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Potential and Limits of OEE in the Total Productivity Management

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ABSTRACT

For years, management of companies has been turning to proven techniques and tools to achieve even higher productivity. They hope for, if possible, all-inclusive, easy and efficient procedures to manage their production systems. In principle, this applies to all organizations, regardless of the sector or the company focus. Especially in industrial enterprises with different machines and equipment for production processes, the quantitative indicator „Overall Equipment Effectiveness" (OEE) has been used in recent years as a key indicator to monitor their efficiency and process performance. This indicator provides relatively simple information about the possibilities and utilization of machines and equipment as well as the quality achieved in the production processes. If the OEE indicator is determined correctly, based on the available and correct data in a system, processes can be better controlled, managed and improved. However, it is important to properly monitor (decode) the data and to understand them. The paper presents the potential but also the limits (obstacles) of Overall Equipment Effectiveness (OEE) on case studies in selected domestic enterprises in the Moravian-Silesian region.

Keywords: potential, limits, OEE, productivity

INTRODUCTION

The key performance indicators monitored by a company management include productivity indicators and value added processing. Companies are forced to pay the utmost attention to all processes and to the entire production system in the sense of the need to continuously increase productivity. Productivity means the relationship between the outputs produced (the effort to maximize them) on the one hand, and the inputs needed to implement them (the effort to minimize them) on the other. Here, the common factor is time. The logical endeavour of the company management is the way of minimising costs while shortening the times for the production itself [1, 5, 13].

If the equipment and its operation are the primary factor of the value added during the manufacturing process, it is clear that it is necessary to pay attention to this area. The Overall Equipment Effectiveness (OEE) performance indicator can be used to track the production cell or production cycle of the line. The monitoring is focused on the identification and quantification of losses, particularly when examining bottlenecks in the production flow in three main directions (areas): Availability, Performance and Quality. The OEE indicator can be meaningful not only in connection with the TPM itself but also in terms of planning and managing the production process with regard to the three above-mentioned directions. The OEE-based monitoring and control looks simple but it actually is not. It has to considered how will the individual sub-indicators (values) be determined, if enough information is available, how often and where will the data be evalauted, etc. Determining the OEE indicator does not mean the end of the work, but rather its beginning. The work with OEE should change to OEE benchmarking [3]. In case the OEE results and thus its individual parameters are not satisfactory enough, it is necessary to use additional tools to analyse and identify the problems, which will lead to the proposals of possible solutions. Here, the time-proven tools and approaches associated with the methodology of lean production or tools used within Six Sigma can be successfully employed. In today´s world, lean production (manufacturing) is used in all branches. It represents an approach which should help businesses respond flexibly to the current and future, ever-changing and growing customer demands in a competitive environment. This corresponds to the access to costs and their minimization to the necessary amount regarding the value added through processing.

Lean manufacturing is associated with the Toyota production system (TPS) developed after World War II. Lean manufacturing, or lean enterprise, uses a variety of techniques, tools and methods to operate, such as 5S, Kaizen, Kanban, Total Productive Maintenance (TPM), Structured Problem Solving, etc. [13].

Studies have shown that the application of the lean production principles still takes place in a fragmented manner, frequently without logical continuity [8]. The principle of continual improvement is one of the inseparable approaches to the production itself, but it entails the application of many of tools (Figure 1). There is a wide range of tools available, and each enterprise has to determine if it is advantageous for them to use the given tools in their processes, and to what extent, especially due to the cost-benefit balances which are involved in each of these tool implementations [6].

BASIC METHODOLOGY

Figure 1 summarizes the selected main notions and connections of various known tools, approaches and methodologies which can be used and have the impact on the company effectiveness.

