CHAPTER 5

RESULT AND DISCUSSION

5.1 INTRODUCTION

This chapter includes Study and Act phase (of PDSA cycle) which consists of analysis of collected data using several engineering techniques. Finally comparison of data in OEE, MTBF, monthly output and percentage of loss of material per hour before and after implementation are made and improvement is evaluated.

5.2 STUDY PHASE

After data collection, the data are presented in tabular and graphical form. Then analysis of data is done to evaluate the improvement. To be specific, tasks done in study phase are:

- Data presentation
- Analysis of data

5.2.1 Data presentation and Analysis of data

The data of before and after implementation of FMS are combined. Line or column graphs are drawn to observe the trend the data. Comparison is made in the following section.

Line and Column Chart

There are 2 types of chart: line and column (or bar) chart used in this analysis. Column chart represents discrete data. Column charts are used for MTBF, monthly

output, loss of material per hour and reworked material per month. Line chart represent continuous data. Line chart is used in OEE of machines. The nature of OEE is actually continuous. However, the data collecting methods have to be discrete. This is because continuous data collecting is costly. Therefore, line chart can be used to present OEE of the machines.

OEE and Mean Time Between Failure (MTBF)

The OEE values from March to November are combined into a single table. Line and column chart is drawn for the ease of comparison. Line and column chart are able to show the trends of the data. The MTBF is time between 2 failures. From Figure 5.1, it can be seen that with increment in MTBF, OEE of machine is increased. Before implementation of FMS (July), MTBF and OEE of the machine does not change much and the data for OEE are in the range of 5.76%, whereas the range for MTBF is 23 minutes. The range is very small and it shows stable trend. Starting from July, OEE and MTBF are increased until September. This is because the workers are more and more familiar and adapt to the new implemented system as time goes by. Moreover, it can be seen that there is a significant improvement of MTBF and OEE values after the implementation of FMS.

