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Analysis of Jacket Cooling Cracks on Main Engine Performance Reduction

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Abstract**—** This study analyzes the performance reduction of a ship's main propulsion engine caused by cracks in the jacket cooling system. Efficient engine cooling is vital for maritime transport safety and operational efficiency, yet systems often face critical technical failures. Utilizing a qualitative descriptive case study design aboard the bulk carrier MV Sarah S, research data was gathered through observation, semi-structured interviews with engine officers, and logbook documentation. The results reveal an abnormal operating condition in cylinder No. 2, where coolant leakage through material hairline cracks led to a critical drop in jacket cooling pressure (from 3.5–4 bar down to 2–2.5 bar) and a significant surge in exhaust gas temperature to 590°C. Triangulation analysis identified poor cooling water quality (pH below the 8–10 standard) as the dominant root cause accelerating corrosion, material fatigue, and structural cracking. Consequently, heat dissipation failed, disrupting combustion and lowering engine efficiency. This study concludes that temporary corrective measures are insufficient. Sustained propulsion efficiency requires immediate structural repairs combined with rigorous water treatment management and strict adherence to the Planned Maintenance System (PMS).

*Keywords***—***Jacket Cooling System, Main Propulsion Engine, Material Cracking, Water Quality, Planned Maintenance System.*

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I. INTRODUCTION

Ships are a means of maritime transportation that play an important role in supporting distribution and mobility activities worldwide. Particularly in Indonesia, an archipelagic country consisting of thousands of islands, maritime transportation is essential to support economic growth and ensure the smooth movement of goods, both on a national and international scale [11]. Therefore, ships are considered one of the most effective and efficient modes of transportation in supporting development.

To support the smooth operation of maritime transportation, various types of ships are used, with sizes and specifications adjusted to water conditions and operational requirements. One of the main factors determining the success of ship operations is the performance of the main propulsion engine. This engine functions as the primary source of power, making its role vital in moving the ship [15]. Therefore, the main propulsion engine must be properly maintained to ensure it operates in accordance with operational demands Efforts to maintain engine reliability are carried out through planned and continuous maintenance based on the Instruction Manual Book, as well as in accordance with regulations established by the International Maritime Organization through the SOLAS 1974/1978 convention and the implementation of the ISM Code [3] [5].

The implementation of a Planned Maintenance System (PMS) aims to minimize the risk of damage so that ship operations can run safely and efficiently. The main propulsion engine is often referred to as the “heart” of the ship because it plays a crucial role in ensuring smooth voyages. Its performance directly affects ship speed, fuel efficiency, and navigation safety. In operation, a diesel engine produces mechanical energy through the combustion of fuel in the combustion chamber [11] [15]. This process generates high temperatures, making a cooling system necessary to maintain stable engine temperatures.

One of the cooling systems used is the jacket cooling system, which functions to absorb heat from the cylinder walls and other engine components by circulating coolant fluid. This system is essential for maintaining the engine’s operating temperature within normal limits and preventing overheating. This is

Furthermore, that “engine thermal management improves engine performance and reduces fuel consumption.” This indicates that controlling engine temperature has a significant impact on the performance and efficiency of the main propulsion engine [12]

In practical ship operations, the jacket cooling system is not free from various technical problems, one of which is the occurrence of cracks in cooling system components. These cracks can cause coolant leakage, pressure drops, and a decrease in the system’s ability to absorb heat. As a result, engine temperature increases and may disrupt the fuel combustion process [12].

Cracks in materials subjected to heat transfer can disrupt temperature distribution and accelerate material degradation [13. Leakage in cooling systems can lead to operational disruptions and economic losses due to suboptimal cooling performance [4].

If this condition is not addressed promptly, it can lead to further impacts such as increased component wear,

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reduced fuel efficiency, and even total engine failure. Therefore, an in-depth analysis is needed regarding the impact of cracks in the jacket cooling system on the decline in the performance of the main propulsion engine on board ships.

Based on the above explanation, the author is interested in raising this issue and compiling it into an applied scientific paper entitled: "Analysis of the Impact of Cracks in the Jacket Cooling System on the Decrease in Main Propulsion Engine Performance on Board Ships."

II. METHOD

This study employed a qualitative descriptive research design with a case study approach to analyze the impact of cracks in the jacket cooling system on the performance decline of the main propulsion engine on board ships. The qualitative approach was selected because this study aims to obtain an in-depth understanding of the cracking phenomenon in the cooling system and its impact based on actual operational conditions. This approach allows the researcher to explore the problem comprehensively, including technical, operational, maintenance, and crew experience aspects in handling cooling system failures [1] [6].

