Measurement of the Performance of the Sugar Cane Grinding Machine at the XYZ Sugar Factory

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Abstract

XYZ Sugar Factory is a sugar factory which has problems related to the effectiveness of the machines at the sugar cane milling station. This can be seen in the condition of machines that are outdated and in 2013 the level of machine downtime at milling stations tended to increase and exceeded the standard percentage set by the company for the last 3 months. Measurement of machine performance at this milling station uses the Overall Equipment Effectiveness (OEE) method, which is then carried out by measuring six big losses to determine the amount of efficiency lost. From the six factors, it can be identified which factor of losses has the biggest contribution in influencing the level of machine effectiveness by using the Pareto diagram. The data used were data from 12 May - 10 November 2014. During that period, the availability value was 94.72%, the performance value was 90.31%, and the quality was 96.78%, so that the OEE value was 82.95%, which means has not met the best practice OEE value, which is at least 85%. The main factors that affect the effectiveness of the machine are idling and minor stoppages losses, namely the machine is idle due to the time waiting for the sugarcane to enter and the problem of machines outside the milling station.

Keywords: *milling station, overall equipment effectiveness, pareto diagram, six big losses, sugarcane*

1. INTRODUCTION

XYZ Sugar Factory is a sugar that has an automatic processing system with machines that operate continuously 24 hours per day for about 150 days. The problem that often arises in sugar factories is regarding to the condition of the machines which are often damaged, resulting in high stopping hours for milling factories (Sriwarna, 2007). It is also caused by the condition of the machine that is outdated.

In the 2013 milling season, the amount of downtime caused by the machine factor at the XYZ Sugar Factory milling station tended to increase compared to the downtime in the 2012 milling season. During the last 3 months of the 2013 milling season, downtime was also seen to exceed the percentage of the company standards. According to the head of the installation department of XYZ Sugar Factory, the accumulated downtime standard for several machines at milling stations in 2012-2013 is 1%. This condition affects the effectiveness of machines in achieving output and production quality levels.

OEE is a metric or a measurement to evaluate the effectiveness of a machine / equipment. OEE seeks to identify indirect and hidden losses of production and other costs, which have a major contribution to the total cost of production (Nakajima, 2006). This loss or loss is defined as a function of a number of related exclusive components, namely: availability, performance and quality (Huang et al, 2003). The reliability of OEE with its ability to measure the total effectiveness (complete, inclusive, whole) of the performance of an equipment in doing a work that has been planned, and is measured from actual data related to availability, performance efficiency, and quality of product (Williamson, 2006). OEE information is used to identify and classify the causes of the underperformance of an equipment. This study aims to measure the effectiveness of the sugarcane milling station machine and determine the factors that affect the effectiveness of the machine.

2. MATERIAL AND METHODS

2.1 Research Approach

Data collection was carried out in two ways, namely field surveys and recapitulation of XYZ Sugar Factory daily reports of sugarcane milling machines for the last 6 months. The data needed to calculate the value of OEE (Overall Equipment Effectiveness), namely data on machine breakdown, machine stand by, and planned maintenance on this machine, data on operating time, total production and number of defects. The data were obtained from daily reports from May to November 2014. The data obtained from the daily recap of XYZ Sugar Factory were the time of engine failure including its duration, type of engine failure, and the cause of damage every day.

2.2 Data Processing

2.2.1 OEE Element Calculation

The elements of OEE in machine and plant equipment management in general are illustrated by EXOR / Data Visor Marquees as in Figure 1.

