FMEA and Reliability Analysis of Critical Equipment Machinery in the Malaysian Palm Oil Mill

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ABSTRACT – The paper present Failure Modes and Effects Analysis (FMEA) and reliability analysis of the Mlaysian Palm Oil Mill (POM). The criticality of failure mode based on was discussed.

1. INTRODUCTION

Equipment failure could bring huge impact not only to effectiveness performance, but also to economic, environment and society [1]. For Malaysian palm oil mill, failure equipment could interrupt the process of the whole production system as the system is constructed in a serial configuration. Failure Modes and Effects Analysis (FMEA) as a significant tool in finding, measuring, evaluating and assessing potential failure modes and risk management have been extensively applied in the research. Notwithstanding the fact that the operational level of the manufacturing system is considered as the heart of the organisation, the challenge of aligning operational processes for greater performance.

2. METHODOLOGY

Field observation was adopted in the study to gain more in depth information or knowledge on the related issues as well as to increase the internal validity. The data collected in real-time through field observation were considered as primary data and beneficial and recommended for the study. The operational flow and the functions of the related system were studied through actual operation observations, production handbooks and operation manuals. Besides, to have a clear understanding of the current process and problems under studied, archival records, documents and photographic evidence are reviewed. The documented data from the history records available such as production downtime, preventive maintenance duration and other required data in the reliability measurement and FMEA.

3. RESULTS AND DISCUSSION

The selection of the critical machinery equipment from the whole POM production system is based on the Pareto chart of the failure frequency as shown in Figure 1. The data of the failure frequency was collected from the maintenance records for 1 year of time period. In getting better accuracy and understanding on the data, the assistant manager of maintenance department was referred. From Figure 1, the equipment with the highest failure frequency are loading ramp, steriliser, thresher, and boiler. The cumulative percentage for these four equipment are 52 %. The rest of the 48% of the failure are from screw press, shell cyclone, claybath separator, oil purifier, vacuum dryer, vibrating screen, clarification tank, nut and fibre separator, and others. For reliability analysis, the study choose the top four of the equipment.

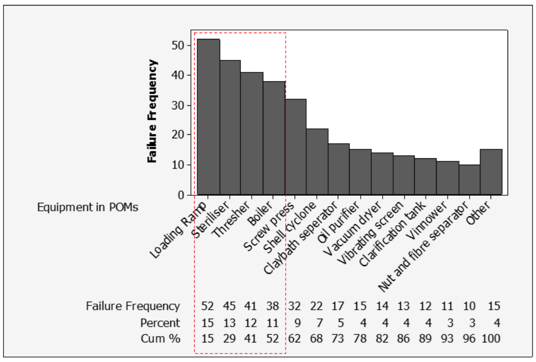

Figure 1: Frequency of Equipment Failure in the POM

The reliability principle is based the failure behaviour description from shape parameter of the Weibull distribution. Table 5.7 shows reliability performance level as suggested by Samat et al. (2012)The reliability of equipment performance that fall in the Level 1 is reflected as in good condition. However, any performance level between Levels 2 and 5 should be further analysed and improved. The statistical parameter of the TBF data is observed in terms of shape parameter, scale parameter, Mean Time Between Failure (MTBF) and standard deviation based on Weibull distribution. The example of the probability distribution function (PDF), Goodness-Of-Fit, Survival, and Hazard Rate Plot of Boiler is exhibited in Figure 2.

Functional Block Diagram (FBD) system is developed so that functional failure analysis can be performed systematically by referring to the identified sub-function. The adoption of FBD provides a diagrammatical and structural breakdown of a complex system in functional terms. The knowledge acquired is then used to separate the production line into several systems to simplify the analysis process. Thus, the failure mechanism underlying the sub-functions, which includes failure modes, causes, and failure effects, can be investigated. The FBD of the boiler are illustrated in Figure 3. Then, from the data of the potential failure modes, causes of failure, and potential failure effects for boiler in the POM is analysed and summarized in the Table 3. The results of the RPN calculation of FMEA indicated the functional FB5 has the highest level of criticality.

