



ANALYSIS OF THE MAIN GENERATOR DUAL FUEL DIESEL ELECTRIC (DFDE) 12V50DF SUDDEN TRIP

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Abstract: In the 20th century, the growth of marine transportation has grown rapidly in line with technological advances. Given that the marine transportation sector is one of the pollutants that exist today, the use of energy sources with better thermal efficiency and combustion that does not have a negative impact on the environment is needed in the modern era. In accordance with the regulations stipulated by IMO in the Marine Pollution (Marpol) Annex VI Regulation 14 which regulates the prohibition of ships from using fuels with sulfur content higher than 0.5%. The need for alternative fuels in the shipping industry is an important thought to support the efficiency of the shipping industry. Liquid Natural Gas (LNG) is currently being developed by the government as a fuel for vehicles and environmentally friendly industries. In addition to its availability, natural gas is also considered effective for combustion. Methane / LNG gas is one of the most dominant alternative fuels at this time. This fuel can also save company expenses, namely reducing the cost of providing fuel for energy needs as a source of propulsion on board the ship. For the above, ships, especially LNG carriers, have used a lot of diesel engines to propel their ships using LNG fuel with the concept of the engine being Two Fuel Diesel Electric (DFDE) where the engine can use Marine Diesel Oil (MDO) and LNG. The DFDE engine drives the Generator and the Generator generates electricity to drive the Electric Motor and the Electric motor moves the propeller shaft, this DFDE engine in the future will replace conventional diesel engines because it is more cost efficient, but requires Engineers who understand DFDE engine technology.

Keywords: Marpol; Liquid Natural Gas (LNG); Marine Diesel Oil (MDO); Electric motor; Dual Fuel Diesel Electric (DFDE); Environmental

INTRODUCTION

On the LNG / C TF ship where the author conducted research where the ship is equipped with a main engine generator that uses Boil-off Gas (BOG) as fuel, namely Wärtsilä dual fuel diesel electric 12V50DF which uses Marine Gas Oil (MGO) and other materials. fuelgas methane/ Liquified Natural Gas (LNG). The main fuel is LNG which is compressed with air

by ignition using a small amount of ignition Marine Gas Oil (MGO) as the initial. Boil-off Gas (BOG) is generated, sucked and flowed by a compressor called the Low Duty Compressor (low pressure compressor) from the cargo tank to the main generator engine in the engine room. Before LNG is supplied to the main generator engine, the LNG is regulated by a gas valve unit (GVU). In distributing the fuel from the GVU to the main generator engine, LNG is supplied through the main gas pipe to the gas pipe of each cylinder. Each cylinder has a gas admission valve which regulates the amount of LNG that enters the cylinder with the air during the intake stroke. After the air and LNG mixture enters the cylinder at the end of the compression stroke, a small amount of compressed MGO fuel is injected to initiate combustion. The role of the DFDE generator on the author's ship is very vital, in addition to being used as a power source on the ship, the DFDE generator engine also acts as a source of power to move the ship through the main electric motor propulsion.

The main generator engine has three operating modes for fuel operation, namely, gas mode, diesel mode and backup mode. Gas mode is a mode that is commonly used when the engine is operating starting at an engine load above 40% to 100%, Diesel mode is the mode that is used at the start of the operation of the DFDE Generator Engine until it reaches a load of 40%. while the backup mode works when the generator engine is in trouble. When on a trip, either when using gas mode or Diesel mode, if a problem occurs, the DFDE Generator Engine will switch to backup mode. In this backup mode, the main generator engine will automatically replace the fuel using MGO.

On the ships studied, the main generator engine often experienced several problems in combustion which resulted in the main generator engine switching from Gas Mode to Diesel mode and back up mode and the Generator experiencing a trip on the main switch board. This occurs when the main generator engine uses LNG as its fuel, the high exhaust gas when in gas mode, low LNG temperature and pressure before entering the main generator engine, detonation occurs in each cylinder when the main generator engine uses LNG. as fuel, there is a lack of understanding in the supply of LNG fuel from the evaporation process to the engine room area. This causes disruption of the ship's operational processes while sailing. Seeing the importance of the main generator dual fuel diesel electric engine on the ship, the researchers raised in their research.

