Analysis of the Impact of B35 Fuel Utilization on the Operation of a 26M Tugboat at PT. Patria Maritim Perkasa

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Abstract

The Government of Indonesia has implemented the mandatory B35 fuel policy, consisting of 35% biodiesel (FAME) and 65% pure diesel, as part of efforts to reduce carbon emissions and dependence on fossil fuels. However, its application in tugboats poses several technical challenges that require further evaluation. This study aims to analyze the impact of B35 fuel on the fuel system and engine performance of a 26-meter tugboat (TB. Armada Maritim I) operated by PT. Patria Maritim Perkasa. The research employed a direct observation method supported by trial and sea trial testing. After switching to B35, the fuel supply pressure was recorded as stable at around 13 psi and 0.8 bar. In contrast, prior to using B35 with conventional diesel (B0), pressure readings were inconsistent, reaching 29 psi and 0.3 bar. Furthermore, engine speed improved from 560 RPM to 830 RPM following the use of B35. Despite this improvement, issues such as fuel filter clogging were observed, caused by the monoglyceride content and the hygroscopic nature of B35, which promotes emulsion and sediment formation. There was also evidence of oxidation and corrosion in the injector components when the engine was idle. To address these problems, improvements were made to the filtration system, and a preheater was installed to maintain fuel stability during operation. This study concludes that B35 fuel can be functionally applied in tugboat operations, provided that supporting systems are upgraded to prevent performance disturbances.

Keywords: *B35, biodiesel, tugboat, fuel system, filter clogging, preheater, oxidation.*

1 Introduction

Global warming, triggered by the increase in carbon dioxide (CO_2) emissions, has become one of the most pressing environmental issues, as this gas significantly contributes to the acceleration of climate change. According to 2023 data, carbon dioxide emissions increased by 1.1% compared to 2022, reaching the highest level in history at approximately 36.8 billion tons [1].

This situation has encouraged many countries, including Indonesia, to adopt cleaner, environmentally friendly, and sustainable energy sources. One of the government's efforts is the implementation of biofuel policies, particularly biodiesel, as an alternative to fossil fuels in order to minimize environmental impacts. The Indonesian government officially enforced the B35 biodiesel policy on February 1, 2023, which consists of a blend of 35% Fatty Acid Methyl Ester (FAME) biodiesel and 65% pure diesel. This Indonesian regulation is stated in the Minister of Energy and Mineral Resources Decree No. 12 of 2022 concerning the provision of biofuel as an alternative fuel [2].

The main objectives of the B35 policy are to reduce dependence on fossil fuels, lower carbon dioxide emissions, and promote renewable energy within the national energy mix [3]. For instance, research by Aris Palinggi et al. shows that the use of B35 in diesel engines still delivers strong power performance across various engine load conditions, with relatively stable fuel consumption [4]. Similarly, a study by R.R. Tannady et al. highlights that the quality of B35 can be improved through proper filtration, which extends the service life of fuel system components [5].

On the other hand, several technical challenges have also been reported. Knothe et al. revealed that prolonged biodiesel usage may damage injection components due to oxidation and deposit formation [6].

Likewise, Y.P. Pramudito stated that biodiesel has the potential to accelerate corrosion in metal components, especially when not managed properly [7]. Technical notes from Eon Chemicals and reports from Aprobi (Association of Indonesian Biofuel Producers) also emphasize issues such as fuel filter clogging, increased maintenance frequency, and reduced engine performance if biodiesel is not supported by proper fuel management.

Although the application of B35 fuel provides clear environmental and economic benefits, its use in the maritime sector, particularly tugboats, requires further evaluation regarding its impact on engine performance. Tugboats operate under extreme environmental conditions and high operational demands, making it important to assess whether B35 can be optimally used without causing risks of damage to the fuel system.

Based on this background, this research was conducted to analyze the impact of B35 fuel on the operational aspects of a 26-meter tugboat at PT. Patria Maritim Perkasa. The study specifically aims to evaluate the influence of B35 fuel on the tugboat's fuel system and engine performance.

To keep the research focused, the scope is limited. This study does not cover financial or economic aspects related to operational fuel costs, environmental impacts, or non-engine systems such as electrical or navigational equipment. The main focus is strictly on analyzing the impact of B35 fuel on the fuel system and engine performance of the tugboat.

2 Research Methodology

2.1 Research Method

This study employed the direct observation method to analyze the impact of B35 fuel on the performance of a 26-meter tugboat engine. Direct observation was selected as it enables the researcher to obtain factual and objective data directly from field conditions [8]. All observation processes were conducted systematically, with detailed documentation through photos, videos, and measurements of engine system pressure to ensure data accuracy.

