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TEMPERATURE EXHAUST GAS ANALYSIS ON THE SHIP ENGINE

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The dual-fuel diesel engine is an engine with the use of two fuels in the combustion process to get labor on the engine. The types of fuels used include methane gas and marine gas oil fuels. Methane is produced from vapor cargo tank liquified natural gas. The purpose of this study was to determine what causes high exhaust gas temperatures on the performance of the dual-fuel diesel engine using the fault tree analysis data analysis method. From the analysis of the research data, several problems were formulated, namely, the factors that could cause high exhaust gas temperatures in the dual fuel diesel engine were the lack of combustion air supply in the engine combustion chamber, incompatible combustion composition between oil and gas fuel, and the engine room that is extremely hot. The impact caused is damage to the machining components and decreased performance of the dual-fuel diesel engine. To overcome the decrease in work on the dual fuel diesel engine is to carry out maintenance and repair on every component of the engine that has problems and damage in accordance with standard procedures.

Keywords: *Dual Fuel, Methane, Diesel Engine*

1. INTRODUCTION

A diesel engine is an internal combustion engine that uses the heat of compression to create ignition. Ignition then ignites the fuel that is injected into the combustion chamber. The diesel engine operates on the diesel cycle, with a compression ratio of 14:1 to 24:1, the compressed air temperature reaches ±750 o C. Unlike eight cycles (1:9 compression) which operate at constant volume, the diesel engine operates at a constant pressure [1]. Ideally, maximum combustion engine efficiency can be achieved by combining the principles of both cycles. The combustion engine operates on compression combustion but operates on eight cycles. Likewise, compression combustion engines, in which a constant volume of the eighth cycle will ensure greater efficiency in compression. Compression ignition engines produce high exhaust emissions that are harmful to health and the environment. Characteristics engine performance can be expressed by the parameters of the relationship between speed, torque, fuel consumption specific, and engine output power [2].

Various types of gaseous fuels have a high flash point, some are natural gas, CNG or LNG, hydrogen, biogas, production gas (gasification from biomass or coal), and LPG, an alternative fuel for diesel engines. it is a standard diesel engine that is added with 3 other fuels in the air intake and the ignition of the fuel is done through a diesel spray which is called pilot fuel. In other words, liquid or gaseous fuel can be introduced by making a hole in the intake manifold of the diesel engine.

The diesel engine is a type of internal combustion engine which is also often referred to as pressurized ignition, spontaneous ignition of fuel because fuel is injected into a cylinder filled with air and at high pressure [3]. The mixture of high-pressure air and fuel will cause the temperature to rise to a high level so that the ignition process during the combustion process becomes easier [4]. The combustion process will stop if the temperature is too high due to cooling problems, which will affect the combustion process. Sumardiyanto and Susilowati reported that the decrease in combustion air quality was influenced by less than optimal air cooling and air duct disturbances due to dirt on the filter [5]. Indartono and Murni reported that the use of a fuel heater can reduce fuel consumption by an average of 8.22% compared to not using a fuel heater. Diesel engine working time will affect the performance of the engine itself [6].

Dual fuel diesel engine is one of the new technology engines with the use of two fuels in the combustion process to get labor on the engine [7]. The types of fuels used include gas and marine gas oil fuels. The type of fuel gas used is methane, whose main content consists of hydrocarbons. Methane is produced from vapor cargo tank LNG. For maintenance on LNG cargoes by maintaining a constant pressure in the range of

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18 kPa, if the pressure exceeds that pressure, the LNG vapor must be burned or used as a dual fuel diesel engine fuel[8]. The main fuel is gas that is compressed with air by igniting using MGO fuel as an initial lighter. The vapor (gas vapor) produced is inhaled and flowed by a compressor called a low duty compressor to a diesel engine in the engine room. The disruption to the use of methane gas to fuel the dual fuel diesel engine is the high temperature of the exhaust gas which exceeds the normal limit, thus affecting the performance of the dual fuel diesel engine[9]. Based on the background that has been described this research aims to analyze the factors that influence the high temperature of the exhaust gas, the impact and efforts to anticipate the decline in performance on the dual fuel diesel engine.

2. LITERATURE REVIEW

Natural gas, also known as natural gas or swamp gas, is a gaseous fossil fuel consisting of methane CH4. Natural gas can be found in oil fields, natural gas fields, and even coal mines. It is rich in methane, resulting from decomposition by anaerobic bacteria from organic materials other than fossils is called biogas. The main component of natural gas is methane (CH4), which is the shortest and lightest chain hydrocarbon molecule. contains sulfur (sulfur). Methane is a greenhouse gas that is responsible for global warming when released into the atmosphere and is generally considered a pollutant rather than a useful source of energy. However, methane in the atmosphere reacts with ozone, producing carbon dioxide and water, so the greenhouse effect of methane released into the air is relatively short-lived[10].