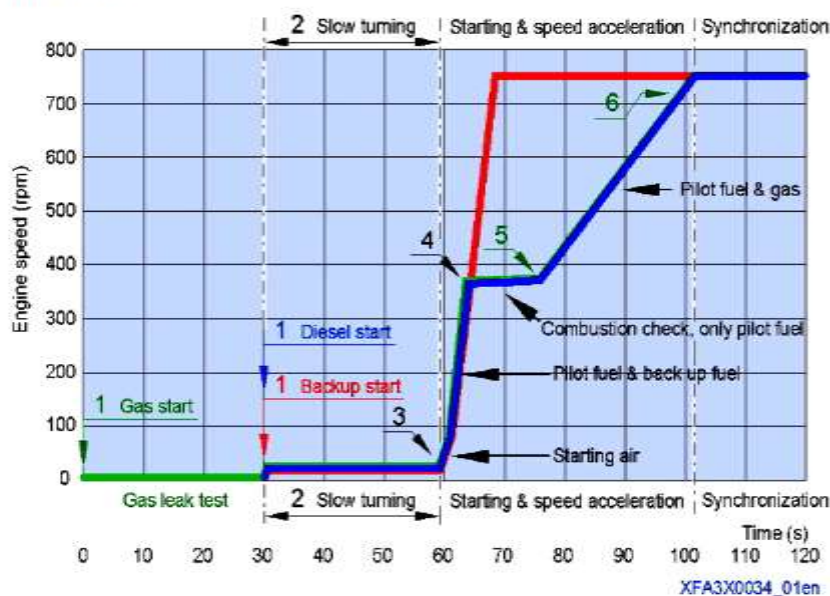
METHODE

According to Janne Kosoma, (2002; 8) The DF-electric LNG carrier concept, the dual fuel diesel electric wartsila is a 4 stroke engine that can be operated alternatively in gas mode or liquid fuel mode diesel. In gas mode, it runs as a machine learn-burn according to the otto cycle. Ignition begins by injecting a small amount of diesel oil (pilot fuel), providing a high ignition source for the main fuel gas in the cylinder. The pilot micro-injection system uses less than 1% of the nominal fuel input power. In diesel fuel this engine works like a normal diesel engine, using a fuel injection pump system. Switching the fuel mode without changing engine power. Its main benefits are as fuel flexibility, operating with natural gas more efficiently in use, and on diesel oil itself when necessary.

The concept of engine dual fuel electric is a concept of a 4 stroke diesel engine that produces electric power to drive the electric motor as the main motor of the ship (main electric propulsion motor). This engine utilizes gas vapor or LNG vapor as the main fuel which is compressed with air by ignition using MGO (marine gas oil) as an initial trigger starting by spraying a little MGO or commonly called pilot fuel. The pilot fuel injection system is a high-pressure MGO injection unit which is then distributed to each cylinder as a trigger during gas mode by using a 1% ratio of output power. This machine can also operate using only MGO fuel which uses a fuel injection pump system on each cylinder. This machine has one injector in each cylinder with two nozzles, namely the pilot nozzle and *main nozzle*.

STARTING THE ENGINE

Starting in different modes



WÄRTSILÄ Engines

Fig. name: Starting in different modes

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How the works dual fuel diesel electric generator

The main generator engine works dual fuel diesel electric as follows:

a. Gas mode

Gas mode uses LNG as the main fuel. In this mode the LNG is mixed with the incoming air according to the arrangement above the cylinder head and is assisted by using MGO fuel as ignition which will be injected through the pilot nozzle. Before LNG is supplied to diesel engines, it passes through the gas regulating unit. This gas regulating unit consists of filters, pressure regulator, shut-off valve and ventilating valve. The output of gas pressure is regulated by the WECS8000 control system (wartsilla electronic control system) according to engine load and ambient

environmental conditions. In its distribution, LNG is supplied through the main gas pipe along the engine and continues to the gas pipe of each cylinder, in each cylinder there is a Gas Admission Valve which regulates the amount of LNG that enters the cylinder, valve this driven directly by the solenoid valve and is regulated by the control system WECS.

