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Review: Implementation of Overall Equipment Effectiveness (OEE) Based on Lean Manufacturing Tools in the Indonesian Pharmaceutical Industry

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Abstract

Increasing production in the industry is important to face the current global competition. Therefore, a performance measurement system is needed for the manufacturing process. Overall Equipment Effectiveness (OEE) is a method for monitoring and improving the efficiency of manufacturing processes. In this article, overall equipment effectiveness (OEE) is described as one of the performance measurement tools that measure different types of production losses and shows areas of process improvement. The analysis is done on how OEE evolved leads to other tools such as the performance of the total equipment effectiveness, such as the effectiveness of production equipment, the effectiveness of the overall plant, and the effectiveness of the asset as a whole. OEE consist of three metric measurement; availability, performance, and quality. Purpose of review articles is to apply these metrics to compare the efficiency and effectiveness of production activity in pharmaceutical industry and to categorize the highly occurence of loss productivity in the production activity that takes place in industry, especially pharmaceutical industry. This review included studies published in ScienceDirect database with the keyword “Lean Manufacturing” and “Overall Equipment Effectiveness”. The results obtained from study of the primary source is the OEE can be used to optimize the production process in the industry, especially the pharmaceutical industry, because this method can produce products efficiently and with the good quality of products that leads to consumer’s satisfactory.

Keywords: Lean Manufacturing, pharmaceutical industry, Overall Equipment Effectiveness (OEE).

1. Introduction

Pharmaceutical industry is a business entity that has a permit from the Minister of Health to perform activities of manufacture of drugs or medicinal ingredients [1]. In the competition of industries, the company is required to optimize resources to the quality of products to increase productivity. When manufacturing companies face this problem, the usual way is to increase

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overtime, add shifts, or buy new equipment. However, it is better to optimize the performance of existing machines to improve equipment reliability, minimize changeover time, improve operator performance, and reduce overall downtime [2]. There are activities in manufacturing companies that are not value-added (non-value added) or waste that will result in inefficient production processes. Waste of time, effort, money, and overworked staff are common problem in many pharmaceutical company [3].

One of the methods to minimize waste in the production process is known as Lean Manufacturing which serves as an effort to improve the efficiency of production process time by identifying waste. Lean Manufacturing is a systematic approach to identify and eliminate waste through a series of improvement activities [4].

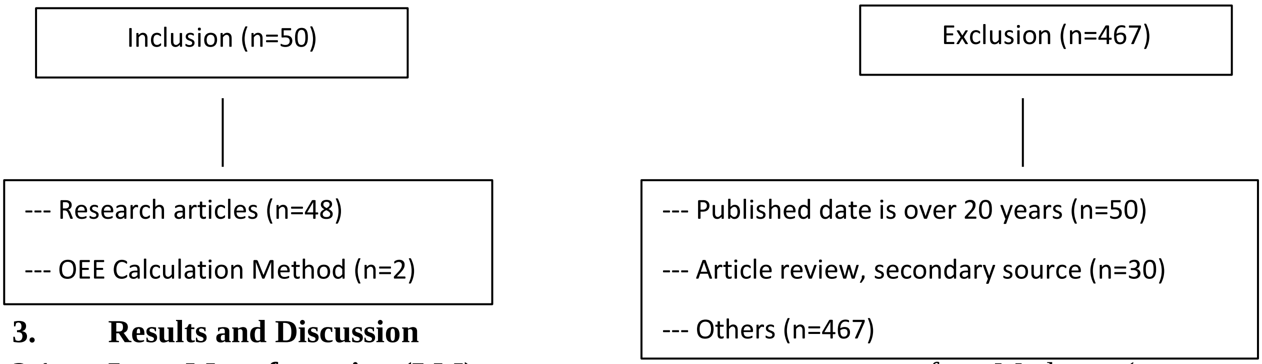
Total Productive Maintenance (TPM) is a lean manufacturing methodology that aims to prevent machine failure and defects in products. And when these things are prevented and eliminated, the operating rates of the machine increase, no additional costs, inventory can be minimized, and labor productivity increased [5,6]. TPM concept which where launched by Nakajima in the 1980s, have quantitative metrics called Overall Equipment Effectiveness (OEE) to measure the productivity of individual equipment in the factory [7,8]. These metrics identify and measure the loss of the important aspects of manufacturing, namely the availability, performance, and quality level [9]. In this case, the support increased the effectiveness of the equipment and thus productivity [10]. The Concept of OEE is become increasingly popular and has been widely used as quantitative tools that are essential to the measurement of productivity, especially in manufacturing operations [11,12]. The OEE measure attempts to identify wastes and the costs associated with a piece of equipment. The main goal is owning a very efficient integrated system.

