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ANALYSIS OF THE OVERALL EQUIPMENT EFFECTIVENESS TO MINIMIZE SIX BIG LOSSES OF COOKIE CAPPER MACHINE-A CASE STUDY IN MANUFACTURING INDUSTRY

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A B S T R A C T

Overall Equipment Effectiveness (OEE) is a method of measuring the effectiveness of the use of equipment. This method is known as an application of a Total Productive Maintenance (TPM) program. The ability to clearly identify the source of problem and it causal factors is the main advantage of this method since the improvement effort becomes focused. Britannia Industries Pvt. Ltd. is one of the manufacturing companies that produce biscuits. Based on data from the Bourbon line production department, for the period of July-September 2019, the production process of bourbon biscuit often experienced constraints due to the high downtime and losses in the cookie capper machine. This resulted in the use of production process equipment that had not been optimal. It is important to find out the source of the problem and its causal factors before the company makes any improvement effort. This study aims to identify equipment losses and measure the achievement of OEE values in the cookie capper machine. The measurement result shows that the average of the effectiveness of cookie capper machine for the period July- September 2019 of was 69.47% and based on Japan Institute Of Plant Maintenance (JIPM) the value has not reached the standard that is > 85%, however, there is still possibility for improvement. The losses that give the most significant effect on the overall equipment effectiveness of the cookie capper machine is reduce speed that was equal to 26.23%. One way to minimize the losses is by maintaining the actual speed of operation and maintaining wear on each cookie capper machine.

1. INTRODUCTION

OEE (Overall Equipment Effectiveness) is a tool developed by S. Nakajima in 1988., who proposed this in order to evaluate the progress of TPM (Total Productive Maintenance) that he originally created. (Sayuti, et al., 2019) OEE is the multiplication of three factors; availability, performance and quality. Its particularity is that the hidden losses are taken into consideration in order to higher the degree of relevance regarding equipment utilization. Before the creation of OEE,

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availability was the only parameter considered which falsified the final result, and an overestimation of equipment utilization was observed. The Effectiveness of the equipment is the Actual Output over the Reference Output. Equipment Effectiveness shows how effectively an equipment is utilized. Overall Equipment Effectiveness shows the effectiveness of a machine compared to the ideal machine as a percentage. OEE is essentially the ratio of Fully Productive Time to Planned Production Time.

OEE have some advantages as follows:

1. OEE can reduce equipment downtime and maintenance costs which in turn will contribute to a better management of the life cycle of the equipment.
2. OEE can increase labour efficiency while at the same time the productivity is also increased due to an improvement in visibility into operations since there is empowerment for the operators.
3. OEE can enhance productivity because of the identification to the bottlenecks is possible to be done.
4. Due to less rework of products, reduces scraps can contribute to improved quality rate.

TPM and OEE have their main role in minimizing the six big losses which are regarded as the main causes of efficiency loss. The relationship between the losses and the effectiveness in TPM is referred to both the quality of the product and the equipment availability. Face losses may be experienced at any operating time and these losses may be visible such as scrap, changeovers and breakdowns or can be invisible like the slow running, the adjustment that is conducted regularly to keep the production within tolerance. In terms of machine maintenance, there are three things every company should avoid, namely downtime, speed losses and defect or quality losses. (Sayuti, et al., 2019).

According to Nakajima, there are 6 equipment losses that cause low performance of the equipment. The six losses are called six big losses consisting of: (1) Equipment failure, (2) Setup and adjustment, (3) Idle and minor stoppages, (4) Reduced speed, (5) Process defect; and (6) Low yield. According to him, equipment failure, and setup and adjustment are categorized as Downtime Losses, reducing availability; (3) idle and minor stoppages and (4) reduced speed is categorized as speed losses, thus reducing performance. Finally, (5) process defect and (6) reduced yields are considered as defect loss generated from low quality.

1.1 Downtime Losses as a function of Availability

It is found out that if the output is zero and the system produces nothing, or when the machine works, but it does not produced any products during the examination period then it is called downtime losses, and it primarily because of two factors namely a breakdown loss, which refers to parts failure where they cannot work properly any longer and repair or replacement is required and the losses are measured by the time needed for labour or parts for fixing the problem; and setup and adjustment time which are related to the changes in the various operating conditions, e.g. the start of production or the start of the different shifts, changes in products and condition of the operation. Equipment changeovers, exchange of dies are the primary examples of this kind of losses and these losses consist of setup, start-up and adjustment down times.

