the film showed that not everything works as it should, because the total changeover time was 3h 52min. This is a very big result, especially since the line overwhelms an average of 1.5 times during one shift, which during the whole day (the company is working on 3 shifts) gives 16h and 14min of line stoppage. This is a huge loss for the company, ignoring the fact that the main assumption of SMED is to achieve the changeover time with the value of a one-digit unit of time.

After the initial analysis of the film, it was noticed that the main problem in the retooling of the above-mentioned machines lies on the side of the bending machine, whose total changeover time amounted to 2h 14min and partly on the RZ side.

For all other machines, the changeover time is adequate to the time specified in the instructions and is relatively short, as it is within 10 - 18 minutes. In addition, the specification of machines is so simple that the possibility of introducing any improvements is impossible. The only machine, as already mentioned, which in addition to the bending machine requires special attention is RZ. This is due to the fact that the retooling process of this machine in a very blatant manner contradicts the principles of ergonomics, which is why this issue certainly needs to be analysed and implemented. In addition, the time of its retooling also exceeds the limit according to the methodology, as it amounted to as much as 2h 28min [25].

3. Analysis of the current state before the introduction of the SMED method

The activities presented in the publication concern the shortening of the changeover time of the multitask bending machine. This is conditioned by the fact that the machine belongs to the bottleneck and significantly affects the much extended time of the entire retooling. In addition, reducing the changeover time of this machine is very important, because it is the most complex machine in the entire machine park, characterized by the largest number of parts for conversion and the largest number of retooling's.

After analysing the video, it was necessary to analyse the current state. First of all, the specification of all the activities performed during the conversion of the machine along with determining the responsibility and time of their execution - this division is presented in the table below (table 1), so that all aspects of the conversion can be analysed in a very clear and transparent way.

The data presented in the table shows a list of all activities performed by the setter during the conversion of a bending machine. Of all activities, all those that result from poor organization of the workplace, improper preparation for retooling or lack of appropriate conversion standards are bolded. As a result, the time wasted to perform unnecessary activities was 490 seconds, which out of a total re-set time of 8150 seconds, gives 6% of the time [25].

Table 1. A list of operations during the retooling of the bending machine before the implementation of SMED [25].

Number	Action name	Time [s]
1.	Preparation of the bending machine for conversion (manual)	20
2.	Securing the bending machine and setting the position „0”	540
3.	Preparation of the safety field	40
4.	**Searching for tools**	**30**
5.	**Importing tools for retooling the bending machine**	**40**
6.	Unscrewing the tension	100
7.	Removing the spigot nut	80
8.	**Organize the trolley with tools**	**60**
9.	Disassembly of 4 hooves	220
10.	Disassembly of the clamping jaw (release)	80
11.	Disassembly of the stem	80
12.	Disassembly of the roller using the traverse • search for traverse tools • access by traverse to the machine.	500 **(240)** (70)
13.	Disassembly of the clamping jaw	30
14.	Setting the height of the clamping jaw	240
14.	Disassembly of the shaft from the clamping jaw	100
15.	Disassembly of the smoothing jaw	140
16.	Assembly of the smoothing jaw	200
17.	Roll assembly	260
18.	**Consultations**	**60**
19.	Mounting the spigot cap	160
20.	**Placing tools on the trolley**	**60**
21.	Mounting the roller to the clamping jaw	90
22.	Mounting of the clamping jaw	30
23.	Assembly and disassembly of jaws from transport	600
24.	Installation of 1 hoof	190
25.	Pipe radius setting	120
26.	Mounting tension	240
27.	Setting the clamping jaw (using the ratchet)	360
28.	Tensioning and pre-setting	240
29.	Unlocking security	240
30.	Mounting and twisting of the spindle	480
31.	Setting the spindle	120
32.	Setting of the bending machine	2400
	Suma	**8150**

Another aspect requiring improvement concerned the time of screwing in and removing the screws. With this machine, the setter has 22 screws to screw in, where it uses a large heavy wrench, a rattle or other screwdrivers, sometimes also assisting with a hammer. The time needed to screw / unscrew the screws in this way was 40 seconds, which in total gives 440 seconds, which in turn makes up almost 11% of the total retooling time of the bending machine.

In this way, after a very preliminary analysis of the operations, it was possible to identify operations that generated as much as 17% of losses in the overall retooling time of the bending machine. It was very important to find a golden mean, so as to be able to reduce the losses to a minimum.

However, at this stage of the analysis it was very important to also retool the machine RZ. As mentioned earlier in the analyses, the time needed for the reconstruction of RZ was 2h 28min, therefore it was very important to analyse all the activities performed during this operation, so as to be able to identify those that we are able to change.

