THE EFFECT OF WORKING HOURS OF THE SHIP'S MAIN ENGINE ON THE TEMPERATURE OF THE FRESH WATER CYLINDER COOLING SYSTEM DIESEL ENGINES

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Abstract

Temperature stability is a critical factor in maintaining the performance of diesel-powered main engines on merchant vessels. The freshwater cooling system of the cylinders plays an essential role in sustaining the required operating temperature. This study aims to analyze temperature variations in the cylinder cooling system of a diesel engine based on different working hours as a basis for determining maintenance requirements. Measurements were conducted on a container ship operating on an inter-island route for 48 hours through the Makassar Strait, with seawater temperature maintained at 29°C. The results show that the cylinder freshwater outlet temperature remained stable between 00:00–16:00, increased during 16:00–20:00, and decreased again during 20:00–24:00. Additionally, cylinder number 7 exhibited a higher temperature compared to the other cylinders. In conclusion, variations in working hours affect the temperature fluctuations of the cooling system, and cylinder number 7 requires further inspection and maintenance to prevent potential damage and maintain optimal main engine performance.

Keywords: *main engine, cooling system, cylinder*

Introduction

As an archipelago nation, Indonesia's logistical and inter-island connectivity heavily relies on maritime transportation, utilizing commercial vessels such as cargo ships, tankers, container ships, and passenger ships (Suswati, Aliudin and Rochanda, 2019; Sutini, 2021; Heni Dwi Iryanti, Wawo and Purnomo, 2025). The main engine (ME) serves as the primary propulsion system responsible for driving the propeller, allowing the vessel to operate efficiently and reach its intended destination. Although several types of engines are available—such as turbines and gasoline engines the diesel engine remains the most widely used in the marine industry, commonly employed in both two-stroke and four-stroke configurations (Na and Hipertensiva, no date; He *et al.*, 2022; Duong *et al.*, 2025). The diesel engine functions as an internal combustion engine in which air is highly compressed within the cylinder, raising its temperature to the point that injected fuel undergoes spontaneous ignition, thereby generating a power stroke that drives the piston (' Kowalski, 2016; Ding, Sui and Li, 2018; Muše *et al.*, 2020).

The continuous and rapid combustion process inherently produces high thermal loads, which, if uncontrolled, can lead to overheating, accelerated wear, and damage to engine components (Zhang *et al.*, 2021; Luo *et al.*, 2024; Lebedevas and Milašius, 2025). Therefore, a robust cooling system is crucial for temperature regulation; this system is typically comprised of two circuits: the seawater cooling system and the freshwater cooling system. Both systems are vulnerable to operational failures that can interrupt the engine's continuous operation during voyages, making routine maintenance mandatory for sustaining normal ship performance (MARINE, 2017; Nugraha and Tiwana, 2021; Ojo, Ujile and Nkoi, 2022; Siahaan *et al.*, 2025). A key indicator of proper cooling system function is the stable temperature of the cylinder coolant, and among the various factors influencing coolant temperature fluctuations, engine operating hours are considered a significant variable. Building upon the premise that the main engine cooling system is crucial for preventing overheating and ensuring the safe operation of merchant vessels, the focus of this study shifts toward an in-depth analysis of engine working hours as a key variable influencing the rise and instability of cylinder cooling water temperature. While faults and maintenance issues within both the seawater and freshwater cooling systems are commonly studied, the novelty of this research lies in its specific effort to identify and model the correlation between the accumulated operational hours of the main engine and cooling temperature fluctuations in order to formulate a more accurate and efficient predictive maintenance strategy, moving beyond conventional routine maintenance schedules.

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Methodology

Penulisan Persamaan

Data Collection

This study employed a quantitative data collection method. Quantitive data, , involves data collected in the form of numerical values. These numerical data were obtained through direct observation of the main engine, specifically recording the coolant temperature of each cylinder as indicated on the cylinder coolant thermometers.