1.2. Speed Losses as a function of Performance

Speed losses occur when the output is smaller than reference speed output and there is no inspection whether or not the output complies with quality specification standard. Speed loss can take two forms: Minor stoppage – it can happen due to machine halting, jamming, and idling. This is considered by many as the breakdowns as it is one important factor that needs to be foreseen. Speed losses occur because of the reduction in the speed of the equipment or in the other words, the machine does not work at its theoretical maximum speed. To deal with regular occurrence of quality defect and minor stoppage problems, the machine can be run at low speed. It is measured by comparing the theoretical to actual working load.

1.3 Defect or quality losses as a function of Quality

When the output produced does not conform to the specification, thus it is considered as a quality loss. This might cause a rework for quality defects that happen during the regular cycle of production. Since the products do not meet the standard, so that rework is conducted to remove the defects. Labour is required to do the rework which means that the company should spend some cost while the materials that have become scraps also disadvantage for the company. The extent of these losses is calculated by the ratio of the quality products to the total production. Second is yield losses which result in wasted raw materials. The yield losses are categorized into two groups - The raw materials losses, which are related to the product design, manufacturing method, etc., and adjustment losses refer to quality defects of the products produced at the beginning of the production, changeovers, etc.

Nowadays, the problems faced regarding repair or maintenance by most of the manufacturers are due to the absence or ineffectiveness of systems or methods that can measure performance of existing equipment and can provide solutions to the source of problems encountered. For that reason, the selection of performance measurement method is very important for the companies in achieving their goals. One method to measure the performance measurement that is widely used by companies, especially by Japanese companies that is able

to overcome equipment problems is Overall Equipment Effectiveness (OEE) method.

Based on the information obtained from the *Bourbon line*, the production process of biscuits often experience constraints due to the high downtime and losses in the cookie capper machine resulting in low productivity of the company. This is due to the lack of intensive handling so that the machine suffers damage and disrupts the production process and the quality of products. To overcome this problem, the correct method to use is the OEE method. This method is used to calculate the level of effectiveness and the level of error that occurs in the production process of bourbon biscuit with OEE method. This method has also been widely applied by Japanese companies as well as some other countries.

The purpose of this research is to find out the value of Overall Equipment Effectiveness (OEE) of cookie capper machine to minimize six big losses.

2. RESEARCH METHODOLOGY

Overall Equipment Effectiveness is a method used as a metric tool in TPM program implementation to keep equipment in ideal condition by avoiding six big losses of equipment (Singh, Shah, Gohil, & Shah, 2013). The OEE measurement is based on the measurement of three main ratios, namely (1) Availability ratio, (2) Performance ratio, and (3) Quality ratio. OEE calculations can be done by multiplying these three ratios. Flow diagram of OEE measurement can be seen in Figure 1 (Nakajima, 1988) and OEE value measurement formula is as follows:

OEE (%) = $Availability \times Performance \times Quality \times$ 100% (1)

Availability ratio is a ratio that describes the utilization of time available for the operation of machinery or equipment. Nakajima states that availability is the ratio of operation time, by eliminating equipment downtime to loading time. Availability can be calculated using formula.

$Availability = Operating\ time\ /\ loading\ time \times$ 100% (2)

Performance ratio is a ratio that describes the ability of the equipment in producing goods. This ratio is the result of operating speed rate and net operating rate. Operating speed rate of equipment refers to the difference between ideal speed (based on equipment design) and actual operating speed. The net operating rate measures the maintenance of a speed during a certain period. The net operating rate measures whether an operation remains stable in the period during which the equipment operates at low speeds. The formula performance ratio can be calculated using formula 3.
Performance = [Total weight produced + Total weight of defect] / speed * operating time * 100 % (3)

Quality ratio is a ratio that describes the ability of the equipment in producing products that conform to the standards. Quality ratio calculation can be done by using formula 4.

