X SHIP COOLING SYSTEM FAILURE ANALYSIS

Shahrin Febrian[1], Aldyn Clinton Partahi Oloan[2]
[1,2]Marine Technology Faculty, Ship System Engineering Majors,
University of Darma Persada

email: shahrin_febrian@ftk.unsada.ac.id, aldyncibitik@yahoo.com ,

ABSTRACT

Indonesia as an archipelagic country has 17,100 islands which are bordered by waters. Because of the vast territorial waters of Indonesia, this country needs many ships as a means of transportation and means to support Indonesia's abundant marine products and massive inter-island transportation. For that PT. DKB builds an X Double Engine type ship equipped with a RAS (Replenishment at Sea) system, which is a ship to help transfer fuel at sea. However, the engine has not functioned optimally due to excessive engine heat, which is the heat released by the engine so that the efficiency of the ship's engine decreases. The heat of the engine is probably caused by a problem with the cooler that is not able to serve the needs of the main engine. For this reason, it is necessary to re-examine this matter so that the engine performance is optimal.

Keywords: *Ship, Heat, Cooler, Engine, Efficiency*

1. Introduction

The boat mounted engines are designed to run with maximum efficiency and run for hours on end. The most frequent and maximum loss of energy from the engine is in the form of heat energy. to eliminate excessive heat energy must use a cooling medium (Cooler) to avoid engine functional disturbances or damage to the engine. For this purpose, a cooling water system is installed on the ship.

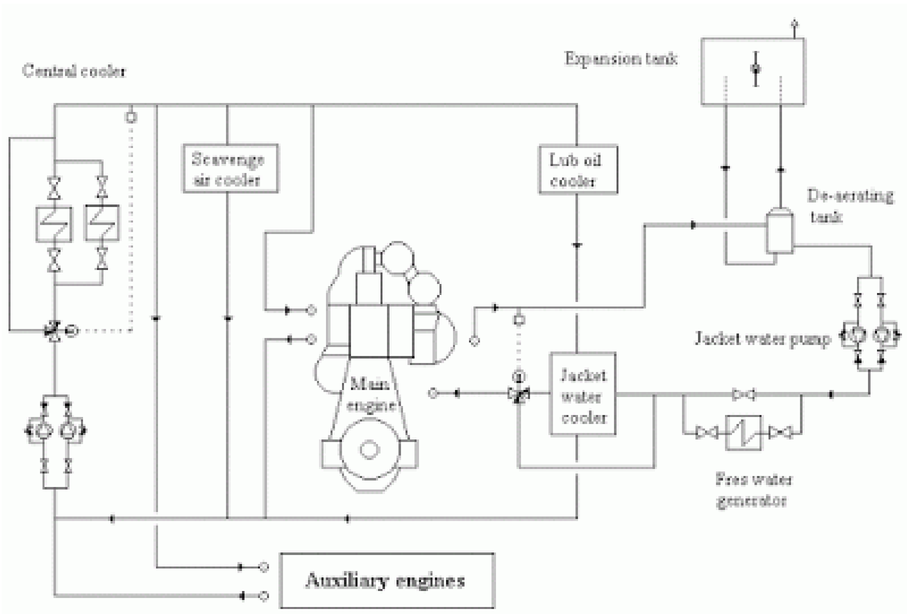

Fig 1. Main Cooling System

This system consists of three different circuits:

1. Seawater System: Seawater is used as a cooling medium in large ocean water cooling heat exchangers which can cool fresh water from a closed circuit. They constitute the main cooling system and are generally installed in the coupling.
2. Low temperature system: The low temperature circuit is used for the low engine temperature region and this circuit is directly connected to the main seawater in the central cooler; hence low temperature compared to high temperature (HT circuit). The LT series includes of all auxiliary systems
3. High Temperature Circuit (HT): The HT circuit mainly includes from the water tube system in the main engine where the temperature is quite high. The temperature of the HT water is maintained by low temperature fresh water following an Expansion Tank which compensates for losses in the closed circuit of fresh water by absorbing the pressure increase due to thermal expansion.

