



Preventive Maintenance Of The Cooling System On The Main Engine On The Mt. Ratu Zainab

Carles YA Nalle ¹, Ashar ²

¹ Carles Y.A. Nalle, Shipping Politechnic of Sorong, Indonesia. Email acarlesnalle@gmail.com

² Ashar, Shipping Politechnic of Sorong, Indonesia

Corresponding Author Email: acarlesnalle@gmail.com

Abstract

Background. The main drive engine is an energy conversion engine that converts thermal energy resulting from chemical reactions between fuel and air into mechanical energy. The process of burning the fuel occurs due to high air pressure in the combustion chamber.

Aims. This research was conducted on the MT ship. Ratu Zainab aims to determine the best practices for preventive maintenance of the cooling system on the main engine and identify the factors that impact her work on the MT ship. Queen Zainab.

Methods. The method used is qualitative descriptive. The study's results highlight the importance of regular maintenance for the freshwater cooling system to ensure optimal engine performance. The main steps include preparing maintenance schedules, creating checklists, and conducting periodic inspections.

Result. Common problems that often occur include a lack of suction in the cooling pump, decreased impeller performance, dirt accumulation in the seals, and leaks in the *intercooler cover*, thus affecting the cooling system of the main engine on the MT. Ratu Zainab's ship. Daily and monthly maintenance is recommended to detect damage early. Factors that affect the performance of the cooling system include corrosion, *clogging of the cooler* by dirt, and wear and tear on the standard components. *Proper preventive maintenance* can reduce damage, improve operational efficiency, and extend the life of machine components. Cooling system failure can lead to overheating, reduced engine efficiency, and severe component damage. Therefore, implementing preventive maintenance is a strategic step to prevent unexpected damage.

Conclusion. This research highlights the importance of proactive maintenance and a thorough understanding of seawater cooling systems to ensure the optimal and safe operation of ships.

Implementation. Thus, implementing proper preventive maintenance on the main engine cooling system is a crucial effort in ensuring the safety, efficiency, and reliability of the overall ship operation.

Keywords: Preventive maintenance, cooler, main engine.



© 2025 The Author(s). This article is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source.

INTRODUCTION

Retrieved on 18 Jul. 23. Pratama, A. A., Astriawati, N., Waluyo, P. S., & Wahyudiyana, R. (2022). The main drive engine, which must operate continuously during operation to support the machine's work, is supported by several vital parts. According to Daryanto (2021), these important parts are related to a system, including the lubrication system and the cooling system, which function to remove heat from the engine. The main drive engine is an energy conversion engine that converts thermal energy resulting from chemical reactions between fuel and air into mechanical energy. The process of burning fuel occurs due to high air pressure in the combustion chamber, which is why it is called a *Compression Ignition Engine* (Serrano et al., 2021). Furthermore, the fuel is injected/fogged into the combustion chamber to produce mechanical power, which serves as the drive for the *crankshaft*. This continuously operating main drive engine will result in high temperatures both in the cylinder chamber and outside, requiring a cooling system to prevent *overheating*.

According to Akhmad et al. (2020), the selection of the main drive engine of the ship is more in diesel engines, with the consideration that the diesel engine has a fairly large power (horsepower) with a smaller size, so that it does not take up too much space in the engine room. Diesel engines are also easier to get on the market, with a wide variety of choices, brands, and easy maintenance.

According to Yusuf et al. (2020), diesel engines are a type of thoracic combustion motor, whose fuel combustion occurs due to high air pressure in the combustion chamber; therefore, diesel engines are also called *Compression Ignition Engines* (CIE). The combustion process of a diesel motor produces heat energy, which raises the high pressure inside the cylinder, and this pressure is converted into mechanical energy on the crankshaft. Then a cooling system is needed on the main engine.

A cooling system is one of the systems that functions to maintain the engine temperature at a specified level according to the design, allowing diesel engines to operate sustainably. Diesel engines that operate produce heat with temperature. This cooling system comprises several constituent components, primarily used to cool the engine block. In addition to cooling the engine block, the cooling system also cools lubricants, scavenges water, and cools *water jackets*.

