DAMAGE ANALYSIS OF TURBO CHARGER ON MAIN ENGINE AT KM. LEUSER

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ABSTRACT

A centrifugal compressor known as a turbocharger is powered by a turbine powered by exhaust fumes from moving vehicles. Usually used in internal combustion engines to increase the air pressure entering the engine and increase engine efficiency. The main benefit of turbochargers is that they provide a significant increase in engine power for just a little extra weight. The research was carried out by direct observation and then recorded the damage that occurred. The results show that damage to the turbocharger includes damage to rotation, damage to the bearings and damage as a result of the main engine. To avoid damage, adequate maintenance is needed so that ship components will last longer.

Keywords: *turbocharger, damage, main engine*

INTRODUCTION

Economic growth and advances in science and technology are both affected by changes in the shipping industry (An et al., 2022; Schröder-Hinrichs et al., 2019; Wang & Yang, 2022; Wong & Yip, 2019), so that many business people rely on sea transportation services to meet their needs (Lun et al., 2013). Given the fierce competition in the shipping industry (Gosasang et al., 2017), the shipping business must be able to offer the best service to customers (Ding, 2012; Ding et al., 2016). The use of onboard technology in the shipping business has made this venture successful (Czachorowski et al., 2019; Jo & D'agostini, 2020; Kitada & Ölçer, 2015; Ziółkowski & Dyl, 2020).

A centrifugal compressor known as a turbocharger is powered by a turbine powered by exhaust fumes from moving vehicles (Muqeem et al., 2015; Von der Nuell, 1963). Usually used in internal combustion engines to increase the air pressure entering the engine and increase engine efficiency (Saidur et al., 2012). The main benefit of turbochargers is that they provide a significant increase in engine power for just a little extra weight (Zheng et al., 2013). Alfred Büchi, a Swiss engineer, invented the turbocharger (Berger & Chenoweth, 1938). A turbocharger patent application was filed in 1905. In the 1920s, the first turbocharged diesel locomotives and boats appeared.

The fact that the compression ratio must be adjusted in a gasoline engine to avoid exceeding the maximum compression pressure and avoiding engine knock is a drawback. This reduces engine efficiency when running at low power. In a carefully constructed turbocharged diesel engine, these drawbacks are absent. However, for high-altitude applications, the increased power from the turbocharger significantly changes the combined power output of the two engine types. This last aspect led to the early development of turbocharged aircraft engines and made them very profitable. Three important components make up this engine component: the turbine wheel, the compressor wheel, and the housing for the shaft (Kusnadi, 2015).

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The compressor wheel rotates with its blades through the turbine wheel shaft to push air into a solid mass as the bladed turbine wheel rotates under exhaust gas pressure (Eryilmaz & Pachidis, 2019; Logan Jr, 2003; Rao, 2011). Given that these components frequently rotate at speeds in excess of 80,000 revolutions per minute, proper lubrication is required. The combustion process of the engine becomes more efficient with the addition of oxygen (due to an increase in the air flow rate) and the combined velocity of diesel and air in the combustion chamber (due to an increase in air pressure after overhaul compared to before). As a consequence, the power generated by the gasoline explosion is also higher. (Alfalah et al., 2018)

A turbocharger is a part of an engine used to increase the volume of air entering a cylinder by harnessing the energy of exhaust gas pressure to rotate a bladed turbine rotor as in fig.1. Air is forced into the cylinder using a compressor rotated by an exhaust turbine in the turbocharger, as opposed to the old method of air intake, which relied on a vacuum created by the motion of the piston during the intake stroke. Additional air must flow into the engine cylinder space while a certain amount of fuel is burned to produce complete combustion. All of the fuel is burned, increasing engine power, if the air density increases before it is injected into the cylinder. To compress air into the engine cylinders, diesel engines are equipped with turbochargers. So that the engine power outperforms the engine of the same size (Yulianto, 2016).

When a diesel engine is started, exhaust gases flow out through the exhaust manifold and gas turbine before being released into the atmosphere (Lefebvre & Ballal, 2010; Lim et al., 2019). The compressor is also rotated through the connecting shaft by the exhaust gas which also turns the turbine. As a result, the compressor draws outside air through the air filter and forces it into the intake manifold, followed by an increase in temperature to increase the amount of incoming air and a decrease in pressure to increase the amount of air entering the cylinder.