Studies on the use of multiple fuels have been carried out using an assessment method using artificial neural network (ANN) modeling or commonly called artificial neural network modeling to predict braking power, torque, and Brake Specific Fuel Consumption (BSFC). In addition, studying exhaust emissions from diesel engines that have been modified [11]. Chedthawut et al. researched diesel engines modified to operate on natural gas to optimize performance when running on gaseous fuels. Various combustion ratios (CR) including 9.0:1, 9.5:1, 10.0:1, and 10.5:1 were used to evaluate engine performance and emissions from the same engine with motor RPM ranging from 1,000 to 4,000 rpm [12].

Alp et al carried out research on PLC control programs, with the main aim of converting the mechanical injection system from a single-cylinder diesel engine to an electronically controlled dual fuel system. 12 The new system consists of two different injectors: the first delivers LPG (liquefied petroleum gas), which supplies diesel, LPG is delivered through the left fuel injection system located at the engine inlet and diesel is injected directly into the first combustion chamber at the dead point. above (TDC).) All injectors are controlled by a Programmable Logic Controller (PLC). After adaptation and testing, the Lombardini type LDA 450 single-cylinder diesel engine was modified into a PLC-controlled high-pressure dual fuel seeker [13].

LNG stands for Liquefied Natural Gas, which is liquefied natural gas whose chemical composition is mainly methane. Then a little ethane, propane, butane, and very little pentane and nitrogen. Methane is the simplest and most abundant hydrocarbon fuel. Methane is composed of carbon. and four hydrogen atoms (CH4) When natural gas is cooled to an ambient temperature of –160°C (260°F), at atmospheric pressure, it becomes a liquid. When natural gas is cooled to LNG, the volume of this LNG will be about 1/600 volume of natural gas before being liquefied, allowing LNG to be delivered Liquefied natural gas at ambient pressure with a temperature of about -160oC (260oF) in a saturated liquid state [9].

In this study the researcher chose the fault tree analysis research method which is an analytical tool developed to evaluate Ballistic Missiles. Launch control system using fault trees as a failure analysis tool by reliability experts. After the use of the first published FTA (fault tree analysis) launch control safety study, Boeing company and AVCO were expanded [14]. The FTA method is an analysis technique that uses the principle of the error tree simply explained as analytical technique, where a problem is determined and analyzed starting from the cause of a problem to the roots of the problem[15]. Until a problem reaches the peak point of the problem (top event). Dual fuel diesel engines are engines that work with natural gas as the main fuel and diesel oil as a backup fuel. This engine is designed to produce electric power to drive the ship's propulsion engines such as propulsion. This engine can be exchanged from gas operations to backup copy fuel operations at any time[16]. The engine can also be exchanged from backup copy fuel operations to gas operations at 80% full load. This machine is also capable of working on HFO and can be operated as conventional diesel engine when working on HFO.

3. METHOD

This research using fault tree analysis. Some stages of the fault tree analysis determine the top/main event; Set the fault tree analysis limits; Check the system of various related elements and the top event; Create a fault tree; Error tree analysis; Prepare a corrective action plan to prevent failure[17]. The purpose of fault tree analysis is to know the factors that cause the high exhaust gas temperature in the dual fuel diesel engine. Define the top event that causes high exhaust gas temperatures on the dual fuel diesel engine. Define the limits, scope of the system and observe the rules of fault tree analysis. this system is designed to be able to look for factors that cause a decrease in performance of the dual fuel diesel engine. This system works well if all the components of each part function properly[18]. This limit covers all possibilities or contribu-

tions that can occur in the system. The initial conditions of this system are all at a time. Boolean algebra is algebra that deals with binary variables and logical operations.

4. RESULT AND DISCUSSION

Based on field study research, several findings is generated.

1. Factors that influence the high exhaust gas temperature in the dual fuel diesel engine.

Problem that exhausts gas temperature is too high to reach a temperature of 550 ° C which is normal when the engine is in gas mode the exhaust gas temperature has an average of 340 ° C. In this study, several top events were found from the occurrence of high exhaust gas temperatures on the performance of the Dual fuel diesel engine, the following is a diagram of a fault tree showing the high exhaust gas temperature on the performance of the dual fuel diesel engine.