The research was conducted during the author's sea practice (PRALA) aboard MV Sarah S, a bulk carrier operating on national routes (Paiton – Morowali – Adang Bay – Muara Pantai – Bohonsuai), from July 11, 2024, to July 19, 2025. The research location focused on the engine room, particularly the jacket cooling system of the main propulsion engine. The object of the study was the cooling system unit of the Mitsubishi UE Diesel Engine type 6UEC50LS II, with emphasis on system condition, causes of cracking, and its impact on engine performance during ship operations.

The variables examined in this study consisted of cracks in the jacket cooling system as the independent variable and the performance of the main propulsion engine as the dependent variable. Supporting variables included cooling water pressure, cooling temperature, exhaust gas temperature, physical condition of system components, maintenance practices, and operational factors affecting engine performance.

This study used purposive sampling techniques by selecting respondents who were directly involved in the operation and maintenance of the engine system. The selected informants included the Chief Engineer, Second Engineer, and Third Engineer, as they possess technical knowledge and operational experience related to the cooling system and its associated problems.

Data were collected using multiple techniques through a triangulation method to ensure data validity and reliability. First, direct observation was conducted in the engine room to monitor the condition of the jacket cooling system, including pressure, temperature, component condition, and indications of cracks or leakage. Second, in-depth semi-structured interviews were carried out with the Chief Engineer and engine officers to obtain detailed information regarding the initial symptoms, causes of cracking, impacts on engine performance, and handling procedures. Third, documentation techniques were used to collect supporting data from engine log books, maintenance records, instruction manuals, and visual documentation of system conditions [1] [6]. In addition, relevant literature such as journals, books, and technical manuals was used to support the theoretical framework of the study.

The collected data were analyzed using descriptive qualitative analysis. The analysis process consisted of several stages: data reduction, data display, and conclusion drawing. Data reduction involved selecting, simplifying, and organizing raw data obtained from observations, interviews, and documentation [6]. Data display was carried out by presenting the data in the form of narrative descriptions, tables, and structured explanations to facilitate understanding of patterns and relationships. Finally, conclusions were drawn based on verified and consistent data, although initial conclusions remained open to revision if new supporting evidence was found.

The validity of the findings was strengthened through data triangulation by comparing and verifying data obtained from observations, interviews, and documentation [1] [6]. This approach ensured that the research findings accurately reflected actual conditions on board and provided reliable information regarding the causes of cracking in the jacket cooling system and its impact on the performance of the main propulsion engine, as well as appropriate maintenance and preventive measures.

III. RESULT AND DISCUSSION

This study was conducted aboard MV Sarah S, a bulk carrier operated by PT. Gurita Lintas Samudera. The object of the study was the jacket cooling system of the Mitsubishi 6UEC50LS II main propulsion engine, which experienced cracking during vessel operations.

Based on direct observations conducted during the research period, an abnormal operating condition was identified in the cooling system, particularly in cylinder No. 2. The initial indication of failure was a low-pressure alarm, followed by a decrease in cooling water pressure from the normal operating range of 3.5–4 bar to 2–2.5 bar. In addition, the volume of cooling water in the expansion tank decreased from 2.0 m^3 to 1.4 m^3, indicating leakage within the system. Table 1 presents the comparison of engine parameters under normal conditions and during the occurrence of cracking.

TABLE 1.
COMPARISON OF ENGINE PARAMETERS (CYLINDER NO. 2)

Parameter	Normal Condition	Condition During Crack	Remarks
Exhaust Gas Temperature	350–400°C	590°C	Abnormal
Jacket Cooling Pressure	3.5–4 bar	2–2.5 bar	Decreased
Scavenge Air Pressure	1.5–2 bar	1.3 bar	Decreased

Visual inspection confirmed the presence of coolant leakage from the *jacket cooling system*, caused by cracks in the cylinder jacket material. The leakage resulted in reduced system pressure and disrupted cooling circulation.

Further observation showed that the cooling water quality was poor, indicated by turbidity and sediment presence. The water did not meet the required standard pH range (8–10), suggesting inadequate water treatment. In addition, corrosion and material degradation were observed on the surface of the jacket, including rust formation, thinning material, and hairline cracks.

Initial corrective actions included adding cooling water and increasing monitoring frequency. However, these actions only provided temporary stability and did not eliminate the root cause of the problem. Permanent repair was planned during the docking period.

The interview results with the Chief Engineer, Second Engineer, and Third Engineer confirmed that poor cooling water quality, lack of routine maintenance, and aging of the engine were the primary factors contributing to the cracking. They also stated that insufficient monitoring of water quality and delayed maintenance accelerated material degradation.

