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Analysis of Mak Diesel Engine Services at Merawang Power Plant Using FMEA Method

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Abstrak. Merawang Diesel Power Plant is one of the power plants that located on Bangka Belitung Islands. PLTD Merawang has many types of engine generators. One of them is the MAK type 8M453 engine generator which produced 2.544 Kilo Watt. The type of routine maintenance in MAK engine are daily, weekly, biweekly and monthly. Although maintenance has good control management, the MAK engine continues to have disruptions and repairs. The frequency of damage that often occurred on the MAK engine were the cylinder head component (compression leakage when the engine is operating), valve (overwork), nozzle injector (fogging pressure), and others. In terms of analyzing the disturbances found on MAK engines using the FMEA method. The objective of this paper to identify and eliminate current defects, as well as searching, solving and drawing the best and potential problems from a manufacturing and to minimize the risk of product failures during production. Three major problems occurred at Merawang PLTD were: broken head cylinder; interference valve, broken nozzle injector. The suggestions for preventive maintenance of this major problems are: lubrication system should be changed and checked regularly, lubrication system should achieve valve system level, and nozzle injection should be replaced regularly. For all the old machines at Menerawan PLTD should be changed to new ones

1. Introduction

In this era of simplification technology, various policy has been made by the government programs towards national aspirations. This conflict improves the standard of living and prosperous material and spiritual people based on Pancasila and the 1945 Constitution. Occupational growth and increased economic activity will cause electricity consumption and continue to increase, for this reason then the activities of producing electricity should be increased too. Electricity is a basic human need, it can be shown by the increasing of electricity demand the growth of people and economic activities. All household or office equipment has been made sophisticated and have to run it by using electricity. In this case, PLN produces electricity from renewable energy such as hydropower or non-renewable energy such as PLTD and PLTU. For PLN effectiveness and efficiency rate, productivities are very important to fulfill large demands and global consumption. Because of this reason, so the production engine must be kept in good condition with routine and periodic maintenance. Maintenance activities can't be underestimated, because most of production activities are powering by engine. Well-



maintained factory facilities will support the company's activities effectively. Company whose doing production activities without noticing maintenance action, will cause difficulties for the company and will affect many complaints from the public [1]. If the company is pressing production by reducing maintenance cost, that will be profitable in the short term. However, in the long term, company will have losses because of spending money repairs the engine and also the factory facilities that are not well maintained [1]. In this paper, FMEA method would diminish the risk of failure and risk of making wrong decisions related to bus exploitation and maintenance, by modification from one of the key failure analysis methods.

1.1 Place and Time of Research

This research was done at PLTD Merawang as subsidiary of PT PLN (Persero) Bangka Belitung Region. This research was doing in August 2018.

1.2 Object Research

Type of research is descriptive. This research attempts to expose problem which exists and factually based on existing data. PLTD Merawang have 5 types of engine diesels. However, in this paper only show the problem of one type engine diesel at PLTD Merawang. MAK engine diesel is the oldest in the PLTD Merawang and the most needed replacement component.

1.3 Research Purposes

The purpose of this research is to acknowledge maintenance problem, and solution from the maintenance problem that have been handled. The main objective of this step is to minimize the risk of product failures during production and during its all activities. For this purpose, the FMEA method is applied.

1.4 Research Design

At the beginning of the research, observations on the MAK engine was done to find out the broken components and the caused problems.

1.5 Data Collection Type

The data used is maintenance data of component parts of the MAK engine.

1.6 Instruments and Techniques

Data collecting methods includes observation, documentation and interviews. Method used regarding data processing is worksheet which are used to record company's data related to repair of MAK engine components. Data acquired are later processed to portrait a picture regarding the faults in those engines.

2. Literature Study

FMEA is a method which enterprises use at preventing and eliminating defects which can appear in the manufacturing process. The procedure of FMEA application includes analysis of potential failure modes, identification of their possible effects, causes and analysis of preventive actions used for failures detection [2]. However, in 1970 this method found application in Europe in the electronics industry but then in the mechanical engineering. The fast growth of the competition in Europe as well as in the world and civil liability behind the produced product (CEE directive of No. 85/374) forced companies into increasing efforts in area of the quality preventions. It's a result was wide spreading FMEA methods in the eighties, above all in the

motorization industry [2]. One of the best tools for sorting out the above-mentioned problems, is FMEA method. FMEA is especially efficient if applied in the analysis of elements which cause the whole system failure. However, it can be very complicated in the case of complex systems (such as vehicles), which have multiple functions and are comprised of a number of components, since a variety of information on the system has to be considered [3]. The analysis of these effects requires a thorough understanding of characteristics and work capabilities of different system components [4].

The FMEA goals are: reduction of warranty costs, trouble-poor start of series production, economical and optimized manufacturing, increase of the function accuracy and reliability of products, shorter processes of development, better adherence to schedules, creation of an in-house knowledge base and reduction of the number of technical changes after SOP (Severity-Occurrence- Detection) [5].