This approach also facilitates the identification of damage or performance degradation in the tugboat's fuel system caused by the use of B35 biodiesel. Comparative data were collected by examining the vessel under two conditions: when using B35 fuel and when operating with B0 (conventional diesel). Testing was carried out in two phases: dock trial and sea trial, allowing a comprehensive evaluation of the vessel's operational conditions [9].

2.2 For Steps

The methodology adopted in this study follows a structured sequence of steps to analyze the impact of B35 fuel on the tugboat.

The research flow can be illustrated in the diagram (Figure 1):

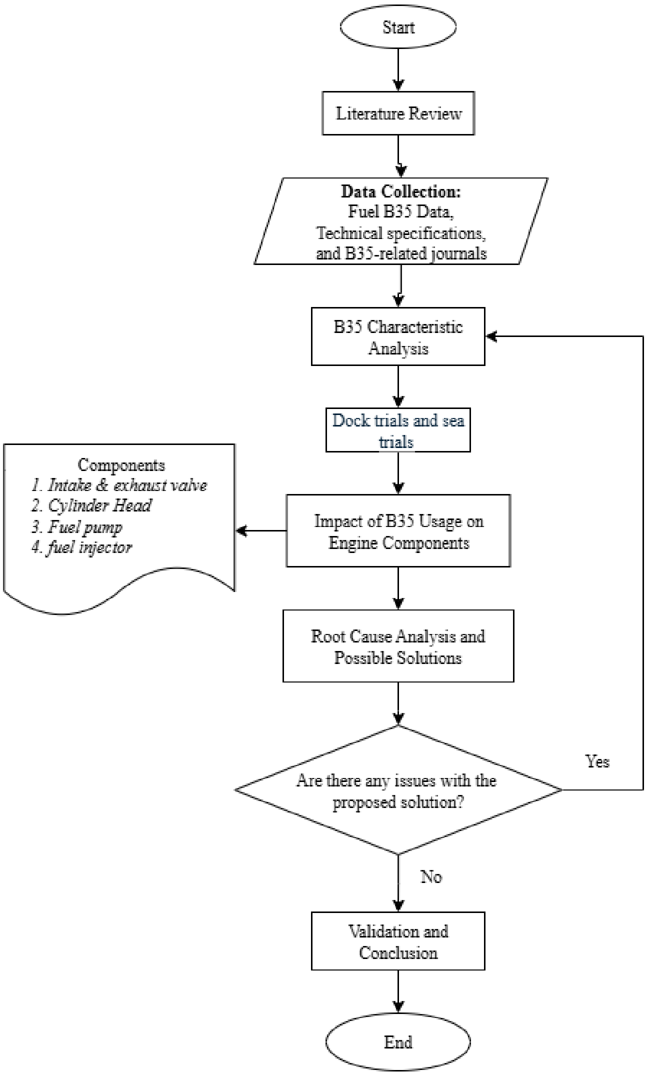

Figure 1. Research Method

The initial step involved a literature review to understand the characteristics of B35 fuel, including its physical and chemical properties, and how these may influence the vessel's fuel system. Relevant supporting references, such as journals and technical reports, were collected to strengthen the study.

Subsequently, a fuel characteristic analysis was conducted, followed by direct field testing in the form of dock trials and sea trials. These tests were aimed at evaluating the real-world performance of B35 fuel when applied in vessel operations. From the observations and analysis of each component, any identified damage or performance reduction was examined further to determine the underlying causes. Based on this diagnosis, possible solutions were formulated. These solutions were then validated to ensure they effectively addressed the issues. The research was concluded with comprehensive validation and the formulation of final conclusions

2.3 Research Object

The object of this research is the 26-meter tugboat *TB. Armada Maritim I*, built at PT. Patria Maritim Perkasa, which operates using B35 fuel (a blend of 35% FAME and 65% pure diesel). The vessel's main dimensions are presented in Table 1.

Table 1. Principal Dimensions of the Vessel

Specification	Value
Ship type	*Tug boat*

LOA	26.00 m
Breadth	8.00 m
Depth	3.65 m
Gross Tonnage	186 ton

The tugboat *TB. Armada Maritim I* was selected because it had already implemented B35 fuel in its operations. This provided an opportunity to directly observe and analyze the impact of B35 usage on both the vessel's fuel system and engine performance.

3 Data Analysis and Discussion

3.1 Characteristics of B35 Fuel

B35 fuel is a blend of 35% biodiesel and 65% diesel oil. This mixture has undergone physical and chemical testing to ensure its compatibility for use in diesel engines. One of its applications is in tugboats, which require reliable performance both during operation and while idle.

The test results show that B35 exhibits significant differences in characteristics compared to B0 (pure diesel) and B30. Table 2 presents the detailed characteristics.