According to Arismunandar and Tsuda (2020), if cooling cannot be done as well as possible, the temperature of each cylinder will rise. This situation will result in damage to the cylinder wall due to normal voltage or damage to the valves, torque peaks and congestion of the torque ring, in addition to that the lubricating oil will evaporate and burn so that there is rapid damage to the cylinder wall torque, but also cause disruption of the engine's work, therefore the engine must be cooled properly. Based on the above considerations, it is evident that the cooling system plays a crucial role in supporting the main engine. With this cooling system, the life of the main engine can be extended.

The main drive engine on every ship is constantly overheating. For this reason, a cooling system is needed to normalize the temperature again. *Overheating* can damage the main drive engine; therefore, proper cooling system maintenance is essential. This study aims to determine the best method for maintaining the cooling system of the main drive engine, which is the primary drive on this ship. The underlying reason for the author to take the title is that the author has an interest in and is also very interested in this research, as the author often hears and reads about damage or disturbances that occur to the seawater cooling system on the main engine. The author aims for the research conducted on the Mt. Ratu Zainab ship to serve as a lesson for future research. Therefore, the author chose the title "*Preventive Maintenance of Cooling Systems on Main Engines on MT Ships. Queen Zainab.*"

Problem Formulation

Based on the background described above, it is necessary to formulate specific problems that will be researched. Then there are various descriptions of problems that can be formulated as follows:

1. How is *preventive maintenance* carried out on the cooling system of the main engine on the MT ship? Queen Zainab?
2. What factors affect the work of the main engine cooling system on MT ships. Queen Zainab?

Problem Limitations

Based on the formulation of the problem above, the author limits the discussion to the preventive maintenance of the cooling system on the main engine of the MT ship. Queen Zainab.

Research Objectives

1. To find out how to do good *preventive maintenance* of the cooling system on the main engine on the MT ship. Queen Zainab
2. To find out what factors affect the work of the central engine cooling system on MT ships. Queen Zainab

Research Benefits

Based on the research conducted by the author on the MT ship. Ratu Zainab regarding *Preventive Maintenance* of Cooling Systems on the Main Engine on MT Ships. Queen Zainab. Therefore, the researcher has a goal to ensure the study is useful to both the writer and the reader. The objectives are as follows:

Theoretically benefits

It can add insight, knowledge, experience, and mental development for ship engineers who work on or are working on ships regarding the Preventive Maintenance of Cooling Systems on Main Engines on MT ships. Queen Zainab. This discussion is intended to serve as a reference for readers when they encounter the same problem.

Benefits in a practitioner way

As a reference for readers, especially friends or colleagues in the same profession who will work on the ship, this document aims to provide a better understanding and serve as a guideline for the crew on the boat, including the ship's crew, regarding the implementation of this cooling system.

LITERATURE REVIEW

Master Machine

According to Ziliwu, B.W., & Tumpu, M. (2020). The main engine is the main driving force that functions to convert mechanical power into driving force for the ship's propeller so that the ship can move, In its operation the main engine which is always in a continuous living condition and causes heat in the engine parts, it will generate heat due to combustion results so that there is an increase in temperature, especially in parts that are in direct contact with

each other with the combustion chamber. In diesel engines, *the marine engine* unit can move due to combustion in the cylinder and produce high enough heat, if it is not cooled there will be *overheating* (the engine overheats) and it usually accelerates wear, so to prevent this, the engine is equipped with a cooling system which this cooling system functions to prevent excessive heat.



Figure 1 Parent Machine
Source: Documentation 2024

Cooling System

Quoted on June 28, 2023. Eko, R. (2019). Refrigerant is a medium that functions to absorb heat. The heat is obtained from the combustion of fuel in the cylinder. In the cooling system, several components work in tandem, including coolers, freshwater circulation pumps, seawater pumps, strainers in the seawater, and *sea* chests. Of these four components, it often causes less-than-optimal cooling results for the main motor. Cooling water plays a vital role in maintaining the smooth operation of the primary motor. To protect the diesel motor building from voltage fluctuations caused by heat, the heat generated must be controllable. This situation can only be overcome by circulating (circulating) the cooling medium with constant pressure to all components of the primary motor.

