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To cite this article: J Alhilman and A F Abdillah 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **528** 012046

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# Analysis of Double indian Ballbreaker Net Sorter Machine Based on Overall Equipment Effectiveness Method Cases in Tea Plantation Plants

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**Abstract.** In a factory, the position of the production machine plays an important role because if the engine is damaged it will disrupt the production target. This study analyzes the performance of Double Indian Ballbreaker Net Sorter (DIBN) machines, one of the machines used to produce orthodox tea which in the fact, this machine often damaged and has high downtime. This leads to a low level of machine availability in the Production Department. For that, we need an Overall Equipment Effectiveness (OEE) method to measure the performance and the level of effectiveness of the machine and six big losses factor analysis to find out what factors cause low of OEE value. Based on the OEE calculation results, the value of OEE DIBN machine is 53.98%. The result is still far from the standard set by the Japanese Institute of Plant Maintenance of 85%. From six big losses, it is known that the most influencing factors to decrease the effectiveness of DIBN machines are rework losses (23.33%), reduced yield losses (20.17%) and reduced speed of 19.49%.

**Keywords:** overall equipment effectiveness, six big losses, performance

## 1. Introduction

### 1.1 Background

Nowadays, the major daily problems that are encountered by many manufacturing companies are equipment breakdown, repair, and quality defects. These problems have a great impact on quality and delivery time [2]. Machine maintenance is inseparable from the problems of efficiency and effectiveness of machinery. Therefore, steps are needed to prevent or overcome the problem of machine downtime. The purpose of this study is to measure the performance of production equipment, find the root cause of the problem and provide suggestions for improvement. There have been many previous studies using OEE methods, including the OEE method used to measure the effectiveness of a machine in a sugar factory and to find the cause of the low effectiveness of the machine [3] and according to [4] to measure the effectiveness of the production machine in the fibre cement plant, the OEE method is used and to determine the critical downtime, Pareto diagram is used. Furthermore, OEE is used to measure the effectiveness of rotary car dumper engines and to find the cause of the greatest contribution to decreasing efficiency, the cause and effect diagrams are used. The result is reduced speed losses factor of 68.25% and breakdown losses of 21.06%. [5] and according to [6] OEE is used to measure the effectiveness of



an 80 ton Press machine on a line of P3C03 3 & 4 steel wheel factories. The results of the fishbone diagram found the biggest cause of low efficiency is the less optimal nursing time and less effective cutting machine factors. The maintenance propose is carried out every 1900 minutes.

This research is implemented in PT. X. PT. X is one of the companies engaged in agro-business and agro-industry. The products produced are various kinds of tea both for domestic consumption and export quality. With high demand, companies always produce tea on a large scale. To pursue the target requires the production department to run non-stop tea production for 24 hours, this causes frequent engine damage that results in not meeting the number of production targets. For this reason, a method is needed to determine the effectiveness of the overall use of factory facilities. The method used is the OEE method. Furthermore, to find out what factors are most influential in reducing the effectiveness of the machine will be analyzed by the six big losses method.

In the tea production process, it is divided into 3 production rooms, namely Laying & Milling Room, Drying Room, and Sorting & Packing Room. This research is a focus to the highest downtime occurred that in the Laying & Milling Room on the Double Indian Ballbreaker Net Sorter machine.

## 2. Methods

### 2.1 Overall Equipment Effectiveness

OEE is a product of six big losses that can measure the overall effectiveness of the equipment by multiplying availability, performance rate, and rate of the quality product [7]. This effectiveness measurement combines the factors of time, speed, and quality of operation of the equipment and measures how these factors can increase added value. OEE tell us whether our equipment is under-utilization or over utilization[8]. According to [9] to facilitate OEE analysis in determining treatment policies, the OEE application was made.