Figure 1. A turbocharger
Source: KM LEUSER

Types Of Turbochargers

Diesel engines are becoming more popular as a result of technological advances, as shown by the increasing number of technologies they have now. Turbochargers are usually added to diesel engines to increase output and improve efficiency. Depending on how the turbine blades are made, there are two types of turbochargers**.**

1. Fixed Geometry Turbocharger

A turbocharger is an instantaneous power boost device consisting of a component with two blades, one of which rotates in response to a jet of gas from the exhaust duct (turbine), and the other connected to the outside air inlet and outlet. . some pressure variations. Because the exhaust rotates in much smaller blades, it spins faster and more air is compressed as a result. As a result, the combustion chamber will receive more oxygen and produce much more power. As a result of turbo lag, which is the power vacuum that occurs before the turbocharger pushes dense air into the engine, the response time is slow. As a result, these are referred to as fixed geometry turbochargers or fixed blade turbochargers.(Irawan, 2018).

2. Variable Geometry Turbocharger

VGT (Variable Geometry Turbocharger) was created to overcome the drawback of FGT by using blades with variable compression. The purpose of these blades is to reduce turbo lag by allowing compressed air to occur at lower engine speeds. In contrast to the FGT, whose power surge was only felt at certain engine speeds, for example 2,000 rpm, its character has also changed, with a wider power range.

Components And Equipment Of Turbocharger

1. Turbocharger Components

Understanding what a turbocharger is can help you understand how it works. Because the component that enters the air depending on the exhaust flow (exhaust manifold) is indeed needed as a thrust air supply. The parts of the turbocharger are as follows::

a. Turbine

Ceramic is now chosen for its low weight and resistance to heat in the turbine wheel of the turbocharger, which starts the entire process of compressing air into the cylinder. To avoid turbo lag, lighter turbines spin faster. It is called turbo when the engine does not respond to the air pressure generated by the turbocharger, usually when the engine is still operating at low rpm. The turbine wheel can rotate between 80,000 and 150,000 times per minute, so careful lubrication is required to prevent damage to the turbine. The turbine shaft (turbine shaft) is connected to the turbine. They run at very high rpm, so a suitable bearing and connection is required between the turbine and the turbine shaft.

b. Compressor

The turbocharged compressor converts the mechanical energy of the shaft into the kinetic energy of the air flow. Since the compressor is positioned on the same axis as the turbine, when the exhaust of the engine starts rotating the turbine, the compressor will also rotate at the same speed. Direct utilization of turbine mechanical energy will be used as a source of power for the compressor. For cold air, the compressor draws ambient air through a water inlet located opposite the turbine as it rotates. The air pressure is increased by the compressor by 6 to 8 psi. The density of air is 14.7 psi at sea level pressure. to allow a 50% increase in the compressor.

Turbocharged compressors convert the mechanical energy of the shaft into kinetic energy of the air flow. The turbine and compressor have the same axis, so that when the engine exhaust starts to turn the turbine, the compressor will also rotate at the same speed. Turbine mechanical energy will be directly converted into compressor power. Airflow velocity will decrease as air is pushed into the compressor casing, which also acts as a diffuser, and static pressure will increase. The increase in temperature will occur after this increase in atmospheric pressure. Additionally, the intercooler accepts compressed air blown in from elsewhere.

c. Bearing Housing / Center Housing

Each turbine and compressor in a turbocharger consists of a housing and a rotor. Both are driven by a shaft that connects the compressor and turbine and are supported by a set of bearings. An assembly system known as a Center Housing & Rotating Assembly (CHRA) combines the turbine casing and the compressor. The turbocharger lubrication system is also centered on the CHRA because the bearing system is also located there (Hendrawan, 2020; Hendrawan et al., 2022). Traditional turbocharger thrust bearings are often made of bronze. Further improvements have resulted in the ceramic ball bearings that are used as turbocharger bearings today. The use of ball bearings is recommended as they increase the service life of the turbocharger.

METHOD

The research was conducted by direct observation on the main engine where there is a turbocharger. Observations are made every time so that the desired data is obtained. Observations were made by researchers and members so that the damage that occurred could be detected. Observations were made by looking directly at the phenomena that occurred on the object of research (Sugiyono, 2018). The data obtained was analyzed qualitatively about what was the cause of the damage.

RESULTS AND DISCUSSION

Result described in table 1. By pumping compressed air into the engine, the turbocharger works to increase engine power (Fu et al., 2013; Purnama & Saksono, 2015). More air enters the engine when the turbocharger boost pressure rises, increasing the pressure the engine produces. Regardless of whether it needs to be replaced or repaired later, the turbocharger should be removed at any sign of tampering. The problems that arose when the authors conducted research at KM. LEUSER is a reduction in engine power due to loss of turbocharger boost pressure.

Table 1 Observation results of damage to the turbocharger on the main engine on the KM LEUSER ship.

