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THE APPLICATION OF *OVERALL EQUIPMENT EFFECTIVENESS* (OEE) TO ANALYZE *LEAN SIX SIGMA CAPABILITY* OF SHRINK LABELS PRODUCTION AT COMPANY X

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ABSTRACT

Overall Equipment Effectiveness (OEE) is used to analyze the lean six sigma capability of PT. X in producing shrink labels. There are four processes in producing shrink labels; drawing, slittering, seaming, and cutting using four type of machines; DM 3, SL 4, SM, and cutting machine. The measurement of OEE was conducted for each machine in 2012. The results showed that all machines have OEE values below the standard. The DM 3 machines have the largest mean time to repair (MTTR) and mean time to failure (MTTF) and this can be categorized as waste.

***Keywords**: OEE, sigma level, shrink labels*

1. INTRODUCTION

PT. X is a manufacturing company that produces plastic packaging materials. One of the products produced by PT. X is shrink labels commonly used as the cover of bottle caps or packaging labels for beverage bottles. In the manufacture of shrink labels PT. X uses four machines, namely the drawing machine (DM 3), slitter machine (SL 4), seaming machine (SM), and cutting machine.

In 2012, a lot of problems occurred in the machines. More than one hundred problems occurred in all types of the machines used. This is certainly a disadvantage in terms of time and cost.

The production equipment is part of the company's assets. The problem that occurs on the equipment will affect the efficiency of the assets. Moreover, the problems in the equipment will also affect the quality of the product. By analyzing the causes of the problems, the improvement can be carried out and the quality of the product is expected to improve accordingly.

2. THEORETICAL BACKGROUND

Six Sigma is a methodology for enhancing profitability through improved quality and efficiency by focusing on the reduction of variation, doing the right thing right and process improvement (Summers, 2007). The Six Sigma approach blends nicely with lean manufacturing techniques, enhancing the effectiveness of both. Six Sigma strengthens company performance by concentrating on reducing process variation and lean thinking enhances company performance by focusing on the reduction of waste.

Overall Equipment Effectiveness (OEE) is a measure of total equipment performance-the degree to which the asset is doing what it is supposed to do (Williamson, 2006). OEE is also a three part analysis tool for equipment performance based on actual availability, performance efficiency, and quality of product or output.

Gibbons and Burgess (2010) proposed an extended OEE framework that incorporates Six Sigma thinking and asset management strategy performance indicators. The proposed OEE is viewed from a lean and waste perspective. The final OEE measure is the value added (VA) element of the base hours available. The availability, performance and quality losses are all categorized as non-value added (NVA), pure waste. The planned downtime is categorized as necessary but non value added (NNVA).

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The proposed OEE framework availability element is enhanced to include three additional measures of asset management effectiveness. The three new indicators are mean time to failure (MTTF), mean time to repair (MTTR) and mean time between failures (MTBF).

MTTF is based on the actual production hours (total operating time minus any down time) divided by the number of asset failures during that time. MTTR is based on the total downtime (due to asset failure) divided by the number of asset failures during the total operating time. MTBF is MTTF plus the MTTR. Unlike MTTF – which is a pure indicator of reliability – MTBF includes the repair time to give an overall indicator of asset management effectiveness.

The proposed OEE framework quality efficiency is based around incorporating an indication of Six Sigma process capability through the defects per million opportunities (DPMO) measure in addition to understanding the usual process quality losses such as setting pieces, attribute inspection failures and dimensional inspection failures.

3. RESEARCH METHOD

The data for OEE measurements is collected from PT X production plant. The data collected is as shown in Table 1:

Table 1. Data Required

Standard minute available	%Availability
Planned downtime	Total product made
Loading time	Cycle time
Adjust process	%Performance
Waiting material	Out of tolerance parts
Waiting operator	Setting part
Asset repair time	Attribute failures
Total lost time	Total bad parts made
Actual runtime	DPMO
Number of asset failures	Sigma level
MTTF	%Quality
MTTR	OEE
MTBF	

The measurement of OEE that incorporates Six Sigma thinking and asset management strategy performance indicators is carried out using the following formula:

Loading time = standard minute available – planned downtime (1)

Total lost time = line changeover + adjust process + waiting material + waiting operator + assest repair time (2)

Actual run time = loading time – lost time(3)

%Availability = actual run time/loading time (4)

MTTF = actual production hours/number of asset failures (5)

MTTR = total downtime/number of asset failures (6)

MTBF = MTTF + MTTR (7)

%Performance = total production/(cycle time/actual run time) (8)

DPMO = (total bad part/total production x1,000,000 (9)

%Quality = total good part/total production (10)

OEE = %Availability x %Quality x %Performance (11)

The OEE is then compared with the world class OEE as standard for improvement analysis. Analysis was also performed based on the lowest OEE correlation with independent variables such as loading time, planned downtime, total lost time, total production, cycle time, and total defect.