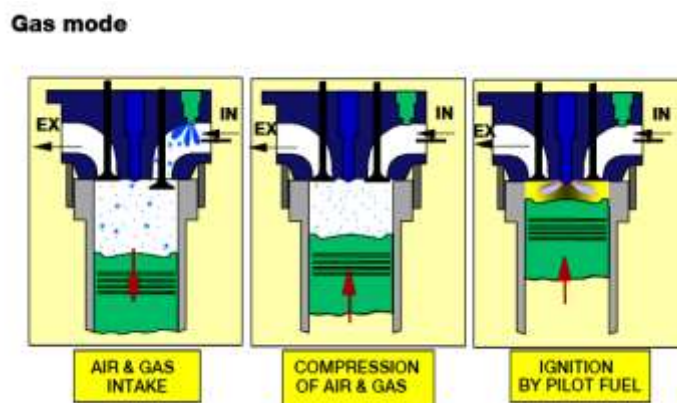


Figure 2. combustion process *Gas(lean burn wartsila instruction manual)*

b. Diesel mode

Using MGO fuel, MGO fuel is injected into the combustion chamber at the end of the compression stroke assisted by an injection pump, the way it works when this diesel mode is the same as a normal diesel engine. In diesel mode, there is no gas mixed with air, but the pilot nozzle injects the MGO fully

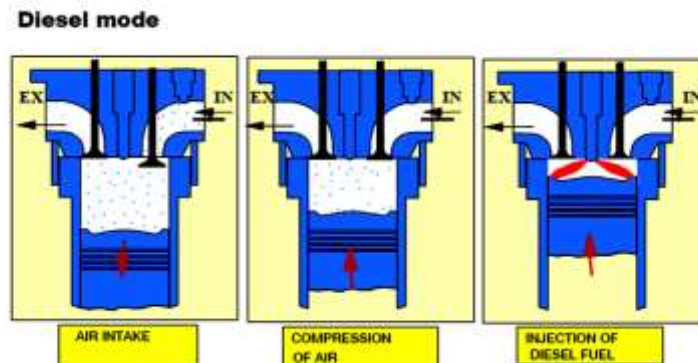


Figure 2.3 combustion process *dieselmodes (lean burn wartsila instruction manual)*

c. Back-up mode

Back-up mode uses MGO as fuel. MGO is injected into the combustion chamber at the end of the compression stroke assisted by an injection pump. How it works when backing up Inmode thisthere is no LNG mixed with air and the pilot nozzle does not inject MGO fuel as the initial trigger, in this mode the pressurized fuel is injected through the main nozzle to keep the generator engine operating using only MGO fuel and not with mixed materials. burn LNG.

Back mode will operate when Gas mode and diesel mode experience problems.

G.A.V (Gas Admission Valve)

GAV (Gas Admission Valve) is an electro-mechanical valve that functions to regulate LNG fuel entering the cylinder on dual fuel diesel electric. The electronic gas intake valve is driven and controlled by the engine control system to provide exactly the correct amount of LNG per cylinder. In this way the combustion in each cylinder can be completely controlled. The independent LNG inclusion ensures the correct air-fuel ratio and optimal operating point for efficiency, and emissions.

The use of LNG as fuel for the Main Generator Engine.

The normal process in this system that occurs is methane that the used as fuel comes from the LNG (charge evaporation process Liquefied Natural Gas) which has a temperature of -160°C and contains methane + 96% which will then be collected in certain parts of the cargo tank, namely Gas Dome for the next process in the LNG fuel supply system. After being collected in the Gas Dome, the LNG is sucked by 2 high-capacity compressors called Low Duty Compressors, inside the compressor the LNG pressure will be set in such a way between 178-650 kPa (determined based on the level of content methane in LNG) in addition to pressure changes, temperature changes between $-30.5 - 66.7$ also occur. In a normal process, only one compressor is operated as an LNG pressure regulator as well as controlling the temperature and flow rate of the LNG fuel. Meanwhile, the other compressor must be in standby position and ready to anticipate a trip on the compressor that is being operated. This is done to ensure the stability of the fuel supply process LNG to the engine room area and prevent the sudden increase in pressure in the cargo tank.

