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The Machines Operation Effectiveness Analysis in Polish industry enterprise

STASIAK-BETLEJEWSKA Renata

Czestochowa University of Technology, Faculty of Management, Department of Production Engineering and Safety, Al. Armii Krajowej 19B, 42-200 Częstochowa, Poland

renata.stasiak-betlejewska@wz.pcz.pl

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Abstract. TPM (Total Productive Maintenance) is one of the main Total Quality Management components. It is an activity aimed at increasing the productivity and efficiency of processes related to maintaining traffic by increasing creative involvement of operational employees involved in these processes. The primary goal of TPM is zero failures and zero defects resulting from machines and devices operation. Machine operation effectiveness and machine modernity level analysis presented in the paper allows for identifying the machine effectiveness level that determines the product quality level in the selected textile industry enterprises.

Introduction

Geosynthetics has now become a group of materials that are attractive to designers, investors and contractors of the construction industry due to potential savings in comparison to traditional engineering solutions. However, it should be remembered that the quality of geosynthetics depends to a large extent on the level of modernity of production machines and the level of effectiveness of their work. According to a definition given by the International Geosynthetics Society, a *geosynthetic* is a flat material made of polymer, used in construction in contact with soil, rock or other geotechnical material [1]. *Geotextiles* (GTX) are the basic group of permeable geosynthetic products. According to [2], they are defined as flat, permeable, polymeric (synthetic or natural) textile products that can be woven, nonwoven or knitted, used in contact with soil and/or other materials in geotechnics and construction. This group includes geo-textiles, geotextiles and geeks. Geotextile (GTX-W), according to [3], is a textile product made of two (or more) systems of yarns, continuous fibers, tapes or other elements, usually interlaced at right angles, made with a classic weaving technique (warp has the longitudinal direction to the length of the fabric, the thread is made of threads perpendicular to the warp) [11,12].

The aim of the research findings presented in the paper is the analysis of the selected machine operation effectiveness and its modernity level with regard to the textile industry product quality that is determined mainly by the machine operation conditions and the machine use level. TPM indicators and the machine modernity level analysis method (ABC method) were used to indicate selected machine conditions responsible for the final textile product quality.

Research methodology

Operation of machines and devices in the textile industry is one of the key factors affecting the final product quality level and thus its functionality and durability. One of the main element of Total Quality Management is Total Productive Maintenance that is aimed at preventing deterioration of machines or defects and eliminating serious factors responsible for losses in the form of low quality products. The essence of the TPM concept is uncompromising prevention of damage, which is based on three assumptions [3, 4]:

1. Maintaining normal working conditions of technical facilities. In order to maintain normal machine working conditions, employees must prevent damage to technical objects by regular cleaning, inspecting, lubricating, tightening loosened components and checking accuracy.
2. Early detection of incorrect work of technical facilities. In doing so, operators should use their senses and measuring instruments available in order to detect the earliest signs of abnormal operation. In order to detect incorrect operation of technical objects, maintenance workers should also carry out periodic diagnostic checks with the help of specialist equipment.
3. Immediate reaction to incorrect work of technical facilities. Operators and maintenance staff cannot afford to delay in responding to malfunction of technical objects, as this could seriously undermine the achieved level of productivity of technical objects.

The TPM concept covers the full life cycle of devices and such issues in the cycle as: operation, inspection, maintenance, repair, diagnostics, design and manufacture of machinery and equipment. Statistical data show that 80% of the full equipment life cycle costs are set at the stage starting from design to commissioning of the machine, while costs related to operation (maintenance, repairs) often far exceed the purchase price of the device [9,10]. The TPM system is a system which serves maximizing the effectiveness of the equipment and establishing a general pro-active service system covering the entire equipment lifetime. It covers all departments (including planning department, departments using equipment, departments supporting equipment), all personnel from top management to workshop staff who participate in it, promotes handling oriented to the manufacturing process thanks to incentive management, directs enterprise activities to the elimination of the so-called six great losses [5].