According to Jusak Johan Handoyo (2016:85). The open cooling system is a seawater media system as the cooling medium after performing the cooling function, then the seawater is immediately discharged to the outside, generally the cooling medium used is seawater, this open media system has a negative impact on materials that are in direct contact with seawater, will be easily rusted, dirty, narrowing of cooling pipes and others. Seawater is directly used

in the engine system as a cooling medium for heat absorption. The seawater cooling system only passes through to absorb heat and will be discarded back into the sea, so it is said that the cooling system is open.

Quoted on June 29, 2023. According to Eko, R. (2019) the cooling process is by taking seawater from the valve through a filter with a seawater pump, then seawater is circulated to all parts of the main engine that require cooling through lubricating oil cooler and air conditioning to cool the cylinder head, cylinder wall and gas release valve then seawater is discharged out of the ship. The advantage of a seawater cooling system (open system) is that it is simpler, and the power required for water circulation is smaller compared to a freshwater cooling system (closed). Additionally, it can save on equipment costs, as this system does not require a water tank and uses fewer pumps to circulate cooling water. Meanwhile, the disadvantage of this seawater cooling system is that in the piping installation, it is very easy to move (rust) because this seawater is corrosive and the cooling water is greatly affected by the temperature of the seawater.

Quoted on July 1, 2023. Sakati, A. W. (2022). The cooling principle is to release engine heat through water as a cooling medium to absorb heat, the components of the system start from seawater being sucked from the *sea chest* using a seawater pump and before passing through the pump must first pass through the *strainer (filter)* then to the *cooler* To absorb heat and pump it back into the sea, seawater is directly used in the engine system as a cooling medium for heat absorption. The seawater cooling system only passes through to absorb heat and will be discharged back into the sea.

Main Components of Cooling Systems

In the cooling system, there are several components that are very important for the smooth operation of the main engine, including:

Sea Chest

A *sea chest* is a device related to seawater on ships that attaches to the inner side of the ship's skin plate, located below the water's surface, used to drain seawater into the boat, thereby meeting the need for freshwater from seawater. The *sea chest* itself contains equipment, such as a sea grating, strainer, or filter, which is always submerged in seawater and can be prone to corrosion.

Sea Grating

Sea grating is a filter or lattice installed on the sea chest to prevent unwanted objects from entering the sea and entering the ship's pipeline system. The function of the sea grating is to filter seawater before it enters the sea chest box, which serves as the initial filter before the seawater enters the system through the *strainer* and filter. This sea grating is tied using

Corrosion-resistant bolts are then fastened together using wire, ensuring the bolts remain secure.

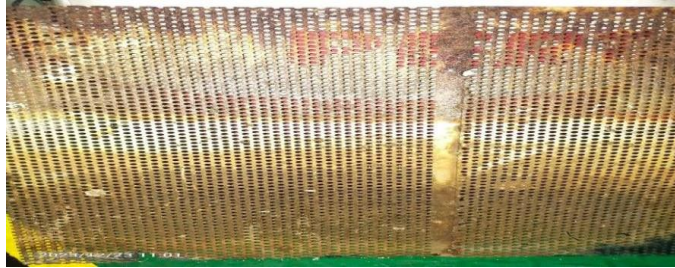


Figure 2 *Sea Grating (sea chest)*. Source: Documentation 2024

Valves

All piping systems in the engine room are equipped with valves that function as doors to open and close the flow of seawater. This is also a safety measure, in case the water flow needs to be pumped due to leaks, firefighting, or other emergencies. The size of the *valve* must be adjusted to the size of the pipe.

Strainer

A *strainer* is a box-shaped or cylindrical tool that is usually attached to a pipe to the main machine, a pipe to an auxiliary machine, or to a pipe bypass. This tool functions as a trap for dirt from the sea; a filter is installed in the strainer. The dirt, if not filtered and deposited on the strainer, will enter the seawater system in the engine room and other areas.



