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Optimization of Fuel Oil Purifier Maintenance on Board MV. Lumoso Permai

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Abstract

The fuel oil purifier is a critical auxiliary equipment on board vessels, responsible for separating sediments, water, and sludge from fuel oil to ensure clean fuel supply for the main engine and auxiliary machinery. This study investigates the causes of fuel oil purifier malfunction on board MV. Lumoso Permai, a bulk carrier operated by PT. Lumoso Pratama Line, and proposes optimized maintenance strategies to prevent recurrence. During the author's sea practice period from September 2021 to September 2022, two primary operational problems were identified on the Mitsubishi SJ20T-60T type purifier. First, excessive fuel oil waste during the purification process was caused by the accumulation of sludge and contaminants on the bowl body and disc assembly, compounded by the selection of an incorrect gravity disc size. These conditions resulted in fuel overflow through the sludge port rather than discharge through the clean oil outlet. Second, the pilot valve malfunctioned due to worn O-rings and contaminant deposits obstructing the valve passages, preventing proper operating water flow for bowl opening and closing operations. The study employed a descriptive qualitative approach with data collected through direct observation, interviews with the Fourth Engineer, and documentation review. Analysis revealed that both problems were fundamentally attributable to inadequate adherence to the Planned Maintenance System (PMS) schedule and insufficient compliance with the manufacturer's instruction manual. The recommended corrective measures include implementing strict periodic bowl and disc cleaning schedules in accordance with the PMS, conducting routine pilot valve inspection and O-ring replacement, and ensuring proper gravity disc selection based on fuel specific gravity and operating temperature.

Keywords: *fuel oil purifier, maintenance optimization, bowl disc cleaning, pilot valve, planned maintenance system*

I. INTRODUCTION

In the operation of the main engine and various auxiliary machinery on board merchant vessels, fuel oil serves as the primary energy source for propulsion and power generation. Given the critical role of fuel oil in maintaining the normal operation of the vessel, it is essential to ensure that the fuel is maintained in a clean and contaminant-free condition. Impurities present in fuel oil, including water, sludge, sediment, and metallic particles, can cause accelerated wear, corrosion, and damage to fuel injection systems, cylinder liners, and piston rings if not adequately removed before combustion. The fuel oil purifier is the principal auxiliary equipment responsible for this purification process, operating on the principle of centrifugal separation to remove contaminants based on differences in specific gravity.

The fuel oil purifier functions by rotating a bowl assembly at high speed, typically between 1,500 and 1,900 RPM, generating centrifugal force that separates the heavier contaminants (water, sludge, and solid particles) from the lighter clean oil. The separated fuel is directed through the clean oil outlet to the daily service tank, while the accumulated sludge is periodically discharged through the sludge port during the automatic desludging cycle. The internal components of the purifier, including the disc stack, bowl body, gravity disc, distributor, main seal ring, and pilot valve, must be maintained in optimal condition to ensure effective separation performance.

During the author's sea practice period on board MV. Lumoso Permai, a 26,040 GRT bulk carrier owned by PT. Lumoso Pratama Line, the fuel oil purifier of type Mitsubishi SJ20T-60T experienced repeated malfunction incidents. On one occasion, the purifier alarm activated, indicating that the purified fuel oil was not being discharged through the normal outlet pipe but was instead overflowing through the sludge port, resulting in significant fuel waste. Subsequent investigation revealed elevated outlet pressure readings on the fuel oil purifier. On a separate occasion during a voyage to Bunati, the purifier experienced another malfunction, and a detailed inspection revealed that the pilot valve had ceased to function properly.

Based on these operational experiences, this research was conducted to identify and analyze the root causes of the fuel oil purifier malfunction and to propose optimized maintenance strategies that would prevent recurrence of similar problems. The study focuses on two primary research questions: (1) What causes the excessive fuel oil waste during the purification process? (2) What causes the pilot valve malfunction?

II. LITERATURE REVIEW

A. Fuel Oil Purifier: Definition and Operating Principle

According to Jackson and Morton (1977), a purifier is an auxiliary device used for the separation of two liquids with different specific gravities using centrifugal force. Rowa (2002) further defines the purifier as an auxiliary machine that separates oil from sludge and other contaminants based on centrifugal force generated by high-speed rotation. On board ships, the purifier plays an essential role in cleaning fuel oil from both liquid and solid contaminants (sludge) to prevent damage to the main engine and its components that would otherwise result from the use of contaminated fuel.

