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Using Overall Equipment Effectiveness indicator to measure the level of planned production time usage of sewing machine

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Abstract. The chapter presents the results of utilization of the OEE indicator to measure the level of operating time usage of sewing machine production of air bags. The idea of an OEE indictor, which is a key metrics in Total Productive Maintenance (TPM) program, is presented. The goals and benefits of its calculation are included. The research object – KL 110 air bags sewing machine - what for the machine is used. The calculation of TPM indicators for the analysed machine is presented. The calculation of TPM indicators was undertaken over a period of six months of the machine's working time. It was indicated that the overall effectiveness of the machine is at a level of 65,7%, the time losses were 34,3%. Most of the losses were related to low performance. Only *Availability* indicator reaches a word class level, if other indicators such as *Performance*, *Quality* and *OEE* should be improved, their value should be increased. Activities to improve the effectiveness of the machine utilization were determined.

Key words – air bags sewing machine, TPM, OEE, improvement

1. OEE indicator as key metric in TPM program

Overall Equipment Effectiveness (OEE) is a key metric in Total Productive Maintenance (TPM) program (BORKOWSKI S., SELEJDAK J., SALAMON S. 2006; BORKOWSKI S., ULEWICZ R. 2009). The Total Productivity Management TPM is a program of preventive maintenance of machines in the factory (KRYNKE M., KNOP K., MIELCZAREK K. 2014). OEE is embodied in the first pillar of TPM - Focused Improvement (from eight pillars), that guided all TPM activities and measured the results of these loss-focused activities.

OEE is a measure of total (complete, inclusive, whole) equipment performance - the degree to which the asset is doing what it is supposed to do (SALAMON S. 2006). OEE is also a three-part analysis tool for equipment performance based on actual availability, performance efficiency, and quality of product or output (BORKOWSKI S., KRYNKE M., RUTKOWSKI W. 2011; BORKOWSKI S., MIELCZAREK K., M. JAGUSIAK-KOCIK 2012).

OEE is used to identify a single asset (machine or equipment) and/or single stream process related losses

for the purpose of improving total asset performance and reliability (KNOP K., SELEJDAK J., MIELCZAREK K. 2010). OEE is used to identify and categorize major losses or reasons for poor performance (KNOP K., CZAJA P., OCIEPA I. 2009). OEE provides the basis for setting improvement priorities and beginning root cause analysis. OEE is used to track and trend the improvement, or decline, in equipment effectiveness over a period of time. OEE can point to hidden or untapped capacity in a manufacturing process and lead to balanced flow. The use of OEE is also intended to develop and improve collaboration between asset operations, maintenance, purchasing, and equipment engineering to jointly identify and eliminate (or reduce) the major causes of poor performance since "maintenance" alone cannot improve OEE (WILLIAMSON R.M. 2006).

2. Research object – a sewing machine

The analyzing KL 110 sewing machine is a universal sewing machine which was made in 1998 by the German KSL company. KL 110 is an innovative sewing device dedicated to precision work with medium and heavy materials. The machine is used for sewing car upholstery, airbags, safety belts and other technical textiles. The most important factor that distinguished the analysed machine from other similar devices is full automation, which allows excellent accuracy and speed, so increased productivity, quality, seamless and complete product can be observed. A view of the analysed machine is shown in Fig. 1.

Fig. 1. KL 110 sewing machine view.

Source: www.ksl-lorsch.de

3. OEE analysis for the sewing machine

Calculation of TPM indicators was made for a period of six months, taking into account the basic technical and organizational parameters of the machine, i.e.: work in three shifts, shift working time of machine in one month - 672 hr, the standard number of staff operating on the machine - 1, the ideal cycle time to produce one product - 0.03 hr/pcs, the ideal number of products manufactured in the period of one month without any downtimes - 19200 pcs.

The results of TPM indicators for the analysed machine were shown in Table 1, based on form standard in work (KNOP K., CZAJA P., OCIEPA I. 2009).