The triangulation analysis identified several contributing factors grouped into four main categories:

1. Material – Corrosion and weakening of jacket material due to prolonged exposure to poor-quality cooling water.
2. Maintenance – Inadequate implementation of Planned Maintenance System (PMS), including lack of water treatment, flushing, and inspection.
3. Operation – Continuous engine operation under high temperature and pressure conditions.
4. Aging Factor – Long service life leading to material fatigue and reduced structural strength.

The analysis indicated that poor cooling water quality was the dominant root cause, which triggered corrosion and eventually led to cracking of the *jacket cooling system*.

The findings demonstrate that the cracking of the *jacket cooling system* was primarily caused by poor cooling water quality, which led to corrosion and gradual material degradation. This condition reduced the structural integrity of the cylinder jacket, making it unable to withstand operational pressure and temperature, ultimately resulting in cracks and leakage. The results also indicate that system failure cannot be resolved through temporary corrective actions alone, such as adding cooling water or increasing monitoring frequency [2] [8].

Although these measures helped maintain short-term stability, they did not address the underlying issue. The system performance only returns to optimal condition after eliminating the root cause, namely by repairing or replacing the damaged component and improving water quality management [7] 10] [14]. These findings are consistent with previous studies that highlight the importance of cooling water treatment in preventing corrosion and maintaining heat transfer efficiency.

Poor water quality can accelerate scale formation and corrosion, which reduces cooling effectiveness and leads to overheating. In this study, the increase in exhaust gas temperature to 590°C confirms that the cooling system failed to dissipate heat effectively [2] [9].

Another important finding relates to maintenance practices. The study revealed that routine inspections did not adequately cover water quality monitoring and internal system conditions. This reflects a gap in the implementation of the Planned Maintenance System (PMS) [5] [7] [14]. Preventive maintenance, including regular pH control, flushing, and water replacement, is essential to maintain system reliability and prevent unexpected failures.

From an operational perspective, the impact of cracking on engine performance is significant. The leakage of cooling water reduces pressure and circulation efficiency, leading to uneven temperature distribution and the formation of hot spots in certain cylinders. This condition decreases combustion efficiency, reduces engine power output, and may cause a drop in engine RPM and propulsion performance.

Furthermore, prolonged operation under such conditions increases the risk of secondary damage, including piston and liner damage, as well as lubrication system contamination. If not addressed promptly, these issues may lead to severe engine failure and operational disruption. However, this study has several limitations. The research was conducted on a single vessel (MV Sarah S) and focused on one engine type, which may limit the generalizability of the findings. In addition, the study primarily uses qualitative analysis, so quantitative relationships between variables such as temperature, pressure, and efficiency are not extensively explored.

Future research is recommended to include multiple vessels, apply quantitative measurement techniques, and investigate advanced monitoring systems to improve early detection of cooling system failures.

Overall, the findings emphasize the importance of proper cooling water management, systematic maintenance, and continuous monitoring to ensure the reliability and performance of marine engine cooling systems.

IV. CONCLUSION

This study concludes that the occurrence of cracks in the *jacket cooling system* of the main propulsion engine is primarily caused by poor cooling water quality, inadequate maintenance practices, and the aging of engine components. Cooling water that does not meet the required standards, particularly in terms of pH balance and cleanliness, accelerates corrosion within the cooling system.

Over time, this corrosion weakens the structural integrity of the jacket material, making it more susceptible to cracking. This condition is further aggravated by the lack of routine maintenance, such as infrequent water replacement, insufficient system cleaning, and irregular inspection, as well as the long service life of the engine, which reduces material strength and durability.

The impact of these cracks on engine performance is significant. Leakage of cooling water leads to a reduction in coolant volume and system pressure, resulting in inefficient heat absorption. Consequently, engine temperature increases and may lead to overheating conditions. This directly affects engine performance by reducing operational efficiency, disrupting combustion processes, and lowering overall engine output. If left unaddressed, the condition can cause further damage to critical engine components and increase the risk of complete engine failure. To address this issue, corrective actions must include immediate repair of cracked components through welding or replacement, along with thorough inspection to ensure the cooling system operates properly. Preventive measures are equally important and should focus on maintaining cooling water quality within the standard pH range of 8–10, conducting regular inspections every 1–2 weeks, performing periodic flushing and cleaning of the cooling system, and implementing the Planned Maintenance System consistently.

Additionally, continuous monitoring of engine temperature and timely replacement of aging components are necessary to sustain optimal engine performance.

The novelty of this study lies in its integrated analysis of technical, operational, and maintenance factors contributing to *jacket cooling system* failure under real shipboard conditions. By combining field observations, crew insights, and documentation data through triangulation, this research provides a comprehensive understanding of how cooling system degradation directly affects engine performance. The findings imply that improving water treatment management and strengthening preventive maintenance practices are essential strategies to enhance the reliability, efficiency, and safety of marine propulsion systems.

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