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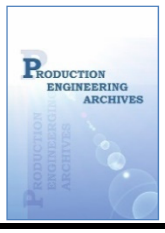

Plastic production machinery – the evaluation of effectiveness

Krzysztof Mielczarek[1], Marek Krynke[1]

[1] Department of Production Engineering and Safety, Faculty of Management, Czestochowa University of Technology, Armii Krajowej 19B, 42-200 Czestochowa, Poland, e-mail: krzysztof.mielczarek@wz.pcz.pl

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Abstract
In this paper TPM and PAMCO coefficients were shortly characterised. On the basis of TPM coefficients its effectiveness was estimated. Thanks to using time and PAMCO coefficients, the utilization of working time machines was researched. Moreover, there a correlation between TPM coefficient and the quality level was examined. A histogram was drawn up in order to illustrate the distribution. The obtained results allowed to evaluate the effectiveness of the machine. The period of research embraced fifty-two weeks (1 year) and the object of the analysis is the injection moulding machine.

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1. Introduction

The object of the survey is an enterprise which manufactures different type of products made from plastics, such as control panels, hand grips, push-buttons, drawers and other accessories for washing machines, refrigerators and dishwashers.

The enterprise owns a well equipped machine park, which enabled to create many products ordered by customers. The machine park is subjected to constant production control of the technical-production department. Major repairs, routine repairs and periodical survey are conducted regularly. Due to frequent technical survey and maintenance, its functioning is improved and prospective break-downs are prevented from happening so often. The object of the analysis is injection moulding machine produced in 2004. The period of investigation amounted to one year.

2. The influence of TPM coefficients on an injection moulding machine

TPM (Total Productive Maintenance) is an approach to servicing technical objects and its equipment (NIWAS, R., KADYAN, M.S., KUMAR, J. 2016). The TPM depends on the maintenance service of technical objects realized by staff responsible for its maintenance inside the whole enterprise through operators and staff responsible for its maintenance (HOOI, L.W., LEONG, T.Y. 2017, KNOP, K., ROSAK-SZYROCKA, J. 2016). If an enterprise wants to introduce some changes, it must rely on introducing new technologies, and has to estimate the existing conditions. The assessment of work effectiveness for machines utilization in plastics production was carried out by means of total productive maintenance coefficients. One of the most important aims of introducing TPM is the identification of losses, and an attempt to eliminate the ones caused by uneconomical maintenance of technical objects, such as time, speed and the quality. Through their elimination it is possible to improve the productivity of a plant and equipment. The implementation of TPM system can bring many advantages for an enterprise, such as: the increase of effectiveness of work machines (NG, T.C., YANG, T.X., YEW, M.C., SAW, L.H., YEW, M.K., CHEN, K.P. 2017). To achieve it, the system including the whole enterprise and participation of all employees from management personnel to laborers should be introduced (SELEJDAK, J., INGALDI, M. 2013, NOWAKOWSKA-GRUNT, J., MAZUR, M. 2016). The assessment of work effectiveness for injection moulding machine machine was carried out by means of total productive maintenance coefficients. In the evaluation of maintenance performance, the overall equipment effectiveness (OEE) is used as metric to evaluate the manufacturing capability and is a function of equipment availability, performance efficiency and the quality (KARDAS, E. 2017, KRYNKE, M., KNOP, K. 2017). For researched injection moulding machine, the average result about 75% means that

from machine ¾ of products can be obtained, in an ideal condition. An 85% OEE is considered world class and enterprises should try to reach it. In Fig. 1 the average value of the coefficient of exploitation (WE), the performance coefficient (WW) and the overall equipment effectiveness (OEE) were introduced, in consecutive research period.

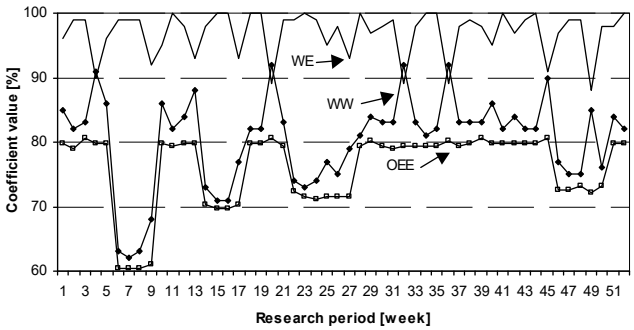

Fig. 1. TPM coefficients value for injection moulding machine in individual research periods