$Quality = Net\ produced\ (processes\ amount) - defect\ amount\ /\ Net\ produced\ (processes\ amount)$ ×100% (4)

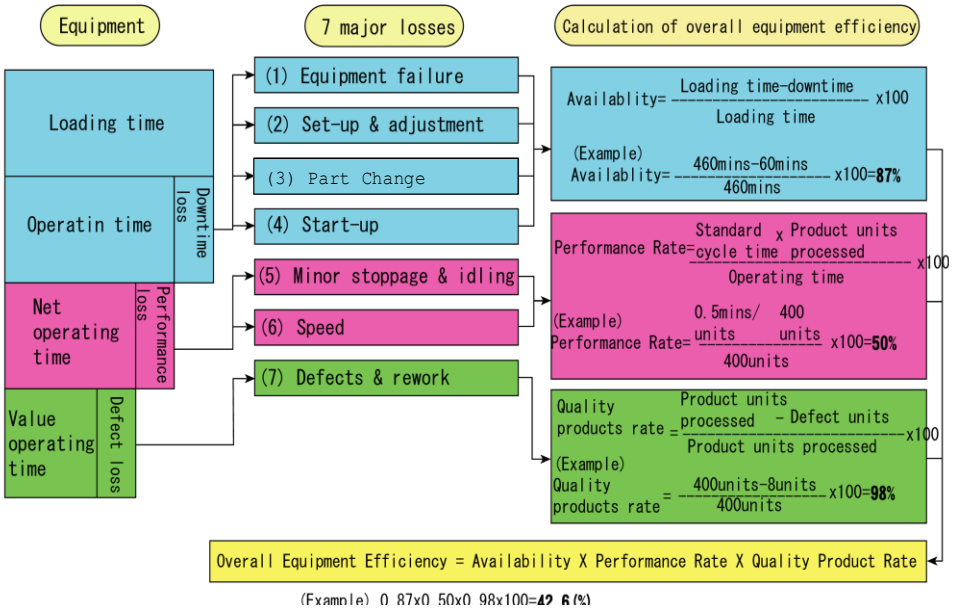

Figure 1. Relationship between 7 Major Losses on Equipment and Overall Equipment Efficiency

After the calculation and analysis done, then the next step is drawing the conclusion by following the standards of world-class companies as shown in Table 1. Then suggestions are provided for improvement.

Table 1. World Class OEE Factor

OEE Factor	World class
OEE	>85.0%
Availability	>90.0%
Performance Rate	>95.0%
Quality Rate	>99.9%

3. RESULTS AND DISCUSSION

3.1 Availability rate

Availability is the comparison between the actual operating time and the loading time. Availability rate can be seen in table 2. It can be concluded from the above calculation results that the availability value of pulp machine from january to april 2016 did not experience fluctuating movement. One of the factors that influence the low availability is activity that should be conducted outside the schedule of production activities, so that it can hamper the production process and result in downtime.

3.2. Performance Rate

Performance rate is performance measurement that will describe the speed of the machine in producing in ideal time against the engine operating time. Performance Rate calculation is as shown in table 3.

3.3. Quality Rate

Quality Rate is a measurement of the percentage of the number of products that meet the specification standard of all production. The results of the Quality Rate calculation can be seen in Table 4.

Table 2. Availability Rate

Month	Loading time (Min)	Planned down time(Min)	Operating time(Min)	Availability Rate%
July	36327	153	30045	82.71%
August	35287	713	32358	91.70%
September	32327	793	29918	92.55%
Total	103941	1659	92321	
Average				88.99%

Table 3. Performance Rate

Month	Total weight produced	Total weight of defect	Speed	Operating time	Performance Rate
July	62138	4757	2113	30045	93.65%
August	59598	4846	2382	32358	88.42%
September	59011	4271	1879	29918	91.63%

Table 4. Quality Rate

Month	Defect loss	Net produced	Quality rate%
July	1911	66895	86.58%
August	2470	64444	84.50%
September	2065	63282	86.22%

Based on the results of the calculation of the quality rate in Table 4, it can be seen that the value of quality in August month was quite low, although in other months it increased. The rise in the value of quality in other month was influenced by defective products and good products.

3.4 Calculation of OEE

After obtaining the availability rate, performance rate and quality rate, the next step is to calculate the OEE cookie capper machine value for the period of July-September 2019. The OEE calculation for July-September 2019 period can be seen in Table 5.

Table 5. Overall equipment effectiveness value

Month	Availability%	Performance%	Quality%	OEE%
July	82.71	93.65	86.58	66.06%
August	91.70	88.42	84.50	68.51%
September	92.55	91.63	86.22	73.12%
Average	88.98%	91.24%	85.77%	69.47%

Based on OEE calculation results in Table 5, it can be seen that the average value of effectiveness (OEE) of cookie capper machine in the period of July-Sep 2019 was 69.47%. However, based on *Table 6*, the OEE value had not reached the global standard set by the Japan Institute of Plant Maintenance (JIPM) of > 85%. Among the availability, performance and quality values that make up the OEE value of the cookie capper machine, the lowest percentage of values is at a quality rate with a percentage rate of only 85.77% (Table 5).

