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

Lina Gozali*, Kenty Lieanda, Lilyana Jap, Frans J. Daywin
Department of Industrial Technology, Faculty of Engineering, Universitas Tarumanagara

*ligoz@ymail.com

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](image)

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.
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 condesat |
| 5  | Check temperature on exhaust gas |
| 6  | Check oil lubricant governor level |
| 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 |
| 2  | Clean automatic BBM filter |
| 3  | Check / addition of oil lubricant to engineer |

| 125 H |

Figure 2. MAK Diesel Engine
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                                | Quantity |
|----|------------------------------------------------|----------|
| 1  | Check clearance valve                          |          |
| 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                                | Quantity |
|----|------------------------------------------------|----------|
| 1  | Check governor performance                     |          |
| 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 Semester 1 | 2016 Semester 1 | 2017 Semester 1 | 2018 Semester 1 | TOTAL |
|----|--------------------|-----------------|-----------------|-----------------|-----------------|-------|
| 1  | Turbocharger       | -               | 1               | 1               | -               | 1     | 4    |
| 2  | Expansion Joint   | -               | -               | -               | -               | -     | 1     |
| 3  | Charge Air Cooler | -               | -               | -               | -               | -     | 1     |
| 4  | Cylinder Luer     | -               | -               | -               | 1               | -     | 2     |
| 5  | Cylinder Liner    | -               | 2               | 1               | 1               | 3     | 4     |
| 6  | Nozzle Injector   | -               | -               | 1               | 1               | 3     | 3     |
| 7  | Thermometer       | -               | 1               | 1               | -               | 1     | 3     |
| 8  | Pump               | -               | -               | -               | -               | -     | 1     |
| 9  | Silencer           | -               | -               | -               | -               | -     | 1     |
| 10 | Valve              | 3               | 2               | 1               | 5               | 3     | 1     |
| 11 | Cylinder Head      | 4               | 3               | 4               | 4               | -     | 1     |
| 12 | Governor           | -               | -               | -               | -               | -     | 1     |
| 13 | Injection Pump     | 1               | 1               | 1               | 2               | -     | 1     |
| 14 | Fuel Injection Pipe| -               | 1               | 1               | -               | -     | 2     |
| 15 | Cylinder Block     | 1               | 1               | -               | -               | -     | 1     |
| 16 | Radiator           | -               | 1               | -               | -               | -     | 1     |
|    | TOTAL              | 8               | 15              | 12              | 18              | 7     | 14    | 75   |
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        | drop in temperature              | machine ejection from system    |
| 3  | Nozzle injector | broken nozzle    | can't reach pressure revolution level when operated | exhaust temperature decrease    | machine ejection from system    |
| 4  | Thermometer     | broken thermometer | foggy glass                        | vibration on thermometer exhaust | machine ejection from system    |
| 5  | Oil lubricant separator | foggy glass, difficulty in checking condition of machine | leakage of oil in separator | faulty in innerpart separator | decrease in machine performance |
| 6  | Valve           | overwork         | big load in hunting                 | jammed valve                     | machine ejection from system    |
| 7  | Cylinder head   | broken stud      | leakage in compression when machine is operated | vibration on cylinder head       | machine ejection from system    |
| 8  | Governor        | broken, needed reconditioning | response of machine slowing down due to load | governor perlu rekondisi dan kalibrasi uang | decrease in machine performance |
| 9  | Injection pump  | leakage in seal and rack of fuel | uneven opening of fuel rack of every cylinder | few broken adjusting screw on injection pump | decrease in machine performance |
|    |                 |                   |                                    | leakage of fuel in sela flange injection pump |                                 |


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.

8. References
[1] Press D., 2003 Guidelines for Failure Mode and Effects Analysis (FMEA), for Automotive, Aerospace, and General Manufacturing Industries. CRC Press
[2] Dudek-Burlikowska M., 2011 Journal of achievements in Materials and Manufacturing Engineering, 45(1):89-102.
[3] Rausand M, Høyland A., 2004 System reliability theory: models, statistical methods, and applications. John Wiley & Sons.
[4] Popović V, Vasić B, Petrović M., 2010 Journal of Mechanical Engineering, 56(3):179-85.
[5] Stamatis D.H., 2003 ASQ Quality Press
[6] Dailey, K. W., 2004, The FMEA pocket handbook, Port St Lucie, FL: DW Publishing