The purifier operates by introducing heated fuel oil into a rapidly spinning bowl assembly containing a stack of conical discs. The centrifugal force generated by the bowl rotation, which is significantly greater than gravitational force, drives the heavier contaminants (water, sludge, and solid particles) outward toward the bowl periphery, while the lighter clean oil migrates inward toward the central axis. The clean oil is collected and discharged through the oil outlet, while the accumulated sludge is periodically ejected through the sludge ports during the automated desludging cycle controlled by the operating water system.

B. Key Purifier Components and Functions

The internal components of the purifier include the disc stack, which retains and slows the fuel flow to enhance separation efficiency; the bowl hood, which houses the disc stack and serves as the primary separation chamber; the main seal ring, which provides the seal between the main cylinder and the bowl hood to prevent fuel leakage during operation; the distributor, which directs incoming contaminated fuel into the bowl and distributes it evenly across the disc stack through distributor holes; the main cylinder, which forms the inlet channel for contaminated fuel; and the gravity disc, which is a ring installed at the top of the bowl to control the position of the oil-water interface within the separation zone. External components include the gear pump for fuel supply, the electric motor for bowl rotation, the heater for fuel preheating, pressure gauges, thermometers, and the three-way solenoid and cylinder valves for operating water control.

C. Pilot Valve Function and Operating Water System

The pilot valve is a critical component that controls the flow of operating water into the bowl assembly. It manages two distinct water flows: the low-pressure operating water (closing water), which pushes the sliding bowl bottom upward to create a tight seal between the sliding bowl bottom and the bowl hood during normal purification operation; and the high-pressure opening water, which forces the sliding bowl bottom downward to open the sludge discharge ports for the desludging cycle, typically performed at maximum intervals of four hours. The pilot valve contains O-ring seals that are susceptible to wear from temperature exposure and contaminant ingress, and the valve passages can become obstructed by scale deposits and debris, leading to malfunction of the entire bowl opening and closing mechanism.

D. Maintenance Strategy Framework

According to Handoyo (2015), maintenance is the single most important factor in preserving the condition of equipment. The NSOS (2004) maintenance framework classifies maintenance strategies into two primary categories: incidental maintenance (allowing equipment to operate until failure) and planned maintenance. Planned maintenance is further divided into corrective maintenance (repair of anticipated failures) and preventive maintenance (actions taken to prevent failures or detect them early). Preventive maintenance encompasses both periodic maintenance, conducted at fixed intervals based on running hours or calendar time in accordance with the instruction manual, and condition-based maintenance, where intervention timing is determined through direct monitoring of equipment condition parameters.

III. RESEARCH METHOD

This research was conducted during the sea practice (Prala) period on board MV. Lumoso Permai from September 23, 2021, to September 23, 2022, a total duration of approximately 11 months. The vessel is a bulk carrier with an IMO number of 9106728, a gross tonnage of 26,040 tons, and a deadweight of 45,216 tons, built in 1994 and registered in Jakarta under Indonesian flag. The main engine is a Kobe Diesel Co. 6UEC52 LS, and the fuel oil purifier under investigation is a Mitsubishi SJ20T-60T type with a capacity of 3,050–3,150 liters per hour.

A. Data Collection Techniques

Data collection was performed using four techniques. Direct observation was conducted on the fuel oil purifier system during normal operation and malfunction incidents, with particular attention to the bowl and disc condition, pilot valve function, and outlet pressure readings. Interviews were conducted with the Fourth Engineer (Masinis IV) responsible for purifier operation and maintenance, using both structured and unstructured questioning techniques. A literature study was performed using the Mitsubishi Selfjector instruction manual book, relevant maritime engineering textbooks, and published maintenance management references. Documentation review included engine log books, monthly engine room reports, damage reports, and Planned Maintenance System (PMS) records.

B. Data Analysis Method

The collected data were analyzed using the descriptive qualitative method, where the author explains findings based on direct field experience and observation. The analysis focused on identifying the causal relationships between the observed symptoms (fuel waste and pilot valve malfunction) and their underlying root causes, then evaluating alternative corrective and preventive measures to determine the most effective maintenance optimization strategy.

