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THE EVALUATION OF EFFICIENCY OF THE USE OF MACHINE WORKING TIME IN THE INDUSTRIAL COMPANY – CASE STUDY

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Abstract:
In the paper the evaluation of efficiency of the use of machines in the selected production company was presented. The OEE method (Overall Equipment Effectiveness) was used for the analysis. The selected company deals with the production of tapered roller bearings. The analysis of effectiveness was done for 17 automatic grinding lines working in the department of grinding rollers. Low level of efficiency of machines was affected by problems with the availability of machines and devices. The causes of machine downtime on these lines was also analyzed. Three basic causes of downtime were identified: no kanban card, diamonding, no operator. Ways to improve the use of these machines were suggested. The analysis takes into account the actual results from the production process and covers the period of one calendar year.

Key words: *effectiveness, OEE analysis, machines and devices*

INTRODUCTION

Modern companies struggle with economic crisis and try to cope with the extreme competition on the increasingly demanding customer market. In order to meet needs of the market, the company must have a fully operational production system and operating logistic chains. The optimally functioning information system that supports the management process is also very important element. Thanks to this the implementation of changes in the production process without any disruptions are possible.

Machines and devices used for the production of finished products are one of the most important elements of each production system. Different production processes use machines with various degrees of automation: from simple hand controlled devices to automated production lines. It depends on type of production process and type of organization of production. Thanks to developed and technologically advanced machines, production process takes less time than several years ago. Shortening production time reduces production costs, and thus increases the efficiency of the company.

Optimal organization of work and proper use of machines and devices in production process are important for the operation of the production process. Conducting regular analysis of the use of machines and devices operating in the production system is extremely important for the companies although many of them underestimated them. Thanks to the knowledge the level of machine work the operation of production system can be improved so that the possibility of use of machines in the process are optimized.

The main purpose of this paper is the evaluation of the effectiveness of one of main elements of production system, machines and devices used in the chosen company. The company deals with the production of tapered roller bearings.

PROBLEMS OF OPTIMIZATION OF PRODUCTION PROCESSES

In a rapidly changing environment, the functioning of the company, that is characterized by growing competition and increasing customer demands, the rapid development of available technologies, requires improvement of its business. The availability of a large number of concepts and methods to support the company management allows for a wide implementation. Today, the use of modern tools is necessity to solve increasingly complex problems. Methods for the development of modern companies are constantly being developed and new ones are being created.

Rapid changes in production technology, processes and innovations force to search new solutions for production management, such as [1]:

– diversification of products manufactured from standard components,
– reduction (minimum) of the order cycle,
– short production cycles,
– piece production or small batch production,
– production on request, not on stock,
– flexible production systems,
– implementation of self-control instead of standard control systems,
– the increase of versatility and universality of employees,
– low repeatability of batches of products.

All these factors show that economics of diversity displaces the economics of scale, what is now the necessity in business management. Competition is possible only when the company is able to offer the customer the right products with the required standard, the right price, in the right time and place, respecting requirements of the customer [2].

Maintaining the technical infrastructure of company at the appropriate level of productivity and efficiency requires, above all, the use proper methods and tools of management and proper organization of service responsible for its implementation. The use of various indicators is the inseparable part of assessing the effectiveness of these activities and operation of machines in company. The selection of appropriate indicators for assessing the key actions that are carried out as a part of process of maintenance of machines, which show the efficiency of the activities carried out in relations to the goals of organization, are the basis of the assessment [3, 4].

Literature defines various indicators for evaluation the effectiveness of machines and devices, among them are: MTBF, MTTR, PAMCO or OEE.

The OEE indicator describes three basic areas of the production activity: availability of machines, performance and quality of products. The calculation of OEE allows to define the improvement actions in the field of production processes, allows to change their effects after their implementation and eliminate existing problems. It helps to identify bottlenecks and major problems of the company [5, 6].

The essence of the OEE method is to compare the actual use of the machine to the ideal use, which occurs when production and its preparation are carried out in accordance with the plan [3, 6].

OEE method is turning towards the process. It means that it takes into account not only the availability of time machines but also the performance (actual yield/nominal performance) and the quality factor (production with good quality/total production). The generally accepted world-class targets for each ingredient vary from one industry to another [7].

THE SUBJECT OF THE ANALYSIS

The analysis was based on the actual results from the manufacturing company producing various types of bearings. The analysis includes production of tapered roller bearings used primarily in the automotive, agricultural (farm equipment) and other devices. The efficiency of the production process was evaluated at the department of grinding rollers. Working in the department is carried out in three shifts, five-day work week [8, 9].

In the department there are 17 working automatic grinding lines divided into two zone. In the first zone there are seven modernized grinding lines with the capacity of 8-10 thousand pieces per hour. The second zone includes ten unmodified grinding lines with the capacity of 4-7 thousand pieces per hour [8, 9].