RESULT AND DISCUSSION

Data description

In the description of this data, the events related to the sudden trip analysis of the will be described as a Dual Fuel Diesel Electric (DFDE) 12V50DF main generator as a ship propulsion at TF LNG/C result of several problems, namely:

The low temperature and pressure of LNG before entering the main generator engine.

An error that occurs in the process of processing LNG fuel from the cargo tank is the occurrence of excessive use or load high on the GCU. This results in reduced pressure and temperature from LNG which is supplied to the engine room drastically which triggers a trip in the main generator.

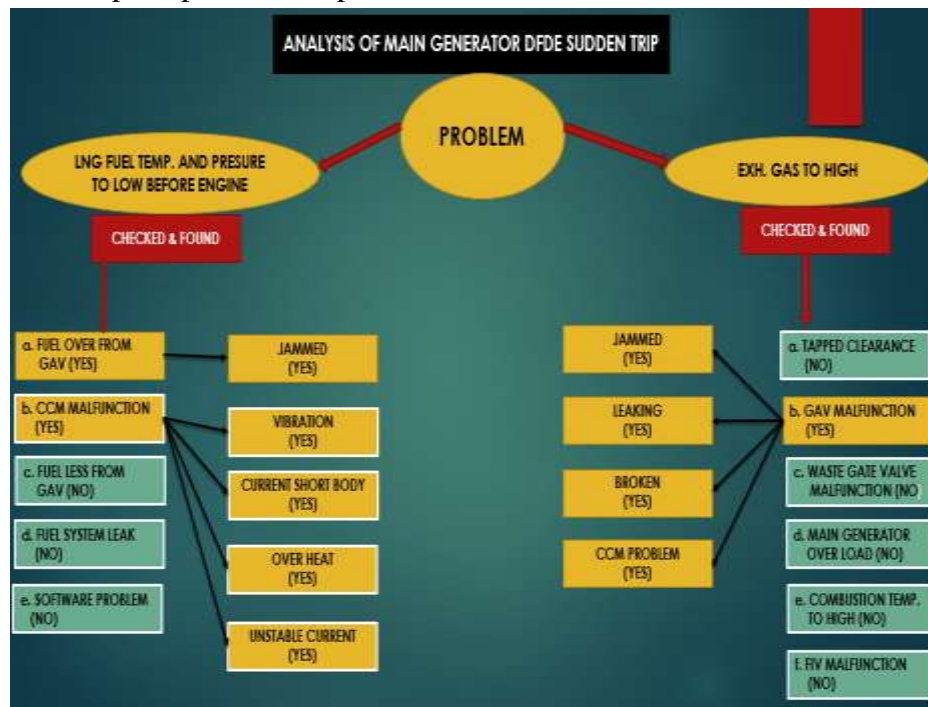
High temperature exhaust gas when in gas mode.

The decline in the performance of the main generator was triggered by an indication of damage to the GAV (Gas Admission Valve) which resulted in a high exhaust gas temperature when in gas mode so that it could trigger a trip on the main generator.

Data analysis

In this analysis will focus on how the process of decreasing temperature and pressure of LNG before entering the main generator engine which results in a decrease in the performance of the main generator on board the LNG / C TF ship and an increase in exhaust gas temperature

at generator number 2 when in mode. gas. The purpose of this data analysis is to analyze the problem so that the perception of the problem can be found.



Cause Low LNG temperature and pressure before entering the main generator engine. Use over of Combustion Gas

In normal process, this system runs by maintaining fuel pressure from methane 420 to 550 kPa, and temperature of 35-50. Due to the use of a load GCU that is too large at the same time as the use of gas mode on the main generator or a leak in the fuel supply pipes methane to the engine room to enter the main generator engine, the LNG temperature and pressure decrease suddenly it finally happened. This is detected by the main generator's security system so that as a protective measure for the main generator itself, the relay module will send a signal to activate the main generator trip mechanism to prevent further damage and even greater impact.