Research Location

The research was conducted aboard an inter-island container vessel with a Gross Tonnage (GT) of 35,901. Data collection spanned a continuous period of 48 hours (two 24-hour cycles), with readings taken from 00:00 to 24:00. The study was executed across two distinct voyages: The first leg was across the Java Sea, from Tanjung Perak Port (Surabaya) to Balikpapan. The second leg was across the Makassar Strait, from Balikpapan, East Kalimantan, to Bitung Port, North Sulawesi KM Citra Spil.

Research Object: Main Engine

Data concerning engine operating hours and the temperature of each individual cylinder were recorded in the engine room during watch duty and subsequently documented in the engine log book. The research object was the vessel's main engine, a four-stroke diesel engine of the Man B & W type, rated at 31,990 kW. The main engine specifications can be visualized in the figure 1.

Figure 1. Main Engine B&W 31990 KW

Cylinder Freshwater Cooling System

The research was carried out by measuring the temperature in the main engine's cylinder freshwater cooling system for each individual cylinder. The vessel's cooling arrangement consists of two interconnected circuits: a freshwater cooling system and a seawater cooling system, which operate together to maintain optimal engine temperature during operation (Miller *et al.*, 2024; Xu, Lin and Ye, 2024). In this setup, the freshwater cools the engine components before the heated freshwater is, in turn, cooled by the seawater within a dedicated cooler (heat exchanger). The schematic diagram illustrating the cylinder freshwater cooling system is presented below.:

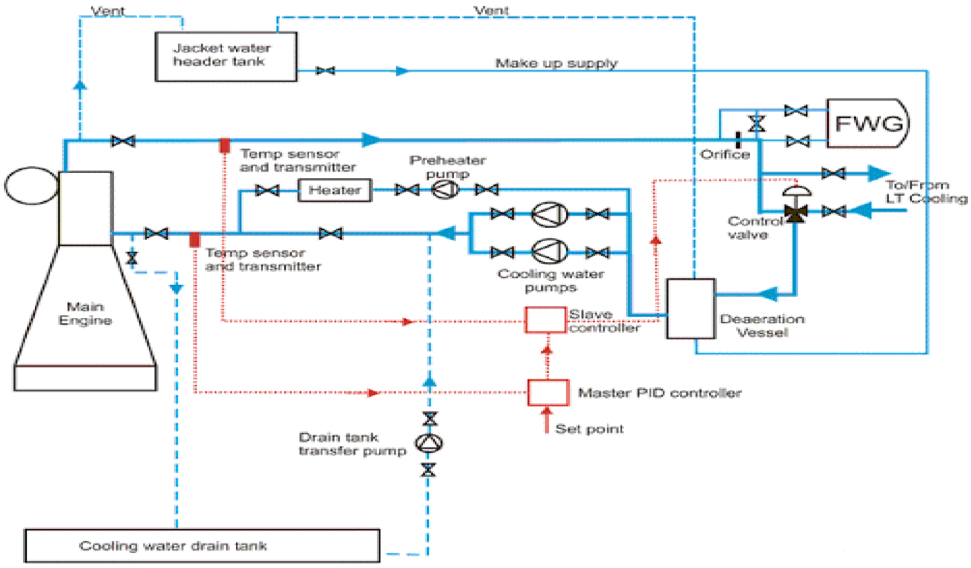

figure 2. fresh water jacket cooling Main Engine (Rosa-Clot and Tina, 2020)

Results and Discussion

Seawater Temperature Analysis

The seawater temperature serves as the ultimate heat sink for the entire cooling system. Table 1 presents the seawater temperatures recorded during the 48-hour observation period across the two voyage legs.

Table 1. Seawater Temperature During the Voyage

Time Interval (Operating Hours)	Java Sea Temperature (°C)	Makassar Strait Temperature °C)
00.00 - 04.00	28	29
04.00 - 08.00	28	29
08.00 – 12.00	29	29
12.00 – 16.00	29	29
16.00 – 20.00	29	29
20.00 – 24.00	29	29

The data in Table 1 reveals that the average seawater temperature used to cool the freshwater in the heat exchanger (cooler) remained remarkably constant at approximately 29°C throughout the 48-hour study period in both the Java Sea and the Makassar Strait. This constancy is likely due to the geographical proximity and interconnection of these maritime areas. The research was conducted in September, a period coinciding with the end of the transitional monsoon. As the sun traverses the equator during this period, wind patterns tend to be less predictable, but the massive thermal inertia of the sea results in stable surface temperatures. This stability confirms that the seawater cooling capacity was consistent, allowing any observed fluctuations in the freshwater system to be attributed primarily to internal engine dynamics or atmospheric factors rather than the primary cooling medium.cooling temperature every 4 hours workik entry to cylinder.