The maximum different in OEE before and after implementation

= OEE in September – OEE in April

= 73.18% - 31.08%

= 42.1%

The maximum different in MTBF (monthly) before and after implementation

= MTBF in September – MTBF in March

= 401 minutes – 214 minutes

= 187 minutes

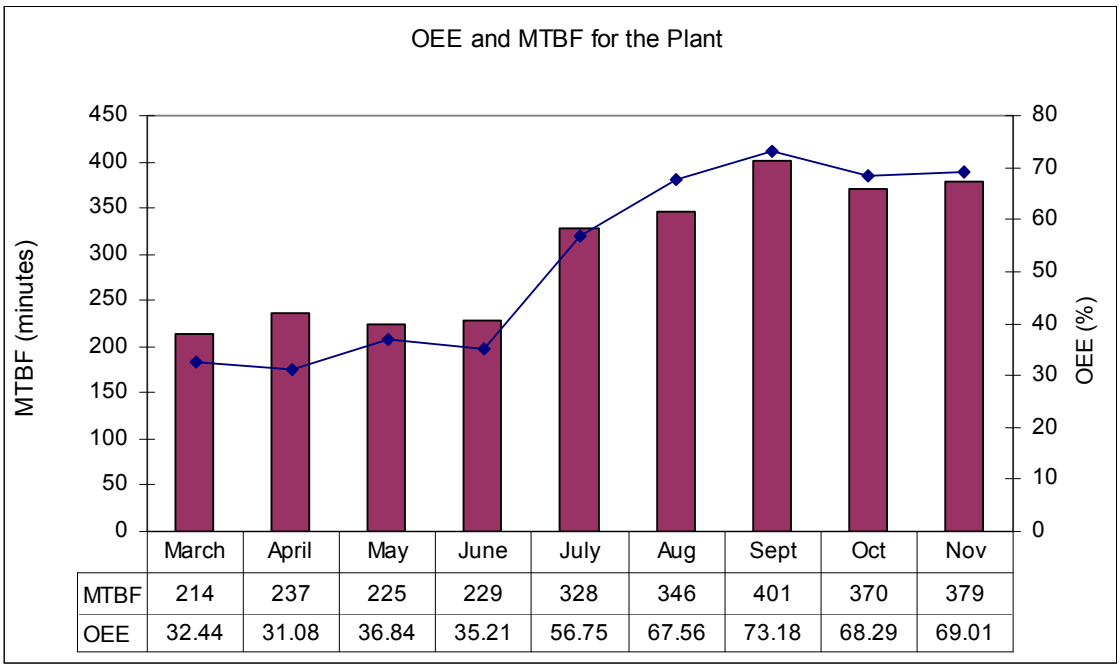


Figure 5.1 OEE and MTBF of 9 months

Monthly output

Monthly output reflects the productivity of a plant. Before month of July, monthly output of the machine does not change much and is in the range of 356.55 tons. The range is very small and it shows stable trend. Starting from July, monthly output is increased until September. Productivity is depending on OEE, so the trend for OEE and monthly output are same. From Figure 5.2, it can be seen that there is a significant improvement of monthly output after the implementation of FMS.

The maximum improvement in monthly output before and after implementation

= Output in October – Output in May

= 8967.06 tons – 6495.57 tons

= 2471.49 tons

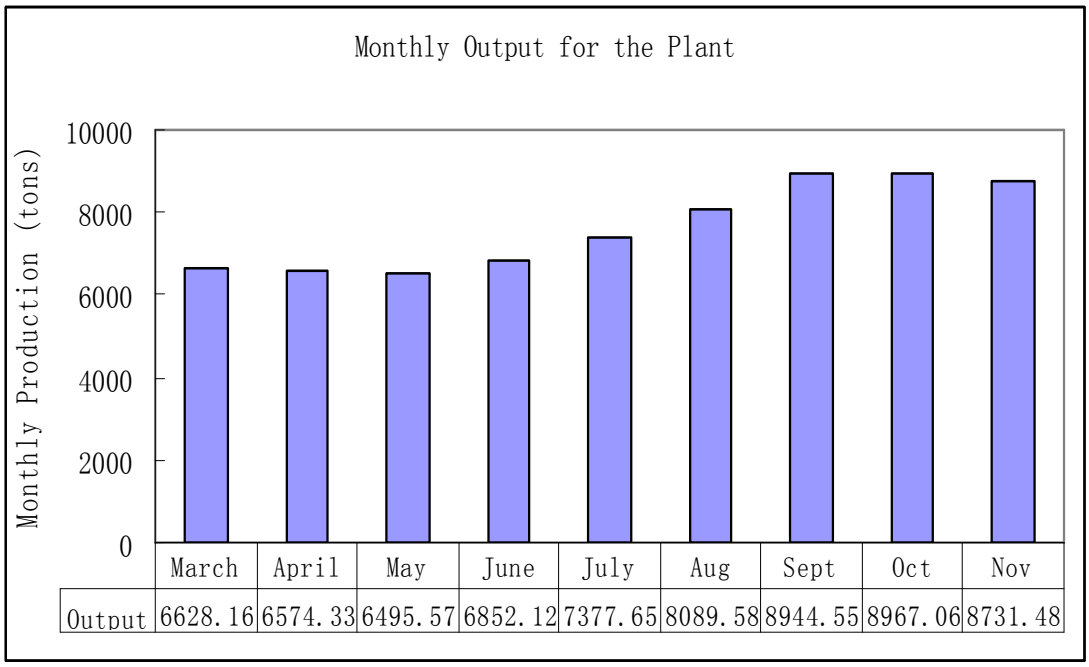


Figure 5.2 Monthly output for 9 months

Percentage of Loss of material per hour

Loss of material reflects the waste of a plant. The loss of material is calculated in percentage per hour. Waste of plant should be kept as low as possible. From Figure 5.3, it can be seen that there is a significant decrement in loss of material after the implementation of FMS. The highest percentage of loss of material, 34.55% happened at June. However, the values dropped drastically after July (18.28%) when FMS is implemented. This means that the FMS succeed in reducing the loss of material effectively. Loss of material is affecting OEE values. The least of loss of material in September provides the highest OEE of machines in the same month.