Quantitative indicator OEE, as an integral part of the total productive maintenance (TPM) concept, is connected with the name of Seiichi Nakajima [7]. Nowadays, OEE is widespread in repeated production (middle- , large-volume or mass) all around the world. If potential production time, theoretical outputs and its full quality are considered as a base, then max. 100% can be gained (it means indicator 1). The best world-class

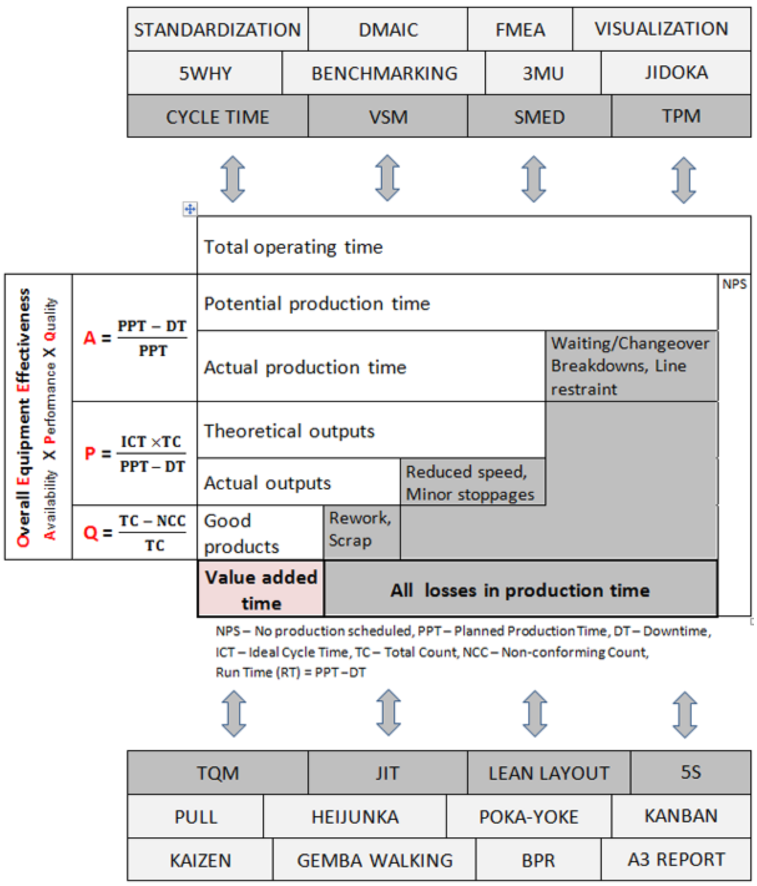


Fig. 1. OEE in context

companies achieve OEE value of 85%, but some of the companies achieve, for example, only 65% [4] or less [11]. The result of OEE depends on the type of production, sufficient production requirements, real situation, and other conditions and variables.

Implementation and monitoring of OEE is the source of many benefits, as many authors have shown. [2] These benefits include:
- Identification of losses and their quantity;
- Reduction of total downtime;
- Better equipment utilization;
- Shorter lead times;
- Higher productivity;
- Better results in quality;
- Cost reduction etc.

The question is if it is also possible to use the benefits of OEE indicator in another type of production for example for planning and control in piece production and to what extent; or, if it is possible to employ the results of OEE in another area than usual.

In fact, in practice it is possible to find different tools (or meanings) with relationships which are based on (derived from) OEE like TEEP (Total Effective Equipment Performance), PEE (Production Equipment Effectiveness), OFE (Overall Factory Effectiveness, OAE (Overall Asset Effectiveness), OPE (Overall Production Effectiveness) etc. [9, 12]. They can be used not only for monitoring and control of the equipment performance but also for measuring the processes or utilization of an entire system.

The OEE indicator can also be used for benchmarking. The term benchmarking has numerous definitions [18] It could be defined as: “Measurement and process analysis and performance of the organization and finding the best solutions through systematic comparison with the performance of others. It is the sharing of experiences and the best practices of comparable organizations and the opportunities can be identified to improve processes and procedures within your organization as well” [15]. Some authors consider benchmarking a part of continuous improvement [3]. Internal or external benchmarking can be distiguished. The basis of the term „benchmarking“ is a word which can be understood as “standard“, “comparative point” or “scale”.