3. Research Methodology

FMEA relies on a team-based analysis of risks of potential failures. The procedure of FMEA application includes [6] analysis of potential failure modes (function and failure analysis), identification of their possible effects (risk analysis) and causes and analysis of preventive actions used and actions for failures detection (optimization) as seen in figure 1.



Figure 1. FMEA Research Methodology [6]

4. Data Collection and Analysis

4.1 The Engine

In PLTD Merawang, the quantity of MAK engines on site is one unit. Picture of the engine can be seen along with its specification in figure 2 and table 1.



Figure 2. MAK Diesel Engine

Table 1. Specification of MAK diesel engine

Engine Brand	MAK # 2
Engine Type	8M453
Number Series Engine	26892
Capacity Power (kW)	2.544

4.2 Maintenance MAK Engine

Preventive maintenance has been done in many ways. There were daily, weekly, biweekly, and monthly routine checks.

4.2.1 Daily Check Routine

Daily check has been done every day on each shift. Daily check routine for generator engines in table 2.

Table 2. Sample of daily check routine

NO	JOB DESCRIPTION	
1	Check joint ring between liner and the cylinder head for gas leakage	
2	Check oil lubricant level on the turbocharger glass	
3	Check panel instrument	
4	Pour out from air condensat	
5	Check temperature on exhaust gas	24
6	Check oil lubricant governor level	H
7	Check temperature and pressure of the water jacket	
8	Check temperature and pressure of secondary water	
9	Check temperature and pressure lubricant system	
10	Check oil lubricant level	
11	Check daily fuel tank level	

4.2.2 Weekly Check Routine

Weekly check routine has been done in a total 125 working hours. Weekly check routine for generator engines shows in table 3:

Table 3. Sample of weekly check routine

NO	JOB DESCRIPTION	
1	Clean BBM strainer	125
2	Clean automatic BBM filter	H
3	Check / addition of oil lubricant to engineer	

4	Check turbocharger condition (oil, sound, vibration & level)
5	Clean oil strainer
6	Clean oil separator
7	Check oil & lubricant piping

4.2.3 Biweekly Check Routine

Routine biweekly check routine has been done in a total 250 working hours. Regular bi-weekly check routine for generator engines shows in table 4.

Table 4. Sample of Biweekly Check Routine

NO	JOB DESCRIPTION	
1	Check clearance valve	250 H
2	Check injector pressure	
3	Check timing injection pump	
4	Check tightness of rocket arm screw	
5	Check condition of cover crankcase	
6	Check sensor temperature cylinder condition	

4.2.4 Monthly Check Routine

Monthly check routine has been done in a total 500 working hours. Monthly check routine for generator engines shows in table 5:

Table 5. Sample of monthly check routine

NO	JOB DESCRIPTION	
1	Check governor performance	500 H
2	Add / change oil lubricant turbocharger	
3	Check machine performance	
4	Check / set BBM rack	

5. Data Calculation

The table 6 shows a table of minor damage data on the MAK engine at Merawan PLTD happened from 2015-2018.

Table 6. Data of minor damage of MAK engine from year 2015 – 2018

No	Item	2015		2016		2017		2018		TOTAL
		Semester 1	Semester 2	Semester 1	Semester 2	Semester 1	Semester 2	Semester 1		
		Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity		
1	Turbocharger	-	1	1	-	1	-	1	4	
2	Expansion Joint	-	-	-	-	-	-	1	1	
3	Charge Air Cooler	-	-	-	-	-	-	1	1	
4	Cylinder Liner	-	-	-	-	1	-	2	3	
5	Nozzle Injector	-	3	1	1	3	4	1	13	
6	Thermometer	-	1	1	-	-	-	1	3	
7	Pump	-	-	-	-	-	-	1	1	
8	Oil Separator	-	-	-	-	2	-	1	3	
9	Silencer	-	-	-	-	-	-	1	1	
10	Valve	3	2	1	-	5	3	1	15	
11	Cylinder Head	4	3	4	-	4	-	1	16	
12	Governor	-	1	2	-	-	-	1	4	
13	Injection Pump	1	1	-	-	2	-	1	5	
14	Fuel Injection Pipe	-	1	1	-	-	-	-	2	
15	Cylinder Block	-	1	1	-	-	-	-	2	
16	Radiator	-	1	-	-	-	-	-	1	
TOTAL		8	15	12	1	18	7	14	75	
		23		13		25		14		

The figure 3 shows a graph of the number of minor stop MAK engines.