In the analysis of six big losses, the highest losses value affecting the low percentage of OEE that is listed below in Table 7 & also shown in figure 2 in Pareto chart.

Table 6. Comparison between world class measurement and the company measurement

	Company OEE	World class OEE
Availability	88.98%	>90.0%
Performance Rate	91.24%	>95.0%
Quality Rate	85.77%	>99.9%
OEE%	69.47%	>85.0%

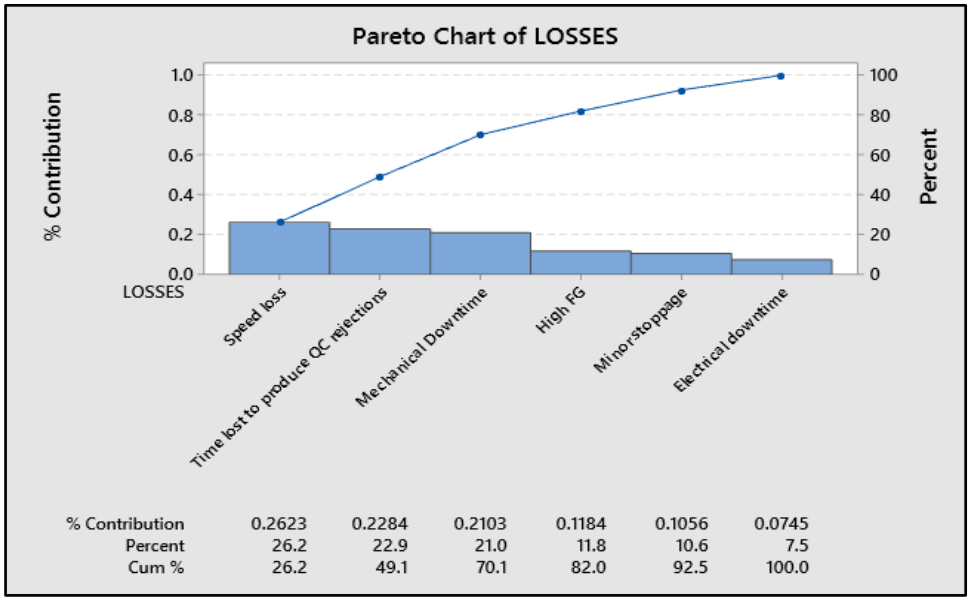

Figure 2. Pareto Chart of Losses

Table 7. List of Six big losses affecting low % OEE

LOSSES	Downtime July	Downtime Aug	Downtime Sep	% Contribution
High FG	35.53%	0%	0%	11.84%
Speed loss	21.55%	29.65%	27.50%	26.23%
Time lost to produce QC rejections	19.16%	24.26%	25.135	22.84%
Mechanical Downtime	17.43%	20.14%	25.54%	21.03%
Minor stoppage	6.30%	10.40%	15.00%	10.56%
Electrical downtime	0%	15.53%	6.82%	7.45%

3.5 Result Analysis

Based on the calculation of the effectiveness value (OEE) of the Cookie capper machine, it was found that the losses that have the most effect on the effectiveness of the machine was reduced speed losses which is 26.23%. This loss occurs because the engine speed decreases, so the engine does not operate optimally. After knowing that the reduce speed losses is the biggest factor causing the decreasing effectiveness of the machine, next is to identify the cause of the reduction speed losses. Among its factors are human factor (lack of intensive maintenance, lack of supervision and mismatch setting), Machine factor (Cookie Capper pipe change, Plate belt change, Biscuit alignment), and raw material (Cream delay, Cream melting).

Based on these factors, actions needed to be taken to avoid the occurrence of reduce speed losses are as follows:

1) Maintain the actual speed of operation as the standard machine speed which is 145CRM.
2) Conduct intensive monitoring and maintenance.

4. Summary

The conclusion that can be drawn from the discussion of OEE measurement is that the average level of machine effectiveness in Cookie Capper machine for period July-September 2019 was 69.47% and according to Japan Institute of Plant Maintenance (JIPM), the value has not reached the standard, which is> 85%, however, the improvement is still possible to happen. The losses that have the most significant effect on the low effectiveness of the overall equipment of the Cookie Capper machine is reduced speed in the amount of 26.23%. To minimize the losses, one of the ways that can be done is by maintaining the actual speed of operation and continuous monitoring and maintenance of machine.

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