2. Methods

The preparation of the article review is done by a literature search of primary and secondary sources, namely regulation and standard of authority institutions in Indonesia, academic journal, and reference books related to Lean Manufacturing. The primary data obtained from the journal, which then carried out the screening of the journal published during the last 10 years as a criteria needed. The literature obtained online in various international journals and national accessed from the site ScienceDirect with the keyword "Overall Equipment Effectiveness" and "Lean Manufacturing System (LMS)". Articles are displayed with the keyword in the database ScienceDirect shows the results of 517 articles [50 inclusion, 467 exclusion (50 years of publication more than 20 years, 30 review articles, 387 other)].

Table 1. Methods performed for review

Articles from the database: 517 articles



3. Results and Discussion

3.1 Lean Manufacturing (LM)

The first concept LM proposed by the Japanese automotive company Toyota during the 1970s when it was known as the Toyota Production System (TPS). The first objective of TPS is to increase productivity and reduce cost by eliminating waste or activities that are not value-added [13]. There are nine obstacles that play an important role in the success of the implementation of the LM, i.e. a high rejection rate, setup time high, lead time, high inventory levels are high, the lack of commitment of top management, lack of employee involvement and training, the level of OEE is low, the lack of a supplier who is dedicated, and the lack of infrastructure and computerized systems [14,15].

LM refers to the process of a new dynamic and developing of production include the overall company, covering all aspects of industrial operations (product development, manufacturing, organization and human resources, customer support) and includes the network of suppliers-customers, which are governed by a set of systems, principles, methods, and practices [16]. Principles LM is of perfect quality, minimization of waste by removing all activity that does not add value, continuous improvement, flexibility, and long-term relationships [13]. LM can be considered as an essential element of any approach to the seven types of Muda (waste: Transportation, Inventory, Motion, Waiting, Over-processing, Over-production, Defects) [5,17].

The principle of Lean Manufacturing is essentially driven by customer value, which makes the production of industry is right on target and effective. There are five basic principles of the LM, i.e.: [18,19]

- *Understand customer value*. This point can be identified by observing about the value that customer needs, especially what most people need.
- *Value stream analysis*. After understanding its value to the customer, the next step is to analyze the business process to determine which ones actually beneficial or adding value. If an action does not belongs to added value, then it should be modified or eliminated from the process.
- *Flow*. Focus on the groove of organizing sustainable through the production or supply chain rather than move commodities in large quantities.
- *Pull*. Inventory is considered one of the biggest waste in any production system. It is required to manage supply chain in purpose to prevent the production of commodities to be stored. So, the product are created at

the time that they are needed and just in the needed quantities.

- *Perfection*. Elimination of non-value added (waste) is a process that is continuously carried out. There is no end to reduce the time, cost, space, error and effort.

However, the principle does not always apply when the customer demand in the conditions of unstable and unpredictable[20]. Seven types of waste are avoided and are not of value-added: [21,22]

1. Defect (defects)

The form of the imperfection of the product, lack of manpower at the time the process runs, the process of rework (rework), and claims from customers.

2. Waiting (waiting)

The form of the process of waiting for the arrival of the materials, information, equipment, and supplies. The workers only observe the production machine is running or standing waiting for the next process step.

3. Unnecessary inventory

Storage of inventory that exceeds the volume of the warehouse specified, a material which is damaged because of too long stored or expired.

4. Improper processing

The process / method of operation of the product is not appropriate due to the use of tools that are not in accordance with its function or the error of the procedure/ operating system.

5. Unnecessary movement

In the form of movements that should be avoided, such as components and controls that are far from reach, double handling layouts that are not standard.