Figure 3 *Strainer* Source: Documentation 2024

Pump

Seawater pumps function to suck, distribute, and compress seawater into the system, then circulate it so that it can cool the cooled part. Generally, ships utilize centrifugal or vertical seawater pumps.



Figure 4 Fresh water pump. rce: Documentation 2024

Pipes *by-pass*

Pipes by-passes are used to connect one sea chest to another, with the aim of helping seawater supply to a specific location within a system, if one of the systems experiences difficulties or obstacles in seawater supply.

Cooler

This tool functions as a cooling medium, absorbing heat from inside the machine by using seawater to cool the press being cooled, such as fresh water and lubricating oil, which enter small pipes to absorb heat.



Figure 5 *Cooler* Source: Documentation 2024

Master Engine Cooling Maintenance

For the maintenance of the main engine cooler, here are some things that can be done:

Regular cleaning of the cooling system



Figure 6 *Cooler Gear Box* Source: Documentation 2024

Cleaning parts of the cooling system such as radiators, pipes, and water tanks to ensure that there is no contamination of dirt or scale on the surface.

a. Check pressure and moisture content

In the cooling system Make sure that the cooling system has sufficient pressure and proper moisture content to prevent leakage or overheating.

b. Change *the coolant* regularly

Don't forget to replace the *coolant* every time frame specified by the engine manufacturer. This aims to keep the engine temperature stable and prevent corrosion of the cooling system components.

c. Check the function of the water pump

The water pump functions to switch cooling water to the engine. Make sure that the pump is working properly to prevent *overheating* in the engine.



Figure 7 Impeller Engine Cooling Pump Source: Documentation 2024

By performing regular maintenance, you can ensure that the cooling system of the main engine is always in good condition, thereby maintaining optimal engine performance.

Preventive Maintenance of Seawater Cooling System

- a. To carry out *preventive* maintenance on the main engine cooling system, several things that can be done include:
- b. Cleaning the air filter
- c. The air filter in the cooling system should be cleaned regularly to maintain optimal airflow.

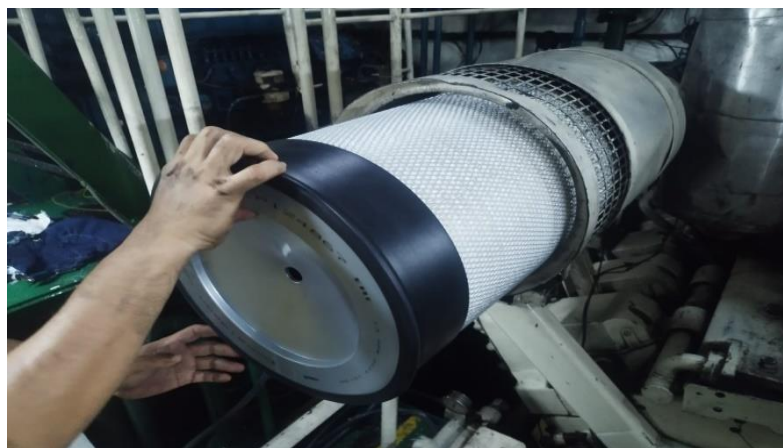


Figure 8 Air Filter Source: Documentation 2024

d. Checking the water pressure in the cooling system

Make sure the water pressure in the cooling system is at a sufficient level and not excessive. If it is too low, add water a little at a time until it reaches the desired level.

e. Checking the condition of hoses and pipes

Ensure that all hoses and pipes in the cooling system are in good condition and free from leaks. If damage or leaks are found, it should be replaced with a new one.



Figure 9 Checking the condition of the pipeline Source:Documentation 2024

f. Cleaning the Machine

Cleaning the engine regularly can help prevent damage to the cooling system. Clean the machine using a special cleaner and don't forget to clean hard-to-reach parts such as vents and small crevices.

g. Checking the temperature of the machine

Regularly checking the engine temperature can help prevent damage to the cooling system. Make sure the engine temperature is not too hot or too cold. By doing these things on a regular basis, the

The main engine cooler can function properly and prevent unwanted damage from occurring.