6. Data Analysis

From the figure 3, we know that MAK engine damage occurred with fluctuating movement. The disturbances in term 1 in year 2018 occurred 14 times, in year 2017 occurred 18 times for term 1 and occurred 7 times for term 2, in year 2016 occurred 12 times for term 1 and occurred 1 times for term 2, and in year 2015 occurred 8 times for term 1 and occurred 15 times for term 2. Disturbance based on the FMEA at table 7 for the Merawang PLTD, maintenance will be prioritized on the 9 main causes with the most frequency. It concluded the 3 main causes of minor stops on the Merawang PLTD. There were 16 frequency head cylinder interference, 15 frequency interference valves, and 13 frequency nozzles. The most important damage that regularly occurred is the cylinder head leakage.



Figure 3. The number of damage of MAK engine from year 2015-2017

Table 7. FMEA (failure mode and effect analysis) method used to determine the failure mode, failure cause, and failure effect.

No	Item	function failure	Failure mode	Failure cause	Failure effect
1	Turbocharger	defect of turbocharger	machine can't cope up with maximum load	defect in turbocharger blade	machine can't be operated with max load
2	Cylinder liner	water leakage	water leakage at carter room water leakage when blow up	drop in temperature	machine ejection from system
3	Nozzle injector	broken nozzle	can't reach pressure revocation level when operated	exhaust temperature decrease	machine ejection from system
4	Termometer	broken thermometer	foggy glass loose on locking system	vibration on thermometer exhaust leakage on thermometer	machine ejection from system
5	Oil lubricant separator	foggy glass, difficulty in checking condition of machine	wasted oil leakage of oil in separator	faulty in innerpart separator wear on several part of the separator	decrease in machine performance
6	Valve	overwork	big load in hunting smoke spewing out of the cylinder head	jammed valve logged nozzle injector	machine ejection from system
7	Cylinder head	broken stud	leakage in compression when machine is operated	vibration on cylinder head fracture stud cylinder head	machine ejection from system
8	Governor	broken, needed reconditioning	respon of machine slowing down due to load	governor perlu rekondisi dan kalibrasi ualing	decrease in machine performance mesin tidak dapat diberi beban maksimal
9	Injection pump	leakage in seal and rack of fuel	uneven opening of fuel rack of every cylinder leakage of fuel in sela flange injection pump	few broken adjusting screw on injection pump faulty seal flange injection pump	decrease in machine performance

This is fishbone diagram from the FMEA MAK engine in the Merawang PLTD could be shown at Figure 4.

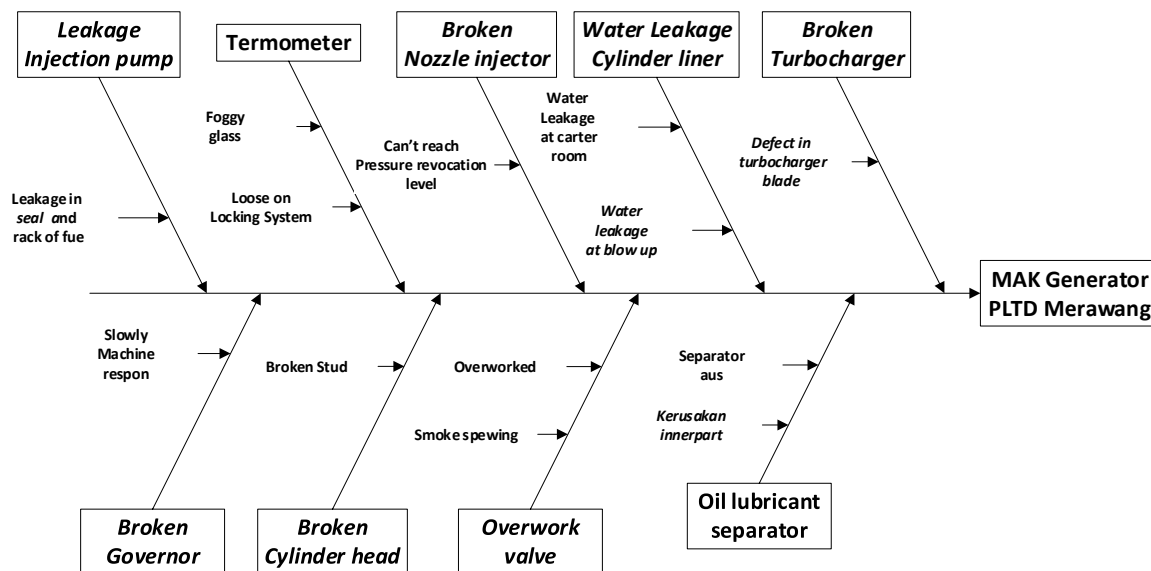


Figure 4. Fishbone Diagram of FMEA MAK Engine at Merawan PLTD

7. Discussion and Suggestion

Three major problems occurred at Merawang PLTD were: broken head cylinder; interference valve, broken nozzle injector. The suggestions for preventive maintenance of this major problems are: lubrication system should be changed and checked regularly, lubrication system should achieve valve system level, and nozzle injection should be replaced regularly. For all the old machines at Menerawan PLTD should be changed to new ones.

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