The maximum reduction in loss of material per hour before and after implementation

= Loss of material in June – Loss of material in September

= 34.55% – 10.58%

= 23.97% per hour

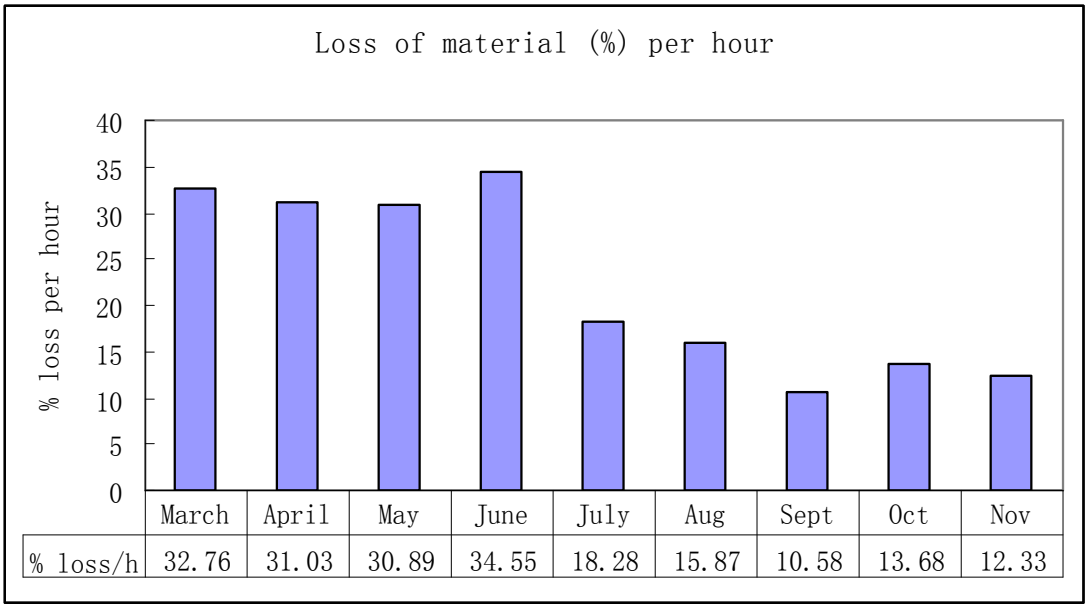


Figure 5.3 Loss of material (% per hour) for 9 months

Reworked Material per Month

In this study, quantity of reworked material reflects the quantity of WIP material and inventory level of a plant. The reworked material adds load to WIP material, and affect the performance and disrupt the schedule of the plant. Reworked material is considered as quality losses. Before July, the maximum quantity of reworked material is 156.97 tons, which is 2.29% of the monthly output. After July, it can be seen that there is a significant decrement in reworked material after the implementation of FMS, and the quantity of reworked material is maintained almost constant over these 5 months. The minimum percentage of reworked material in monthly output occurs in September because it has the lowest reworked material and highest monthly output.

Percentage of reworked material in monthly output

= quantity of reworked material / monthly output X 100%

= 77.52 tons / 8944.55 tons X 100%

= 0.867%

This means that reworked material only consume 0.867% of the total output of the plant in September.