### 2.2 Availability

According to Moubray [7], availability (A) is the ratio between the operating time of the tool minus the downtime, compared to the operating time of the tool. In its calculation, availability is formulated in the following equation [3]:

$$Availability = \frac{Operation\ Time}{Loading\ Time} \quad (1)$$

$$A = \frac{Loading\ Time - Downtime}{Loading\ Time} \quad (2)$$

### 2.3 Performance Efficiency

Performance Efficiency (P) is the ratio of the ratio of the actual production level to the expected level of production or the ratio of machine capability that is realized by multiplying the number of goods produced with the ideal time which is then divided by the operating time stated in the percentage [9], or the product times operating speed rate and net operating rate. For this reason, the mathematical formula is:

$$Performance\ Efficiency = \frac{Theoretical\ Cycle\ Time \times Processed\ Amount}{Operating\ Time} \times 100\% \quad (3)$$

Where :

Theoretical Cycle Time = the operating time performed by the machine per day or per hours based on theoretical / standard.

Processed Amount = number of products processed by the machine

Operation Time = the operating time of a machine in one day

### 2.4 Rate Of Quality Product

The third element of OEE is quality (Q). The rate of quality is the ratio of the number of products that is better to the total number of products processed. In the calculation, the rate of quality is formulated in the following equation:

$$Q = \frac{\text{Input-volume of quality defects}}{\text{Input}} \quad (4)$$

### 2.5 OEE Calculation Procedure

Steps involved to calculate OEE based on [8] are as follows

- Input the value of Total shift time
- Input the value of Planned downtime
- Calculate Loading time = Total time - Planned downtime
- Input the value of all downtime and all stop time
- Calculate operating time = Loading time (all downtime + all stop time)
- Availability = Operating time / Loading time
- Input value of actual cycle time and theoretical cycle time
- Calculate operating speed rate = Theoretical cycle time / Actual cycle time
- The input value of the Actual processing time and the total amount produced
- Calculate net operating rate = Actual processing time / operating time.
- Calculate performance efficiency = net operating rate X operating speed rate
- Input the value of defect amount
- Calculate Quality rate = (total amount produced - defect amount) / total amount Produced.
- OEE = Availability X Performance Efficiency X Quality

### 2.6 Six Big Losses

Furthermore, after the OEE calculation is carried out, to analyze the causes of losses and to measure the effectiveness of machinery or equipment can be identified through the six big losses [3], including:

#### 2.6.1. Equipment Failures

Equipment failures are caused by equipment malfunction that requires upgrading and a breakdown time. Major losses include product opportunity loss, spare parts loss, and sporadic losses. Equipment failures can be calculated by the following formula [4]:

$$\text{Breakdown Loss} = \frac{\text{Total Breakdown Time}}{\text{Loading Time}} \times 100 \% \quad (5)$$

#### 2.6.2. Setup and Adjustment

Setup and adjustment are caused by changes that occur when the engine is operating, such as changes in the type of product that is made, changes in work shifts, and adjustments to operating conditions that make the machine stop working. Setup and adjustment can be calculated by the following formula [4]:

$$\text{Set-up and Adjustment} = \frac{\text{Total Set-up and Adjustment}}{\text{Loading Time}} \times 100\% \quad (6)$$

#### 2.6.3. Idling and Minor Stoppages

Idling and minor stoppages are sensor errors or activities waiting for material/parts to come or be processed. Idling and minor stoppages can be caused by the engine being blocked or having stopped for a while, or the engine that stops working because it has to wait (idling). Idling and minor stoppages can be calculated by the following formula [4]

$$\text{Idling and Minor Stoppages} = \frac{\text{Nonproductive Time}}{\text{Loading Time}} \times 100\% \quad (7)$$

$$\text{Nonproductive Time} = \text{Ideal Cycle Time} \times \text{Production Difference} \tag{8}$$

**2.6.4. Reduce Speed Losses**

Reduced speed losses are caused by a decrease in engine speed when operating, ie when the engine does not work at its normal speed. Reduced speed losses can be calculated by the following formula [4]:

$$\text{Reduced Speed Losses} = \frac{(\text{Actual} - \text{Ideal Operation Time})}{\text{Loading Time}} \times 100\% \tag{9}$$