The value of individual coefficients is not subjected to a significant fluctuation in research period. For the first six weeks the value of coefficients was on a high and rather stable level. In the following weeks there was a gradual fall of the value the performance coefficient (WW). It was caused by a decrease in production efficiency. It is also reflected in a significantly lower value of OEE. For ten weeks, the value of coefficient was again on a high and stable level. It shows that the value of individual coefficients reached optimal values. As a result of the conducted research, it was confirmed that overall effectiveness of machine is on an appropriate level as the analysed TPM coefficients reached optimal values. Nevertheless, the average value of quality level more than 1.5% shows that researched machine manufactured a high level of incompatible products. It was caused, among other things, by shutdowns of machine work that results from break-down.

On the basis of calculated correlation coefficient for individual relationship it can be affirmed that there is a negative correlation for quality level (PJ) and WE coefficient. In Fig. 2 correlation between the quality level (PJ) and WE coefficient was introduced.

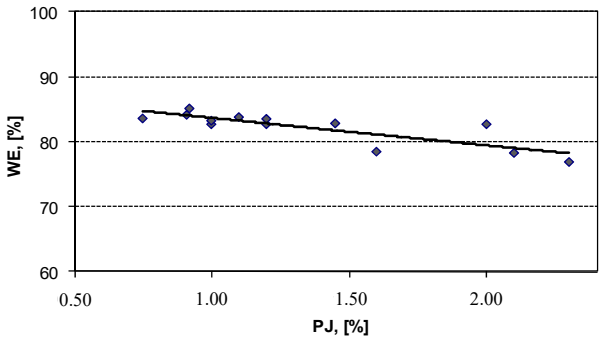

Fig. 2. Relationship between quality level (PJ) and coefficient of exploitation (WE) for production during one year.

In periods, when coefficient WE was lower, the failures occurred more frequently. In this period, a regulation was conducted, and also the break-down time was on high level. The result was that in these periods the number of faulty products was bigger.

Shutdowns in machines work were divided into the following kinds: break-down time (TA), instrumentation change (ZO), regulation (R). The level of an individual shutdown for a researched machine was presented in Fig. 3. The greatest share of shutdown during the whole year comprised of the ones caused by a break-down (44%).

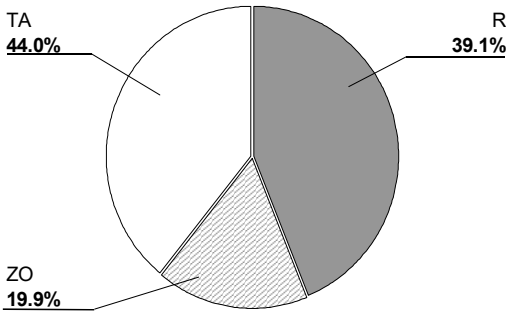

Fig. 3. Shutdowns level for injection moulding machine work in one - year period

The cause of frequent break-downs was detraction process of machine elements and also insufficient conservation quality. The elimination of the above-mentioned losses can contribute to a significant rise in the effectiveness of the researched device (BRZEZIŃSKI, S. KLIMECKA-TATAR, D. 2016).

On the basis of a calculated correlation coefficient for an individual relationship, it can be stated that there is a positive correlation between a quality level and all kinds of stoppages. It means that shutdown times are one of the elements that have an influence on a quality level of product manufactured by injection moulding machine. In Fig. 4 correlation between quality level (PJ) and break-down time (TA) was shown.

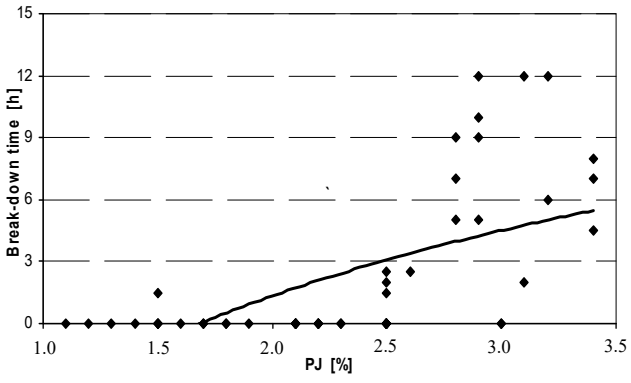

Fig. 4. Relation between quality level (PJ) and break-down time for injection moulding machine

For periods in which the break-down occurred frequently there were also more defective products.