Table 1: Reliability Performance Level

Reliability (%)	Equipment performance level
80 - 100	Level 1
60 - 79	Level 2
40 - 59	Level 3
30 - 49	Level 4
Below 29	Level 5

Table 2: Summary of Reliability Analysis of Critical Equipment in the POM

Equipment	Loading ramp	Steriliser	Thresher	Boiler
Shape Parameter (β)	1.32694	6.25501	1.14306	1.29767
Scale parameter (η)	178.153	197.199	216.995	237.444
MTBF (hour)	163.881	183.364	206.882	219.377
Failure Rate at MTBF	0.0072639	0.0220401	0.0051607	0.0056148
Reliability at MTBF	40.5257	52.2913	42.7935	32.4660
Performance Level	Level 3	Level 3	Level 3	Level 4

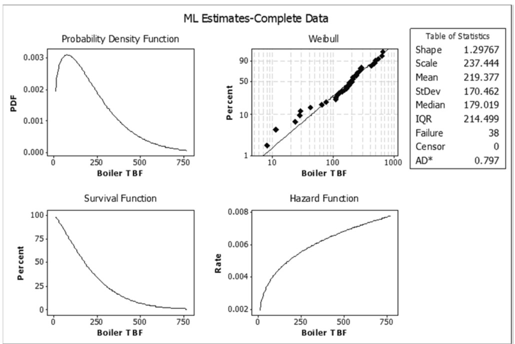

Figure 2: PDF, Goodness-Of-Fit, Survival, and Hazard Rate Plot of Boiler

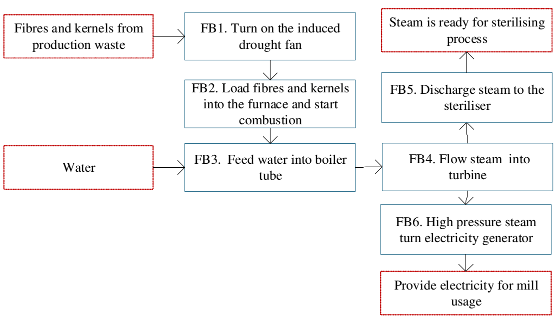

Figure 3: Functional Block Diagram of Boiler

Item	Potential Failure Mode	Potential cause of failure	Potential effect of failure
FB1	Flow air and ratio inconsistent	Bad proportion of air-fuel mixture where air flow is below 30%	The unit had to shut down Bad combustion Grain size of coal increase Dust in fuel increase
FB2	Flame failure	Insufficient air supply in furnace	Incomplete combustion Proper steam cannot be supply Air-fuel losses Boiler tube wall damage
		High moisture content of FFB waste	Poor combustion
FB3	Reduced flow, loss of pressure indication	Pressure lines leak or crack	Leakage of water to the atmosphere steam oozes out
	Acute water shortage	Feed water pump seizure	Boiler malfunction Reduced steam outage
FB4	Boiler tube leak	Cracks or corrosion	Steam water leaks to fire chamber Reduced flow Explosion
	Primary super heater erosion	Constant exposure to flue gas aging	Steam leakage Poor efficiency
	Boiler feed pump stopping due to low suction pressure	Leakage of water	Tripping
FB5	Boiler cannot discharge water	Blowdown valve locked	Regulation inhibited Operation boiler unit inhibited

Table3: Results of RPN for Boiler

Functional	O	S	D	RPN	Criticality level
FB1	3	7	8	168	Level 1
FB2	7	9	6	378	Level 2
FB3	6	4	5	120	Level 1
FB4	8	7	8	448	Level 3
FB5	9	10	7	630	Level 4

4. CONCLUSIONS

The study presented the results of the FMEA and reliability analysis of the critical machine in the POM. Assessing performance level of the machine could help the management review the system performance for better efficiency and effectiveness.

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