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MEASURING PRODUCTION EFFECTIVENESS: INDUSTRIAL CASE FROM ELECTRONIC INDUSTRY

Abstract:

Purpose – Production effectiveness have been recently, viewed as a critical factor in manufacturing system. A theoretical maximum capacity must be compared with the actual output and production time, equipment speed and quality of production processes must be adequately considered. The OEE approach is the only production indicator combining the factors of time, speed and quality in useful and straightforward way. The OEE is calculated by multiplying the availability rate, performance rate and quality rate, representing simple and valid way to measure production effectiveness, but literature does not discuss difficulties with determination of all the factors of the OEE calculation, especially causes of time losses and determination of productive and non-productive time. Measurement of availability loses due to breakdowns, changeover, waiting or administration activities must be closer supervised to identify potential decrease of performance and related costs.
Design/methodology/approach - Based on theoretical basis concerning determination of relevant productive and non-productive administrative activities, there was performed research and time analyses in manufacturing company by realized measurement of OEE and time analyses.
Findings – Realized study and time analyses contribute to understand the OEE value calculation and identification of time loss causes. The discussion of the industrial case shows the importance of crucial identification of productive and non-productive time for efficient OEE calculation.
Originality/value – The paper deals with industrial case, performed in collaboration with important enterprise of electronic industry; by realized measurement of productive and non-productive times in relation to OEE calculation there was obtained an original qualitative analysis, showing contribution to OEE value and identified difficulties with proper identification of availability loses due to non-productive and non-value added activities.

Keywords:

production efficiency; operation management; value-added activities; corporate effectiveness

JEL Classification: D20, D24, L23

1. Introduction and literature review

Lean management represents current mostly accepted managerial approach to reach corporate effectiveness. Requirements of competitive environment, global markets conditions and customers' needs, tends to improve the productivity of a manufacturing organization with respect to different markets and product mixes (Hilmola, 2005, p. 48). The concept of Lean Manufacturing identify the seven wastes (7 Mudas) that must be removed from corporate processes and as a basic measure of efficient production there is usually compared the theoretical maximum good output with the actual good output. The OEE (Overall Equipment Effectiveness) indicator was developed and used, in order to find all potential losses in effectiveness and to summarize them in one indicator.

The OEE is a metric originally developed by Seiichi Nakajima in the 1960s based on the multiplication of equipment availability, performance and quality (Nakajima, 1998). The concept was later improved by Tajiri and Gotoh, classifying major losses into six groups (Tajiri and Gotoh, 1992). According to Nakajima, Tajiri and Gotoh, the availability of an equipment is influenced by breakdown losses, setup and adjustment losses. Minor stoppage/idling and reduced speed losses are considered as performance losses and defects in process (scrap/rework) and reduced yield are defined as quality losses. Jeong and Phillips (2001) present more detailed loss classification scheme, but most authors adopted Nakajima's loss classification without further discussion (Jeong and Phillips, 2001, p. 1414). Jonsson & Lesshammar (1999) improved definition of quality as a proportion of defective production to the total production volume; the original concept only involves defects that occur only on a specific machine or production line (Jonsson & Lesshammar, 1999, p.75). Konopka and Trybula (1996) describe application of OEE to the semiconductor industry known as CUBES (Capacity Utilization Bottleneck Efficiency System) based on the total calendar time-based approach instead of loading time-based approach. (Konopka and Trybula, 1996, p. 138).

The OEE is calculated by multiplication of the availability rate (the relationship between actual production time and potential production time), performance rate (the relationship between actual output and potential output) and quality rate (the relationship between good products and actual output); the OEE assumes a theoretical maximum capacity on the one hand and the actual output. Due to the multiplicative effect, corporations follow and require high OEE value and use OEE indicator as a common and overarching corporate performance goal (or KPI). Value of OEE indicator usually mentioned in literature indicates good equipment effectiveness around 85% (World class), but according to Williamson (2006), there is no specific reason to maximize and pursue high OEE value; typical value of OEE is generally accepted as 60% and optimal levels of OEE depend of capacity, the demands, and constraints in the process flow (Williamson, 2006).