In order to implement the TPM system in an enterprise, PM (Preventive Maintenance), that is prophylactic maintenance of technical facilities should be introduced first. The implementation of TPM brings many benefits. According to [6], the main benefits include reduction of failures by 90%, reduction of customer complaints by 75%, reduction of the maintenance services need, increase of technical facilities readiness for immediate production by 40%, increase of technical facilities work rate by 10%, increase of productivity by 150%, reduction of maintenance costs and technical objects maintenance with a 30% reduction in manufacturing costs by 30%, reduced inventory levels by 50% and a serious decrease in the number of the work accidents.

To measure the effectiveness of TPM implementation, the OEE (Overall Equipment Effectiveness) parameter describing overall efficiency of equipment is used. It is calculated as a result of the mentioned indicator which calculates the device availability indicator, the use of working time indicator, the efficiency indicator and production quality indicator. In general, it is calculated as [6]:

$$\text{OEE} = \text{availability} \times \text{use of working time} \times \text{efficiency} \times \text{quality}. \quad (1)$$

Equipment availability (availability) is the percentage of time in which the station is available for production. The use of working time (operating efficiency) is the percentage share of the actual operating time in the time available for production. The use of working time is affected by periods of inactivity of the device due to the lack of product, lack of operator, break for meals and breaks at meetings of production staff.

Efficiency, as the efficiency ratio (efficiency rate) is the ratio between the capacity of the actual and theoretical maximum efficiency of the device. *Quality*, as the quality index (rate of quality) indicates the percentage of good products in total production made on the device. Products that are eligible for improvement are also considered to be defective [7].

Machine components modernity level is the next element which is crucial for the product quality level identification. The level of modernity of the machine can be assessed by the ABC method using the Parker scale with the following levels [5, 6]:

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- level 1 - simple parts, it is possible to create them with the help of craft techniques, e.g. cover,
- level 2 - parts for which unchanged and well-known technologies have been used for many years, e.g. standard engine cooling system,
- level 3 - parts produced using a controlled technology, requiring appropriate technical knowledge, e.g. a standard electric motor,
- level 4 - parts that have been produced using modern market technologies, e.g. displaying information on the monitor of the control panel,
- level 5 - parts resulting from the production of a combined use of modern technologies, patented and existing only in a specific company's machine.

The use of this modern categorization allows for the alignment of component parts at the level of relevance of their development and investment, e.g. decision on which of them need to be moved to a higher level. Technologies often create constellations that use rules of scientific approach to a problem. However, the ABC analysis of the technology always allows for the specification of significant technological capabilities of the company. The ABC analysis of technology is based on the principle that each statistical group can be distinguished by several of its segments, conventionally marked with the A letter, which determines the main part of the effects. At the other end of distribution there are many members of the group marked with the C symbol, with a small contribution to the results of its activity. However, their work cannot be completely disregarded. Others are an indirect group members marked with the B letter [5, 6, 8]. The ABC analysis consists in classifying technologies used in a given machine or device. Basic technologies are technologies of A category, which include fundamental components of machines that give a product special attributes. The B category is assistive technology, often of a general nature. Side technologies, the C category, are mainly technologies that are not subject to any innovative activity of the user and are of little importance when buying new machines.

Research object and research findings analysis

The subject of the analysis in the article is a selected machine that plays a key role in the process of weaving a geotextile in the form of a flat loom. Weaving involves the interlacing warp thread resulting in a fabric. Two main mechanisms of the loom are involved in the weaving operation: the feeding mechanism which provides the warp and the metastatic mechanism which introduces the weft. The employee is responsible for the operation of a machine and controls a visually resultant fabric. Characteristics of a flat loom has been presented in the context of the analysis of the results using the ABC method.

The analyzed machine, named Sulzer Power Leno loom, was manufactured in 2007. It is used for the production of polypropylene fabrics. It consists of two main elements: the loom and winder. It has two types of sensors spurt: the sensor warp and sensor weft. Specifications loom flat are as follows: 8 kW power output, yield 265 rev / min, voltage of 400V, the noise level approx. 75 dB. The level of modernity of the loom was assessed based on a comparison of this machine with a loom manufactured by Textima, a market leader. Using a scale and the method of Parker ABC technology, results were obtained which are shown in Table 1.