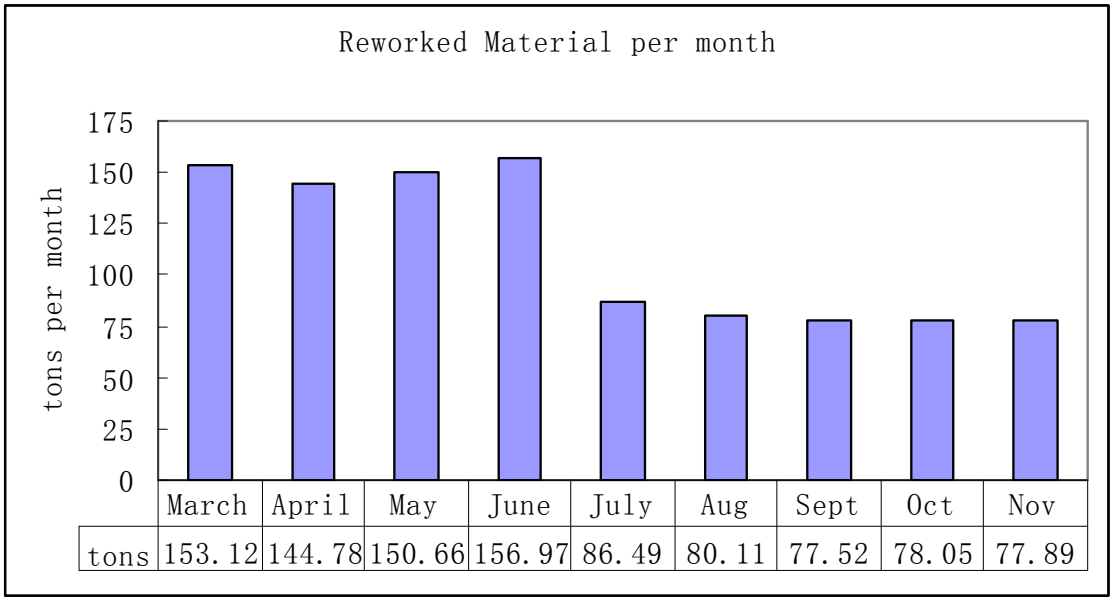


Figure 5.4 Reworked material (tons per month) for 9 months

5.2.2 Data Screening

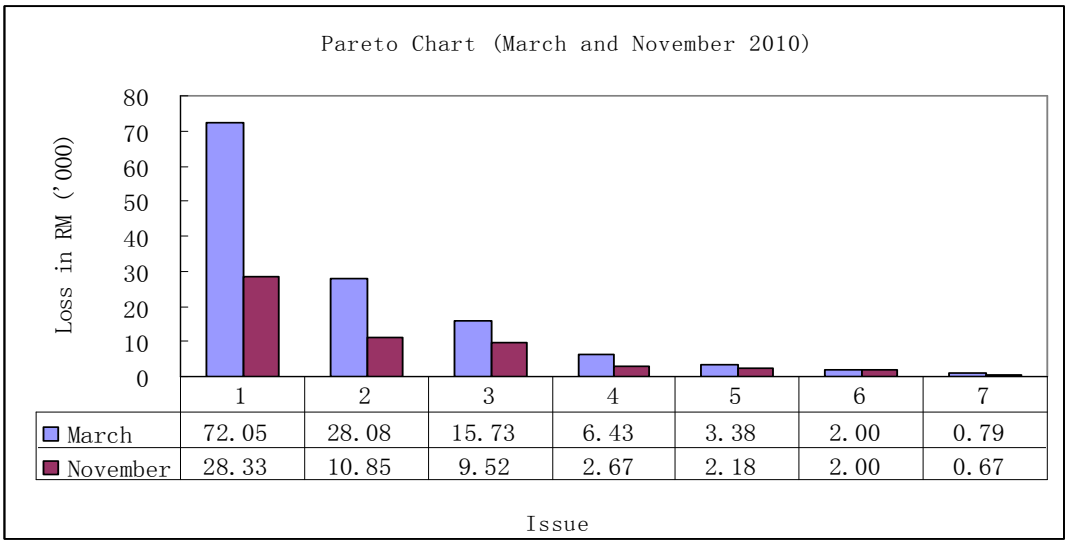
The objectives of the study are to evaluate the results after 3 months of implementation of FMS, which is November. Therefore, data for March and November are compared in this section. As stated, the main issue to be solved is all about the decrement of loss of material. The loss of material is directly related to the percent quality loss (Q %). From Table 5.1, it can be seen that after the implementation of FMS, the quality rate is increased from 48.23 percent to 80.47 percent, with improvement of 32.24 percent. The OEE is increased from 32.44 percent to 69.01 percent. The monthly earning capacity is increased from RM 719,389 to RM 1,530,365, with improvement of RM 810,976. The MTBF is increased from 214 minutes to 379 minutes, with improvement of 165 minutes or 77.1 percent. The monthly output is increased from 6628.16 tons to 8731.48 tons. The percentage of loss of material per hour is decreased from 32.76 percent to 12.44 percent. The quantity of reworked material is decreased from 153.12 tons to 77.89 tons, with improvement of 49.13%. The percentage of reworked material in monthly output is decreased from 2.31% to 0.892%. Therefore, all 4 objectives of the study are achieved.