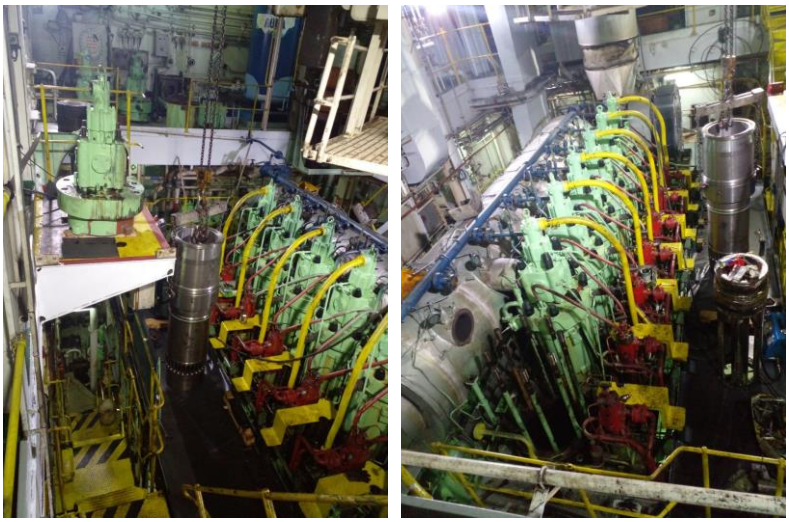

Figure 1. Diesel Main Engine

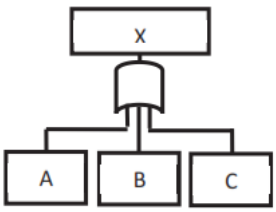

Figure 1. Analysis of the high causes of high exhaust gas temperatures

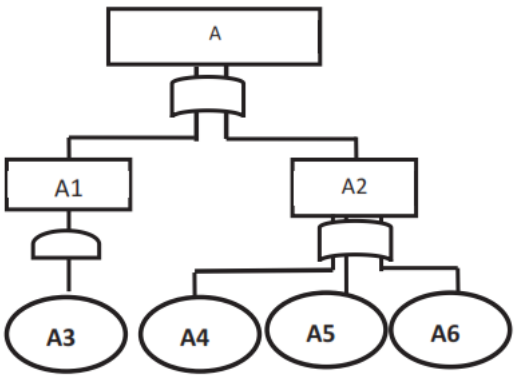

Figure 2. The fault tree lacking the supply of combustion air in the cylinder chamber

Information:
A: Lack of combustion air supply in the cylinder chamber
A1: Lack of air supply from fan supply blowers
A2: Less than the maximum performance of Turbocharge

A3: Electro motor damage
A4: The opening is incompatible Exhaust Gas Waste Gate Valve
A5: The turbine side blade is dirty on the Turbocharge
A6: Exhaust gas leak below

The two pictures above explain the analysis of the causes of high exhaust gas temperatures and an explanation of the fault tree for the lack of combustion air supply in the cylinder chamber. Explanation of the fault tree from the first top event lack of supply of combustion air into the cylinder chamber. Under normal circumstances for lean burn combustion engine air supply into the cylinder reaches more than 30:2, and air flow when the engine is working at a maximum of 18 kg/s, due to several factors so that the air supply into the cylinder only reaches 12 kg/s, then from this statement can be drawn several factors, namely as follows:

a. Lack of air supply from

Blower supplay fan (A1) lack of air supply from the blower supplay fan as an intermediate event is the link between the top event and the basic event, from the intermediate event the lack of air supply from blower supplay fan (A1) will described again as the basic event of damage to the electro motor (A3). electro motor damage, from the intermediate event the lack of air supply from the blower supplay fan can be drawn into the basic event the damage to the motor electrons on the fan supply affects the combustion quality and the performance of the machining itself.

b. Less than optimal work from turbocharge (A2)

Incorrect opening of the Exhaust Gas Waste Gate Valve (A4) will result in too much exhaust gas directly by pass to the chimney before passing through the turbine side on turbocharge, so that will result in a decrease in the rotation of the turbocharge which will ultimately reduce the compressor speed on the turbocharge. Another factor is the turbine blade is dirty, in turbocharge (A5) The cleanliness of the turbine blades is very influential on the rotation of the turbocharge and also influences the air capacity generated from the rotation, so the cleaning conditions of the blades from the turbocharge must be considered to obtain maximum work value Exhaust gas leak below (A5) is events that have been experienced are also a reference source for a less than optimal performance of the turbocharge, a decrease in the speed of the turbocharge caused by the leakage of exhaust gas below, the position of the component is very influential on the performance of the turbocharge because it is located on the by pass exhaust gas valve located at the intersection between the direct direction to the chimney and the direction to the milk-blade on the turbocharge. Analysis of the second cause of the top event is a problem about the composition of the fuel that is less appropriate. The following is a description of the intermediate event and basic event for this problem.