Figure 10. Checking the temperature of the primary engine cooler Source: Documentation 2024

METHODS

Scientific paper plan

This research is carried out using a qualitative descriptive analysis method where it is carried out by starting the steps of observing the object being studied and recording the data, then analyzing the object to present in detail the data obtained to provide information about planning for the problems that arise, and the subjects chosen are the crew of the engine ship including; Chief Engineer and Oiler. This research is the focus of data collection in a study. This subject will be analyzed to address the formulation of problems or hypotension related to the discussion material in this Applied Scientific Paper. The type of qualitative descriptive research describes the conditions as they are, without intervening or manipulating the variables being studied. The type of qualitative descriptive research is a type of research with the process of obtaining data as is. This research places greater emphasis on the meaning of the results.

Research Time and Place

The author conducted a study on "*Preventive Maintenance* of the Pending System of the Main Engine on the Mt. Ratu Zainab Ship. At the time, the writer undertook marine practice in semesters V and VI as a machine cadet for approximately one year on the Mt. Ratu Zainab ship, from June 20, 2023, to June 22, 2024.

The author conducted research activities on the MT ship. RATU ZAINAB belongs to the company PT. BAROKAH PERKASA GROUP with the following ship data:

Name of Ship: MT. RATU ZAINAB

Call Sign / IMO No : YDLF2 / 9934656
Flag : Indonesia
Place of Built: Samarinda
Made at the Shipyard: PT. Dock Barokah Perkasa Group
Type of ship: Oil Tanker
G.R.T : 3239
N.R.T : 1617
D.W.T : 6089
L.O.A : 89.75 meters
L.B.P : 84.25 meters
Length Everywhere: 89.75 Meters
Length BP: 84.25 meters
Breadth: 21.95 Meters
Depth : 6.10 Meters
Type Engine Propulsion : CUMMINS KTA 38-M2
Type to Engine : Deutz WP6CD120.16
Output Engine Propulsion : 2 x 1200 HP 1800 RPM
Output Engine Aux : 2 x 90 kw 1500 RPM

Data Collection Techniques

According to Sugiyono (2016:309) stated that "data collection is carried out under natural conditions, primary data sources, and more on participatory observation, in-depth interviews and documentation". The types of data collection carried out in this study are observation, interviews, and documentation. This type of data collection is expected to complement each other, ensuring that the information gathered is in accordance with the research.

Observation

Observation is a data collection technique by observing every event that takes place and recording it using an observation sheet. This observation method uses direct observation of an object, condition, situation, or behavior.

Interview

Interviews, according to Sugiyono (2016:194), are used as a data collection technique when the researcher wants to conduct a preliminary study to identify the problem that needs to be researched, and also when the researcher wants to gather more in-depth information from the respondents. The researcher employed an interview technique to gather in-depth information from respondents about character card games as a character education learning model for students' parents. In the interview, the researcher acts as both the interviewer and a leader in the interview process, which is not scheduled in advance. Meanwhile, respondents are individuals who are interviewed by researchers and asked for information.

Document

According to Sugiyono (2016:329), documents are records of past events; document studies are complementary to the use of observation and interview methods in qualitative research. In this study, the researcher attempted to collect the documents obtained in the field.

Data Analysis

Data analysis according to Sugiyono (2018:482) is the process of systematically searching and compiling data obtained from interviews, field notes and documentation, by organizing data into categories, describing it into units, synthesizing, arranging it into patterns, choosing which ones are important and what will be studied, and making conclusions so that they are easy to understand by themselves and others. Meanwhile, according to Moleong (2017:280-281)

Data analysis is the process of organizing and categorizing data into patterns, units of description, and themes, allowing for the identification of patterns and the formulation of hypotheses based on the data. The accuracy and accuracy of the data collected is very necessary, but it is also undeniable that different sources of information will provide different information. The work of analyzing data requires effort to concentrate and exert one's own physical and mental energy. In addition to analyzing the data, researchers also need to delve into the literature to confirm the theory.