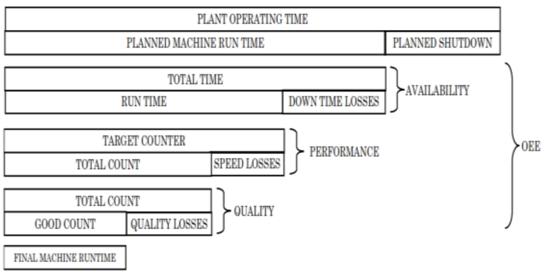

Figure 1. Scheme of OEE
Source: EXOR/ Data Visor Marquees

It can be seen in Figure 1 that the imperfection of the level of effectiveness of machines / tools in a factory is due to various losses, which are based on the cause Wauters and Mathot classifies them into: (1) losses due to machines that do not function according to plan (malfunction), (2) losses in the process, and (3) losses due to external factors (external losses). Furthermore, it is explained that losses due to malfunction and process are categorized as losses due to technical factors (technical losses), while external losses can be grouped again because the causes are planned (planned losses) and because they are not planned (unplanned losses). Losses due to planning can occur due to: (a) modification or repair of machines / tools (during the mill mill phase), (b) certain needs (quantity and quality of products) which have an impact on the capacity and / or speed of production machines, or (c) social considerations (holidays, etc.) which have an impact on factory working hours. Unplanned losses occur due to: (a) shortage of manpower / operators (common in XYZ Sugar Factory around Eid), (b) shortage of raw materials (due to poor management of sugarcane cutting and transport at XYZ Sugar Factory), (c) environmental factors impact on mill mill hours. The concept of OEE is generally applied to the manufacturing industry, while sugar factories are closer to the process industry (Subiyanto, 2014). The calculation of the OEE element is carried out with the following formula.

$$Availability = \frac{Run\ Time}{Total\ Time} \text{x } 100\ \% \qquad (1)$$

...(1.17 (1)

$$Performance = \frac{Total\ Count}{Target\ Count} \text{x } 100\ \% \qquad (2)$$

$$Quality = \frac{Good\ Count}{Total\ Count} \text{x } 100\ \% \qquad (3)$$

$$\text{OEE} = Availability \text{ x } Performance \text{ x } Quality \qquad (4)$$

2.2.2 Six Big Losses Calculation

Six big losses are six losses that must be avoided by every company that can reduce the level of effectiveness of a machine. Six big losses consist of:

a. Breakdown Losses, this loss is caused because the existing machine is damaged so that it cannot operate, which results in the production process being disrupted. Breakdown Losses was calculated using equation (5).

$$\frac{\text{Total of Breakdown Time}}{\text{Delay Time}} \text{ x } 100\ \% \qquad (5)$$

b. Setup and Adjustment Losses, lost time due to adjustments and setup processes performed by machine operators. Set-up and Adjustment Loss was calculated using equation (6)

$$\frac{\text{Total of Setup \& Adjustment}}{\text{Delay Time}} \text{ x } 100\% \qquad (6)$$

c. Idling and Minor Stoppages, losses caused by stopping of equipment due to temporary problems, such as intermittent engines (halting), jamming and idling (idling). Idling & Minor Stoppages was calculated using equation (7).

$$\frac{\text{Total of Idling \& Minor Stoppages}}{\text{Delay Time}} \times 100\ \% \qquad (7)$$

d. Reduced Speed Losses, a condition where the engine is operated at a speed that does not match the design speed of the machine because usually the actual speed is lower than the ideal speed. This causes losses because the machine is not operated at its true capacity. Reduced Speed Losses =

$$\frac{\text{Actual Production Time} - \text{Ideal Production Time}}{\text{Loading Time}} \times 100\ \% \qquad (8)$$

$$\frac{\text{Actual Production Time} - (\text{Ideal Cycle Time} \times \text{Total Product Process})}{\text{Loading Time}} \times 100\% \qquad (9)$$

e. Rework and quality defects, this loss occurs because of product defects during production. Products that do not meet specifications need to be reworked or made scrap. Labor is required to carry out the rework process and the material that is converted into scrap is also a loss for the company. Rework and quality defects were calculated using equation (10).

$$\frac{\text{Rework} \times \text{Ideal Cycle Time}}{\text{Loading Time}} \times 100\% \qquad (10)$$

f. Yield lossess occurs due to wasted raw materials. This loss is divided into two, namely the loss of raw materials due to product design and manufacturing methods as well as adjustment losses due to defects in the quality of products produced at the beginning of the production process and when changes occur. Rework and quality defects were calculated using equation (11).