Malfunction to The Cylinder control module (CCM)

Control module functions to Control the gas admission valve and pilot fuel injection valve using high energy type PWM (pulse width modulation) outputs. Each module is equipped with a PWM-type control signal at the three gas admission valve and three pilot fuel injection valve, the module also calculates the duration of the relevant results reinjection of gas fuel and timing. carburetion pilot fuel Both information is sent to the main control module (MCM) via CAN (controller area network). The CCM also provides command signals at the relevant angular position, the cylinder control module also needs accurate information from the speed sensor and phase sensor. The CCM also takes care of cylinder specific measurements, i.e. exhaust gas temperature and low LNG temperature and pressure which enters the main generator. On all this information is sent via CAN to MCM.

From the results of data analysis, it was found that damage to the CCM resulted in low LNG pressure and temperature upon entering the main generator

Damage to the CCM can be caused by several things, ie:

- 1) Unstable ship electricity
- 2) Engine vibration is too large
- 3) The occurrence of grounded cable system on CCM
- 4) CCM is too hot

The less capacity of LNG fuel supply

In the DFDE generator engine, gas is supplied through a common pipe that runs along the engine, followed by individual feed pipes to each cylinder. Gas intake is controlled by the "Main Gas Admission Valve" for the main gas intake. The valve is a solenoid valve that is actuated directly controlled by the control system (WECS). The main gas pressure on the engine can be checked from the local panel display. The alarm is set for the low pressure difference between the combustion air pressure and the gas pressure.

Leak in natural gas system

Before fuel is supplied to the DFDE generator engine, natural gas will pass through the gas regulating unit. This unit includes a filter, pressure regulator, shut-off valve and vent valve. The pressure of the gas outlet is controlled by the control system (WECS) in accordance with the engine load and conditions ambient temperature at the location. After checking the gas intake system (pipes, valves), there were no leaks which referred to the problem.

The setting in the software and module not appropriate

This module is a master in the system WECS 8000. software This handles the processing of all strategic engine control functions. The main processes are engine start & stop, engine safety and combustion control. Based on the internal load / speed control algorithm, gas pressure, gas ingress and pilot fuel injection / timing calculations are made. This system handles the information sent by all other modules, and it sends a reference signal to the cylinder control module regarding the gas intake, fuel quality for the pilot nozzle and the timing of its injection. Thus the setting software on the module is an important role related to the automatic system on the main generator. After checking the software, there were no problems that could interfere with the control of LNG gas intake as fuel.

From the results of the data analysis above, it was found that excessive use of GCU and damage to the CCM could cause low LNG temperature and pressure before entering the main generator engine.

The cause of the high temperature exhaust gas when in gas mode.

Tappet clearance valve is too small

After checking the yoke bolt tightness based on the Wartsila instruction manual book, there were no problems that could cause the tappet clearance valve to be too large / changed from what was determined by the manual.

Malfunction on GAV

Malfunction gas admission valve affects the amount ratio of fuel and air in the cylinder, it can cause high exhaust gas temperature at the main generator.

- 1) GAV freezes when open
- 2) There is a leak in GAV
- 3) Broken part of the moving plate
- 4) Damage cylinder control module

Mechanism malfunction of Exhaust Gas Waste Gate Valve

From the results of the data analysis, there was no error in the mechanism for opening the exhaust gas waste gate valve and the turbocharge component in good condition.

Generator overload

However, in fact the ship is sailing at normal speed and has not reached the critical speed (more than 20 knots), so it can be concluded that excess engine power (generator overload) is not the cause of the high exhaust gas temperature of each cylinder.

High temperature of combustion air.

After checking the combustion air system, the combustion air entering the engine cylinder is in accordance with the engine manufacturer's provisions listed in the main generator manual.

Fuel injector abnormalities

After checking and testing the fuel injector components, no abnormal conditions were found, meaning that the fuel injectors were working according to their function. From the results of the data analysis above, it was found that a failure of the gas admission valve could cause a high exhaust gas temperature in the main generator.