Data Reduction

According to Sugiyono (2018:247-249), Data reduction involves summarizing, selecting the main points, focusing on important aspects that align with the research topic, identifying themes

and patterns, and ultimately providing a clearer picture, making it easier to collect data further. In reducing data, it will be guided by predetermined goals that have been achieved. Data reduction is also a critical thinking process that requires intelligence and a high depth of insight. Data Presentation

Data Presentation

After reducing the data, the next step is to present the data. In qualitative research, data presentation can be done in the form of tables, graphs, *flowcharts*, *pictograms* and the like. Through the presentation of this data, data can be organized and arranged in a relationship pattern, so that it will be easy to understand

The final step in analyzing qualitative research is to conclude. According to Sugiyono (2018:252-253), conclusions in qualitative research can answer the formulation of the problem posed from the beginning, but they may also not, because, as has been stated, problems and problem formulation in qualitative research are still temporary and will evolve after the research is conducted in the field. Conclusions in qualitative research are new findings that had never existed before. Findings can be in the form of a description or description of an object that was previously unclear, so that after research, it becomes clear.

DISCUSSION

Overview of Research Locations

This research was conducted during the author's sailing practice at MT. Ratu Zainab for approximately 12 months, starting from August 2023 to February 2024. This ship is one of the company's fleets, PT. Barokah Perkasa Group.



Figure 11 MT. Ratu Zainab Source: Documentation 2024

The ship with GT 3239 and the Cummins 2x1200HP main engine features a 4-stroke, 12-cylinder engine. This ship was made in Samarinda in 2021, which contains oil and operates in the Indonesian part of Kalimantan (Balikpapan-Banjarmasin). The following is data from the MT ship. Queen Zainab.

Name of Ship: MT.RATUZAINAB

Call Sign/IMO No : YDLF2 / 9934656

Flag : Indonesia

Place of Built : Samarinda

Made at the Shipyard: PT. Dock Barokah Perkasa Group

Type of ship: Oil Tanker

G.R.T 3239

N.R.T 1617

D.W.T 6089

L.O.A: 89.75 meters

L.B.P : 84.25 meters

Length Everywhere: 89.75 Meters

Length BP: 84.25 meters

Breadth: 21.95 Meters

Depth : 6.10 Meters

Type Engine Propulsion : CUMMINS KTA 38-M2

Type to Engine : Deutz WP6CD120.16

Output Engine Propulsion : 2 x 1200 HP 1800 RPM

Output Engine Aux : 2 x 90 kw 1500 RPM



Figure 12 Ship Particular. Source: Documentation 2024

In this applied scientific paper, the author will provide an overview of the research objectives carried out during the practice of sailing in MT. Ratu Zainab, under the title of the applied scientific paper taken by the author, namely "**Preventive Maintenance Cooling System On The Main Engine On The Mt. Ratu Zainab**". So that with the description of the general description of the object of this research, the reader can understand what happened to the author when carrying out the practice of sailing in MT. Ratu Zainab.

DISCUSSION

Data presentation

Observation

On August 15, 2024, at 16:30, while the ship was sailing from Balikpapan to Banjarmasin, the writer was carrying out a guard service alongside the driver II. When checking the engine room, the writer got the exhaust gas temperature. On each cylinder, the pressure rises above the standard limit. Immediately, the writer reported to the driver who was on guard. After the maintenance driver conducted a more in-depth check, it was discovered that the temperature of the fresh water cooler for the main engine had also reached a high level.

On January 17, 2024, when the ship had anchored in Banjarmasin, the KKM immediately

ordered repairs and *maintenance* of the *fresh water cooler*. After the *freshwater cooler* was opened, it turned out that *the tube* on the *freshwater cooler* was filled with dirt.

Interview

Cadet: Good evening, Chief. Please allow me to ask for time for an interview.

KKM: Tonight, okay, what would you like to ask?