In order to improve the efficiency of work the company implemented the following improvement methods: 5s, work standardization, TPM, kaizen, kanban, process mapping and control zones [8].

THE ANALYSIS OF EFFECTIVENESS OF USE OF MACHINES AND DEVICES USING OEE METHOD

In order to perform the analysis of efficiency of machines and devices according to the OEE method, the components of this indicator should be identified. Three main elements influence this efficiency:

- availability indicator,
- performance indicator,
- quality indicator.

These indicators are determined in accordance with formulas that will be given later in the paper. Values of OEE indicator accepted by the company that are assumed to be achieved are presented in Table 1.

Table 1
Accepted targets of OEE at the world level

Element of OEE	World Class
Availability	90.0%
Performance	95.0%
Quality	99.9%
OEE	85.0%

Source: [3, 7].

The average value of OEE for the whole company was determined for the years 2010-2015. The results are presented in Figure 1. As it can be seen the value of the OEE indicator increases year after year and is close to the optimum value.

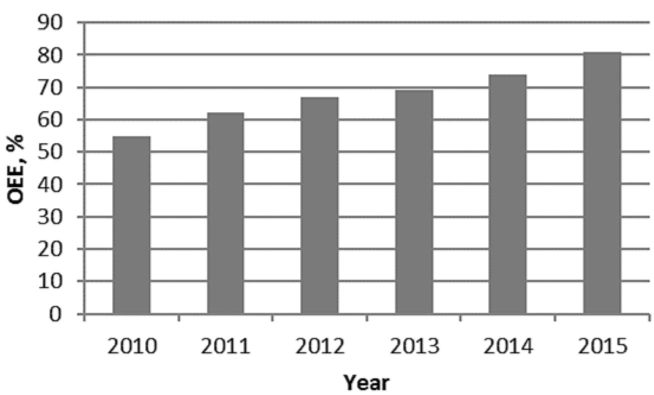

Fig. 1 Results for OEE indicator in 2010-2015
Source: Own study based on [8, 9].

The detailed analysis of OEE indicator for each 17 automatic grinding lines working in the period of time from 1th of April 2015 to 14th of April 2016 was made. Individual elements and OEE for each line and the whole department value were calculated.

The availability indicator takes into account the planned working time of machines minus all downtimes – all incidents that cause the stoppage of production process that can be registered. Figures 2 shows the values of availability indicator for each grinding line and total department calculated according to formula 1 [3]:

$$Availability = \frac{planned\ working\ time - downtimes}{planned\ working\ time} \quad (1)$$

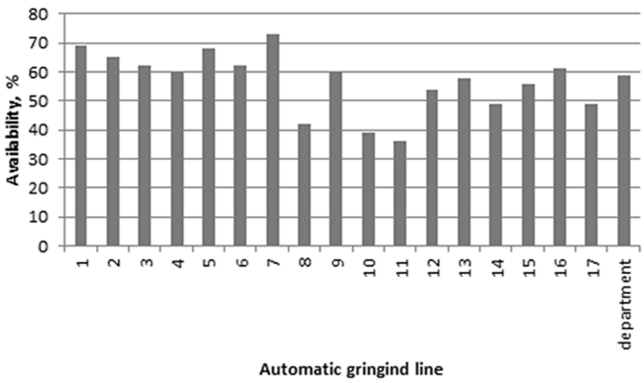

Fig. 2 Results for availability indicator for automatic grinding lines in the study period
Source: Own study based on [8, 9].

As it can be seen in Figure 2, the value of availability indicator for each grinding line varies between 36-73% and does not reach the goal on the level of 90%. The value of indicator for the whole department is 59%. It should be noted, however, that lines from 1 to 7 was modernized and have higher availability. They produce rollers for bearings for wholesale customers (automotive companies for the first assembly). These rollers are produced for store, the volume of the production is not limited to short and small production orders and consequently frequent rearming and small number of production kanban cards. Lines from 8 to 17 are not modernized, the rollers are mainly produced for a specific customer order, the short batches (3 to 5 production shifts) are usually produced. Orders for shore batches cause the frequent rearming and losses of availability.