Table 1. Evaluation of the Sulzer Power Leno loom parts modernity level

Part category	**No**	**Machine subassembly**	**Technology level**
A	A1	The control system	5
	A2	Control panel	5
	A3	Programming system	4
	A4	Measuring system	4
	A5	Repair system	4
	A6	Winding the finished product	4
	A7	Automatic change in threading density	4
	A8	Fabric regulator	4
B	B1	Main propulsion system	4
	B2	Adjustment system	4
	B3	Pneumatic system	5
	B4	Compressor (air network)	4
	B5	Attaching the workpiece	4
	B6	An innovative system of changing the weaving isthmus	5
C	C1	Machine construction (housing)	4
	C2	Lubrication system	4
	C3	Ribbon guide elements	5

Source: own elaboration.

The ABC analysis of the technology of individual components of the Power Leno flat bar components using the Parker five-degree scale showed that 71% of its components are at the 4th level of modernity of this scale, while the remaining 29% are components classified at the 5th level of modernity according to the Parker scale. The occurrence of parts at the modern level 5 indicates that the machine uses the latest technology. It is a guarantee of producing high quality products.

The evaluation of the effectiveness of the use of the Power Leno flat loom with the use of TPM coefficients were carried out for a period of 22 weeks. The individual elements of the OEE calculation sheet have been presented in Table 2.

The value of the overall efficiency of the OEE device allows for assessing the overall efficiency of the flat loom. The analyzed machine achieves results in the range of 48.42% ÷ 59.25%. The UCD indicator reaches values in the range of 68.27% ÷ 83.75%. The machine also achieves a high level of WJ index that is over 99% (which guarantees the production of high-quality geotextiles).

Conclusions

The article presents the results of the efficiency factor analysis for 22 weeks. The value of OEE (desirable over 60%, satisfying over 80%) allows for the assessment of the efficiency of the use of machines, and consequently of the whole process from the point of view of machines and devices.

The analysis of TPM coefficients for machines involved in the production of geotextiles made it possible to state that the efficiency of these machines is not satisfactory. The desired value of OEE should be at the level of 60%, and satisfactory at above 80%.

Table 2. Analysis of the efficiency of the Power Leno flat loom during the research period of 22 weeks

The research period [week]	Shift work time fund TZ [h]	Downtime TP [h]	Machine operation time (TZ-TP) [h]	Operating coefficient WE [%]	Perfect unit time ICJ [min/rot.]	Real unit time RCJ [[min/rot.]	Operating speed factor WPD [%]	Production P [rot.]	Usable time of action UCD [%]	The efficiency coefficient WW [%]	The quality level PJ [%]	The quality coefficient WJ [%]	Total machine efficiency OEE [%]
1	168	8	160	95.24	0.004	0.0055	72.73	2371200	81.51	59.28	0.05	99.95	56.43
2	168	6.5	161.5	96.13	0.004	0.0055	72.73	2335300	79.53	57.84	0.05	99.95	55.57
3	168	5	163	97.02	0.004	0.0055	72.73	2318200	78.22	56.89	0.10	99.90	55.14
4	168	3.5	164.5	97.92	0.004	0.0055	72.73	2489900	83.25	60.54	0.05	99.95	59.25
5	168	5.5	162.5	96.73	0.004	0.0055	72.73	2474500	83.75	60.91	0.10	99.90	58.86
6	168	3.5	164.5	97.92	0.004	0.0055	72.73	2255000	75.40	54.83	0.05	99.95	53.66
7	168	9	159	94.64	0.004	0.0055	72.73	2337050	80.84	58.79	0.05	99.95	55.62
8	168	7	161	95.83	0.004	0.0055	72.73	2265500	77.39	56.29	0.05	99.95	53.91
9	168	4	164	97.62	0.004	0.0055	72.73	2035700	68.27	49.65	0.10	99.90	48.42
10	168	9.5	158.5	94.35	0.004	0.0055	72.73	2376500	82.47	59.97	0.10	99.90	56.53
11	168	3.5	164.5	97.92	0.004	0.0055	72.73	2277600	76.15	55.38	0.05	99.95	54.20
12	168	2	166	98.81	0.004	0.0055	72.73	2134050	70.71	51.42	0.10	99.90	50.76
13	168	4.5	163.5	97.32	0.004	0.0055	72.73	2385000	80.23	58.35	0.25	99.75	56.64
14	168	8	160	95.24	0.004	0.0055	72.73	2175500	74.78	54.39	0.15	99.85	51.72
15	168	4	164	97.62	0.004	0.0055	72.73	2253000	75.56	54.95	0.05	99.95	53.62
16	168	4.5	163.5	97.32	0.004	0.0055	72.73	2346500	78.93	57.41	0.05	99.95	55.84
17	168	10	158	94.05	0.004	0.0055	72.73	2354600	81.96	59.61	0.05	99.95	56.03
18	168	6.5	161.5	96.13	0.004	0.0055	72.73	2355300	80.21	58.34	0.10	99.90	56.02
19	168	4	164	97.6	0.004	0.0055	72.73	2375500	79.67	57.94	0.25	99.75	56.42
20	168	7	161	95.83	0.004	0.0055	72.73	2379500	81.29	59.12	0.10	99.90	56.60
21	168	3.5	164.5	97.92	0.004	0.0055	72.73	2365400	79.09	57.52	0.05	99.95	56.29
22	168	7	161	95.83	0.004	0.0055	72.73	2374750	81.13	59.00	0.10	99.90	56.49