6. Transportation (transportation)

Wastage of time due to the distance of the warehouse of raw materials to the remote machine or remove material between machines or from the engine to the warehouse of finished products.

7. Overproduction (excess production)

In the form of the production of goods that have not been ordered or the product is idle.

3.2 Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is a management methodology that aims to maximize plant and equipment effectiveness to achieve the optimum life cycle cost [23]. This principle was originally introduced in 1971 by Nakajima as productive maintenance carried out by all employees thoroughly [9]. Until this time, this principle has evolved and customized by the needs of one’s industry.

An indicator to quantify Total Productive Maintenance (TPM) of an industrial process is by calculating Overall Equipment Effectiveness (OEE). OEE as a metric to evaluate the ability of manufacturing, with the goal to improve the value of OEE. [24,25] OEE is a metric to measure the percentage of time that is truly productive [26]. OEE is calculated by multiplying availability, performance and quality, and represented by a percentage.

3.3 Overall Equipment Effectiveness (OEE)

OEE is designed to identify losses that reduce the effectiveness of the equipment. The disadvantage of this is the activity that absorbs resources but creates no value. OEE is a tool to measure the degree to which the equipment is doing what it should do, based on availability, performance, and quality level [27,28]. OEE measurement is obtained by comparing the results (output) of the equipment divided by the result (output) maximum equipment on the condition of the equipment performance the best [29]. It is a bottom-up approach where labor is integrated strives to achieve overall equipment effectiveness by eliminating the losses [30]. The bottom-up approach is done when we want to assess how much variation in cost that is required in the production activity [31].

Losses avoided in the method of OEE, namely: [32,33]

Downtime losses:

a. Breakdown losses are includes wasting of time and quantity losses because of the impact in stopped production caused by machine failure, so that the machine can not be operated.
b. Loss of set-up and adjustment occurs when the production is changed from the needs of one item to the other items. In the industry, the type of loss is encountered during the set-up of the machine between different products, testing during start-up, and fine-tuning of the engine and instruments.

Speed losses:

a. Idling (waiting time) occurs when the production is interrupted by a malfunction while or when the machine is in the idle state.
b. The reduction of the loss of speed refers to the difference between the speed of the design of the equipment and the speed of the actual operation.

Quality losses:

a. Quality defects and rework are the quality loss caused by malfunctions of the production equipment.
b. The reduction of the production yield is the yield loss that occurs from a machine that does not work stable.