A CASE STUDY ON THE APPLICATION OF OEE IN PRACTICE

The contribution presents the results based on the analyses conducted in 4 different national and international companies.

The first company produces seat and drive systems. This type of production represents a middle- or large-volume manufacturing. The company has been keeping track of the OEE indicator for a long time. OEE is measured after the output from the final assembly. The data are obtained directly from the assembly station programmable logic controller (PLC). The data depend on set standard (MTM) and time when individual final assemblies go out from the station.

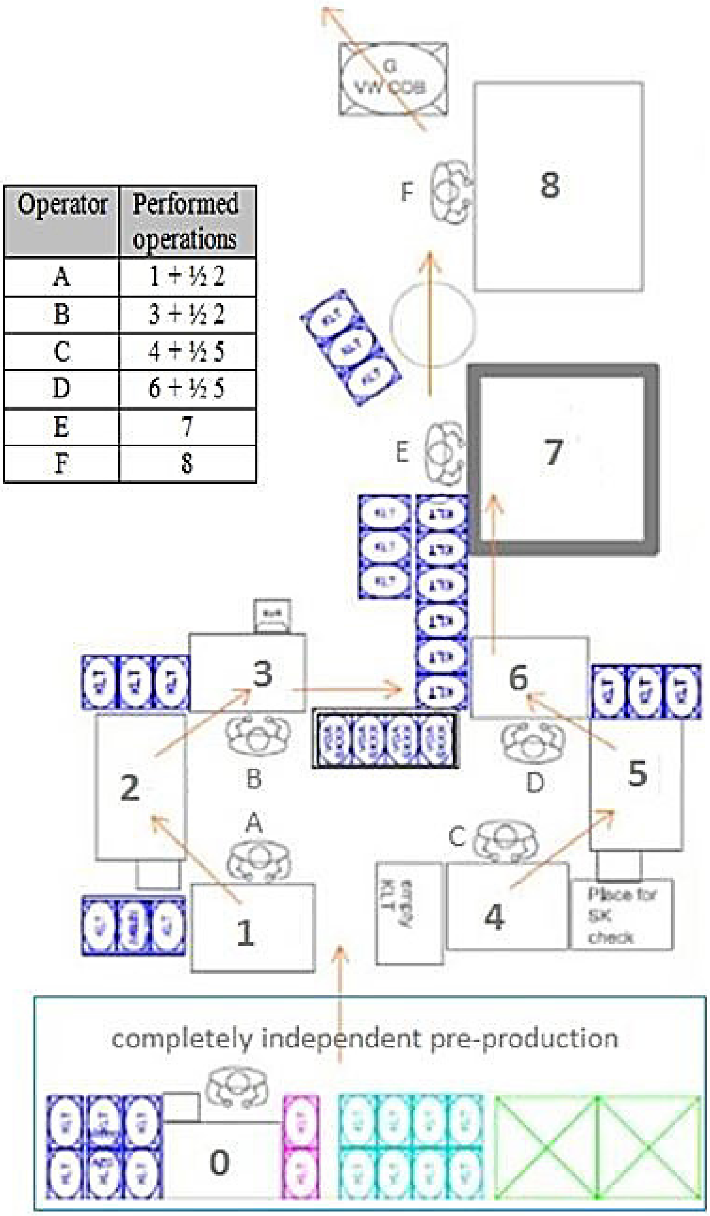
Adjusting the lines from one variant to another product takes about 5 minutes, on average. It is automatically included in line availability when the PLC indicates that the station is not in automatic mode.

The production line is comprised of 8 stations where individual operations are performed, see Figure 2. Manufacturing of the product is thus composed of machine operations and manual operations (handling) which are performed by operators. It is obvious from Figure 3 that the proportion of manual operations in production is significantly higher than the proportion of machine operations.