Cadet: What bus permit causes the cooling temperature of the main engine on this ship to work suboptimally?

KKM: The Treatment of the cooler that is not properly maintained will make it easier for corrosion to occur on the cooler plate. The impact of corrosion on the cooler plate causes fresh water and seawater to work not optimally

Cadet: In addition to the factors that have been explained, are there other factors that affect the performance of the central engine cooling system

KKM: Environmental factors also influence the performance of the central engine cooling system. With this ship's shipping route entering the river area, the potential for garbage entering the cooling system increases, which can cause problems for the freshwater cooler if the garbage clogs. The impact will be an instability in the temperature of the cooling water, which will affect the performance of the central engine cooling system.

Cadet: What efforts are we making to overcome this problem? KKM: With supervision and maintenance of each component of the central engine cooling system, it will avoid damage that causes the main engine to work suboptimally. Cleaning on cooler plates and strainers. Check the sea chest to ensure the faucet's entrance and exit are open, and inspect the pipe for signs of leakage.

Cadet: Alright, chief, thank you for your time. Please allow the chief of KKM to return:

Okay, det

Documentation

Taking documentation in the form of photos as a backup when the author carried out the research. The following are the results of the documentation obtained by the author from observations and interviews:

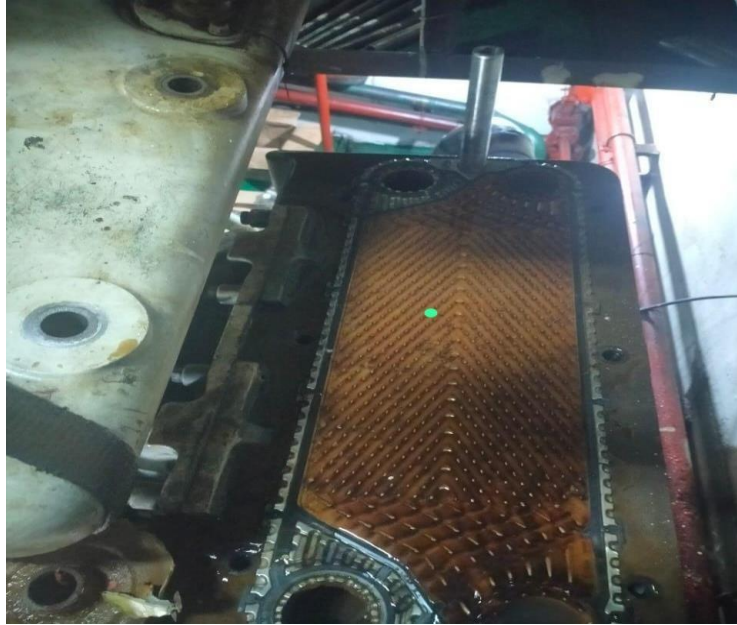


Figure 13 Dirty Plate Cooler on Feeder. Source: Personal documentation



Figure 14: Dirt Accumulating in the Master Machine Strainer. Source: Personal documentation

CONCLUSION

The large amount of impurities that enter with seawater into the freshwater cooler will inhibit the flow of seawater that enters the cooler as a cooling medium, thereby reducing the cooling effect on the freshwater. In this case, of course, it will result in the freshwater cooling temperature from the freshwater cooler that will enter the main engine not being as desired. The large amount of dirt on the freshwater cooler plate can be caused by the seawater filter not working properly to filter the impurities that come with the seawater.

In the picture above, it can be seen that the cause of the non-optimal cooling system on the main engine is due to the presence of dirt or mud that accumulates on the strainer of the main engine so that the seawater cooling system that enters the main engine is carried away by dirt and causes the cooler to be clogged due to dirt entering the main engine. If left unchecked, this can damage the components moving in the engine because of the lack of seawater entering the main engine to cool the intercooler, which is not optimal; therefore, maintenance must be carried out immediately.

