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Adaptation of the OEE Indicator in the Footwear Manufacturing Sector in Mexico

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ABSTRACT: The Lean Manufacturing philosophy has been adopted in recent years by companies that have traditionally manufactured their products with artisanal processes and now seek to be competitive in today's market. The adaptation of the concepts established in this philosophy in the local industry has been one of the main limitations in the successful application of this philosophy. One of the most important measurements in the area of Lean Manufacturing is the OEE indicator, which indicates the real capacity to produce without defects. This article presents an adaptation of this indicator and its implementation in one of the industrial sectors with the greatest impact in the Mexican Bajío region, such as footwear manufacturing. This adaptation of the indicator can be applied to any company in this sector.

KEYWORDS: Lean Manufacturing, OEE, Footwear manufacturing.

INTRODUCTION

The need for changes in production processes to take advantage of resources has forced local companies to adopt new work schemes that allow them to be competitive in today's market. A manufacturing philosophy that has recently helped world-class companies to remain at a highly competitive level is Lean Manufacturing; however, adapting the concepts proposed by this philosophy to companies in the region has not been easy.

Lean is an English word that can be translated as “fat-free, scarce, slim”, but applied to a production system it means “agile, flexible”, i.e., capable of adapting to customer needs (Rajadell and Sanchez, 2010). Lean manufacturing is the name given to the Just in Time system in the West, also called Toyota production system. This work philosophy can be defined as a continuous and systematic process of identification and elimination of waste or excess, understanding as excess any activity that does not add value in a process, but does add cost and labor. This systematic elimination is carried out by working with teams of well-organized and trained people (Socconini, 2019; Hernández-Vázquez et al., 2021).

In this paper, an adaptation of the OEE indicator is made and its implementation in the footwear manufacturing industry is presented. This indicator represents the main measurement criterion in Lean Manufacturing since it allows us to know the real capacity to produce without defects.

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is an indicator that is calculated daily for a piece of equipment or groups of machines and establishes the comparison between the number of parts that could have been produced, if everything had gone perfectly, and the units without defects that have been produced (Hernández and Vizán, 2013). The OEE then represents the time worked, without downtime, at the established capacity and without defects (Socconini, 2019; Hernández-Vázquez J. I. et al., 2024; Hernández-Vázquez J. O. et al., 2024). OEE is obtained through the multiplication of three factors (Stamatis, 2017; Socconini, 2019; Singh et al., 2021):

$$OEE = Availability \times Performance \times Quality \quad (1)$$

Subsequently, the operating time is determined with the following equation:

$$Available\ time = Total\ time - Planned\ time \quad (2)$$

Subsequently, the operating time is determined with the following equation:

$$Operating\ time = Available\ time - Downtime \quad (3)$$

The first factor, availability, is defined as follows:

$$Availability = (Available\ time - Downtime) \div Available\ time \quad (4)$$

Performance, which is the second factor, is obtained with the formula:

$$Performance = Total\ production \div (Operating\ time \times Capacity) \quad (5)$$

The last factor to be calculated is quality, this is generated through:

Quality = (Total production − Defects and rework) ÷ Total production (6)

Adaptation of the OEE indicator in the footwear manufacturing industry

One of the main difficulties is the application of equations 1-6 in footwear manufacturing, because they are limited to the analysis of the manufacture of a single model in the production line. However, in the aforementioned industry, on most occasions different models of shoes are manufactured on the same day.

Another issue that is not mentioned in the literature consulted and that affects the daily productivity of companies is the number of operators in the process. Therefore, the use of the OEE indicator becomes a bit complex for those who start with the implementation of the Lean Manufacturing philosophy.

The following is a modification of equations 2-6, which includes the concepts of model variation and the number of operators involved.

Available time = (Total time X Number of workers) - (Planned time X Number of workers (7)

Operating time = Available time - (Downtime X Number of workers) (8)

Availability = [Available time - (Downtime X Number of workers)] ÷ Available time (9)

Performance = Total production in pairs ÷ (Planned pair scheduling) (10)

Quality = (Total production in pairs - Defective pairs and rework) ÷ Total production in pairs (11)

To obtain the efficiency (equation 10), it is necessary to know the planned pair programming, it is important to mention that this data must be fixed based on the capacity of the process according to the number of operators and the models to be produced. Another aspect to point out is that the planned pair programming must contemplate a maximum production time equal to the available time, since failure to comply with this condition would generate an overload in the production line and the OEE calculation would be inaccurate.