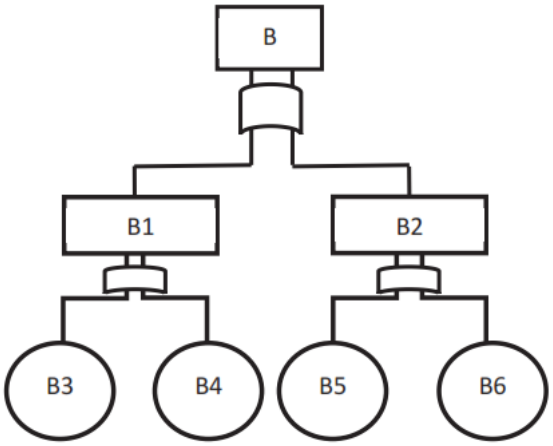

Figure 3. The fuel composition error tree for combustion is not suitable

Information:
B: The composition of the fuel for combustion is lacking corresponding
B1: Too much fuel content in the combustion
B2: Lack of supply of methane gas fuel
B3: Faulty fuel injector valve
B4: The fuel record setting is not appropriate
B5: Decreased inlet gas pressure
B6: Damage to admission gas valve

The description of the second top event of the composition of the fuel for combustion that is less appropriate, will be described in several factors that influence the event, the factors causing are too much fuel oil in combustion (B1). Proper combustion composition between air, fuel oil and gas is an absolute require-

ment to get the perfect combustion value in the cylinder, because the quality of combustion also affects the work value produced in the machining. From the Figure 3, it can be explained that the factors causing too much fuel oil content in combustion are faulty fuel injector valve (B3). The effect caused if the fuel injector valve is not functioning optimally is the composition of the fuel oil as a combustion media in the cylinder chamber that is too much, if the quantity of fuel oil in the combustion chamber is too much, it will cause one of them, namely the exhaust gas temperature on the dual fuel diesel engine too high. Another factor is the setting of the fuel record is not appropriate. Fuel consumption settings the fuel injection pump also affects the quantity of fuel that enters as the combustion media in the cylinder. From the above data, it can be described using boolean algebra using or logic gates, because each basic event does not affect each other and does not occur. If only one of the basic events occurs, an intermediate event will occur. • Lack of supply of methane (B2) gas fuel

In a normal process, the system runs with maintaining methane fuel pressure at 410 - 540 kPa, and temperatures at 330 - 410C. Due to the use of G.C.U at the same time, there was e leak in the pipes supplying methane fuel to the engine room. Decreasing inlet gas pressure (B5) this is due to split supply of methane fuel for the parent generator and G.C.U. This problem is found in the indicators shown in the G.V.U space. Normally the temperature for methane fuel a minimum of 330C and a minimum pressure of 440 kPa. In the picture that can be seen in attachment shows that the problem of decreasing methane fuel pressure is ranged on 380 kPa.

The erosion of the surface at the lower plate is caused by friction. Where springs or springs on the moving plate are experiencing slack so that the closing and opening of the moving plate is uneven. When the valve process is open, this solenoid works to adjust and pressurize the spring so that gas enters the cylinder. Circumstances on the moving plate broken on the outside between the spring runways. This missing or broken part is about 27 mm long. Factors causing the broken outer part of the perimeter are caused because the material has decreased violence so that the occurrence of the fracture. This reduction in violence is also supported by the erosion of broken parts, thereby increasing the burden of violence on this material. Analysis of the third top event engine room temperature is too hot, then below will be explained about the factors causing these problems.

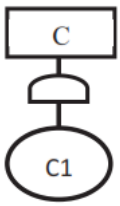

Figure 4. Engine room temperature error tree is hot

From Figure 4, it can be explained that there is a single factor causing the high engine room temperature to be too hot (C), namely the climate in which the ship is located (C1). The Tangguh Palung LNG / C ship operating area is more in the tropics or around the equator so the temperature in the air outside the ship is already high and if it enters as combustion air it also affects the high fuel temperature. The air temperature in the tropics reaches 34 ° C compared to the temperature in the temperate and cold climates the outside air temperature below 21 ° C this is very influential on the quality of the incoming air used as a combustion composition in the cylinder chamber. Then it can be concluded that the single factor causing the intermediate event to be too high in engine room temperature (C) is the climate in which the ship is located (C1).

