Identification Performance and Machine Failure of Manufacturing System Based on OEE and FMEA Methods

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Identification Performance and Machine Failure of Manufacturing System Based on OEE and FMEA Methods (Case Study on PT. APF)

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ABSTRACT

This paper concern for identification machines performance and the most dominant failure mode appears in the PT. APF that causes low levels of quality of the products produced by the machine SDS 700 and SDS 900 in the manufacturing process at the texturizing (TX-1) department of PT. APF. The analysis was done by calculating availability machine 90%, performance rate <95%, and the quality rate <80% of the Overall Equipment Effectiveness (OEE) value of <85%. While the identification of failure modes with FMEA method the highest RPN value is 30 for misthreading failure, which the contribution method and maintenance of machinery by 48% of the processing of the fishbone diagram.

Key words: availability, performance, OEE, FMEA.

1. INTRODUCTION

All of activities within an industry subjected to gain maximum profit as much as possible, with minimize the amount of input and maximize the amount of output (Chand, Shirvan, 2000). Grover (2001) said that from a whole of manufacturing times, only 5% times that used for machining process. About 70% from machining time used just for loading process, positioning, gagging, etc. Waste elimination within manufacturing process should keep on working for getting an optimal performance from a machine. Overall Equipment Effectiveness (OEE) is one of methods are common used within company which oriented on Total Productive Maintenance (TPM) for machine and equipment performance measurement. This method used to identify location of the problems on manufacturing tool and machining (Themestani, et. al., 2011)

The topical data a number of manufacturing PT. APF year 2011 shows that machine SDS 700 only reach 83% and machine SDS 900 about 94.5%. Lack of numbers this achievement is caused by many things, especially waste activity which occurs in manufacturing activity. Due to the dominant that posed by the problems itself is its influence in quality, cost and delivery on texturizing (TX-1) department. This Paper will identify OEE performance and failure mode that happened in TX-1 departement.

2. THEORETICAL BACKGROUND

2.1. Overall Equipment Effectiveness

Nakajima (1988) introduced quantitative matrix that usually called OEE for measure performance of equipment manufacturing. This concept then was studied and developed in a semiconductor industry on America which done by Giegling, et. al., (1997). OEE is formulated with the function from some interrelated components, that is availability efficiency, performance efficiency, and quality efficiency (Nakajima, 1988). The success value within OEE appropriate with the international standard is about ≥ 85%, while for each parameter is 90% for availability, 95% efficiency, and 99% for quality rate (Bendaya, et. al., 2009).

According to Muchiri, et al. (2009) 85% industrial world used OEE as an extremely important for knowing the damage that happened within shop floor. The calculation for availability value, performance, quality and OEE can used the equation (1), (2), (3),...
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(4) such as being delivered by Costa and Lima (2002).

\[
\text{Availability} = \frac{\text{Operating Time}}{\text{Planned Production Time}} \times 100\% \quad (1)
\]

\[
\text{Performance} = \frac{\text{Total Actual Produced}}{\text{Total Target Produced}} \times 100\% \quad (2)
\]

\[
\text{Quality} = \frac{\text{Total Actual Produced} - \text{Defect}}{\text{Total Actual Produced}} \times 100\% \quad (3)
\]

\[
\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} \quad (4)
\]

In OEE concept is known six big damages that cause reduction labor productivity of the company. The six big damages are Breakdown, Set up and adjustment, Small Stop, Reduced Speed, Startup rejects or reduced yield, Manufacturing reject (Nakajima, 1988).

2.2 Failure Mode and Effect Analysis (FMEA)

FMEA is a technical that use for identifying, prioritizing, and reducing problems from system, design, or process before the problems are happened (Kmenta, 2002). While J. Rhee (2003) claims that FMEA is a tool that use widely in automotive industry, aerospace, and electronic for identifying, prioritizing, and eliminating failure potential, problems, and error system in design before the product is launched. This method counts failure potential, problems with Risk Priority Number (RPN).

\[
RPN = S \times O \times D \quad (5)
\]

RPN is used by a lot of FMEA procedures for estimating the risk use three criteries; Severity (S), Occurrence (O) and Detection (D). The value of RPN itself can be count by using equation 5.