**2.6.5. Defect Losses**

The defect is caused by the product being produced outside the specified specifications, or defective during the normal production process. The quality of the resulting product is bad. Products must be reworked or redesigned so that they can be used or sold. Defect losses can be calculated by the following formula [4]:

$$\text{Defect Losses} = \frac{(\text{Total Reject Product} \times \text{Ideal Cycle Time})}{\text{Loading Time}} \times 100\% \tag{10}$$

**2.6.6. Reduce Yield**

Reduced yield is caused by the length of the machine to adjust conditions to normal conditions, causing the number of products to be rejected. The loss is caused by a situation where the product produced is not in accordance with the standard, because there is a difference in quality between the time the machine was first turned on and when the machine was operating stably. Reduced yield can be calculated by the following formula [4]:

$$\text{Reduce Yield} = \frac{(\text{Ideal Cycle Time} \times \text{Reject Product})}{\text{Loading Time}} \times 100\% \tag{11}$$

The relationship between equipment, OEE, and Six Big Losses can be seen in table 1.

**Table 1.** OEE metrics [2]

| OEE Loss Classifications | Six Big Loss Category     | Computation of OEE   |
|--------------------------|---------------------------|--|
|                          | Equipment failure         |  |
| Availability Rate        | Setup and adjustment      | Availability=Operating time/loading time                           |
| Performance Rate         | Idling and minor stoppage | Performance rate = Net operating time/operating time               |
| Quality Rate             | Reduced speed             | Quality rate = (processed amount – defect amount)/processed amount |
|                          | Defects in process        |  |
|                          | Reduced yield             |  |

**3. Results and Discussion**

**3.1 Calculation of Overall Equipment Effectiveness**

The DIBN engine OEE calculation based on damage data for 2016-2017 is shown in Table 2.

**Table 2.** Overall Equipment Effectiveness Value of the DIBN Machine

| Year    | Month | A     | P     | Q     | OEE   |
|---------|-------|-------|-------|-------|-------|
| 2016    | 1     | 98.45 | 75.90 | 80.20 | 59.93 |
|         | 2     | 97.99 | 89.39 | 65.89 | 57.72 |
|         | 3     | 95.81 | 99.65 | 78.88 | 75.31 |
|         | 4     | 88.45 | 87.55 | 65.67 | 50.85 |
|         | 5     | 86.80 | 85.55 | 75.45 | 56.03 |
|         | 6     | 96.95 | 98.65 | 55.80 | 53.37 |
|         | 7     | 97.85 | 90.90 | 80.53 | 71.63 |
|         | 8     | 99.65 | 78.90 | 72.20 | 56.77 |
|         | 9     | 89.75 | 89.75 | 65.58 | 52.83 |
|         | 10    | 79.90 | 90.75 | 55.51 | 40.25 |
|         | 11    | 85.78 | 90.25 | 57.78 | 44.73 |
|         | 12    | 89.86 | 89.50 | 76.87 | 61.82 |
| 2017    | 1     | 90.79 | 88.78 | 45.80 | 36.92 |
|         | 2     | 89.55 | 90.98 | 54.68 | 44.55 |
|         | 3     | 87.88 | 79.88 | 67.89 | 47.66 |
|         | 4     | 90.42 | 78.43 | 78.76 | 55.85 |
|         | 5     | 92.35 | 87.80 | 68.90 | 55.87 |
|         | 6     | 94.21 | 86.56 | 78.65 | 64.14 |
|         | 7     | 90.35 | 88.66 | 55.65 | 44.58 |
|         | 8     | 89.57 | 87.56 | 75.65 | 59.33 |
|         | 9     | 94.25 | 89.89 | 60.65 | 51.38 |
|         | 10    | 91.12 | 87.76 | 65.67 | 52.51 |
|         | 11    | 97.66 | 88.99 | 78.65 | 68.35 |
|         | 12    | 81.85 | 78.45 | 55.60 | 35.70 |
| Average |       | 91.55 | 87.52 | 67.37 | 53.98 |

The OEE value for DIBN machines in 2016-2017 was obtained from the results multiplication of the Availability(A), Performance(P) and Quality(Q) rate.