The performance indicator takes into account all the factors that cause the production is made with less than maximum speed. It is calculated according to formula (2). Figure 3 shows results for the calculated performance indicator for each grinding line and total department [3]:

$$Performance = \frac{Production\ made(correct+incorrect)}{shift\ time-shift\ performance} \quad (2)$$

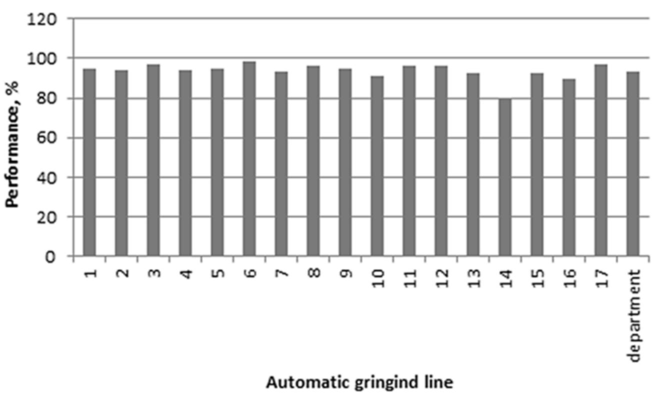

Fig. 3 Results for performance indicator for automatic grinding lines in the study period
Source: Own study based on [8, 9].

According to the Table 1, the accepted goals of performance indicator at the global level are 95%. The results presented in Figure 3 shows that only for 5 grinding line the accepted goal for this indicator was exceeded (3 – modernized: 1, 3, 6, 2 – unmodernized: 11, 17). This shows that on these lines the cycle time was suited to net time and shift performance on these lines was the highest. On the 14th line the indicator was significantly different from accepted goal and was on the level of 78%. The lowest value is due to the fact that this line produces the largest type of rollers in small batches. This line is also characterized by the lowest volume of production during the period of time under study.

The quality indicator is calculated using formula (3), taking into account all losses resulting from production of parts that do not meet quality standards, including non-conforming products. The results of this indicator are shown in Figure 4 [3]:

$$Quality = \frac{Production\ made - non-conﬁrming\ products}{Production\ made} \quad (3)$$

The goal for the quality indicator is on the level of 99,9%. Because of complicated process of grinding of rollers and high quality requirements of the finished product, limit of non-conforming products are set at high level. The acceptable level of non-conforming production for the whole department of grinding rollers was set at 2.1%. Based on the results presented in Figure 4 it can be said that quality level was achieved. The variation of the value of quality indicator is low because it fluctuates between 97-99%.

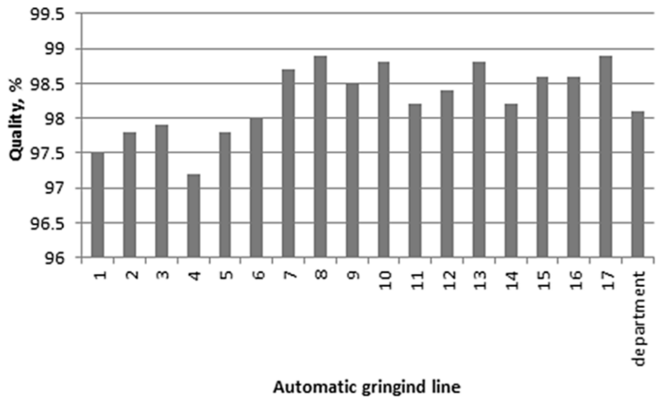

Fig. 4 Results for quality indicator for automatic grinding lines in the study period
Source: Own study based on [8, 9].

The OEE indicator can be calculated using formula (4). Indicators values for each line and the whole department are presented in Figure 5 [3]:

$$OEE = Availability\ x\ Performance\ x\ Quality\ x\ 100\% \quad (4)$$

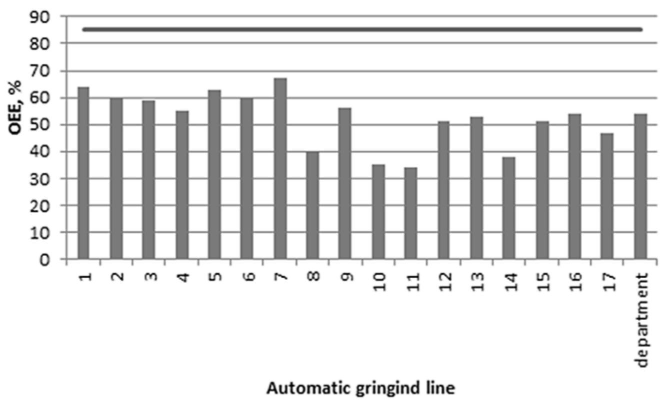

Fig. 5 Results for OEE indicator for automatic grinding lines in the study period
Source: Own study based on [8, 9].

The values of OEE indicator (Figure 5) show significant differences between the goal and the results achieved and are characterized by significant variation (34-67%). The highest value of the indicator is reached by modernized lines 1-7. The average value for these lines is 61% and is 15% higher than the average value for unmodernized (8-17). As two component of this indicator – quality and performance – reach higher values, the problem of low value of OEE is connected with the availability that significantly underestimates the value of the whole indicator. It means that company has problems with downtime of machines.