Problem solving alternatives

In the alternative problem solving section, the writer wants to provide several alternative solutions to problems in accordance with what the author has explained in the data analysis section, alternative solutions to the problem are:

1. The low temperature and pressure of LNG before entering the main generator engine
 - a. Replacement of the cylinder control module
 - b. Changing the low duty compressor into high mode
The problem that occurs is the lack of LNG which will be supplied to the main generator engine when the GCU operates. Therefore, the cargo engineer as the operator of the LD compressor must increase the capacity of the machine to avoid dropping LNG pressure and temperature in the engine room area.
2. High temperature exhaust gas when in gas mode.
 - a. Make repairs to the Gas Admission Valve damaged
 - b. Maintain or pay attention to working hours on magnetic filters and cartridge filters.
 - c. Complete replacement of parts Gas Admission Valve .

Evaluation of problem solving alternatives

In the evaluation section of problem solving alternatives, each alternative that the writer considers as an alternative problem solving will be evaluated. The evaluation will be done by looking at the author's weaknesses and strengths, weaknesses and strengths, disadvantages and advantages to facilitate decision making in choosing the right problem solution.

The low temperature and pressure of LNG before entering the main generator engine

Changing Low Duty Compressor into high mode One alternative solution to the problem is by increasing the supply capacity of LNG as fuel. This method is done by changing the low duty compressor into high mode and increasing the opening of the VDV (variable diffuser vane).

1) Advantages

Does not cost anything

2) Disadvantages

It is quite difficult because it requires the very high accuracy of the load driver.

Replacement of the Cylinder Control Module

In the evaluation of alternative solutions to this problem, the author provides an evaluation of this method to be an effective way because it can almost always solve the causes of problems related to the exhaust gas in the main generator.

3) Advantages

- The new CCM will work perfectly because all the components are in new condition and calibrated as a whole which will make the CCM system work well integrated in the system unit.

- The new CCM has a good ability to detect LNG fuel pressure and temperature on the main generator

4) Disadvantages

Large costs because the CCM component is a very expensive part

High temperature exhaust gas when in gas mode.

Repair the part of the Gas Admission Valve damaged. The leak in the gas admission valve is caused by the moving plate, whose surface starts to become uneven and the eroded moving plate is due to the uneven load of the spring pressure so that when the valve is closed there is still gas entering the cylinder.

1. Advantages:

- a. Can cut the cost of purchasing spare parts.
- b. Can be done during emergencies such as scarcity of spare parts

2. Disadvantages:

- a. Time of use cannot last long
- b. Need measurement and high accuracy when repairing
- c. Unable to measure the end of life of GAV the improved.
- d. Replacement of parts Gas Admission Valve as a whole or parts thereof is an alternative solution to the problem that can be done to the problem that the author is experiencing.

This is due to the problem that occurs, namely the high temperature of the exhaust gas from the main generator engine as a result of poor LNG fuel injection in the combustion chamber by GAV. Here are the advantages and disadvantages of a comprehensive replacement GAV solution alternative:

1. Advantages:

- a. Replacement of GAV can help overcome too wide or too narrow GAV Opening
- b. The filter on GAV can function properly to filter out impurities and carbon contained in LNG.
- c. GAV can function properly and will have no problems with GAV which is still new.
- d. The new GAV can know the end of its working hours because it refers to the manual bookk.

2. Disadvantages:

The cost is quite large in replacing GAV because this part is quite expensive.

c. Make changes to the magnetic filter and cartridge filter.

To avoid dirt entering the system, it is necessary to maintain and pay attention to working hours or conditions on the magnetic filter and cartridge filter, if the dirt escapes and damages the O-ring in GAV it will cause leakage in GAV

1. Advantages:

- a) Filter replacement can solve problems quickly and keep the system clean
- b) Can reduce the risk of damage to the gas valve in the future.

2. Disadvantages:

The cost is large enough to replace the magnetic filter and cartridge filter

Selected problem solving

Based on the evaluation of problem solving, the writer will provide an effective problem solving for the problems that the authors discuss in this thesis.