BIBLIOGRAPHY

- Ahmad, A. S., & Sudarmanta, B. (2017). *Experimental Study of Dual Fuel System Diesel Engine Performance with Injection Pressure Variation in Yanmar TF 55R-Di Engine Injector*. ITS Engineering Journal, 4(1).
- Eko, R. (2019). *Maintenance and repair of freshwater cooling systems on the main engine on motor boats*. Mahkota Nusanta. Paper.
- Lestari, R. E., & Abadi, A. M. (2015). *Fuzzy Logic application on air cooler settings for rooms*. In *National Seminar on Mathematics and Mathematics Education UNY* (Vol. 27, pp. 367-374).
- Luthfiani, F., Nugraha, I. M. A., & Ilham, M. (2022). *Preventive Maintenance on the main engine cooling system on the Arimby motor sailing ship*. Journal of Megaptera, 1(1), 33-38.
- Mustain, I., & Abdullah, U. (2020). *Pressure Drop on Seawater Pump on Ship Engine Engine*. Maritime Echo Scientific Magazine, 22(1), 27-33.
- Nurhaya, F. A., & Astuti, E. S. (2016). *Pltd diesel engine damage detection expert system uses the forward chaining method*. Journal of Polynesian Informatics, 2(2), 81-81.
- Ozi, A. (2019). *Optimization of cooling water treatment on the main engine to prevent damage*

- to the MT ship. Buana Mas PERSADA PT. Indomas Bahari Makmur. Paper.*
- Pratama, A. A., Astriawati, N., Waluyo, P. S., & Wahyudiyana, R. (2022). *Optimization of the maintenance of the main engine cooling system on the MV ship. Rainbow Santara 101*. *Jogja Maritime Scientific Magazine*, 20(1), 1-11.
- Pratama, A. (2023). *Analysis of cooling system failures on passenger ships. Journal of Marine Engineering*, 15(2), 78-92.
- Ritonga, H. S., Nisa, A. F., & Khosiyono, B. H. C. (2021). *Implementation of the Integrated Islamic Elementary School Curriculum*. In *Proceedings of the National Seminar on Language, Literature, Arts, and Basic Education (SENSASEDA)* (Vol. 1, pp. 85-90).
- Salim, S. (2017). *The Role of the Sea Chest in Ship Operations*. *Jogja Maritime Scientific Magazine*, 15(25), 43-56.
- SAKATI, A. W. (2022). *Analysis of the performance of the freshwater cooling system to maintain the cooling temperature of the main engine in MT*. *Asian Gas 2 (Doctoral dissertation, Jakarta College of Shipping Sciences)*.
- Sroyer, D. W., Abrori, M. Z. L., & Sidhi, S. D. (2019). *Fresh Water Cooler Maintenance on the Cooling System of Diesel Engine Driving Electric Generators on Navigation Ships belonging to the Class I Ambon Navigation District*. *Aurelia Journal*, 1(1), 1-11.
- Sulistyo, B. (2022). *Preventive maintenance management for ship engine systems. Journal of Industrial and Logistics Management*, 6(1), 45-60
- Taufan, D. S. (2021). *Maintenance of the Mitsubishi 4D31 KMN Main Engine Cooling System*. *Kartika UPP Class III Juwana*. Paper.
- Wibowo, W., & Astriawati, N. (2021). *The closed cooling system on the MAK 8M32 diesel type diesel engine is the main drive of the LIT ENTERPRISE motor ship*. *Journal of Polymers*, 19(1), 28-34.
- Winarto, S. (2016). *Pump Energy Optimization*. *Swara Patra: Scientific Magazine of PPSDM Migas*, 6(2).
- Yando, M., Kusumaningrum, S., & Akbara, N. R. (2021). *Analysis of the Effect of Seawater Cooling Pump Pressure on MV Main Engine Fresh Water Cooler*. *Ibrahim Zahier. Meteor STIP Marunda*, 14(1), 69-77.
- Ziliwu, B. W., & Tumpu, M. (2020). *Maintenance and Repair of Engine Cooling System on Fishing Boats*. *Accelerator: Journal of Applied Science and Technology*, 1(2), 11-19.