Source: own elaboration.

References

[1] Recommended descriptions of geosynthetics functions, geosynthetics terminology, mathematical and graphical symbols. International Geosynthetics Society, 2000.

[2] PN-EN ISO 10318:2007 Geosyntetyki. Terminy i definicje.

[3] J. Łunarski J. Zarządzanie jakością. Standardy i zasady, Wydawnictwo Naukowo – Techniczne, Warszawa, 2008.

[4] S. Borkowski, R. Ulewicz, J. Selejdak, M. Konstanciak, D. Klimecka-Tatar, The Use of 3x3 Matrix to Evaluation of Ribbed Wire Manufacturing Technology. METAL 2012. 21st International Conference on Metallurgy and Materials. Conference Proceedings. TANGER. May 23rd - 25th, Brno, Czech Republic. 2012.

[5] S. Borkowski, J. Selejdak, S. Salamon. Efektywność eksploatacji maszyn i urządzeń, Wydawnictwo Wydziału Zarządzania Politechniki Częstochowskiej, Częstochowa 2006.

[6] J. Pietraszek, M. Kolomycki, A. Szczotok, R. Dwornicka, The Fuzzy Approach to Assessment of ANOVA Results, Computational Collective Intelligence, ICCCI 2016, PT I, Lecture Notes in Artificial Intelligence 9875 (2016), pp. 260-268

[7] M. Urbaniak. Zarządzanie jakością. Teoria i praktyka, Wydawnictwo Difin, Warszawa. 2004.

[8] R. Ulewicz, D. Jelonek, M. Mazur, Implementation of logic flow in planning and production control, Management and Production Engineering Review 7/1 (2016), pp. 89-94. https://doi.org/10.1515/mper-2016-0010

[9] Maszke A., The analysis of machine operation and equipment loss in ironworks and steelworks, Production Engineering Archives 17(2017), pp. 45-48. https://doi.org/10.30657/pea.2017.17.10

[10] S. Stasiak-Betlejewska, R. Ulewicz, The effectiveness of selected machinery and equipment in the woodworking joinery, Path forward for wood products: a global perspective, Proceedings of scientific papers, 2016 , pp. 149-156.

[11] T. Ylipaa, A. Skoogh, J. Bokrantz, Jon; et al., Identification of maintenance improvement potential using OEE assessment, International journal of productivity and performance management 66(1)2017. pp.126-143. https://doi.org/10.1108/IJPPM-01-2016-0028

[12] A. Tifan, Directions for improving management accounting in the textile industry enterprises, Industria Textila 65(2) 2014, pp.101-106