2. METHODOLOGY

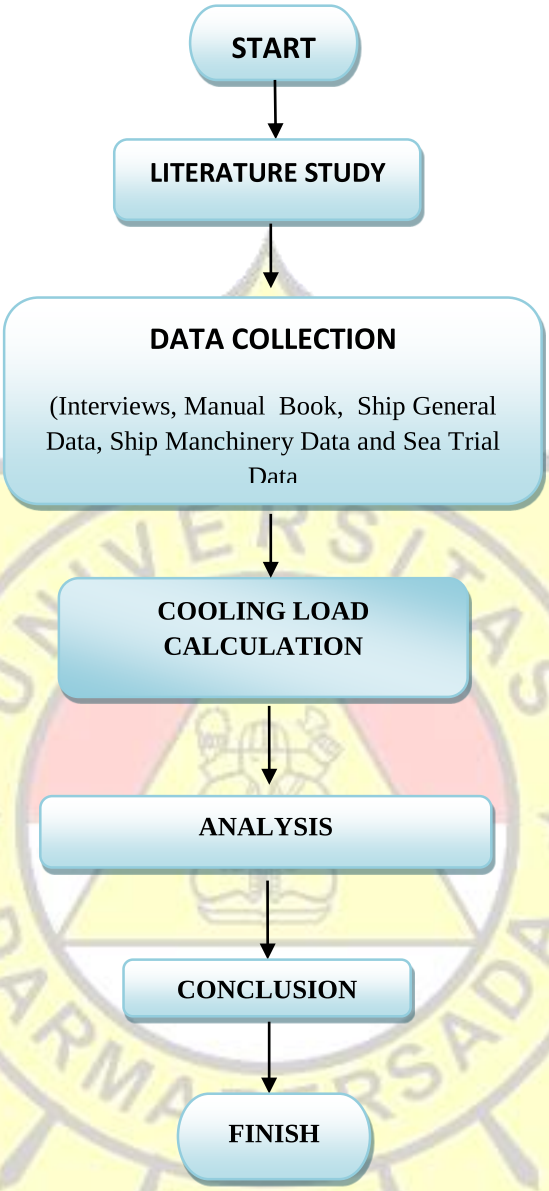

Fig 2. Methodology

3. ANALYSIS

At first ship X was ordered with a speed of 18 knots but after the Sea Trial test it was found that the maximum speed of the ship was only 17 knots this was due to the heat of the Main Engine so that the rotation of the propeller could not produce maximum rotation, and the heat of the main engine was known to be due to insufficient cooler capacity. And must be added in order to cool the Main Engine. The inlet and outlet temperatures for fresh water measured from the main engine are 56.45 ^{o}C and 38.38 ^{o}C, while the inlet and outlite temperatures of the fresh water cooler are 50.60 ^{o}C and 38 ^{o}C. Then the sea water, inlet and outlite temperatures measured on the machine are

32 ^oC and 45 ^oC while the planned inlet and outlite sea water temperatures on the cooler are 32 ^oC and 40.96 ^oC. From this description, it can be seen that the capacity of the cooler is indeed lacking and must be increased in order to cool the main engine and obtain the desired speed. After examining ship X, it can be seen that the ship's speed cannot reach the maximum speed, this is due to a lack of cooling capacity, causing the engine to heat up so that the ship's speed cannot be met.

The following are calculations performed to increase the capacity of the cooler: In the Cooler data, it is known that the Mass Flow in Fresh Water is 138488 kg/h while at Sea Water is 205448 kg/h, and after measurements are made when ship X is operating:

1. Mass Flow
   a. *Fresh Water (FW)* = 138488 kg/h =138,488 m^3/h

During Inspection: Low Temperature (LT) Pump Capacity in the field 140 m3/h
Then it can be concluded that there is no problem in the flow of the Fresh Water (FW) Pump

   b. *Sea Water (SW)* = 205448 kg/h = 205,448 m^3/h

At the time of inspection: Sea water Cooling pump capacity in the field 200 m3/h
Then it can be concluded that there is no problem in the flow of *Sea Water (SW) Cooling pump*.

2. Heat Balance According to the machine manufacturer's recommendation

To calculate the Heat Balance formula, the formula obtained in the book is used: *The Theory Behind Heat Transfer* dari *Alfa Laval Plate Heat Exchanger (page 8).*

T1 *Inlet FW* = 56,5 ^oC
T2 *Outlet FW* = 41 ^oC
T3 *Inlet SW* = 32 ^oC
T4 *Outlet SW* = 46 ^oC

Δ Ta = T1 – T4
= 56,5 ^oC – 46 ^oC
= 10,5 ^oC

ΔTb = T2 – T3
= 41 ^oC – 32 ^oC
= 9 ^oC

$$LMTD = \frac{\Delta Ta - \Delta Tb}{\ln \frac{\Delta Ta}{\Delta Tb}}$$

$$LMTD = \frac{10{,}5 - 9}{\ln \frac{10{,}5}{9}}$$

LMTD = 9,734

3. Calculation of the required area of the cooler capacity

To calculate the area of the cooler capacity area, the formula contained in the book can be used: *The Theory Behind Heat Transfer* dari *Alfa Laval Plate Heat Exchanger (page 9).*

P = K x A x LMTD
Noted : The capacity of the tool is known from the cooler per unit

$$Ln = \frac{P}{AxLMTD}$$

$$Ln = \frac{2020\ kw}{34{,}77\ m^2\ x\ 7{,}68\ ^oK}$$

Ln = 7,56 kw/m^2 ^{o}K

Then for the needs that must be added are:
2020 = 7,56 x A x 9,734

$$A = \frac{2020}{7{,}56x(9{,}734 - 7{,}68)}$$

A = 130 m^2
P = 7,56 kw/m^{2o}C x A x 9,734
P = 2558,7 kw

$$A = \frac{2558{,}7}{7{,}56x7{,}68}$$

A = 44,07 m^2

Lack of cooling area :
= 44,07 – 34,77 = 9,3 m^2 (Need to add 27.75% of cooler capacity)