The OEE value indicates current utilization of equipment. Reasons of low or lower values are however usually hidden and must be searched for to find out the causes of losses and start the improvement of OEE level. The relationship between losses and OEE must be clearly identified to closer understand the loss reasons. The OEE value would be affected by many factors; production planning, scheduling, batch sizes, and quality management activities are the most important parameters influencing OEE calculation. Schmenner and Vollmann (1994) argued that most organizations were both using wrong

measures and failing to use the right measures of the OEE in correct ways (Schmenner and Vollmann, 1994, p. 62), Muchiri (2007) supported their conclusions and demonstrated, that there is a significant difference between theoretical and practical assessment of OEE (Muchiri, 2007, p. 3517). Puvanasvaran, Teoh & Tay pointed out that, the machine with various product-typed productions causes many changeovers, decreasing the availability of the machine. As another influencing factor they mentioned risk of human bias during the record of the data and unavailability or infeasibility to collect data. (Puvanasvaran, Teoh & Tay, 2013, p. 509). Tsarouhas (2007) present detailed analysis of setup and changeover as time losses (Tsarouhas, 2007, p. 9), Raja and Kannan (2007) present realized industrial case solving problem with material wasting and yield losses (Raja & Kannan, 2007, p. 1736), Jebaral (2013) present study concerning reducing or eliminating the small stop time losses (Jebaral et al., 2013, p. 793).

Data collection process suffers by many problems; there can be recognized problems with identifying productive/non-productive/idle times; operation and administration activities related with production process and data collection can be considered as productive activities but in some cases can lead to lower speed, minor stoppages, waiting or breakdowns. There is necessary to perform detailed time analyses to fully understand causes of availability and performance losses.

2. Case study

The industrial case deals with a very important producer of electronic components for the automotive, aerospace, energy and other machinery industries. The producer enjoys significant competitive advantage by unique production know-how, proven production technology along with high product quality and durability. This is a very good representation of the production system oriented on production efficiency, product quality and low working capital requirement leading to low level stocks of materials, as well as products.

Research was realized for Tubing line producing plastic tube components for electronic cables, connectors, markers and other products. Production process follows operation: Extrusion – Beam – Expansion – Finalization. At the end of process, final product is cutted up, controlled, adjusted and packaged. To maintain and improve efficient manufacturing system the OEE indicator was implemented and measured. Overall measurement of OEE indicator shows unsatisfactory low level of OEE ratio around 60 %. Measurement of OEE for Tubing line for 6 month period is shown in Table 1 and Table 2.

Table 1: The OEE calculation data over 6 months

OEE times		10/14	11/14	12/14	01/15	02/15	03/15	Total
Total available time		44640	43200	44640	44640	40320	44640	262080
Maintenance and Repair		1100	2300	0	562	2155	908	7025
Potential available time	A	43540	40900	44640	44078	38165	43732	255055
Waiting		785	1125	980	856	802	1329	5877
Changeover		4205	3855	3760	4222	4140	3492	23674
Theoretical available time	B	38550	35920	39900	39000	33223	38911	225504
Reduced speed / minor stoppages		4520	13600	8550	8920	14080	10492	60162
Actual available time	C	34030	22320	31350	30080	19143	28419	165342
"Scrap" time		2240	2600	343	840	2650	2500	11173
"Good product" time	D	31790	19720	31007	29240	16493	25919	154169

Source: Own adjustment based on performed corporate OEE calculation

Table 2: The monthly and overall OEE

OEE rates	10/14	11/14	12/14	01/15	02/15	03/15	Total
Availability rate (B/A)	88,5%	87,8%	89,4%	88,5%	87,1%	89,0%	88,4%
Performance rate (C/B)	88,3%	62,1%	78,6%	77,1%	57,6%	73,0%	73,3%
Quality rate (D/C)	93,4%	88,4%	98,9%	97,2%	86,2%	91,2%	93,2%
Total OEE	73,0%	48,2%	69,5%	66,3%	43,2%	59,3%	60,4%

Source: Own adjustment based on performed corporate OEE calculation

An OEE score around 60% is fairly typical for discrete manufacturers, but indicates there is substantial space for improvement and company set the long-term goal concerning

OEE value to 85%. Preliminary analysis of causes influencing availability and performance losses was performed, to identify reasons of lower effectiveness. As the most probable reason were determined administrative activities of line operators concerning quality data collection, operation records and other administrative records. These activities were considered mostly as non-productive, influencing line speed, causing idle times and overall decrease of availability and performance (According interviews with line operators).