Cylinder Freshwater Inlet Temperature

The temperature of the freshwater entering the main engine cylinders (post-cooler) is controlled to ensure efficient operation. Table 2 presents the recorded inlet temperatures every four operating hours.

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Table 2. Freshwater Coolant Inlet Temperature to Cylinders

Time Interval (Operating Hours)	Java Sea Temperature (°C)	Makassar Strait Temperature (°C)
00.00 - 04.00	76	78
04.00 - 08.00	78	80
08.00 – 12.00	68	74
12.00 – 16.00	77	79
16.00 – 20.00	78	80
20.00 – 24.00	69	69

The inlet temperatures displayed a degree of variability, which is expected as the thermostatic control system works to maintain the set point. Notably, the highest inlet temperatures for both the Java Sea (78 ∘C) and the Makassar Strait (80∘C) occurred during the 16:00 – 20:00 work interval. Conversely, the temperatures dropped significantly during the 20:00 – 24:00 interval, reaching lows of 69∘C in both locations. This cyclic pattern is strongly correlated with the combination of increasing engine load during the active daytime/early evening shift (16:00 – 20:00) and the influence of the external environment. The peak temperature observed may be exacerbated by the warm atmospheric conditions of the late afternoon ("sea breeze" phenomenon), which affects the engine room environment. The subsequent sharp temperature decline (20:00 – 24:00) is likely due to the reduced ambient temperature of the evening and night ("land breeze" phenomenon), which enhances the efficiency of heat dissipation from the engine room, thereby reducing the thermal burden on the cooling system(Zhu *et al.*, 2023; Chen *et al.*, 2025).

Correlation Between Operating Hours and Cylinder Coolant Outlet Temperature

The sudden drop to 69∘C suggests that the thermostatic control valve may be over-correcting, allowing too much coolant to pass through the cooler, which warrants further investigation into the control system's response speed or sensitivity. The change in the freshwater coolant temperature exiting each cylinder of the main engine, relative to the variable operating hours, demonstrates a variable temperature condition. The temperature changes for each respective cylinder can be seen in the figure below:

