Chapter 8

Jacek Selejdak[1]

AN EFFECTIVENESS ANALYSIS OF A MACHINE USED FOR MANUFACTURING OF CONSTRUCTION EQUIPMENT COMPONENTS

Abstract: This chapter focuses on the analysis of the effectiveness of a machine used for manufacturing of construction equipment components. The TPM and PAMCO times were measured and then used for computation of TPM and PAMCO coefficients. The study found that the overall equipment effectiveness (OEE) in the machine studied reached the level of over 90%. Furthermore, PAMCO coefficients reached the value of over 96%.

Key words: TPM coefficients, PAMCO coefficients, effectiveness

8.1. Introduction

TPM (Total Productive Maintenance) system is understood to mean a comprehensive or productive maintenance of machines. However, the system is not universal for all the enterprises (BORKOWSKI S., SELEJDAK J. SALAMON S. 2006, GÓRALCZYK A. 1996, MACIEJEWICZ J. 1999, ELLIOT B. R., HILL G. 1999, BORKOWSKI S., ULEWICZ R. 2009). Implementation of the TPM system through e.g. the use of times and coefficients provides information about performance of machines and equipment (ZAPŁATA S. 2003, ULEWICZ R., JUST K. 2012, KURZAK L., MAJOR M., MAJOR I. 2012, BORKOWSKI S. KRYNKE M., RUTKOWSKI W. 2011, JAGUSIAK M., KLIBER J., KNOP K. 2010).

[1] dr hab. inż. Prof. PCz, Department of Building Structure and Engineering, Faculty of Civil Engineering, Czestochowa University of Technology,
e-mail: jaceksel@poczta.onet.pl

This chapter also presents the analysis of effectiveness (CZAJKOWSKA A., MASZKE A., KNOP K. 2008) of a machine used for manufacturing of construction equipment components based on PAMCO times and coefficients. Plant & Machine Control (PAMCO) allows for application of uniform criteria for comparison of enterprises with similar profile of manufacturing and similar stock of machinery. In 1990, PAMCO definitions were simplified and unified for all the enterprises so that their results could be easily and quickly compared. This system reduces the number of previously used parameters and provides the basis for evaluation of the equipment that can be modified (SELEJDAK J., ULEWICZ R. 2005, BORKOWSKI S. KRYNKE M., SELEJDAK J. 2006, BORKOWSKI S., MIELCZAREK K. 2009).

8.2. Research results

The analysis discussed in this chapter focuses on the machine for manufacturing of construction equipment components in the enterprise studied. For this purpose, the authors determined individual times (BORKOWSKI S., SELEJDAK J. SALAMON S. 2006)) of operation of the machine. The times obtained were used for calculation of TPM and PAMCO coefficients. All the measurements of times were taken under industrial conditions during the process of manufacturing (MAZUR M., ULEWICZ R. 2007) of construction equipment components. The research period of the analysis was 12 months.

8.2.1. TPM times and coefficients

TPM times for the machine used for manufacturing of construction equipment components are compared in Table 8.1. Fig. 8.1 presents the time of machine standstill in the month studied (TP) divided into planned time (PP) and unplanned time (TA).

Table 8.1. TPM times for the machine used for manufacturing of the construction equipment components in the period of 12 months of the study

Research period [month]	Shifting available standard hours of work (TZ) [h]	Planned standstill time (PP) [h]	Unplanned machines standstill (TA) [h]	Time of machine standstill (TP) [h]	Machine operating time (TZ – TP) [h]	Number of processed products (P) [m]	Product processing ideal time per unit (ICJ) [h/m]	Product processing real time per unit (RCJ) [h/m]
1	744	19.0	5	24.0	720.0	86740	0.008	0.0083
2	672	15.0	1	16.0	656.0	79030	0.008	0.0083
3	744	15.0	1	16.0	728.0	87702	0.008	0.0083
4	720	15.0	4	19.0	701.0	84455	0.008	0.0083
5	744	15.0	1	16.0	728.0	87700	0.008	0.0083
6	720	15.0	3	18.0	702.0	84568	0.008	0.0083
7	744	16.0	2	18.0	726.0	87463	0.008	0.0083
8	744	12.0	0	12.0	732.0	88187	0.008	0.0083
9	720	18.0	0	18.0	702.0	84569	0.008	0.0083
10	744	19.0	1	20.0	724.0	87220	0.008	0.0083
11	720	14.0	0	14.0	706.0	85053	0.008	0.0083
12	744	13.0	3	16.0	728.0	87762	0.008	0.0083

Source: Own study

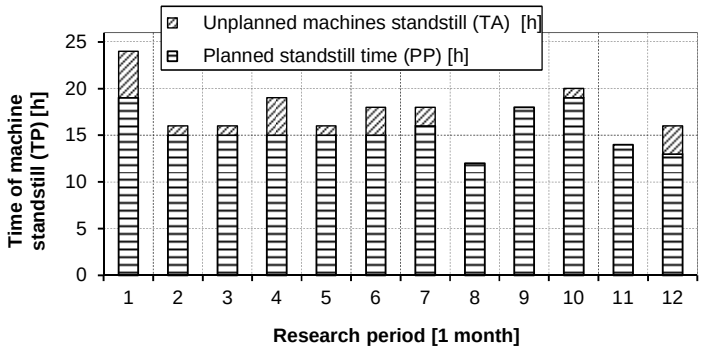

Fig. 8.1. Time of machine standstill in the studied period of 12 months.