Machine times are mostly overlapped by other necessary working operations carried out by operators. Operation 8 is fully automated (the operator only deploys and removes products).

Table 1. Monitored companies

Type of company	Industry	Production	Number of employees
Multinational company (GE) branch in CZ	Automotive	Production of seat and drive systems	3 000
A subsidiary of an international company (USA)	Automotive	Assembling recirculation of exhaust gases	130
National company (CZ)	Engineering	Production of machine parts, equipment and steel structures; maintenance and service of technological equipment	705
National company (CZ)	Engineering	Steel cut shapes production	49



Operator	Performed operations
A	1 + ½ 2
B	3 + ½ 2
C	4 + ½ 5
D	6 + ½ 5
E	7
F	8

Fig. 2. Layout 1[10]

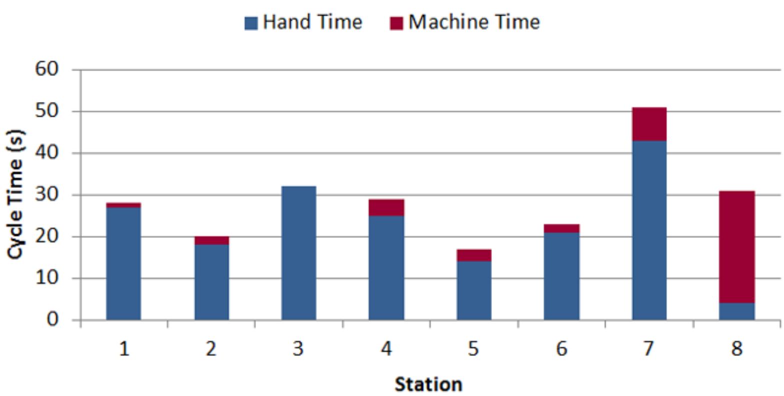


Fig. 3. The ratio of machine and hand times [10]

As can be seen in Figure 3, station 7 and station 8 are bottlenecks due to its machine times. In both cases, the OEE indicator is monitored in the enterprise. The results achieved before and after optimization are shown in Table 2. The optimization proposals concerned the introduction of regular weekly maintenance and maintenance plans, process control for adjusters, setting up cleaning plans and cleaning the machines for operators, elimination of redundant steps and transfer of operators, reduction of the distances and checking the process data. The OEE was increased in both stations. At station 7, the availability was decreased due to the introduction of downtime for regular weekly maintenance. On the other hand, the performance can be increased compared to the current state. The original weekly outputs (15 shifts) of 7.212 pieces could be increased to the final 11.839 pieces.

Checking of data obtained from the process

The data obtained from the Company Machines Data Collection System are stored in standard MySQL database [14]. Afterwards, they are exported into the Excel sheet and large amounts of data are checked (their trends by linear approximation) in a longer period (week) by using contingency tables. An example of the available data from the enterprise system is shown in Figure 4.

The OEE potential to increase productivity is obvious from the above. However, at this point it is good to mention the difficulties (obstacles) which the system set up in the company involves. The established used OEE tracking system is the same for both machine and manual operations. at the stations with manual operations, it would be useful to follow or work with a different indicator, such as Production Equipment Efficiency. With manual operations, the MTM method was used for determination of time standards. Determination of the right standard depends on the experience and practice of the person setting the standards. It can be seen that a standard can be increased to 130%. It would mean that the standard was not set precisely or appropriately.