The impact caused by the high exhaust gas temperature on the performance of the dual fuel diesel engine. The high temperature of the exhaust gas on the dual fuel diesel engine will cause damage to the components on the engine, with damage to the engine components or no longer functioning as it should, it will affect the performance of the dual fuel diesel engine, damage to the components of the Dual Fuel Diesel Engines are rupture below on the exhaust manifold by-pass. The high exhaust gas reaches a temperature of 500 ° C when the dual fuel diesel engine uses gas as the main fuel will cause damage to the machining components, one of which is the component below in the exhaust manifold bypass, one of the factors causing damage to the component is the high temperature of the exhaust gas, the picture can be seen in the appendix.

The removal of the exhaust cylinder head on the dual fuel engine because the temperature of the exhaust gas that is too high also affects the condition of the cylinder head, especially those related to the output path of the temperature exhaust gas, so that resulting in erosion of the surface of the exhaust cylinder head, the following picture is shown damage from the exhaust cylinder head. The surface erosion of the dual fuel diesel engine exhaust valve which In line with the output path of the exhaust gas, the condition of the exhaust valve is also strongly influenced by the temperature of the exhaust gas. In this problem, high exhaust gas temperatures will result in physical conditions of the exhaust valve is also affected, especially the effect on

the surface condition of the exhaust valve that is experiencing erosion, the following will be shown the state of the exhaust valve that has been influenced by exhaust gas temperatures that are too high.

To overcome the decrease in performance of the dual fuel diesel engine caused by high temperatures exhaust gas is to take the following actions, there are treatment plans according to the treatment system planned maintenance system consists of many elements such as planning, work implementation, recording and evaluation. The purpose of this system is to prepare plans and operational work on a ship that has been established by the company responsible for operational management and based on International Safety Management.

Perform Incidental Care that is replacement of Gas Admission Valve (GAV) as a whole. Basically, the work process of G.A.V is based on the actuator that receives an electric signal from the cylinder control module which then from the actuator will open or close in accordance with the control system that has been integrated in G.A.V itself. At the time of the delay in receiving the response from the controller and the opening delay of the G.A.V itself which can be caused the condition of the G.A.V parts that are not working optimally, so that some parts in the G.A.V are replaced including O-rings which are very important in terms of keeping the vacuum. But in the event of damage to the filter, a complete replacement must be done. This is because, the filter on G.A.V has been integrated and cannot be removed. In order to achieve maximum work value, maintenance and repairs should be carried out periodically if damage or decline in the work value of the turbocharge is found, maintenance is by flashing the turbine blades when the engine is operating, by flashing so that it can reduce the volume of soot attached to the the blades. Waste gate valve is a vital component that affects the performance of the turbocharge, if there is damage or calibration error of the component, inspection must be carried out immediately and if necessary, immediate handling must be done.

5. CONCLUSION

Fault tree analysis method is obtained by intermediate event factors causing high exhaust gas temperatures, namely the lack of combustion air supply in the cylinder chamber, the fuel composition for combustion that is less suitable is indicated with a reduction in the incoming gas fuel pressure and the engine room temperature is too hot, and from each intermediate event a basic event will be obtained which cannot be searched again. The impact caused by too high exhaust gas temperature on the dual fuel diesel engine is the rupture below on the exhaust manifold by-pass, the erosion of the exhaust cylinder head on the edge surface, and the erosion of the surface of the dual fuel diesel engine exhaust valve. so that it can affect the service life of these components, if the components are damaged, the performance of the dual fuel diesel engine does not achieve maximum work value. After knowing the factors that influence the high temperature of the exhaust gas in the dual fuel diesel engine, then the way to overcome it is by carrying out planned maintenance in accordance with the manual instruction book and carrying out incidental maintenance namely maintenance and repair of turbocharge components, maintenance and repair of the gas admission valve as a whole or only in parts that are experiencing problems, maintenance and repair of waste gas exhaust gates, as well as the operation of the engine room blower in high speed mode.

6. SUGGESTION

This research recommended that routine maintenance be carried out on components or support systems related to the exhaust gas system on the dual fuel diesel engine, must be in accordance with the Manual Instruction Book so that the engine achieves maximum work value. Need to be done as soon as possible repair and replacement of spare parts for machinery components that are damaged due to the high temperature of the exhaust gas in the dual fuel diesel engine so as not to cause a more fatal impact in the damage of machined components. It is better to carry out maintenance and maintenance of the exhaust system of the dual fuel diesel engine must be carried out systematically and thoroughly. because it is a unity of work and the interdependence of one part with another part.

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