Source: Own study

As Table 8.1 and Fig. 8.1 show, the longest time of machine standstill (TP) occurred in the first research period and was 24 hours. The longest unplanned machines standstill (TA) - 5h was also recorded in this month. The unplanned machines standstill (TA) did not occur in the 8th, 9th and 11th month of the study.

The data contained in Table 8.1 obliczone zostały współczynniki TPM (BORKOWSKI S., SELEJDAK J. SALAMON S. 2006), presented in Table 8.2.

Table 8.2. TPM coefficients for the machine used for manufacturing of the construction equipment components in the period of 12 months of the study

Research period [month]	Availability coefficient (WD) [%]	Operation velocity coefficient (WPD) [%]	Useful operation time (UCD) [%]	Utility coefficient (WW) [%]	Quality level (PJ) [%]	Quality coefficient (WJ) [%]	Overall equipment effectiveness (OEE) [%]
1	99.31	96.39	99.99	96.38	5.0	95.00	90.93
2	99.85	96.39	99.99	96.38	4.0	96.00	92.38
3	99.86	96.39	99.99	96.38	1.0	99.00	95.28
4	99.43	96.39	100.00	96.38	1.0	99.00	94.88
5	99.86	96.39	99.99	96.37	5.0	95.00	91.43
6	99.57	96.39	99.99	96.37	5.0	95.00	91.17
7	99.73	96.39	99.99	96.38	6.0	94.00	90.35
8	100.00	96.39	99.99	96.38	2.0	98.00	94.45
9	100.00	96.39	99.99	96.37	0.5	99.50	95.89
10	99.86	96.39	99.99	96.38	3.0	97.00	93.36
11	100.00	96.39	99.99	96.38	4.0	96.00	92.52
12	99.59	96.39	100.06	96.44	1.0	99.00	95.09

Source: Own study

Fig. 8.2 shows the profile of the quality coefficient (WJ) in the studied period.

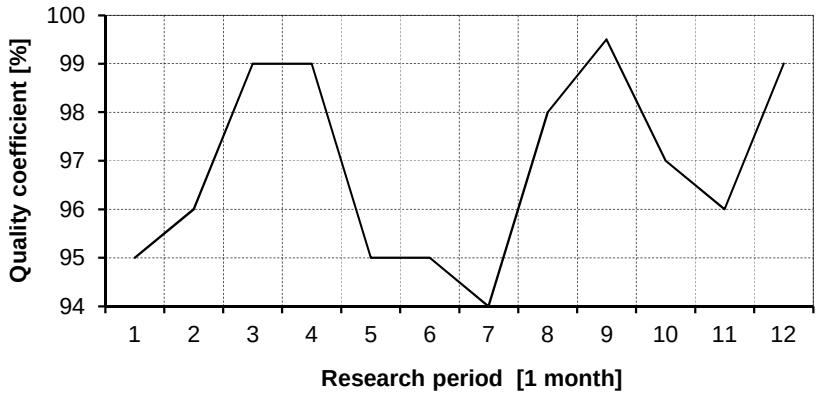

Fig. 8.2. The profile of the quality coefficient (WJ) for the machine used in the study.

Source: Own study

As Table 8.2 and Fig. 8.2 the quality coefficient (WJ) for the machine reached the level ranging from 94.00% to 99.50%. The coefficient reached the minimum value of 94% on the 7th month of the study. Its maximum value of 99.50% was found on the 9th month of the study.

The profile of the most important TPM coefficient i.e. overall equipment effectiveness (OEE) is presented in Fig. 8.3.

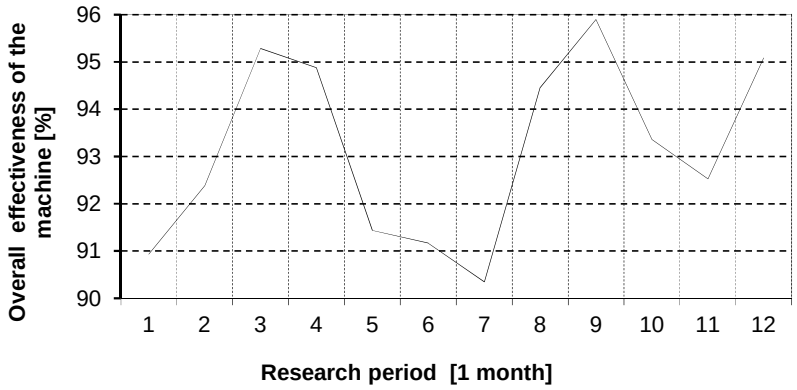

Fig. 8.3. Overall effectiveness for the machine (OEE) evaluated in the study.