The final OEE result (53.98) is the average of OEE values from year 2016 to 2017.

### 3.2 Six Big Losses calculations

After obtaining the results of the OEE, an analysis of the six big losses is conducted to find out the factors which resulted losses. The results of the six big losses are expressed as a percentage of total losses so that it can be seen what factors influence the effectiveness of the machine which can be seen in Table 3.

From table 3 it can be seen that the biggest factor that causes loss are the rework factor of 23.33% , the reduced yield of 20.17% and reduced speed of 19.49%.

### 3.3. Overall Equipment Effectiveness Total

Based on the calculations above, according to Jim's Japanese Institute of Plant Maintenance[10], OEE values can be said to meet the criteria standards if they get a minimum value of 85%. Explanation of the classification of the fulfillment of JIPM criteria for DIBN machines in 2016 and 2017 can be seen in Table 4.

**Table 3.** Value of the Six Big DIBN Machine Losses

| No | Six Big Losses           | Persentase Losses(%) | Total Losses (%) |
|----|--------------------------|----------------------|------------------|
| 1  | Equipment Failures       | 1.45                 | 3.99             |
| 2  | Setup and Adjustment     | 5.55                 | 15.24            |
| 3  | Idle and Minor Stoppages | 6.48                 | 17.78            |
| 4  | Reduce Speed             | 7.10                 | 19.49            |
| 5  | Rework                   | 8.5                  | 23.33            |
| 6  | Reduced Yield            | 7.35                 | 20.17            |
|    | Total                    | 36.43                | 100              |

**Table 4.** Classification of Fulfillment of 2016 DIBN JIPM Engine Criteria

| Year | Availability | Performance Efficiency | The rate of Quality Product | OEE |
|------|--------------|------------------------|-----------------------------|-----|
| 2016 | Fulfillment  | Fulfillment            | NO                          | NO  |
| 2017 | Fulfillment  | Fulfillment            | NO                          | NO  |

Based on Table 4 it can be seen that the Availability and Performance Efficiency factors in 2016 and 2017 meet JIPM criteria standards because the average score is above 85%. The causes that make up the Availability value meet the standards, one of which is the implementation of preventive maintenance activities that are quite good so that the machine is always ready to be produced. Furthermore, the Performance Efficiency factor also meets the standard, one of which can be seen in terms of the total amount of products produced is around the value of the average production target, this indicates the performance of the engine is still pretty good. The last factor is the Rate of Quality which the value 67.37 % does not meet the standard. This can be due to the fact that there are still many products with defects that do not meet the established criteria. Then for the overall OEE value of 2016-2017 is 53.98% does not meet the JIPM criteria standards this is due to the unfavorable quality rate factor which is only around 67.37%, so that in the future it is expected to need preventive maintenance especially an increase in the quality control section than defective products can be reduced and the average good product will increase.

*3.4. Analysis of Six Big Losses*

Based on the results of the analysis of the six losses factors that have been done, it can be seen that the factors of Equipment Failures, Setup and Adjustment, and Idle and Minor Stoppages, contributes relatively low contribution to the OEE value, while the Rework (23.33%), Reduced yield (20.17%) and Reduced Speed of 19.49% contributes significantly to OEE values. this can be due to poor quality control or due to poor raw materials because the raw materials are affected by weather conditions such as the rainy or dry season, to minimize these losses, the machine needs more serious handling that related to reduced speed of machine and also attention to the quality of raw materials so it is expected defective production will decrease.

**4. Conclusion**

The value of OEE at DBIN machines in 2017 based on the results of calculations that have been done is 53.98% this results indicate that the OEE value is below the JIPM standard of 85%. To over come the problem, the machine needs better preventive maintenance with task and certain schedule.

Based on the calculation on the six big losses factor approach, the most influential cause of the problem are the Rework Losses, Reduced Yield Losses and Reduced Speed factors in which the amount of production is not standardized and required rework too much, the percentage of rework losses are

23.33% , reduced yield of 20.17% and reduced speed of 19.49%. So to minimize losses, the company must increase in quality control activities in production line.

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