Table 5.1 Data Screening for March and November

Category	March	November
Monthly output	6628.16 tons	8731.48 tons
OEE	A x P x Q = 0.8589 x 0.783 x 0.4823 = 0.3244 = 32.44 %	A x P x Q = 0.9323 x 0.9199 x 0.8047 = 0.6901 = 69.01 %
Loading time per month	56 hours	56 hours
Net profit to each ton	RM 900	RM 900
Theoretical earning capacity	RM 2,217,600 per month	RM 2,217,600 per month
True earning capacity	RM 719,389 per month	RM 1,530,365 per month
Percentage of loss	67.56 %	30.99 %
Cost of losses	RM 1,498,211 per month	RM 687,234 per month
Loss of material	32.76 % per hour	12.44 % per hour
MTBF	214 minutes	379 minutes
Reworked material	153.12 tons	77.89 tons
Percentage of reworked material in monthly output	153.12 / 6628.16 x 100% = 2.31%	77.89 / 8731.48 x 100% = 0.892%

Pareto Chart

Pareto charts (March and November) of money loss vs. issues were drawn together for ease of comparison. Loss of material is root cause and other issues are induced causes. From Figure 5.5, it can be observed that decrement in root cause causes decrement on induced causes as well.



Issue	
1	loss of material
2	replacement of component
3	rework
4	human error
5	repair
6	extra cleaner
7	other

Figure 5.5 Pareto chart for March and November

5.3 Act phase

In act phase, the final results of the plan are compared with the objectives. If all the objectives are achieved, no change is needed. If the objectives are not achieved, changes are made and the cycle is repeated until the objectives are achieved.

- Result validation
- Changes (optional)
- Future plan

Result validation

The results of the plan are compared with the objectives of the study. The comparison is made below.

Table 5.2 Result validation

Criteria	Objective or target	Result in November	Achievement
Loss of material per hour	15% or less	12.44%	Yes
Monthly output	8000 tons or more	8731.48 tons	Yes
OEE	60% or more	69.01%	Yes
Reworked material per month	90 tons or less	77.89 tons	Yes

From the table above, all 4 objectives of the research are achieved, so no change of plan is needed.

Future plan

The PDSA cycle is a never stopped recycling observation. Future plans of this study are recommended below:

- Design for maintainability: Maintainability is used to reduce system downtime by facilitating the repair effort. From the graphs above, OEE, MTBF and percentage of loss of material show unstable trends after September. It is believed that design in maintainability helps to solve this problem.
- Implementation of 5s': Cleanliness of the fertilizer plant of research is vital, as it is affecting the OEE of machines and quality of product. Therefore it is believed that principle Seisou (Sweeping) helps in keeping the work area clean, and retaining only the information and items needed to work on the specific tasks.