Table 2. World Class OEE

OEE Factor	World Class
Availability	90%
Performance	95%
Quality	99%
OEE	85%

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Table 3. Major Loss Event

Equipment losses	OEE metric	Loss Category	Example
Machine breakdown	Availability	Down time	Equipment Failures, Tooling Damage
Machine adjustment			Process Warm Up, Machine Changeovers
Machine stops	Performance	Speed	Product Misfeeds, Component Jams
Machine reduced speed			Equipment Age, Tooling Wear
Quality defect	Quality	Quality	Tolerance Adjustments, Damage
Yield losses			Assembled Incorrectly, Rejects, Rework

The improvement analysis is conducted using the cause effect diagram (Ishikawa diagram) to determine the sources of a problem (Montgomery, 2005). The final step is to make the proposed improvements to the problems.

4. RESULT AND DISCUSSION

The four processes to produce shrink labels are printing, slittering, seaming, and cutting. The machines used are DM 3 for printing, SL 4 for slittering, BC for seaming and cutting machine for cutting. The average of the availability of each machine is shown below.

Table 4. Availability

Machines	Average
DM 3	87%
SL 4	87%
SM	88%
Cutting	90%

The data shows that all of the availability values except for cutting machines are below standard. The three additional measures for the availability element are shown in Table 5.

Table 5. MTTF, MTTR and MTBF

Machines	MTTF	MTTR	MTBF
DM 3	60.00	38.41	98.41
SL 4	56.23	35.50	91.73
SM	20.00	13.75	29.17
Cutting	22.50	14.17	36.67

The data indicated that DM 3 machines are the machines that need the longest time to repair when they are broken down.
The measurements of performance element are shown on table 6 below.

Table 6. Performance

Machines	Average
DM 3	91%
SL 4	85%
SM	91%
Cutting	82%

The data shows that the performance of all of the machines is below the standard. The measurements of quality element are shown on table 7 below.

Table 7. Quality

Machines	Average
DM 3	94%
SL 4	95%
SM	96%
Cutting	97%

The data shows that all of the quality values are below the standard. The measurements of OEE average for each machine type are shown below.

Table 8. OEE

Machines	Average
DM 3	75%
SL 4	71%
SM	77%
Cutting	72%
Average	74%

The data shows that all of the OEE values of the machines are below the standard. SL 4 machines have the lowest OEE.

Table 9. Sigma Level

Machines	DPMO	Sigma Level
DM 3	57,500	3.0
SL 4	49,167	3.1
SM	36,667	3.2
Cutting	29,167	3.3
Average	43,125	3.2

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The VA of the machines for shrink labels production is 74%. The sigma level of the shrink labels production is 3.2. Furthermore, the data for NVA is obtained from the data of the problems of the machines. The problems can be categorized into availability losses, performance losses, or quality losses.

Table 10. Equipment Losses

Mesin	*Availability*	*Performance*	*Quality*
DM 3	31	12	-
SL 4	22	13	-
SM	11	-	-
Cutting	-	7	6
Total	77	39	6

It can be seen that most of the losses are availability losses. However, the equipment losses on the cutting machine are performance losses. The source of the problems on DM 3, SL 4 and SM machines can be classified as machine breakdown whereas the sources of the problems on the cutting machines can be categorized as machine stop.

Based on the analysis using cause and effect diagram it was found that the sources of the problems are the electricity supply, the spare parts and the technicians.

The supply of electricity used to drive the machines in PT. X is 1600 kW. This is insufficient to support all of the machines simultaneously. Therefore, when the demand for the product is very high and the plant has to use all of the machines, the power will be shut down and result in machine breakdown. This problem can be solved by increasing the supply of electricity.

PT. X has limited technicians to do the maintenance for the machines. There are only two technicians for each shift. This is why the regular maintenances cannot be done in accordance with the maintenance schedule. Besides, the technicians' skills are not sufficient to solve all the problems occur to the machines. PT. X needs to recruit new capable technicians and enhance the skills of the existing technicians by providing them with appropriate trainings.

PT. X also has to deal with the problem of spare parts. When the spare parts wear out, they do not replace them with the new ones. They keep using the worn out spare parts until the parts cannot be used anymore. The spare parts used are also not the genuine spare parts because they are considered too costly. Since the performance of the machines depends on the quality of the spare parts, PT. X has to replace the spare parts whenever they need replacement. PT. X also needs to replace the spare parts with the genuine ones. The initial cost may be high but in the long run it may be more efficient as the genuine spare parts last longer.

The cutting machine requires more attention especially the sharpness of the blades. When the blades wear out, they need to be replaced with the genuine ones. The mistakes of the operators in setting the blades can be improved by providing them with training and clear manual.

5. CONCLUSION

The average OEE of PT. X is 74% that means that the value added (VA) contributed by the machines to the production of shrink labels are 74%. There is room for improvement as the world class OEE is 85%. The sigma level is 3.2 and to attain the international standard six sigma, there are many things to be done. PT. X should make improvements by reducing waste and existing equipment losses. DM 3 machines need more attention because they have the largest *mean time to repair* (MTTR) and *mean time to failure* (MTTF). The value of the MTTR and MTTF shows the waste caused by the repair time.

The primary problems that affect the OEE are machine breakdown and machine stops. Machine breakdown occurs because of several factors, namely human, maintenance and spare parts. Machine stops are caused by human, machines and spare parts. Some improvements are proposed and the improvements are expected to enhance the OEE. The improved OEE will affect the process capability of PT. X in producing shrink label.

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