Analysis of Blade Turbine Damage in Turbocharger System in PLTD Diesel Engine

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Abstract. Damage to the diesel engine turbocharge with a capacity of 11.3 MW which has been operating for around 18 years has caused a halt in electricity supply to one of the regions in eastern Indonesia. The data before the damage occurred was that the generator engine was operating at a load of 10.2 MW, with the engine running hour being 66,930.2 (hours), the exhaust temperature before and after the turbocharge was 514 ° C / 342 ° C and the speed on the turbocharge was 16,637 rpm, where the data is still within the limits of normal operation. After dismantling the turbocharge, it was found that there were damage to the components of the turbocharge, namely: turbine blade, shaft, ring nozzle, and others. To ensure such damage, a number of tests and materials were tested specifically for the turbine blade. The testing method is the methallografy test, chemical composition and hardnes test. The results of the analysis indicated that the turbine blade material was damaged quickly or instantly, so it was believed that the material was damaged because of the impact of foreign material entering the turbocharge system. The total loss of damage to this turbocharge is IDR 10,663,278,512 (Repair and Loss of Profit Costs).

1. Introduction.

Diesel power plant (PLTD) is a power plant that uses a diesel engine as a prime mover, where the engine has a function that produces the mechanical energy needed to turn the rotor generator which then becomes electricity.

According to ESDM statistical data reports in 2017, the percentage of diesel power generation facilities (PLTD) throughout Indonesia is ranked 3rd at 14.32% with a total of 5,889.88 MW. For this reason, the need for diesel power plants (PLTD) is still very much needed in Indonesia, especially in remote areas in Indonesia, such as the Riau Islands, NTT, Bangka-Belitung, Maluku, North Sulawesi, West Kalimantan and Papua, etc. So that the reliability of the diesel generator engines is needed so that the availability of electricity for the community will not be disrupted and fulfilled. Referring to the data above, that the importance of diesel power plants is still very important.

On September 20, 2017 at 21.41 WITA there was a "trip" or a disruption to the engine no. 04 (G # 4) in one of the diesel power plants (PLTD) in Indonesia, where the engine specifications are broken is the Diesel engine 11.3 MW with brand A. Where before the "trip" the engine operates with,

- Load : 10.2 MW
- Hour meter engine : 66,930.2 hours
- Temperature exhaust before / after turbo : 514 ° C / 342 ° C
- Turbocharge speed : 16,637 rpm

Chronologically at the time of the incident the machine is interrupted, starting with an alarm signal in the unit control room indicating failure:

- At Turbine and Compressor Bearing Display Module (BDM) modules on Turbocharge side of bank A
- Vibration Display Module (VDM) horisontal bank A.
- Vibration Display Module (VDM) axial bank A.

After the incident, the operator of the unit conducted an inspection and found that there was damage to the turbocharge side of bank A with an indication of the compressor side and the turbine side looking dark[1]. Initial analysis of these indications is the change in oil color or overheating on the turbocharger, so the need to do the dismantling, repair and also analysis of the causes of damage to the G # 4 engine in the turbocharge. After dismantling the inside of the turbocharge, there are many damaged components such as: turbine blades, shafts, nozzle rings, and others [2].

2. Literatur Review

2.1. Analysis of Domestic Object Damaged (DOD).

From the findings in the field, that the components on the turbine wheel are damaged, namely on the edge of the blade, to ensure that it needs to be tested on the blade material, to determine whether the material has been exhausted (fatigue), wear and tear, crack or not [3].

2.2. Turbine wheel material analysis

This analysis is by taking a sample on the turbine wheel material, which is by cutting some parts of the blade after disassembly. For testing this blade material, we use the methods used, among others: chemical composition testing, hardness testing and metallography testing. This test was conducted at the LIPI PUSLIT Metallurgy and Materials Laboratory - Puspitek Serpong

Figure 1. Turbine blade material specimens after cutting

2.3. Checking the Turbo Housing Component.

In the compressor housing component, no damage was found.