$$\frac{\text{Ideal Cycle Time} \times \text{Scrap}}{\text{Loading Time}} \times 100\ \% \qquad (11)$$

3. RESULT AND DISCUSSION

3.1 Availability Value Calculation

Availability shows the level of effectiveness of sugar mill machine operation, the value of which is a percentage of the number of days or effective hours of milling with the planned number of milled hours. The size of the availability indicates the size of the number of hours or days the factory stops grinding (downtime), and also indicates the factory's ability to perform maintenance management of its machines / tools. The lower the availability number will certainly have an effect on factory productivity because the number of sugarcane that has been successfully milled is increasingly limited. Best practice availability (world class) for industries whose processes work continuously, according to reference is 90% (Wauters and Mathot, 2002). This parameter is very crucial in assessing the performance of machines and tools in sugar mills because factory machines are generally old.

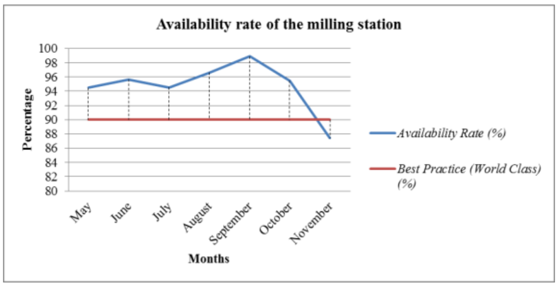

Figure 2. Availability Rate at milling station from May to November 2014

Based on Fig. 2 and the existing references can be presented, referring to the best practice availability, namely 90%, then the availability for 5 months shows an increasing trend and only in November the availability value is not able to reach world class. This is influenced by factors that cause machine delay which is dominated by the waiting time for the sugarcane to enter. However, overall the average availability value during the 2014 grinding period was above best practice, namely 94.72%.

3.2 Performance Value Calculation

Performance shows the effective grinding speed of machines and plant equipment relative to factory installed capacity or shows the ability / consistency of machine performance in producing output according to the theoretical speed for actual operation. In 2014 the installed milling capacity of XYZ Sugar Factory was 3500 tonnes of cane per day (TCD), while in fact this factory only operates at (exclusive) capacity of 2600 TCD. This means that there is a decrease in the speed of the functions of machines and tools, so that their performance can only be achieved by 74.31% (= 2600/3500). Best Practice performance (world class) for industries whose processes work continuously, according to reference is 95% (Wauters and Mathot, 2002).

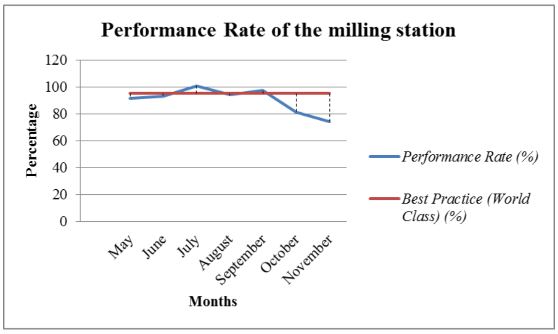

Figure 3. Performance Rate at milling station from May to November 2014

Based on Fig. 3 and the existing references can be conveyed, referring to best practice performance, namely 95%, then the performance that is able to reach world class occurs in July and September. Overall, the average performance value during the 2014 grinding period was below best practice, which was 90.31%. This is dominated by production factors that are unable to reach the installed milling capacity. At a certain level, the milling speed in sugar factories is related to management policies in dealing with equipment conditions and production targets, because there is a trade off between milling speed and sugar losses at the milling station, especially the sugar found in bagasse. If the rotation of the rollers is accelerated, the grinding capacity will increase, but the extraction rate will decrease, because the time for the dregs to be under the pressure of the mill rollers is shorter. Conversely, if you increase the extraction yield by slowing down the roller rotation and increasing imbibition water, or by increasing the pressure, the grinding capacity will decrease. Too slow rolling of the rollers will automatically reduce the grinding capacity.