The low temperature and pressure of LNG before entering the main generator engine.

For the problem of low LNG temperature and pressure, the author describes controlling the capacity Low Duty Compressor as the best solution to the problem. Because besides being able to solve the problem of low LNG temperature and pressure by using this solution, the evaporation rate, temperature and pressure of the LNG in the cargo tank can also be controlled. In addition, the authors suggest to replace the cylinder control module, solving this problem can be classified as effective because it can also solve the problem of high exhaust gas temperatures in the main generator. This CCM is one of the critical equipment, so it is not recommended to make CCM repairs on board.

Ship engineers must also pay attention to the installation of cables that have chipped and cause earth faults, so as to reduce the risk of damage to the CCM in the future.

High temperature exhaust gas when in gas mode.

The solution to the problem chosen for the high exhaust gas temperature when in gas mode is the replacement of the Gas Admission Valve because of the damage that occurred to the Gas Admission Valve, the author also suggests checking and replacing the magnetic filter and cartridge filter to keep the LNG in supply clean. to the main generator and reduce / prevent the risk of damage to the Gas Admission Valve again. Solving this problem also aims to avoid tripping on the main generator engine and prevent sudden damage that will endanger the ship when operating and can help optimize the performance of the main generator engine as a ship propulsion on LNG / C TF where the author conducts research.

CONCLUSION

The performance of the main generator engine cannot be separated from the support of the components contained in the system including the fuel system of the main generator engine itself, starting from the LNG loading process, treatment while in the cargo tank, and the process of supplying it to the engine room. . Then the following conclusions can be drawn:

The low temperature and pressure of LNG before entering the main generator engine.

Which can cause low LNG temperature and pressure due to the small capacity of LNG supply from the cargo tank towards to the main generator engine which is affected by the excessive use of the combustion unit gas. Thenot maximal low duty compressor that is tasked with supplying and pressing LNG is before entering the gas fuel system on the main generator engine. The mismatch between the LNG supply going to the engine room and the demand in the engine room is a major factor. Apart from this, problems can also be caused by a damaged cylinder control module.

High temperature exhaust gas when in gas mode.

The high exhaust gas temperature when the main generator is in gas mode is caused by a malfunction in GAV. GAV jammed when open due to dirt escaping from the magnetic filter and filter cartridge. The dirt that enters it can damage the O-ring on the GAV and cause leakage. In addition to this, another cause is broken moving plate in GAV which is caused by uneven pressing and scratched parts due to friction between two uneven parts in the area moving plate resulting in leakage.

Suggestion

The author has the following suggestions:

The low temperature and pressure of LNG before entering the main generator engine.

For the problem of low LNG temperature and pressure, the authors provide the following suggestions:

- a. Capacity control Low Duty Compressor as the best solution to the problem. Because besides being able to solve the problem of low LNG temperature and pressure by using this solution, the evaporation rate, temperature and pressure of the LNG in the cargo tank can also be controlled.

- b. Replacing the cylinder control module, solving this problem can be classified as effective because it can always solve the problem of high exhaust gas temperatures in the main generator engine. This CCM is one of the critical equipment, so it is not recommended to make CCM repairs on board.
- c. Apart from replacing the CCM, the machinist also needs to pay attention to the installation of chipped cables to avoid earth faults, which aim to reduce the risk of damage to the CCM in the future.

This suggestion can optimize the performance of the main generator engine on the LNG / C TF ship.

High temperature exhaust gas when in gas mode.

To prevent too high a temperature of the exhaust gas from the main generator engine, the authors suggest the following ways:

- a) Replacement Gas Admission Valve, due to damage to the Gas Admission Valve
- b) Check and replace the magnetic filter and cartridge filter to keep the LNG clean which will be supplied to the main generator engine and reduce the risk of damage to the Gas Admission Valve.

The above suggestions can prevent high exhaust gas temperatures when in gas mode. Thus the trip can be avoided and can optimize the performance of the main generator as a ship propulsion on LNG / C TF.

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