2.4. Turbin Blade.

Turbine blade is damage which is quite severe while the compressor wheel has rubbing [4].

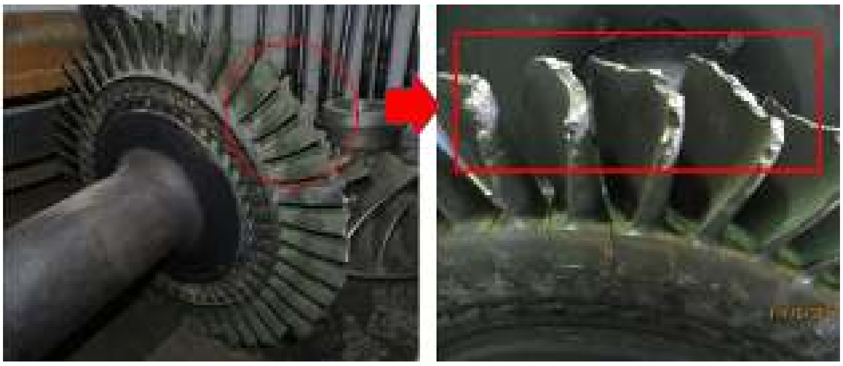

Figure 2. Damaged blades on a turbine blade

2.5. Ring Nozzle.

The ring nozzle suffered quite severe damage to the blades.

Figure 3. Ring nozzle

3. Method

This research method is to find the cause of damage, using the fishbone diagram method, which is as follows:

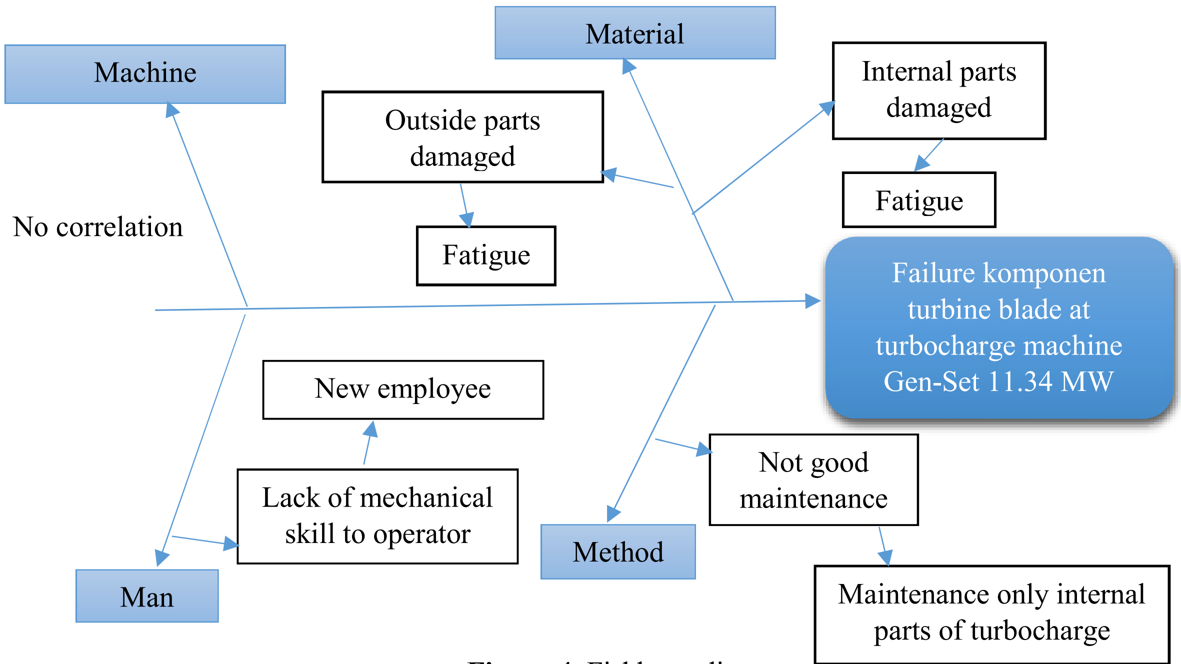

Figure 4. Fishbone diagram

After causing the damage to the turbocharge [5] With the fishbone diagram method as above, it can be concluded that the main causes of damage to the turbocharge are:

a. Self damage to the turbocharge caused by internal material so that the material damages other parts in the turbocharge (Domestic Object Damaged - DOD).
b. The existence of material from outside or called Foreign Object Damaged (FOD) that enters the turbocharge system and damages the turbocharge.
c. Maintenance (maintenance) that is not good on the turbocharge.

4. Results and discussion

4.1. Composition testing

Analysis of chemical composition testing on the turbine blade material was carried out using X Ray Fluorescence (XRF) which is to determine the chemical composition contained in the turbine blade material, so the results of these tests can give an idea whether the type of material [5]. Here are the results of the chemical testing.

From these results, it can be seen that the turbine blade material is a type of "nickel-base superalloys" and is close to the specifications of the Inconel 600 material, which is a material developed to have the ability to maintain its strength at high temperatures (> 650ºC) for a long time. A good combination of high strength and good tenacity at low temperatures and good surface stability, which means surface stability corrosion resistance such as the use of a turbine blade in a turbocharger.

4.2. Hardness test

Hardness testing of the turbine blade material by Vicker's method, which is done cutting the turbine blade material to be made specimens and taken at several test points. Following are the data from metallography testing, with the average value of the hardness test using HVN 405.1, and using HRc 41.3

Figure 5. Specimen of turbine blade material

4.3. Metallography testing

Metallography testing is performed to determine the turbine blade microstructure after damage. Before testing, the material is cut to be made specimens. Here are the results of the microstructure of the turbine blade material

Figure 6. Optical image 50x turbine blade material [5]

4.4. Turbocharger Bellows Analysis..

For the analysis of the bellows themselves, it has been done by the PLTD. Here are the results of turbocharger damage

An indication of welding failure between the metal base and the sliding plate on the bellows, so that the release of the sliding plate on the bellows that finally enters the turbocharge system is caused by the thrust of the exhaust gas resulting from combustion.

4.5. Material on the Sliding Plate

The material used for bellows is Stainless Steel 321 series and sliding plate material is Stainless Steel series 309 material, where both materials are Austenite Stainless Steel which is resistant to corrosive and high temperatures up to 950 °C, so the use of these materials is safe.

4.6. Failure analysis

The cause of failure [2] welding between sliding plate and metal base on the bellows is as follows:

a. Welding conditions or welding on a sliding plate with a metal base are separated evenly and in a circular or no fusion occurs in welding.
b. No indication of a crack was found in the metal base or sliding plate.

Figure 7. Form of welding failure on metal base and sliding plate

5. Conclusion

After conducting research on the causes of damage from Turbocharge from Generator G # 4 owned by the PLTD, as follows: 1) After testing the damaged blade material, no characteristics of fatigue faults were found, such as the absence of "beach mark", so it was concluded the existence of fatigue loading on the turbine blade material but not as a cause of damage to the turbine blade. The SEM photographs show brittle fractures, and intergranular fractures caused by impact overload from external material, so it can be concluded that damage to the turbine blade material is a mode of rapid damage caused by impact overload. 2) The discovery of foreign material (FOD) that enters the turbocharge system, where the material is a sliding plate from Bellows no. 4. 3) According to the statement of the PLTD, the cause of failure of the bellows occurs in welding between the metal base and the sliding plate, where there is an indication that there is no fusion between the metal base and the sliding plate. 4) The total costs incurred for this damage is IDR 10,663,278,512 with details of IDR 5,896,550,000 for turbocharge repair costs and IDR 4,766,728,512 for Loss of Profit. 5) There is no maintenance specifically for bellows.

6. Reference

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