Implementation of the OEE indicator in the footwear manufacturing process

A footwear company that manufactures two different models is considered. The purpose is to determine the OEE value with the following data:

- Time of the working day= 8 hours
- Time allocated to meeting of the day = 20 minutes
- Number of workers = 10
- Delays or stoppages in the production line during the working day = 60 minutes

Tables 1 and 2 show the information on planned production and production achieved at the end of a working day, respectively.

Table 1. Planned production

Production plan			
	Minutes per model	Day's programming	Planned minutes of production
Model 1	10	250	2500
Model 2	7	300	2100
Total		**550 pairs**	**4600 minutes**

Table 2. Production at the end of the working day

Results of the working day				
	Actual production	Defective pairs	Reprocessed pairs	Good quality pairs
Model 1	195	20	10	165
Model 2	270	15	5	250
Total	**465 pairs**	35	15	**415 pairs**

Equation (7) gives the time available:

Available time = (Total time X Number of workers) - (Planned time X Number of workers) (7)

Available time = (480 minutes X 10 workers) – (20 minutes X 10 workers)

Available time = 4800 minutes – 200 minutes = **4600 minutes**

Subsequently, with the expression (8) the operating time is defined:

Operating time = Available time - (Downtime X Number of workers) (8)

Operating time = 4600 minutes – (60 minutes X 10 workers)

Operating time = 4600 minutes – 600 minutes = **4000 minutes**

Once the available time and operating time have been identified, the first availability factor is calculated using the formula (9):

Availability = [Available time - (Downtime X Number of workers)] ÷ Available time (9)
Availability = [4600 minutes – (60 minutes X 10 workers)] ÷ 4600 minutes
Availability = 0.8696 ~ **86.96%**

The second performance factor is then determined with equation (10):

Performance = Total production in pairs ÷ (Planned pair scheduling) (10)
Performance = 465 pairs ÷ 550 pairs
Performance = 0.8455 ~ **84.55 %**

Then the third factor is generated with the expression (11):

Quality = (Total production in pairs - Defective pairs and rework) ÷ Total production in pairs (11)
Calidad = (465 pairs - 35 pairs – 15 pairs) ÷ 465 pairs
Calidad = 0.8925 ~ **89.25%**

Finally, the OEE indicator is determined by multiplying the three factors (equation 1):
OEE = Availability × Performance × Quality (1)
OEE = 0.8696 X 0.8455 X 0.8925
OEE = 0.6561 ~ **66%**

The previously obtained percentage can be translated into the quality time, i.e., determine the time that is worked, without downtime, at the established capacity and without defects. This is achieved with equation (12):

Quality time = Available time X OEE (12)
Quality time = 4600 minutes X 66%
Quality time = **3036 minutes**

It is important to clarify that the calculated value represents the quality time of the 10 operators, therefore, the average quality time of each operator is 303.6 minutes in the workday analyzed.

CONCLUSIONS

This paper presents an adaptation of the OEE indicator and shows its implementation in the footwear manufacturing industry. This indicator is considered as the main measurement criterion in the Lean Manufacturing philosophy since it allows to know the time that is really worked, without downtime, at the established capacity and without defects.

This adaptation allows any company in this sector to evaluate the OEE indicator. Therefore, this represents the main contribution of this document. Another aspect to highlight is the way in which production planning should be done, it needs to consider the time available according to the operators involved in the process. If the production planning in footwear manufacturing is not done based on the established capacity, the OEE evaluation will be inaccurate.

Finally, it is recommended that in future works, adaptations of Lean Manufacturing tools be developed in the industry analyzed in this research, or in industries where the processes are still carried out in a traditional way. This with the purpose that SMEs companies can access to the knowledge of these tools and manage to implement them successfully, increasing their level of competition in the current market.

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