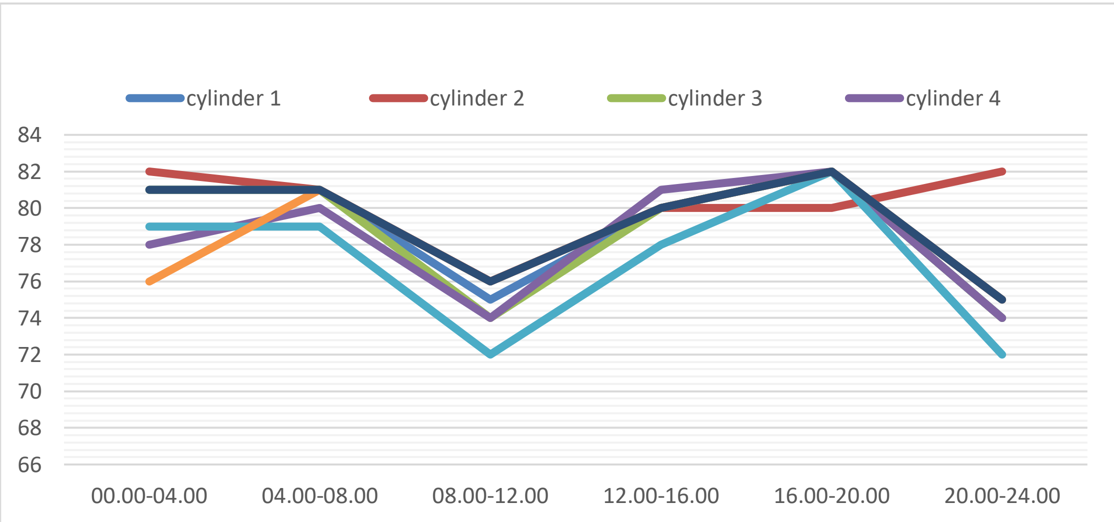

Figure 3 The temperature changes for each respective cylinder java sea

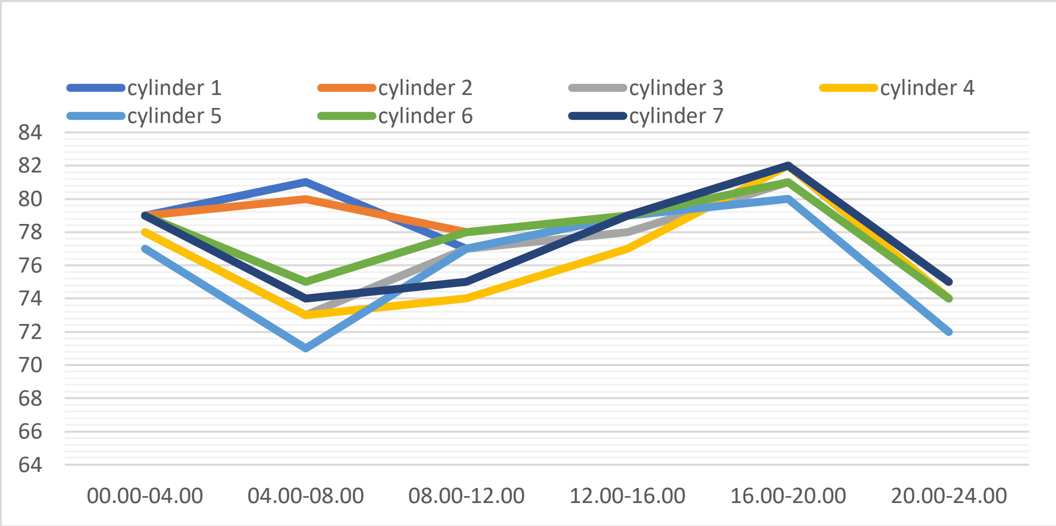

Figure 4. Variation in Cylinder Outlet Freshwater Coolant Temperature Against Operating Hours (Java Sea)

Conclusion and Recommendations

Based on the observations and analysis of the main engine's freshwater cylinder coolant temperature as influenced by engine operating hours, the following conclusions are drawn:

Conclusion

Seawater Temperature Stability: The seawater temperature across the Java Sea and the Makassar Strait remained constant at 29∘C throughout the 48-hour observation period. This stability confirms that the heat sink capacity of the seawater cooler was consistent and did not contribute to any significant fluctuation in the freshwater cooling system. Peak Inlet Temperature: The highest inlet temperature for the cylinder freshwater coolant was recorded during the 16:00–20:00 operating period, reaching a range of 78∘C to 80∘C. This peak is attributed to the combined effects of increasing engine load during the active shift and high ambient environmental temperatures caused by the late afternoon sun. Localized Thermal Anomaly (Cylinder No. 7): A critical finding was the persistently high outlet coolant temperature in Cylinder No. 7. This cylinder consistently showed a significantly higher temperature reading, particularly during the 16:00–20:00 period, peaking at 82∘ C in both the Java Sea and Makassar Strait voyages.Risk of Overheating: The recorded temperatures, with the cylinder outlet reaching 82∘ C, indicate that the engine is operating at or slightly above the standard thermal threshold for some components. If this condition persists, it will lead to reduced performance, accelerated wear, and potential mechanical damage to the main engine.

Recommendation

To mitigate the risk of severe damage and prevent further performance degradation, immediate and targeted maintenance of the freshwater cooling system is highly recommended, with a particular focus on: Cylinder No. 7 Inspection: Conducting a detailed inspection of the cooling jacket of Cylinder No. 7 to check for scaling, flow restriction, or combustion irregularities. System Calibration: Reviewing and recalibrating the thermostatic control valve to ensure a faster and more accurate response to the engine's fluctuating thermal load.

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