The reduction in grinding speed can also be related to the non-uniform capabilities of machines / tools per process station. As it is known that according to the stages of the production process from the milking of sugar cane to the formation of white crystal sugar, the machines and production equipment in the sugar factory are grouped into 8 stations, namely milling, refining, evaporation, cooking, cooling, spinning, kettle, and electricity. The process occurs in 1 production line, so the capacity constraints at one station will have an impact on other stations, which at a certain level can cause a bottleneck. Low performance indicates that management is not able to fully utilize the potential of the machine/ tool, which of course is a disadvantage.

3.3 Quality Value Calculation

Quality ratio is a ratio that describes the ability of the equipment to produce products in accordance with standards, the value of which is the percentage of the number of good products to the total product processed. In sugar factories, the potential amount of sugar is indicated by the sugar cane content, which is a number that indicates the level of sugar (sucrose) contained in sugarcane juice. If the process is complete, the amount of white crystalline sugar produced should be the product of the number of milled sugar cane and sugar cane powder. In practice, the conversion process from sugar cane to crystal sugar is not possible completely, because there is sugar loss at various stages of the process, namely bagasse (pol dregs), solid waste / blotong (pol blotong), and molasses (pol drops). , as well as part of it into conversion sugar. Best practice quality (world class) for manufacturing industries whose processes work continuously, according to references is 99.9% (Wauters and Mathot, 2002). However, the concept of Quality is less relevant to be applied to sugar factories that are closer to the process industry. According to Subiyono (2012), the best practice for overall recovery in the world sugar industry is around 91%.

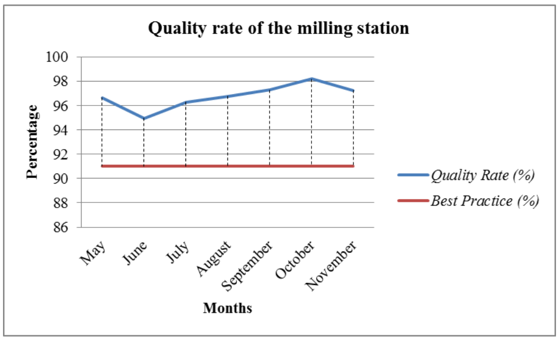

Figure 4. Quality Rate at milling station from May to November 2014

Based on Fig. 4, the quality of sap during the 2014 milling period shows an increasing trend. Overall, the quality value of sap and its average during the 2014 grinding period was above best practice.

3.4 OEE Value Calculation and Analysis

OEE (world class) best practice for industries whose processes work continuously, according to the reference is 85% (Wauters and Mathot, 2002). This figure is in line with the reference given by Bhagat (2012) that the average overall plant efficiency at sugar factories in leading countries is around 85%.

Table 1. Measurement of OEE of milling station from May to November 2014

Months	*Availability Rate (%)*	*Performance Rate (%)*	*Quality Rate (%)*	*OEE (%)*
May	94,50	91,38	96,65	83,46
June	95,66	93,29	94,96	84,74
July	94,52	100,80	96,30	91,76
August	96,59	94,15	96,78	88,02
September	98,89	97,25	97,30	93,57
October	95,50	80,95	98,19	75,91
November	87,40	74,31	97,27	63,18
Averages	94,72	90,31	96,78	82,95

Based on Table 1, it can be seen that the machine OEE value at the XYZ Sugar Factory milling station has not been able to reach world-class best practices. Only in terms of availability and quality values are able to reach best practice, while the performance component is still below world-class best practice.