3. RESEARCH METHOD

This research was conducted in line of manufacturing department TX1 on machine SDS 700 number 24 and 25 and SDS 900A number 4 and SDS 900B number 5 with the normally schedule operation is 24 hour/day. It means there’s no turnover this machine operation that will cause schedule a very high breakdown machine. Texturizing machine consist of 216 positions, where each position is processing a single bobbin of thread. A machine is divided into 2 sides they are side A and side B, where each side has 108 positions which divide again become 9 blocks. In one block consist of 12 positions which divide into 3 levels so that one level consists from 4 positions.

Products that became the object of the research are a whole product that was produced from machine 4, 5, 24 and 25 began from February 2012 until April 2012 especially DTY product type normal (SDC) by either Single Heater process or Double Heater whether using Intermingle (rotto) and non-rotto. Research began by gaining data idle position machine such as being shown in Table 1, actual manufacturing data in Table 2, quality rate. That data are being analyse to get the value of OEE, the result is used for identifying the failure modes that happened in those machines.

Table 1. A Number of Idle Machine Position

<table>
<thead>
<tr>
<th>Machine</th>
<th>SDS 700 (position)</th>
<th>SDS 900A (position)</th>
<th>SDS 900B (position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M4</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>M5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>M24</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M25</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M4</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M24</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M25</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>M4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M24</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M25</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Data on Table 1 will be used for calculating value of availability machine, as one of parameter value OEE.
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While data on Table 3 shows the actual value manufacturing that use for calculating Quality rate.

4. RESULT AND DISCUSSION

4.1 Availability

Machine SDS 700 & 900 that became the object observation have 216 positions in one machine which operate as cell station manufacturing, so that each position produce one new product in every time cycle. *Idle* that happened on machine is in each position and didn't happen in a whole machine. Problem that appears is total time operation in equation (1) was defined that whole positions that available operate entirely. *Idle position* theoretically will influence availability value machine. Then a number of *idle position* and operate position needs to calculate. Calculation by entering factor of *idle position* obtained by multiply number of position available with total manufacturing times and multiply number of position that operate with total operation times. So that for approachment itself needs adaptation availability equation as follows:

\[
A = \frac{(\Sigma P - \Sigma Po) \times (T - D)}{\Sigma P \times T} \times 100\%
\]  

\(\Sigma P\) = *number of a whole position*  
\(\Sigma Po\) = *number of idle position*  
\(T\) = *total production time*  
\(D\) = *downtime*

From data processing on Table 1 by using equation 6 then be obtained the result availability machine such as being shown in Figure 1.

![Figure 1. Availability Rate Machine](image-url)
If we compare with international standard of OEE for *availability value*, that is 90%, then there's some value that place under the standard.

4.2 Performance

*Performance Rate* was obtained from comparison between numbers of target manufacturing in one operation time with number of actual manufacturing by using equation 2. Result of calculating performance manufacturing appropriate with data on Table 2 was obtained result such as being shown on Figure 2.

![Figure 2. Performance Rate Machine](image)

Figure 2 shows graphic *performance rate* than international standard (95%). From Figure 2 can be concluded that the lowest *performance rate* machine 4 is on the second-week of April (61%) and the highest on the first-week of February, third-week of March, and fourth-week of April that is 99,2%. The lowest *Performance rate* machine 5 is on the second-week of February (79,5) and the highest on the fourth-week of April (96%). The lowest *Performance rate* machine 24 is on the third-week of March (68,7%), while the highest value on the first-week of March (84,2%). The lowest *Performance rate* machine 25 is on the first-week of April (79,5%), while the highest value is on the second-week of March (94,8%). Those results are so far under the international standard of OEE that is 95%.

4.3 Quality Rate

*Quality rate* is calculate from comparation between number of *good product*, that is product which has quality *grade A* with produced total actual product. Data that use is data of quality product in units (*bobbin*). As the standard reference is product Grade A, so that the calculation can use the equation 7.

\[ Q = \frac{\sum \text{Produk Grade } A}{\sum \text{Produksi}} \times 100\% \] (7)

Result from calculation of quality rate shows on Figure 3.