Source: Own study

Overall effectiveness (OEE) of the machine used for manufacturing of construction equipment components reached the level ranging from 90.35% to 95.89% (Table 8.2 and Fig. 8.3). The lowest value (90.35%) of overall equipment effectiveness was found in the 7th month of the study, whereas the lowest level (95.89%) was reported on the 9th months.

8.2.2. PAMCO times and coefficients

The results of the study concerning PAMCO times for the machine used in manufacturing of construction equipment components are compared in Table 8.3.

Table 8.3. PAMCO times for the machine used for manufacturing of construction equipment components in the period of 12 months of the study

Research period [month]	Total time TT [h]	Utilized time UT [h]	Planned time non operating PNOT [h]	Operating time OT [h]	Routine stoppages rps [h]	Production time PT [h]	Unscheduled stoppages us [h]	Effective time ET [h]
1	744	742	12,0	730	5	725	5	720
2	672	671	13,0	658	1	657	1	656
3	744	742	11,0	731	2	729	1	728
4	720	719	13,0	706	1	705	4	701
5	744	744	12,0	732	3	729	1	728
6	720	719	13,0	706	1	705	3	702
7	744	744	14,0	730	2	728	2	726
8	744	744	11,0	733	1	732	0	732
9	720	719	16,0	703	1	702	0	702
10	744	743	17,0	726	1	725	1	724
11	720	720	12,0	708	2	706	0	706
12	744	743	11,0	732	1	731	3	728

Source: Own study

The times contained in Table 8.3 were used for computation of PAMCO coefficients (SELEJDAK J. 2006), presented in Table 8.4.

Table 8.4. PAMCO coefficients for the machine used for manufacturing of construction equipment components in the period of 12 months of the study

Research period [month]	Production efficiency PE [%]	Operational efficiency OE [%]	Available utilization AU [%]	Asset availability AA [%]	Asset utilization AUt [%]	Operational utilization OU [%]	Production utilisation PU [%]	Effective utilisation EU [%]
1	99.31	98.63	98.12	100.00	99.73	98.12	97.45	96.77
2	99.85	99.70	97.92	100.00	99.85	97.92	97.77	97.62
3	99.86	99.59	98.25	100.00	99.73	98.25	97.98	97.85
4	99.43	99.29	98.06	100.00	99.86	98.06	97.92	97.36
5	99.86	99.45	98.39	100.00	100.00	98.39	97.98	97.85
6	99.57	99.43	98.06	100.00	99.86	98.06	97.92	97.50
7	99.73	99.45	98.12	100.00	100.00	98.12	97.85	97.58
8	100.00	99.86	98.52	100.00	100.00	98.52	98.39	98.39
9	100.00	99.86	97.64	100.00	99.86	97.64	97.50	97.50
10	99.86	99.72	97.58	100.00	99.87	97.58	97.45	97.31
11	100.00	99.72	98.33	100.00	100.00	98.33	98.06	98.06
12	99.59	99.45	98.39	100.00	99.87	98.39	98.25	97.85

Source: Own study

Fig. 8.4 and 8.5 are a graphical representation of PAMCO coefficients for the machine used for manufacturing of construction equipment components in the studied period of 12 months.

The results of the study show (Fig. 8.4) that the coefficient of asset availability (AA) reached the maximum value of 100% throughout the period of 12 months of the study.

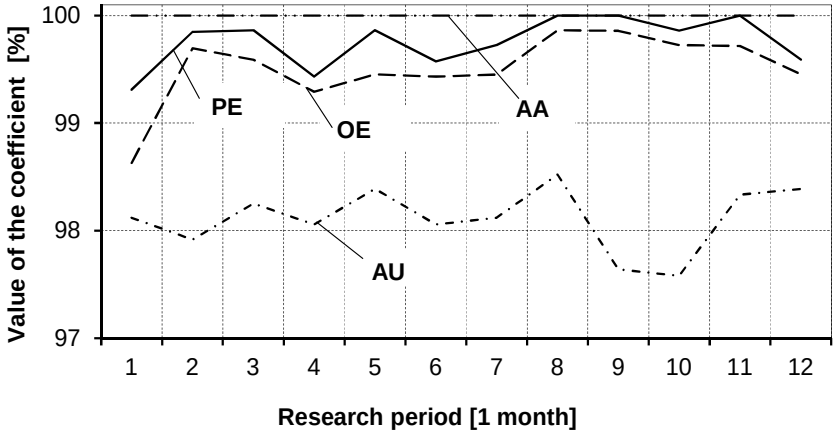

Fig. 8.4. Coefficients of production efficiency (PE), operational efficiency (OE) and asset availability (AA) and available utilization (AU) during the period of the study.