To confirm or reject this assumption one-month times analysis, monitoring times of administrative activities, was realized. Along production line were recognized 9 standard and 2 non-standard administrative activities:

1) Safety records (performed at the beginning of each work shift)
   - Documentation of autonomous maintenance
   - 5S + 1 documentation
2) Administrative records (performed with each order/batch)
   - Filling Accompanying sheet
   - Placing to ERP SW
   - Filling production order
   - Filling operative records
   - Filling special SW records
   - Filling information for SPC diagram
   - Filling information for labeling
3) Non-standard activities (performed only when specific conditions / breakdowns occur)
   - Filling information for Quality Clinic Process Charts (QCPC)
   - Filling information for Layered Process Audit Systems (LPA)

Following Table 3 shows time records of recognized standard and non-standard administrative activities during one month. During times analysis reduced speed and minor stoppages times as a result of administrative activities were measured.

Table 3: Recorded times of administrative activities during last month

Administrative activities	Time recorded /month (min)	Reduced speed / minor stoppages time (min)	Share
1) Safety records			
Autonomous maintenance	612	612	100%
5S + 1	305	305	100%
2) Administrative records			
Accompanying sheet	580	0	0%
ERP SW	534	510	96%
Production order	1064	1064	100%
Operative records	534	410	77%
Special SW records	333	160	48%
SPC diagram	50	0	0%
Labelling	150	0	0%
3) Non-standard activities			
QCPC	not recorded	-	
LPA	not recorded	-	
Total	**4162**	**3061**	**74%**

Source: Own adjustment based on corporate time analyses

The last column shows ratio describing how administrative activities causes time losses. During analyses no non-standard situations occur.

3. Analysis of results

Time analyses show that administrative activities have direct impact on equipment speed and minor stoppages time; during safety records and processing Production order must be machines fully stopped. On the other hand some activities have no relation with time losses and can be performed alongside with production process while the machine is still running and does not contribute to OEE loss.

As an important result, high ratio between monthly time losses and administrative activities times (74%) can be mentioned. Absolute value of time losses (3061 minutes) represent more than 50 non-productive hours per month. Although these hours can be considered as non-productive, administrative activities as such are recognized mostly as necessary and important.

Another interesting result can be concluded from comparison of absolute value of time losses with OEE ratio for particular month (03/2015). Absolute value of time losses as a result of administrative activities (3061 minutes) represents 29% of all Reduced speed/minor stoppages time in March 2015 (10492 minutes (see Table 1)). Administrative activities causing time losses have negative contribution to low Performance rate; contribution can be expressed as 7,9% decrease and an effect on Quality rate can be expressed as 0,9% decrease. An overall effect in March 2015 represents decrease of the OEE ratio by 7%. Although this decrease can be considered as significant, administrative activities have not as dominant effect on OEE level as expected.

4. Conclusions

Industrial case, described in previous chapter, shows the importance of depth oriented analysis of production effectiveness focused on reasons causing time losses. The results and contributions to OEE calculation and efficiency measurement are summarized in the following points:

- Overall Equipment Effectiveness calculated as a summarized ratio must be thoroughly analysed to fully understand where in the company inefficient activities arise; reasons of low or lower OEE values are usually hidden and must be tracked out to find the causes of losses.
- Not all activities and causes resulting in time losses can be considered as non-productive and non-value added; many administrative activities causing time losses are necessary and crucial for quality and customer-oriented production processes.
- Optimal levels of OEE must be adjusted according to equipment capacity, production mix, quality and customers' requirements and other constraints in the production process; simple following and pursuing maximal OEE value do not respect all components of business performance.
- Identification of causes represents time consuming and expensive process; continuous monitoring of production processes along the relatively simple production process and over 6 month period requires full understanding and high responsibility of production line operators as well as record-keepers.

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