THE ANALYSIS OF CAUSES OF DOWNTIMES OF MACHINES

The analysis of causes of losses of machine running time was made. The analysis was conducted for the whole department on the basis of all-year results of the tree-shift production on 17 production lines. Production took place without major changes in technology during the period under study. The production lines were equipped with modern vision systems that keep the control and reject defective products. Production volume on lines depends on current and forecasting orders. Figure 6 presents the Pareto chart showing factors that cause the losses of machine running time and their effect on the overall amount of downtimes in the department.

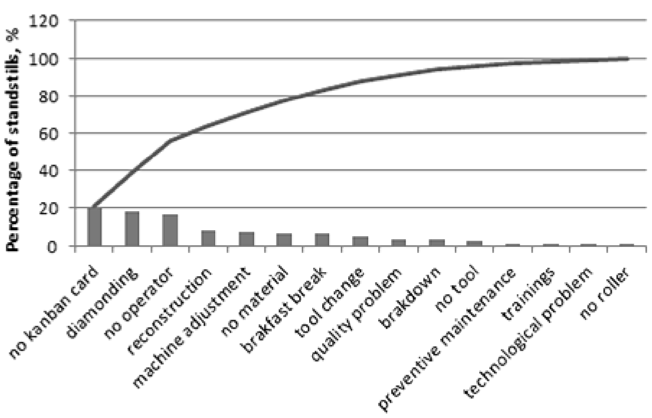

Fig. 6 Pareto chart of causes losses of machine running time for all lines in the study period
Source: Own study based on [8, 9].

Three the most important reasons cause 56% time of downtime of machines. They are:

- no kanban card,
- diamonding,
- no operator.

No kanban card is the most important cause of losses of machine running time. It causes 20% losses of time. Production in the department is based on the kanban system that ensures strict control of stocks and start production at the time when demand for the particular type of rollers appears. In case of custom production the number of production kanban cards is adjusted to the specific order size. No kanban card on the board means the completion of production order and downtime of the line. In case of production for the store, the number of kanban cards is adjusted to the set stock limit. No kanban causes stoppage of production of particular type of rollers, time of stoppage is reported as a loss.

Diamonding (sharpening grindings wheels for grinding rollers) with 18% of percentage of time losses also has significant effect on the machine performance. This operation is part of the process of production preparation and is necessary in the grinding process. At present, technological tests are being conducted to extend the time between processes of diamonding of the machines and reduce from 3 to 2 cycles per production shift.

No operator is another element that causes downtimes of the production lines, its percentage is at the level of 17%. Employment in the department is adjusted to the planned volume of production. The losses generated by this element are associated with sick absenteeism, leave, staff training etc.

WAYS OF IMPROVING IN THE USE OF MACHINES

After the analysis of presented results it can be said that the greatest loss of availability is generated by the lack of kanban cards. The lack of a systematic supply of kanban cards causes the stop of working line what effects on machine performance and consequent financial loss of the department. It shows that the system does not work properly, since the equipped production lines have problems with downtimes. Therefore, continuous and systematic flow of not only kanban cards but also information between the roller grinding department and department od assembly should be ensured. It can be achieved through the collective planning of current production by representatives of departments.

Diamonding that is essential in the technological process of grinding of rollers, unfortunately also leads to the loss of machine running time. The simplest and the most effective way to prevent these losses reducing the number of diamonding cycles and at the same time providing a higher grinding wheel quality allowing for longer running time (keeping current quality parameters) between the diamonding cycles. Another way, but generated high costs, would be the purchase of modern and efficient grinding machines.

The lack of operator is another factor contributing to the loss of working time of machines, which however is not affected by the employer. Every employee should be qualified and prepared to work on a variety of production lines to prevent such crisis situations. Trainings and various forms of motivation of employees play the important role.

Each of proposed changes is related to the human work but also financial expenditures. However, in the end it will improve the work of department and make a profit.

CONCLUSION

The assessment of efficiency of the use of machines in the selected production company was presented. The analysis of effectiveness was done for 17 automatic grinding lines working in the department of grinding rollers. The analysis takes into account the actual results from the production process and covers the period of one calendar year. Based on presented results it can be stated that:

1. The OEE analysis shows that the value of the indicator is between 34-67%. This is not a satisfactory result and much lower than the accepted goal. The calculations show that quality and performance are high, so the main problem is the availability of the lines.
2. Based on Pareto chart it can be said that the main reasons of downtime are: the lack of kanban cards, diamonding (the cause of technological process – sharpening grindings wheels for grinding rollers) and lack of operator. These three causes generate 56% of losses in availability.

3. Implementing all proposed changes can improve the value of availability indicator and thus minimize downtimes, making profit for the company and provide customer satisfaction.

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