4. Main Engine LT Cooler Inspection (Portside)
During *Sea Trial (Portside)*:

This check is carried out on the left side of the engine on the low temperature capacity when the ship is doing the Sea Trial test. The following are calculations performed to increase cooler capacity:

- *Mass Flow*: no problem found
- *Heat Balance*: according to the recommendation of the machine maker

T1 *Inlet FW* = 31,8 ^{o}C
T2 *Outlet FW* = 31,1 ^{o}C
T3 *Inlet SW* = 30,3 ^{o}C
T4 *Outlet SW* = 31,6 ^{o}C
Δ Ta = T1 – T4
= 31,8 ^{o}C – 31,6 ^{o}C
= 0,2 ^{o}C
ΔTb = T2 – T3
= 31,1 ^{o}C – 30,3 ^{o}C
= 0,8 ^{o}C

In the same way as above, we get a shortage of Cooling Area:
= 1,96 – 34,77 = - 32,81 m^2 (the area of the cooler capacity must be increased)

5. Main Engine LT Cooler Mesin Inspection (Starboard)
During *Sea Trial (Starboard)*:

This check is carried out on the right side of the engine on the low temperature capacity when the ship is conducting the Sea Trial test. The following are calculations performed to increase cooler capacity:

- *Mass Flow* : no problem found
- Heat Balance: according to the recommendation of the machine maker

T1 *Inlet FW* = 32,3 ^oC
T2 *Outlet FW* = 31,6 ^oC
T3 *Inlet SW* = 30,1 ^oC
T4 *Outlet SW* = 31,9 ^oC
Δ Ta = T1 – T4
= 32,3 ^oC – 31,9 ^oC
= 0,4 ^oC
ΔTb = T2 – T3
= 31,6 ^oC – 30,1 ^oC
= 1,5 ^oC

In the same way as above, the shortage of Cooling Area is obtained:
= 3,79 – 34,77 = - 30,98 m^2 (the area of the cooler capacity must be increased)

4. CONCLUSION

1. During the Sea Trial test (portside) the capacity of the cooler area needs to be increased by 32.81 m^2 from the previous area of 34.77 m^2 to 67.58 m^2 so that cooler needs can be met
2. During the Sea Trial (Starboard) test, the cooler area capacity needs to be increased by 30.98 m^2 from the previous area of 34.77 m^2 to 65.75 m^2 so that cooler needs can be met.

REFERENCES

1. Alfa Laval Plate, ***Heat Exchanger,The Theory Behind Heat Transfer***.
2. Anonim, *2010,* ***Pembagian Heat Exchanger Berdasarkan bentuk konstruksinya***
3. Anonim, 2012, ***Jenis – jenis alat penukar panas dan tipe aliran Heat Exchanger (HE)***.
4. Djunaidi, 2009, ***Pemeliharaan tube – side penuh kala Rsg – Gas jangka pendek dan jangka panjang****,* Pusat Reaktor serba guna – BATAN. Kawasan puspitek Serpong Tanggerang : Banten.
5. Frank Kreith, Mark, S Bohn,1986, ***Principle of Heat Transfer, 4 th edition****,* Harper collins publishers, New York, ISBN 0-06-043785-5.
6. GEA Heat Exchanger. ***Operating instructions Gasked plate heat exchangers***, Version : 1.6,01-10.2014.
7. F.P Incopera, D.P Dewitt*, 2007,* ***Fundamentals of Heat and Mass transfer, 6 th edition***, John wiley & sons.
8. J.P Holman, 1992, ***Heat Transfer, 10 th edition****, Mc Graw Hill co Singapore.*, ISBN 0-07-112644-0.
9. Marangtu, Stevano Victor, 2011, ***Bagian Dasar-dasar perpindahan panas***,
10. Maysitoh, Zuhrina ST, M.Sc dan Bode Haryanto ST, MT, 2006, ***Perpindahan panas***, (Online. Fakultas Teknik Universitas Medan. Sumatra).
11. Navy Tactics, 2009, ***Techniques, And Procedures*****,** ***Underway Replenishment NTTP 4-01.4. Edition March****.*
12. Rahmi, Ike yulia, 2011, ***Alat Penukar Panas (Heat Exchanger)***

13. Saryanto, H, 2002, ***Perpindahan panas****, Model Bahan Ajar : Teknik Mesin – Universitas Mercu Buana*. Jakarta
14. Yunus A Cengel, 2006, ***Heat and Mass Transfer (SI Units), A Practical Approach, 3rd Edition****.*