The second company produces recirculation of exhaust gases. The layout of workplaces is shown in Figure 5 [17]. The situation is similar to the example above. Figure 6 shows the ratio of machine and hand times. The proposals for the implementation of KANBAN and FIFO systems led to improvement of availability from 89.285% to 94.047%, which meant increasing of volume per shift production by about 207 products to the required volume of 2784 products. Individual

Table 2. OEE [10]

<table>
<tr><td rowspan="2">Station 7</td><td>before</td><td>
</td></tr>
<tr><td>after</td><td>
</td></tr>
<tr><td rowspan="2">Station 8</td><td>before</td><td>
</td></tr>
<tr><td>after</td><td>
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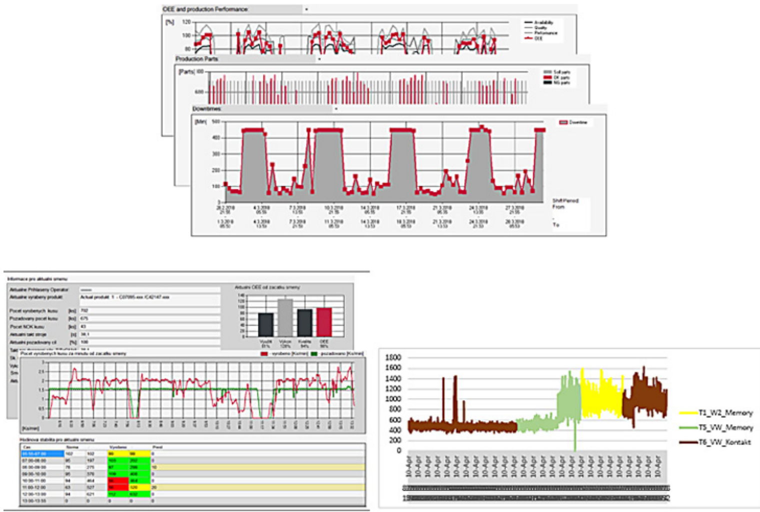

Fig. 4. Data collection [14]

designs were preceded by mapping of the value flow and VSM and VSD processing. This led to a better balance of workplaces on the line, resulting in a reduction of the number of operators on the line and annual wage cost savings of CZK 600.000.

Within the performed analyses it was found out that inaccuracies occur when monitoring and recording data, some changes are not recorded with all the data needed, it is more complicated to search for historical data or time load of workers for monitoring of OEE (approx. CZK 150.000 was spent only on rewriting the OEE forms by the company).

The next company which uses the OEE indicator produces machine parts, equipment and steel structures; it also provides maintenance and service of technological equipment. The data in the table were gained from the company's internal system for all machines and equipment [15].

The data from Table 3 show a low OEE value. Tracking of the OEE indicator is not very suitable for the company, as it focuses mainly on piece production. These indicators are intended especially for serial or mass production. Meaningful OEE monitoring would be possible on condition that the calculations cover a correction indicator including the number of individual orders, including their range (number of pieces) and labour

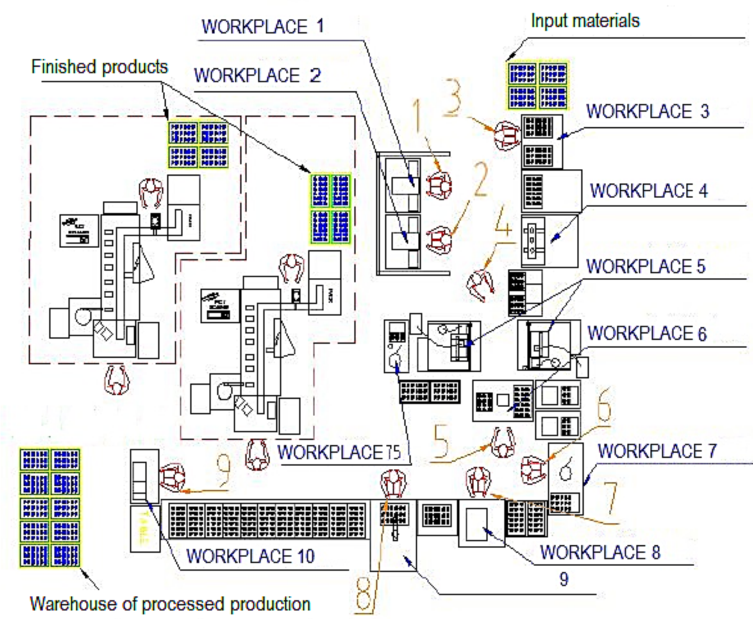

Fig. 5. Layout 2 [17]