3. The analysis of PAMCO coefficient for injection moulding machine

The PAMCO method (Plant & Machine Control) is an important tool for efficiency evaluation of working time machine (STASIAK-BETLEJEWSKA, R., ULEWICZ, R. 2016). According to the PAMCO method, time is divided into kinds and individual coefficients are counted using it. It can be used for evaluation efficiency of machines in different enterprises. Selected PAMCO coefficients for one-year period were calculated: Production Efficiency (PE), Available Utilization (AU), Production Utilization (PU) and Effective Utilization (EU) (INGALDI, M. 2015). The most important coefficient is (EU) – effective utilization whose nominal value should be more than 50% (BORKOWSKI, S., KNOP, K., MIELCZAREK, K. 2014). As based on time analysis, the selected coefficients were counted and the results are presented in Fig. 5.

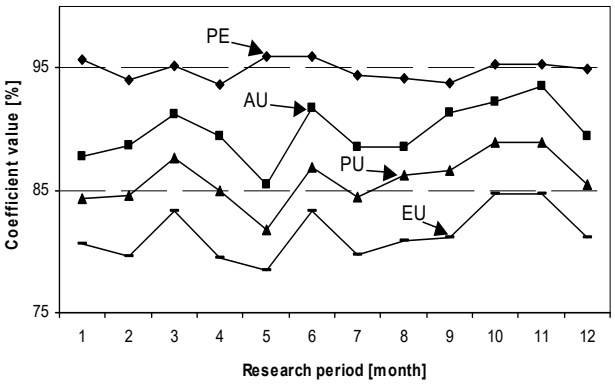

Fig. 5. PAMCO coefficients value for injection moulding machine in individual research periods

The outcomes of the analysis are that individual coefficients reached value near optimal. These coefficients testify about high utilization of machines working time. It shows the value of coefficient in individual months. The coefficient PE during whole year amounted to more than 90% and oscillated about nominal value of 95%. Value of AU – Available Utilization approximated optimal value of 90% during the whole researched period. Production Utilization (PU) reached average value more than 85% which is a very good result. The coefficient EU – effective utilization reached very high value whose nominal value should exceed 50%.

The stability of this coefficient was introduced by means of the histogram. A histogram, one of the basic tools of quality control, is a graphical version of a table which shows what proportion of cases fall into each ~~of~~ category. It presents visual information about the course of the process. In Fig. 6, histograms and Gaussian distribution for EU coefficients were introduced.

Histogram shape for Effective Utilization (EU) resembles Gaussian curve and displays a proper distribution of data as the majority of the results are not in the middle columns. It means that such a PAMCO coefficient is characterized by a high level of stability. It can be observed that a small right-sided asymmetry occurs because the biggest concentration of coefficients values exceeds the average value.

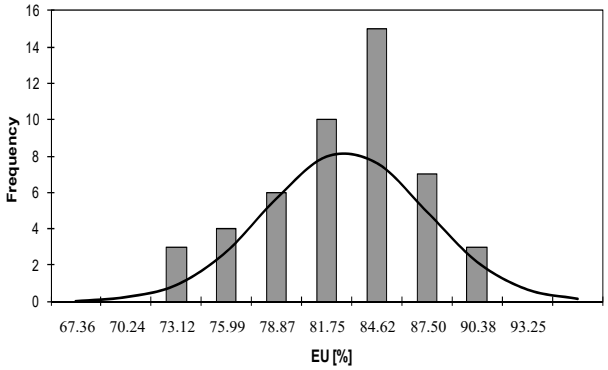

Fig. 6. Histogram and Gaussian distribution for EU coefficient

The Shewarth control cards are one of the basic tools of the quality control and are generally used in a production or manufacturing environment, and they allow checking whether controlled process is in a stable condition. The control card illustrates the degree of samples centring around the average of process to reflect measuring accuracy. R control chart shows the range (R) and also any changes in the dispersion of the process. In Fig. 7 the x - R control card for Effective Utilization (EU) was presented.