Source: Own study

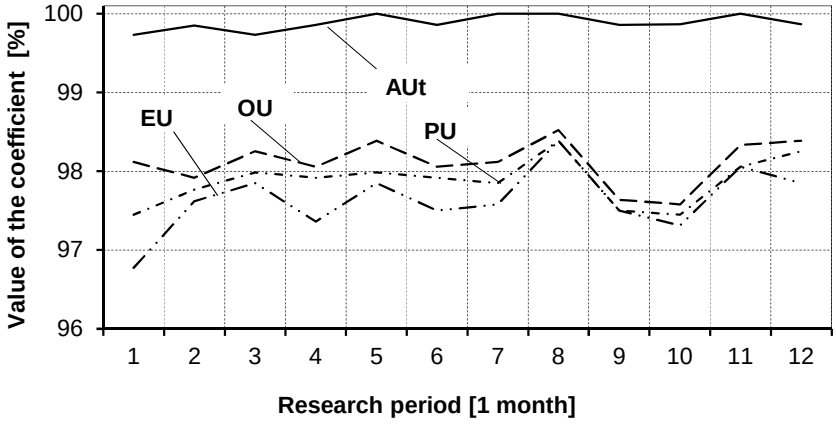

Fig. 8.5. Coefficients of asset utilization (AUt), operational utilization (OU), production utilisation (PU) and effective utilisation (EU).

Source: Own study

The coefficient of production efficiency (PE) (Fig. 8.4) had lower values (99.31% ÷ 100%) than asset availability (AA), except for the 8th, 9th and 11th months of the study, when it also reached the maximum levels of 100%. The lower values (98.63% ÷ 99.86%) than the two latter coefficients were found for the coefficient of operational efficiency (OE). The coefficient of - available utilization (AU) ranged from 97.58% ÷ 98.52%. The coefficient which reached the maximum values in four months (5th, 7th, 8th and 11th month of the study) was the coefficient of the asset utilization (AUt) (Fig. 8.5). Other three coefficients (Table 8.4 and Fig. 8.5) of operational utilization (OU), production utilisation (PU) and effective utilisation (EU) showed the values lower than the coefficient of asset utilization (AUt). Their values exhibited the following respective ranges: 97.58% ÷ 98.52%, 97.45% ÷ 98.39% and 96.77% ÷ 98.39%.

8.3. Summary

The study demonstrated that among all the TPM coefficients studied, the levels recommended by the World Class system (SELEJDAK J., KRYNKE M. 2013) were not reached by the quality coefficient (WJ). The values of this coefficient in the period studied for the machine used for manufacturing of construction equipment components ranged from 94% to 99.50% compared to the recommended level of 99.9%. However, it should be emphasized that, despite the values of the quality coefficient (WJ) which were lower than the recommended level, the quality of the manufactured construction equipment components was high. The availability coefficient (WD) ranged from 99.31% ÷ 100%, which considerably exceeded the recommended value of 90%. The utility coefficient (WW) in the whole period studied also reached the values (96.37% ÷ 96.44%) higher than the recommended level of 95%. Reaching these high values by these coefficients ensured that the overall equipment effectiveness (OEE) of the machine used for construction equipment components met the requirements of the World Class system.

This coefficient ranged from 90.35% to 95.89% while the recommended level is 85%.

Analysis of PAMCO times and coefficients revealed that unavailable time (UAT) in the whole period of the study was 0h, which caused that the coefficient of asset availability (AA) reached the maximum value of 100% for the whole period of the study. Furthermore, two coefficients of available utilization (AU) and operational utilization (OU) in each of the 12 months of the study period reached the same levels. The lowest values among the PAMCO coefficient were recorded for effective utilisation (EU). Individual coefficients showed very similar values, ranging from 96.77% ÷ 100%. The recommended levels of PAMCO coefficients have been presented in the literature (SELEJDAK J. 2006, SELEJDAK J., KRYNKE M. 2013). All the PAMCO coefficients exceeded the recommended values.

The results obtained lead to the conclusion that the effectiveness of the use of the machine for manufacturing of construction equipment components is very high. These high levels of coefficients were obtained through very low machine failure rates, i.e. short times of unplanned stoppages (Fig. 8.1). However, using the selected instruments of quality management, one should identify the causes of the non-conformities of the manufactured construction equipment components and then take corrective measures. Implementation of the corrective measures will ensure the improvement in product quality and will lead to the increase in quality coefficient (WJ) which was the only coefficient that did not reach the recommended levels.

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