Table 1. Results of calculation of OEE indicators for the machine in research period of time

Research period [month]	Total Production Time [h]	Planned shut-downs [h]	Planned Production Time [h]	Unplanned shut-downs [h]	Operating Time [h]	Availability [%]	All products [pcs]	Standard capacity of machine [pcs/hr]	Real capacity of machine [pcs/hr]	Standard cycle time [hr/pcs]	Real cycle time [hr/pcs]	Performance [%]	Number of scraps [pcs]	Quality [%]	OEE [%]
	A	B	C=A-B	$D=\Sigma D_i$	E=C-D	F=E/C	G	H	I=(G/H)*60	J	K=E/G	L=(J*H)/E	M	N=(G-M)/G	O=(I*L*N)/10000
1	672	4.5	667.5	19.5	648	97.08	14391	95.24	33.33	0.0300	0.0450	66.63	72	99.50	64.36
2	672	32.5	639.5	9.5	630	98.51	13984	95.24	33.33	0.0300	0.0451	66.60	95	99.32	65.16
3	672	7	665	17.5	647.5	97.37	14381	95.24	33.33	0.0300	0.0450	66.64	119	99.17	64.35
4	672	17.5	654.5	20	634.5	96.94	15473	95.24	33.33	0.0300	0.0410	73.17	99	99.36	70.48
5	672	57	615	25.5	589.5	95.85	13031	95.24	33.33	0.0300	0.0452	66.32	86	99.34	63.15
6	672	18	654	40	614	93.88	14617	95.24	33.33	0.0300	0.0420	71.43	106	99.27	66.57
Σ	***4032***	***136.5***	***3896***	***132***	***3763.5***	***96.61***	***85877***	***95.24***	***33.33***	***0.0300***	***0.0450***	***68.46***	***577***	***99.33***	***65.70***

Source: own study

The distribution of TPM indicators values (MIELCZAREK K., BORKOWSKI S. 2011) is shown in Figure 2.

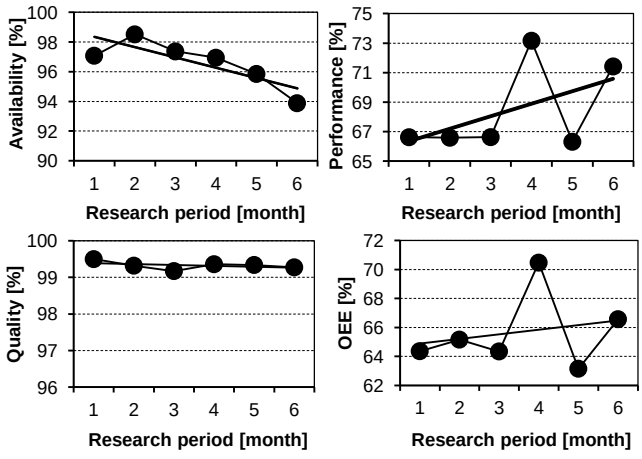

Fig. 2. Values distribution with the trend line of TPM indicators: a) "Availability", b) "Performance", c) "Quality", d) "OEE" for the machine in the research period.

Source: own study

From the analysis of Figure 2 we can see a decrease in the availability level of the machine during the next few months, but we can also see an increasing trend of the performance level and a stable level of quality and the increasing trend of the OEE indicator.

The structure of time losses compared to the effective production is shown in Figure 3.

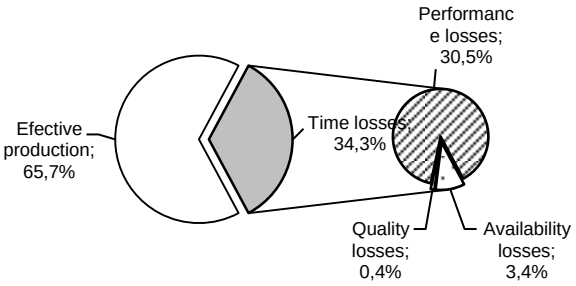

Fig. 3. Structure of time losses in relation to effective time of production.

Source: own study

Time losses accounted for only 32.1% compared to 67.9% of the effective work time, most of the losses were related to the performance, up 30.5%, in second place, with availability (1.2%), losses of quality accounted had only a 0.4% share in total losses.

The distribution of values of TPM indicators in the analysed research period is shown in Figure 4.