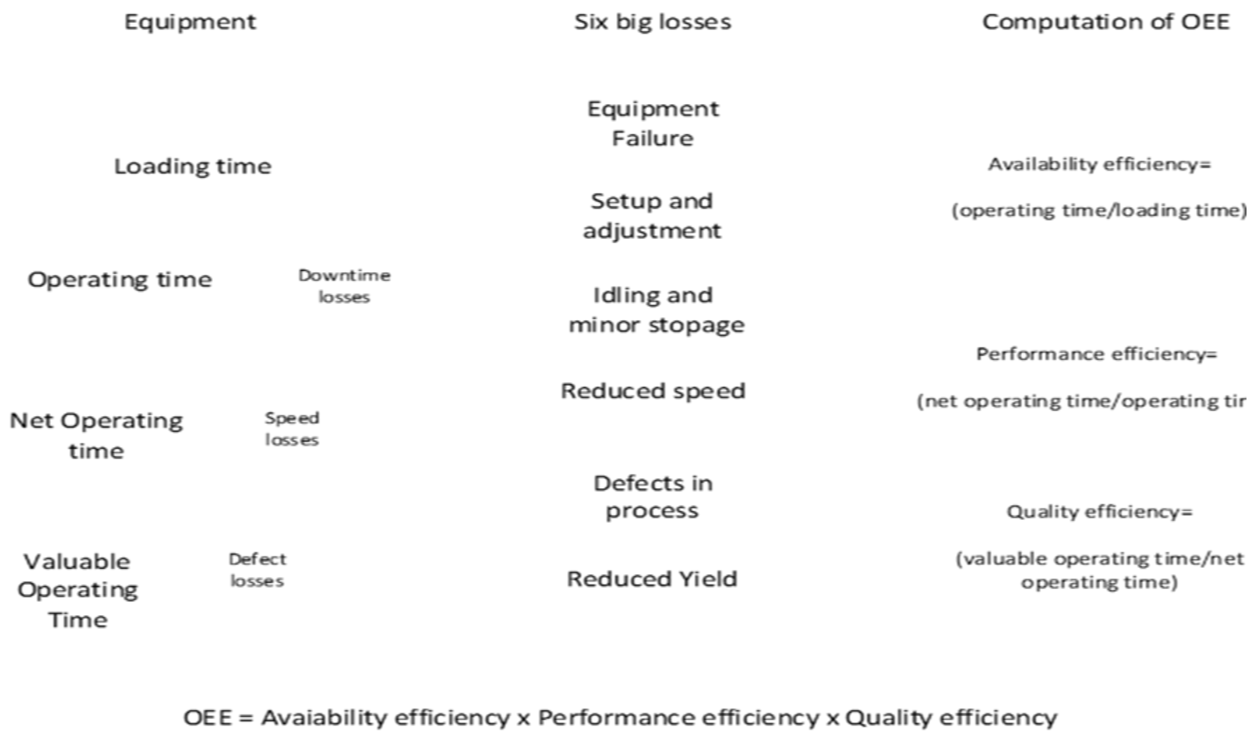


Figure 1. *Overall Equipment Effectiveness* [34]

Measurements with the OEE has advantages in how to integrate the important aspects of manufacturing into one measuring tool. Perspective is integrated with the tool OEE is the effectiveness of the maintenance, production efficiency, and the efficiency of the quality, as shown in Figure 1.

Six big losses are measured by the OEE, which is a function of availability(A), performance (P) and the level of quality(Q) [35]. Where: [36,37]

a. *Availability rate (A) =* $\frac{Operating\ time\ (h)}{Loading\ time\ (h)}\ x\ 100$

Operating time = Loading time – down time

b. *Performance Efficiency (P) =* $\frac{Theoretical\ cycle\ time\ (h) x\ Actual\ output\ (units)}{Operating\ time\ (h)}$

c. *Quality rate (Q) =* $\frac{Total\ production - Defect\ Amount}{Total\ production (units)}\ x\ 100$

d. OEE = A x P x Q

The numerical value of OEE is between 0 and 100%, where 0 is not very efficient and 100% is very efficient and if the OEE value of 85% is considered as benchmarks to be manufacturing capabilities are ideal.[38] Manufacturing the ideal is to produce zero equipment failure, zero defects and rework, and zero industrial accidents. [39]

Indicator OEE are characterized in these following ways:

1. The reliability of the production network [40]
2. An effective tool to maximize production [41,42]
3. Used to measure the productivity of the equipment [43]
4. The ratio of productivity between manufacturing real and what can be produced in an ideal manner [44]
5. Benefits on the side of the equipment, personnel, process and quality [45]

Application the use of OEE in industry, vary from one industry to another. The basis of the measurement of effectiveness is derived from the concept of OEE original, manufacturers have varying OEE to suit their needs with the requirements of the industry [46,47].

OEE is described as a multi-layered indicator that can be used in many industries regardless of whether production is continuous or batch-sized. [45.48] OEE measurement in production is essential for different purposes including planning, capacity estimation, human resource allocation, and budgeting [49].

Furthermore, the term OEE has been modified in the literature for other terms that differ with regard to the concept of the app. This has led to the expansion of the OEE to the overall factory effectiveness (OFE), overall plant effectiveness (OPE), overall throughput effectiveness (OTE), production equipment effectiveness (PEE), overall asset effectiveness (OAE), and the total equipment effectiveness performance (THIP) [36,50].

4. Conclusion

OEE method is used to optimize the production process in the industry, especially the pharmaceutical industry, because this method can increase the production efficiently and the product having quality as expected.

The measurement of OEE can help them optimize the performance of existing capacity. This helps to reduce the variability of the process, reducing the time change and improve operator performance and substantially increase the profit of the production operation and improve the competitiveness of the company.

In addition, regular and consistent maintenance can also be sought to reduce loss time caused by damage to the machine that is light and heavy so that the packaging process can run more effectively and efficiently.

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