Table 1. Fuel Oil Purifier Specification Data – MV. Lumoso Permai

Component / Parameter	Specification
Purifier Type	Mitsubishi SJ20T-60T (Selfjector Excellent Series)
Capacity	3,050 – 3,150 L/h
Bowl Speed	1,500 – 1,900 RPM
Main Engine	Kobe Diesel Co. 6UEC52 LS
Vessel Type / GRT	Bulk Carrier / 26,040 GT
Vessel DWT / LOA	45,216 Ton / 188.83 m

Source: Ship Particular and Instruction Manual Book, MV. Lumoso Permai

IV. RESULTS AND DISCUSSION

A. Excessive Fuel Oil Waste During Purification

During normal operation, the fuel oil purifier is designed to separate contaminants from the fuel oil and discharge clean fuel through the oil outlet pipe to the daily service tank. However, on board MV. Lumoso Permai, the purifier alarm activated on multiple occasions, indicating that purified fuel oil was not being discharged through the normal outlet but was instead overflowing through the sludge port. Investigation of the outlet pressure gauge confirmed abnormally elevated readings, confirming internal flow disruption within the purifier bowl assembly.

A comprehensive root cause analysis identified four contributing factors to the excessive fuel waste problem. First, the bowl body and disc stack were found to be heavily contaminated with accumulated sludge deposits. The contaminants contained in the fuel oil had adhered to the disc surfaces and were not being completely removed during the automatic desludging cycle. Over successive purification cycles, the residual sludge hardened and formed scale deposits on the bowl body and disc surfaces, progressively reducing the effective separation area and disrupting the normal flow pattern within the bowl. The resulting flow restriction caused increased resistance to fuel passage through the disc stack, leading to the elevated outlet pressure and overflow of fuel through the sludge port.

Second, the vertical shaft exhibited instability due to friction-induced wear and deformation. The excessive sludge accumulation created an unbalanced mass distribution within the bowl, inducing abnormal vibration that accelerated wear on the shaft surfaces and bearing interfaces. Third, the high contaminant content in the fuel oil exceeded the purifier's self-cleaning capacity between desludging intervals, causing progressive sludge buildup within the bowl. Fourth, the gravity disc selection was found to be inappropriate for the specific gravity and operating temperature of the fuel being processed, resulting in incorrect positioning of the oil-water interface within the separation zone, which compromised separation efficiency and contributed to fuel carryover into the sludge discharge.

B. Pilot Valve Malfunction

The pilot valve malfunction was identified as a separate but operationally significant problem that further compounded the purifier's performance degradation. The pilot valve controls the flow of operating water that actuates the bowl opening and closing mechanism. The investigation revealed that the O-ring seals within the pilot valve had become worn due to prolonged exposure to elevated temperatures and contact with contaminated operating water. The deteriorated O-rings allowed contaminants to enter the valve passages, where they accumulated and formed deposits that obstructed the normal water flow paths.

The pilot valve malfunction had a direct impact on the purification process through its effect on the operating water system. Under normal conditions, the pilot valve manages three critical phases of the operating water cycle: the closing water phase, where low-pressure water pushes the main cylinder upward to seal the bowl by pressing the main seal ring together; the sealing water phase, which provides flushing and establishes the interface; and the opening water phase, where high-pressure water opens the pilot valve to release the closing water, allowing the main cylinder to move downward under the pressure of the liquid inside the bowl, thereby opening the sludge discharge ports. When the pilot valve failed to function properly, the closing water flow was insufficient to achieve a complete seal between the bowl hood and the sliding bowl bottom, resulting in the loss of sealing water and the uncontrolled discharge of fuel oil into the sludge tank.

C. Maintenance Optimization Strategy

The analysis of both problems revealed a common underlying cause: inadequate implementation of the Planned Maintenance System (PMS) and insufficient adherence to the manufacturer's instruction manual for scheduled maintenance activities. The evaluation of alternative corrective measures led to the following optimized maintenance strategy.

For the fuel waste problem, the most effective corrective measure was identified as the implementation of strict periodic cleaning schedules for the purifier bowl and disc assembly in accordance with the PMS. This involves systematic disassembly and thorough cleaning of all internal components, including the bowl body, disc stack, gravity disc, and distributor, at intervals specified in the instruction manual. Additionally, proper gravity disc selection must be verified each time the fuel specification changes, taking into account the specific gravity, separation temperature, and feed rate parameters as specified by the manufacturer. Regular filter inspection and cleaning within the purifier fuel supply system was also recommended as a supplementary preventive measure.