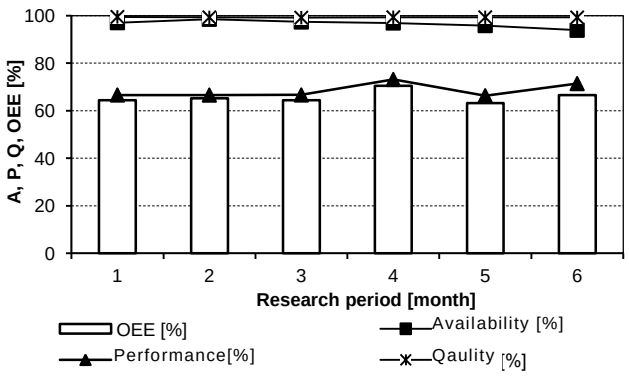

Fig. 4. Distribution of overall value of TPM indicators for the machine in the research period.

Source: own study

The greatest impact on the low value of OEE in the research period had performance losses (slowdown work, minor steps). The lowest impact on the total value of OEE was related to the availability and quality losses.

Fig. 5 presents the difference between the planned and actual number of products manufactured in the analysed research period by the machine.

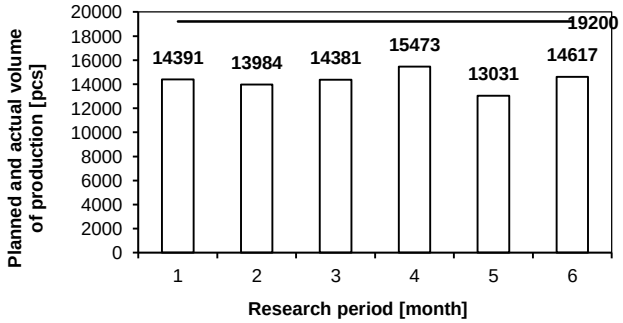

Fig. 5. Plan and production execution - summary of planned and actual number of goods produced on the analysed machine in a period of six months.

Source: own study

The analysis shows that the machine did not reach the target number of produced product pieces, the level of production was lower by 3727 pieces (in the best 4th month) and 6169 pieces (in the worst 5th month) from the target.

Comparison of particular TPM indicators for the machine in the whole research period and comparing the obtained results to the world class level of TPM values is presented in Figure 6.

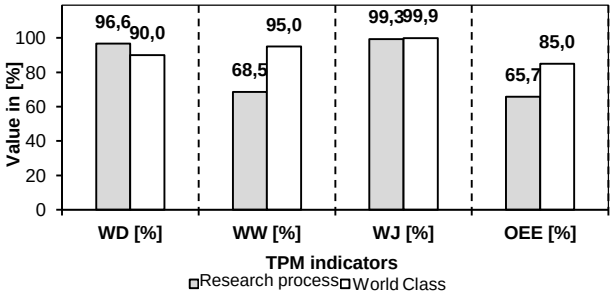

Fig. 6. Comparison of actual values of TPM indicators for the machine with the values of world class level.

Source: own study

The availability indicator of 96.6% suggests that the airbag sewing process on the analysed machine ran at 96.6% without unplanned breaks. The performance indicator of 68.5% means that the process was in 68.5% required (standard) cycle time. The quality indicator of 99.3% means that the analysed machine in produced good products this percentage of times.

Based on a comparison of TPM indicators with the indicators for the world class level, it can be concluded that the availability indicator achieved the world class level. The world class level was even exceeded. At quality indicator level the world class standard hasn't been reached but the level was very close to world class, only the performance indicator was at a lower level than world class.

OEE level for the analysed machine didn't reach the world class level in the whole analysed period, but finally the OEE value had a satisfactory level (> 60%).

4. Guidelines for improving the effectiveness of the machine working time

In order to increase the effectiveness of airbag sewing machines the company can use the following solutions:

- activate staff operating with the machine in action of prevention of machine maintenance (TPM pillar: Autonomus Maintanance),
- conduct a thorough analysis, indicating how well the maintenance department perform their duties in order to identify strengths of this department and those that require improvement. The information will be useful for recruitment and selecting the best people for specific actions,
- in each case analyze the root causes of failure in teams consisting of employees of the 'MD' and production staff,
- measure and analyse reasons for minor steps and slowdown work to find the best solution to reduce them,
- carefully plan the maintenance of machinery and repair work. Planned machine maintenance allows to keep the machine in constant readiness. It gives confidence that when you need specific equipment to perform the contract it will be available and operational.

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