In this case, the analysis of the activities showed that the situation looked very similar to the bending machine, so the issues related to poor organization of the workplace and improper work preparation resulted in the following results [25]:

- 400 seconds of loss for consultations and documentation review, which is more than 4% of total reconstruction time of RZ,
- 2072 seconds of loss to go to the tool magazine for missing parts, results in over 23% of the total changeover time of the RZ.

Issues related to the organization of work resulted in losses in the form of 27% of total changeover time. However, in the case of the RZ machine, the issue of tightening / unscrewing the screws is also of key importance. As with the bending machine, the time needed to screw / unscrew 1 screw was 40 seconds, which with 36 screws gives a total of 1440 seconds, representing in turn more than 16% of the total retooling time RZ.

4. Conclusion

On the basis of the carried out preliminary analysis it was stated that the lack of proper organization of the place and time of work, lack of proper preparation in terms of content and equipment, lack of proper work standards, and what unfortunately in the case of the RZ machine are very important factors of losses. Those factors play a very important role in the analysed changeover. The amount of time lost on the process of screwing in and removing the screws is also important. A positive aspect of the changes that should be carried out is the fact that they are not issues that require large investments.

References

1. R. Wolniak, *Zeszyty Naukowe Politechniki Śląskiej. Seria Org. i Zarz*., **75**, 157 (2014)
2. Bottleneck, https://dictionary.cambridge.org/dictionary/english/bottleneck
3. Bottleneck, http://www.businessdictionary.com/definition/bottleneck.html
4. Bottleneck, https://www.myaccountingcourse.com/accounting-dictionary/bottleneck
5. A. Koliński, *Efficiency in Sustainable Supply Chain* (Springer International Publishing, 2017).
6. A. Koliński, A. Tomkowiak, *Gosp. Mat. i Logist*., **9**, 16 (2010)
7. J. Kolińska, R. Domański, *17th international scientific conference Business Logistic in Modern Management Proceedings* (Osijek, Croatia, 2017).

8. J. Cox, J. Schleier, *Theory of Constraints. Handbook* (McGraw Hill Profesional, New York, 2010)
9. E. Goldrat, *Theory of Constraints / Lean / Six Sigma Integration* (McGraw Hill Profesional, New York, 2010)
10. R. Wolniak, Business and management, **5**, 1093 (2017)
11. R. Wolniak, B. Skotnicka-Zasadzień, M. Zasadzień, *3rd International Conference on Social, Education and Management Engineering* (SEME, Shanghai, 2017)
12. M.M. Srinivasan, *Building Lean Supply Chains with the Theory of Constraints* (McGraw Hill Profesional, New York, 2011)
13. R. Wolniak, B. Skotnicka-Zasadzień, Metalurgija, **4**, 709 (2014)
14. R. Wolniak, Quality & Quantity, **1**, 515 (2013)
15. M. Zasadzień, *6th International Conference on Operations Research and Enterprise Systems* (ICORES, Porto, Portugal 2017)
16. H.W. Dettmer, *Goldrst.s Theory of Constraints: A Systems Approach to Continuous Inmrovement* (ASQ Quality Press, Milwaukee, Wsconsin, 1999)
17. T. Hirts, P. Guernaccini, *Studies in Mana. and Fin. Acc*., **25**, 117 (2012)
18. T.L. Pereira, D.L. Pacheco, L.R. Henrique, D.V. Rafael, *Business Process Man. Jour.*, **6**, 922 (2014)
19. A. Ray, B. Sarkar, S.K. Sanyal, *International Journal of Accounting & Information Management*, **16**, 155 (2008)
20. A. Zivaljevic, *Man. of Envir. Qual.: An Int. Jour*., **4**, 505 (2015)
21. J. Brodny, S. Alszer, K. Jolanta, T. Magdalena, *Arch. Contr. Sci*., **2**, 197 (2017)
22. J. Brodny, K. Stecuła, M. Tutak, Science and technologies in geology, **2**, 65 (2016)
23. M. Wojtaszek, W. Biały, *Manage. Syst. Prod. Eng*., **3**, 133 (2015)
24. J. Sitko, Syst. Wspomag. Inż. Prod., **4**, 90 (2016)
25. M. Ziółkowska, *Doskonalenie procesu produkcyjnego przy wykorzystaniu metody SMED w wybranym przedsiębiorstwie produkcyjnym* (master thesis on supervising B. Skotnicka-Zasadzień, Zabrze, 2018)