For the pilot valve malfunction, the recommended corrective action involved complete disassembly and inspection of the pilot valve assembly, including all internal components and O-ring seals. All worn or cracked O-rings must be replaced as a complete set rather than individually to ensure uniform sealing performance. The pilot valve and its passages must be thoroughly cleaned to remove all scale deposits and contaminant accumulations. Subsequent preventive maintenance should include periodic pilot valve inspection and O-ring replacement at intervals prescribed in the instruction manual, with particular attention to maintaining proper operating water quality and temperature to minimize accelerated O-ring degradation.

V. CONCLUSION

Based on the analysis and discussion presented in this study, the following conclusions are drawn regarding the optimization of fuel oil purifier maintenance on board MV. Lumoso Permai.

The excessive fuel oil waste during the purification process was caused by the accumulation of sludge deposits on the bowl body and disc assembly, unstable vertical shaft operation due to unbalanced sludge loading, excessive contaminant content in the fuel oil, and the selection of an incorrect gravity disc size that was incompatible with the fuel's specific gravity and operating temperature. These conditions collectively disrupted the normal centrifugal separation process, causing fuel to overflow through the sludge port rather than being discharged through the clean oil outlet. The root cause was identified as the failure to implement systematic bowl and disc cleaning in accordance with the Planned Maintenance System schedule and the manufacturer's instruction manual.

The pilot valve malfunction was caused by the wear and deterioration of internal O-ring seals due to temperature exposure and contaminant ingress, which allowed debris to accumulate within the valve passages and obstruct the operating water flow. This prevented the proper execution of the bowl closing and opening cycle, resulting in incomplete sealing of the bowl assembly and uncontrolled fuel discharge into the sludge tank. The corrective action required complete pilot valve disassembly, cleaning, and replacement of all O-rings as a complete set.

Several recommendations are proposed for maintenance optimization. First, periodic internal inspection and cleaning of the fuel oil purifier bowl and disc assembly must be conducted strictly in accordance with the PMS schedule and instruction manual, with particular attention to complete removal of all sludge deposits and verification of component condition during each maintenance cycle. Second, when pilot valve malfunction is detected, immediate disassembly and inspection must be performed, with all worn or damaged O-rings replaced as a complete set; preventive pilot valve inspection should be scheduled at regular intervals as specified in the instruction manual. Third, adequate spare parts inventory, including O-ring sets, gravity discs of various sizes, and replacement pilot valves, must be maintained on board at all times to enable prompt corrective action when required.

REFERENCES

[1] L. Jackson and T. D. Morton, Reed's General Engineering Knowledge for Marine Engineers. London: Thomas Reed Publications, 1977.

[2] S. Rowa, Permesinan Bantu. Makassar: PIP Makassar, 2002.

[3] Mitsubishi Kakoki Kaisha Ltd., Instruction Manual Book: Mitsubishi Selfjector Excellent Series. Tokyo: Mitsubishi, 2000.

[4] J. J. Handoyo, Sistem Perawatan Permesinan Kapal. Jakarta: Departemen Perhubungan, 2015.

[5] NSOS, Manajemen Perawatan dan Perbaikan. Jakarta: Direktorat Jenderal Perhubungan Laut, 2004.

[6] Sugiyono, Metode Penelitian Kombinasi (Mixed Methods). Bandung: CV Alfabeta, 2018.

[7] L. J. Moleong, Metodologi Penelitian Kualitatif. Bandung: PT Remaja Rosdakarya, 2012.

[8] D. Woodyard, Pounder's Marine Diesel Engines and Gas Turbines, 9th ed. Oxford: Butterworth-Heinemann, 2009.

[9] International Maritime Organization, International Safety Management Code (ISM Code), 4th ed. London: IMO Publishing, 2018.

[10] H. Kuiken, Diesel Engines for Ship Propulsion and Power Plants. Onnen: Target Global Energy Training, 2012.

[11] Suparwo, Permesinan Bantu. Jakarta: BP3IP, 2003.

[12] Badan Klasifikasi Indonesia, Rules for Classification and Construction of Seagoing Ships, Vol. III: Machinery Installations. Jakarta: BKI, 2019.

[13] T. Lamb, Ship Design and Construction, Vol. 2. Jersey City, NJ: SNAME, 2004.

[14] S. Jusak, Perawatan dan Perbaikan Mesin. Jakarta: Departemen Perhubungan, 2006.

[15] M. N. Huda, "Optimalisasi dalam Manajemen Sarana dan Prasarana," Unimar AMNI Repository, 2018.