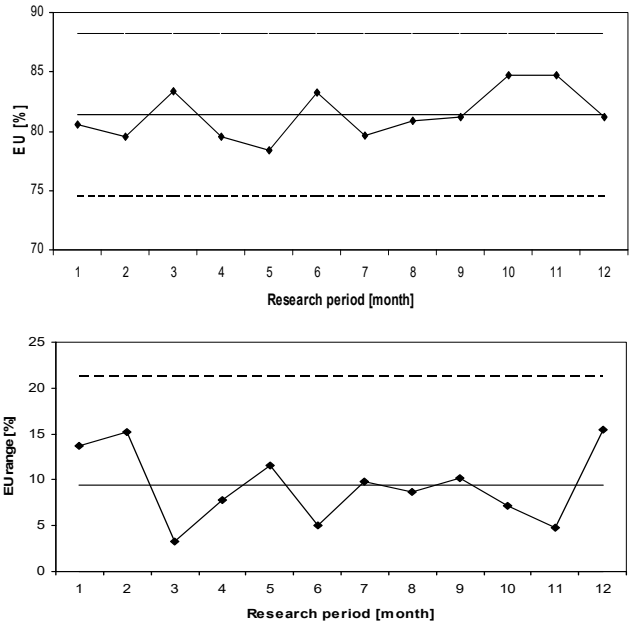

Fig. 7. The x - R control card for Effective Utilization (EU)

All the average values of coefficient are in the required tolerance range, which shows that these coefficients were not subjected to a significant fluctuation in individual periods. For both, card x, as well as R card it is possible to notice, that all the results are situated within the control limits of cards. For Effective Utilization (EU) significantly higher range values (to 15%) were received. However, control limits were not exceeded. When production process of plastics was analysed, it became obvious that this process is closely linked to the orders of clients. It is possible that a correlation exists between them, which can be concluded form the analysis of the production size and PAMCO. This issue was presented in Fig. 8.

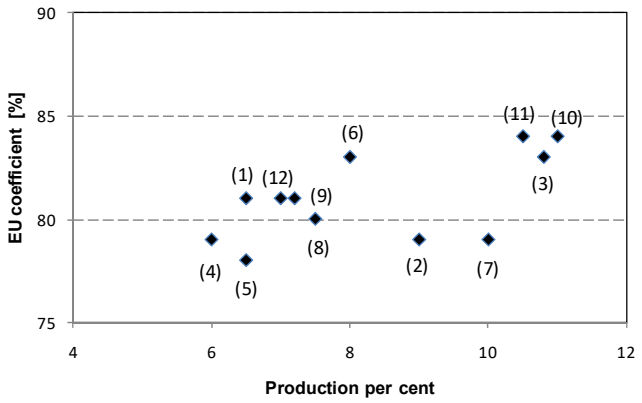

Fig. 8. Relation between EU coefficient and production level of plastics

In months where the production was at its highest there was a large concentration of points in the right top corner. In months where the production was smaller, the points concentrate mainly in the left bottom corner. This means that the rise in production has an influence on increasing value of coefficient EU.

4. Summary

Long, one-year span of research allowed to precisely characterize the efficiency of machine. If one wants to improve production effectiveness they should know what the current situation is. Information about it is delivered by TPM coefficients. As a result of conducted investigations for injection moulding machine it was affirmed that the general effectiveness of machine is on a suitable level because the analysed TPM coefficients reached values approaching the optimal ones. Regardless of good results, the values of individual coefficients should be constantly monitored. It will allow to react quickly when wrong effect of working machine will be noticed. Moreover, the PAMCO coefficients exceeded their nominal level, which proved that exploitation effectiveness is on a high level. It can be confirmed by an individual value of PAMCO coefficients, especially EU – effective utilization whose value was higher than 50%.

The histogram confirmed that the machine is exploited evenly because the results there are in the middle columns.

The number of defective products shaped on 1.5% level. It is caused, among other things, by shutdowns of machine work that results from break-down. It should be remembered that also other factors such as experience of workers, bad quality of materials and other factors can have decisive meaning in creating quality.

The proper training of staff in the field of machine servicing in a direct way can result in a smaller number of defective products. To improve the production process some repair actions are recommended, such as introducing ~~to~~ technological processes an additional operator control, training for workers and introducing a range of visual control.

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塑料生产机械 – 有效性的评估

关键词
TPM
PAMCO
质量
效用

摘要
在本文中 TPM 和 PAMCO 系数很短的特点。 在 TPM 系数的基础上估计其有效性。 由于使用时间和 PAMCO 系数，对工作时间机器的使用进行了研究。 此外，还检查了 TPM 系数与质量水平之间的相关性。 绘制直方图是为了说明分布。 获得的结果可用于评估机器的有效性。 研究期限为 52 周（1 年），分析对象为注塑机。