![Figure 3. Quality Rate Machine](image)

From figure 4.7 that shows *quality rate* machine it can be seen that the lowest *quality* (65,5%) and the highest is on the third-week of March (77,5%). The lowest *Quality rate* machine 5 is on the second-week of February (60,6%) and the highest is on the fourth-week of February (76,5%). The lowest *Quality rate* machine 24 is on the the third-week of March (58,9%) and the highest is on the third-week of February (75,3%). The lowest *Quality rate* machine 25 is on the second-week of March that is 64% and the highest is on the fourth-week of February that is 76%. If it’s compare with the intenational standard of *quality rate* OEE that is 99% then a whole of *quality rate* machine 4, 5, 24 and 25 is on under theinternational standard, even all of them are under range 80%.

4.4 Overall Equipment Effectiveness Rate

Calculation value of OEE rate can use equation 4, for identifying effectiveness from a manufacturing machine or commonly can be used for measuring manufacturing performance from PT. APF. Result calculation of OEE rate shows on Table 4:
Table 4 shows value of OEE rate a whole machine if they are compare with international standard of OEE rate is on under the standard that is 85%.

4.4 Failure Mode and Effect Analysis (FMEA)

After it’s known that height number of grade X is because the medium thread, in this step will it’s used FMEA method for knowing factor that being effect of the broken threads that appear with medium weight thread. Problem that cause the broken thread appear in material reception, loading material, continuation process, start/threading and texturizing machine process. Calculation number of occurrences performed by using the approach number of break each ton that occurred. It’s known that average number of break each ton is about 33 break each ton of every machine, it means that in 1.000 kg each machine use 216 position, the average of break product is about 33 break product.

Table 4. OEE Rate

<table>
<thead>
<tr>
<th>BLN</th>
<th>MG 1</th>
<th>MG 2</th>
<th>MG 3</th>
<th>MG 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEBRUARI</td>
<td>75</td>
<td>64.3</td>
<td>67.3</td>
<td>64.1</td>
</tr>
<tr>
<td>MARET</td>
<td>60.5</td>
<td>74.1</td>
<td>76.5</td>
<td>69.4</td>
</tr>
<tr>
<td>APRIL</td>
<td>60.2</td>
<td>37.9</td>
<td>63.4</td>
<td>65.9</td>
</tr>
</tbody>
</table>

From Occurrence that can be identified RPN for knowing the most often failure mode happened, such as being shown on Table 6.

From Table 6. We can conclude that the highest value of RPN is 30 that is misthreading, where the lane entry of the thread is mislocation or detached. The highest rank of severity (5) because misthreading can cause lapping that make machine performance become weight until stop. Some failure detection of misthreading is figure out in fishbone diagram that shows on Figure 4.

Table 6. RPN FMEA Value

<table>
<thead>
<tr>
<th>Item</th>
<th>Moda Kegagalan</th>
<th>O</th>
<th>D</th>
<th>RPN (S x O x D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penerimaan</td>
<td>Kondisi material tidak sesuai standar</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Material</td>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Loading</td>
<td>Bottom Layer</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Laju benang terhambat</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Penyambungan</td>
<td>Gagal sambung</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Start/Threading</td>
<td>Misthreading</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Proses mesin</td>
<td>Fly waste mesin</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Texturizing</td>
<td>Putus merambat</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 4. Fishbone Diagram Cause Medium Weight (Broken Thread)

Number of this percentage was obtained from number of occurrence in FMEA, that was distribute to the factor in fishbone diagram. Percentage factor in fishbone sequentially are method (48,5%), material (21,2%), equipment (21,2%) and human (9,1%). Occurrence with the highest value is misthreading with presentation method 39,4% from presentation method 48,5%. 
5. CONCLUSION

Based on identification by OEE method, quality problem become the main problem factor of performance productivity. Dept. TX 1. Generally, value of OEE rate machine 4, 5, 24 and 25 still in the range of 35% to 75% which means still far from international standard OEE (99%). Data shows that low value of quality rate on OEE is caused by medium weight because the broken thread happened in process. The results of the data processing show that misthreading FMEA RPN has the highest value (30), so it should be a priority of improvement.

6. REFERENCES