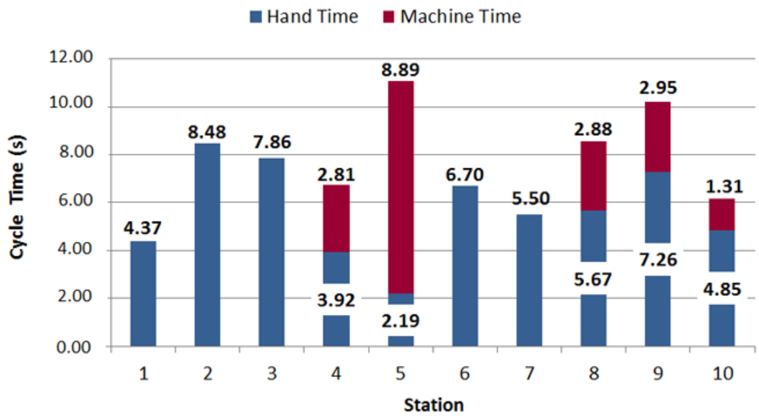

Fig. 6. The ratio of machine and hand times [17]

intensity on a device in the given period. This would lead to the balance of the values between individual periods, which could then be compared with each other and serve as a benchmark indicator. However, this does not change the fact that the achieved OEE would remain low due to the production type.

However, another problem has been identified in this case, namely that if we assume that the maximum value of the OEE coefficient equals 1 (100%), then it is obvious that the quality indicator must be higher than 100%, which is a nonsense. This implies that the setting of the internal system to calculate the OEE is poor and therefore the information for the management is misleading (Table 4).

The last monitored company is engaged in the production of steel cut shapes. It is a piece to small-scale production in a traditionally managed company which tries to invest in new production facilities and information system. The company's management does not avoid any possibilities how to improve the production system and remain a competitive company. Therefore, the company considered the possibility of taking advantage of the OEE monitoring in the manufacturing process. In this case, it was not possible to determine the OEE because, in principle, all the required data could not be obtained from the newly built information system (first deployed in 2016). This was caused by insufficient or sometimes even incorrect records into the system, by a system which was not connected with the system used at the workshop etc., but also by an inappropriately selected information system that is not primarily designed to control production and will be difficult to modify for that purpose. Here, the high importance of choosing the right ERP system that will support business planning and management can be seen.

Table 3. Value of OEE [15]

Equipment	Availability (%)	Performance (%)	OEE (%)
Lathes	43	77	41
Milling machines	32	58	29
Carousels	48	57	36
Others	22	100	22

CONCLUSIONS

The achieved results demonstrate and prove that the OEE indicator has a great significance for monitoring and control of production performance. Using the OEE and its visualization has brought positive results with an impact on efficiency of the production process. The OEE

Table 4. Value of OEE [15]

Equipment	Availability (%)	Performance (%)	OEE (%)	Quality (%)
Lathes	43	77	41	124
Milling machines	32	58	29	156
Carousels	48	57	36	132
Others	22	100	22	100

indicator can also be used in a transformed form in other areas than usual, at least as a benchmark.

Currently, the ERP systems contain a huge amount of stored data. However, it turns out that there is not enough time left to carry out relevant analyses due to the pressure of increasing efficiency and dedication only to what brings a return. An important role is also played by the properly chosen system in which the data is processed.

Unlimited confidence in the faultlessness of the used applications can be misleading. It must be borne in mind that even misinterpretation of data can lead to erroneous conclusions. The practical implementation has shown the advantages but also the problems of using the OEE in practice.

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