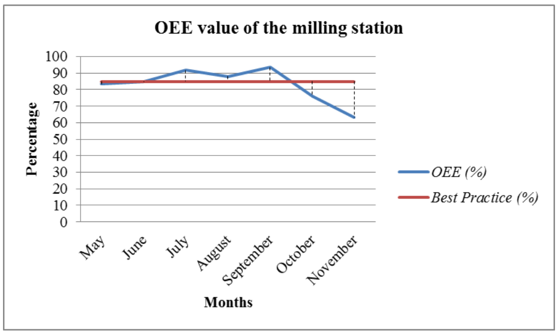

Figure 5. OEE at milling station from May to November 2014

Figure 5 shows the tendency for OEE to decline. In July, August and September 2014, OEE scores above best practice were achieved. The average OEE value during the 2014 grinding period had not yet reached best practice, namely 82.95%.

3.5 Six Big Losses Analysis

Table 2 shows the percentage of the six big loss factors for machines at the milling station based on secondary data on the stop hours of grinding XYZ Sugar Factory during the 2014 grinding period. outside the milling station which causes the milling process to stop because the sugar production system at XYZ Sugar Factory consists of 1 production line which if a problem occurs in one line it will greatly affect the other lines.

Table 2. Factors of six big losses at milling station

Months	*Delay time* (hour)	*Downtime Losses*		*Speed Losses*	
		Equipment Failure Losses/ Breakdown (hour)	*Setup and Adjustment Losses* (hour)	*Idling and Minor Stoppages Losses* (hour)	*Reduced Speed Losses* (hour)
May	26,4	3,33	4,74	18,33	-
June	30,3	7,99	14,48	7,83	-
July	25,98	13,33	7,49	5,16	-
August	22,89	1,16	0	21,73	-
September	7,98	4,83	0,83	2,32	-
October	31,74	2,08	0,5	29,16	-
November	30,25	1,08	0,17	29	-
Total	175,54	33,8	28,21	113,53	-
Percentage (%)		19,25	16,07	64,67	-

At XYZ Sugar Factory, the observation of reduced speed was carried out incidentally, making it difficult to document. As for process defects, because there is no rework in sugar production, there is no data related to process defects, and there is no production scrap data, so there is no data for reduced yield losses.

3.6 Analysis Diagram of the Cause of the Low OEE Value

The results of identification and the percentage of the machine's six big losses factor at the milling station have been calculated and can be seen in table 2.Then from the six points, only 3 points are seen which are factors for the engine delay at the milling station, namely Equipment Failure Losses/ Breakdown, Setup and Adjustment Losses, and Idling and Minor Stoppages Losses. Furthermore, these three factors have been described in the Pareto diagram so that it is clear the order of the three factors that influence the effectiveness of the machine at the sugarcane milling station.

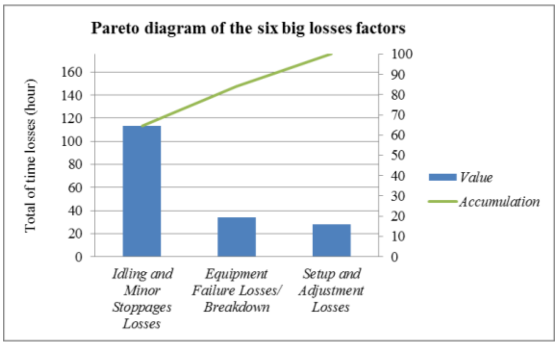

Figure 6. Pareto diagram of six big losses factors at milling station

Figure 6 shows that the factors that cause machine time loss during the sugarcane milling process are idling and minor stoppages. This factor is caused by events such as waiting time for the sugarcane to enter and damage to the machine outside the milling station, which requires the grinding process to be stopped since the sugar production system at XYZ Sugar Factory is one line.

4. CONCLUSIONS

1. The OEE value of the machine at the milling station is 82.95%, which means that it has not been able to reach the best practice world class (at least 85%).
2. The main factors that affect the value of OEE are idling and minor stoppages losses, namely idle machines due to waiting time for sugarcane to enter and machine problems outside the milling station.

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