No.	Turbo charger failure	Information
1.	Damage to Turbocharger Rotation	due to metal bearing failure, which causes the turbo rotor to rotate slowly and unevenly. Since the tolerance of the turbo rotor is already at the maximum level due to wear and tear, it is better to let the turbine blades rub against the turbo housing bearings to extend the life of the turbochargerer..
2.	Turbocharger Bearing Damage Or Not In Accordance With Standards	Frequent damage to turbochargers caused by the use of non-standard turbocharger bearing clearances will impede operation..
3.	Turbocharger Damage to Main Engine	When the engine is first started, the turbo starts cranking, but the oil takes some time to circulate. As a result, accelerating the engine or running the engine under load will result in the turbo experiencing a lack of lubrication.
4.	Damage Caused by Foreign Objects	Foreign objects, among other things, that enter through the air intake pipe can deform or damage the impeller and make noise.
5.	Surging On Turbochargers	When the auxiliary diesel engine is running, there is a loud bang which indicates that the turbocharger in the auxiliary diesel engine is surging. This affects the irregular rotation of the turbocharger. Due to the turbocharger's stray state, the regular clockwise rotation of the turbocharger is now reversed and forward.

Examination revealed that a damaged turbocharger shaft bearing, which causes excessive friction and resistance between the compressor wheel, turbine wheel, and housing, is the root of the lower turbocharger boost pressure. The turbocharger can rotate at speeds up to 100,000 rpm, so if the turbocharger shaft bearings rotate too much, the turbocharger wheels will come into contact with the housing. This will cause too much friction, which will prevent the turbocharger wheels from turning and prevent the turbocharger from generating its maximum boost pressure (Evans & Ward, 2005; Toussaint et al., 2014; Hendrawan, 2020). Removing the intake or exhaust pipes allows you to see inside the turbocharger and fix any bearing or contact problems between the turbo housing and wheels. As the bearings wear out, there is evidence of friction on the turbocharger blades and housing, which means they need to be replaced (Philip Kristanto et al., 2001).

Due to the high rotational speed of the shaft and contaminated or unclean oil, turbocharger shaft bearings are prone to damage. This bearing interior erosion is the result of these two factors (Dwiono et al., 2021). There are several checks that must be carried out to help optimize the performance of the main engine, including: check the radial play of the turbine shaft. Insert the dial indicator so that it hits the center of the shaft from the oil channel hole through the spacer bearing hole. Measure the radial motion of the turbine shaft as it is raised and lowered. Replace the turbocharger assembly after 0.09 radial clearance. Check the condition of the compressor blades

To ensure the compressor blades are functioning properly, a blade check is carried out. Because the compressor blades force air into the air cylinder which contains abrasive particles, this can damage or destroy the turbine blades and reduce the air pressure generated by the turbocharger (Irawan, 2018).

Here's how to check the bar:

1. Remove/unscrew the turbocharger intake air filter
2. Rotate the blades carefully and slowly as you inspect them one by one. If there is significant damage, have it repaired or replaced, Yuan.
3. Rearrange the parts in the manual's recommended order
4. Double check to make sure nothing is missing

Compressor wheel rotation check is an inspection of the compressor wheel that is carried out to maintain the smooth rotation of the compressor turbine and prevent excessive friction on the turbine shaft or with the turbocharger cover which can inhibit rotation and result in less than ideal rotation.

Remove the air filter hose.

1. Turn the compressor wheel manually to see if it rotates smoothly. Replace the turbocharger unit if it doesn't spin smoothly.
2. Check that the turbine rotates freely and that there are no foreign objects in it as this could damage the turbocharger.
3. Replace the components in the correct order or according to the turbocharger maintenance instructions.

Check for leaks or debris clogging between the air filter and the turbocharger inlet, and between the turbocharger outlet and the cylinder head. If a problem is found, clean, repair or replace the components. Checking the exhaust system (Kusnadi, 2015). Look for leaks or obstructions between the exhaust pipe and the turbocharger outlet and between the cylinder head and the turbocharger inlet. If a problem is found, clean, repair, or completely replace the component.

CONCLUSION

Damage to the turbocharger shaft bearings is one of the reasons why the turbocharger generates less boost pressure than it should because it causes excessive friction and pressure between the compressor wheel and the turbine wheel, as well as between the compressor wheel and the housing, which prevents the turbocharger wheel from rotating and prevents the turbocharger from producing the maximum boost pressure.. The way to fix bearing problems or contact between the housing and the turbo wheel is to remove the intake or exhaust plumbing so you can peek inside the turbocharger, on the turbocharger blades and the housing there are signs of friction because the bearings are worn out so replacement is carried out.

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