Table 2. Characteristics B35, B0 & B30

No.	Parameter	Unit	B0	B100	B30	B35	B35/B0 (%)	B35/B30 (%)
1.	*Cetana number*	-	48	51	49.9	48.1	2.2	0.3
2.	*Calorific Value*	MJ/kg	43	37	41.2	40.9	4.9	0.7
3.	*Density*	Kg/L	0.84	0.84	0.9	0.9	1.1	0.2
4.	*Viscosity*	mm2/s	3.3	4.15	3.5	3.6	9.7	1.3
5.	*Monoglycerides*	%	0	0.525	0.165	0.184		11.4

The use of B35 fuel shows several characteristic differences when compared to B0 (fossil diesel) or B30 (30% biodiesel and 70% diesel). One of the advantages is its higher cetane number, which increased by 2.2% compared to B0 and 0.3% compared to B30. A higher cetane number improves combustion quality.

However, there are also consequences. The calorific value of B35 decreased by 4.9% compared to B0 and 0.7% compared to B30, meaning fuel consumption tends to increase because the energy produced per unit volume is lower.

Physically, the density of B35 is 1.1% higher than B0 and 0.2% higher than B30. Viscosity also increased significantly—by 9.7% compared to B0 and 1.3% compared to B30. Furthermore, the monoglyceride content in B35 is 11.4% higher than in B30. This higher monoglyceride level may increase the frequency of filter replacement and the risk of deposit formation in the fuel system.

3.2 Hasil Uji Lapangan

Field tests in the form of sea trials and dock trials were carried out on the 26-meter tugboat on April 29, 2024, using B35 fuel. The results indicated that the pressure of the fuel oil supply entering the engine was stable, as shown on the pressure gauge readings in Figures 2 and 3.

Gambar 2. Manometer *(pressure gauge)*

Figure 2 shows an analog manometer used to measure fluid pressure (liquid or gas) in psi (pounds per square inch). The needle indicates 13 psi, which is within the medium and stable range. This type of manometer, a Bourdon tube, is commonly used for pressure systems on ship engines. A stable pressure reading suggests that fuel circulation is functioning normally without disruption.

Gambar 3. Manometer *(pressure gauge) 2*

Figure 3 displays a manometer measuring fluid pressure in bar, commonly applied to fuel and injection systems in marine engines. The reading shows approximately 0.8 bar, which falls into the low-to-medium pressure range (1 bar = 14.5 psi). This is suitable for the low-pressure stage before injection. The manometer serves to monitor pump performance and detect drops in pressure that may result from clogging or leakage.

Gambar 4. *Engine Control Panel*

igure 4 presents the engine control panel, which functions as the central unit for monitoring and controlling main engine parameters. The tachometer (center dial) shows the engine speed in revolutions per minute (RPM), with the needle pointing at 8.3 (x100), indicating 830 RPM representing a low but stable engine speed. On the left, the temperature gauge displays engine cooling temperature; on the right, the oil pressure gauge shows the engine oil pressure within its optimal range, ensuring proper lubrication. At the lower left, the voltmeter indicates normal electrical system operation.

By comparison, sea trial and dock trial tests conducted earlier on April 25, 2024, before the implementation of B35 fuel, showed less stable fuel supply pressure, as illustrated in Figures 5 and 6.

Gambar 5. Manometer *(pressure gauge) 3*

Figure 5 shows an analog manometer with its needle pointing to 29 psi, indicating a high and unstable system pressure. Another manometer nearby shows approximately 0.3 bar (≈4.35 psi), which is below the ideal medium pressure and reflects instability. This significant discrepancy suggests possible issues within the fuel system.

Gambar 6. *Engine Control Panel*

Figure 6 shows the engine control panel during pre-B35 operation. The tachometer needle points to 5.6 (x100), equivalent to 560 RPM, representing a lower and less stable speed. On the left, the temperature gauge shows a cooling water temperature of 60°C, indicating suboptimal heating. On the right, the oil pressure gauge shows a high range (75–80 psi), suggesting excessive oil viscosity. The voltmeter at the lower left indicates a steady 24 volts, confirming that the electrical system is operating properly,

3.3 Problem Identified

The field tests revealed several technical issues associated with the use of B35 fuel during vessel operations. These identified problems are summarized in Table 3:

Tabel 3. Identified Operational Issues

No.	Problem Identified	Cause	Effect
1.	Hygroscopic nature of B35 increases water content (1.05 ppm/day).	Formation of emulsions and microbial growth (algae, fungi, etc.)	Fuel filter clogging, corrosion in the combustion chamber, and reduced engine power.
2.	Limited oxidation stability	Oxidation of residual fuel in	Filter clogging and injector

	and monoglyceride content in biodiesel.	the injector when the engine is off; electrostatic-induced filter oxidation.	deposits, leading to reduced engine output.
3.	Lower calorific value of B35 compared to diesel.	Increased fuel consumption required for equivalent power output.	Higher engine workload, risk of accelerated wear, and overall performance degradation.

The results indicate that while B35 use stabilizes the fuel supply pressure, technical challenges persist, particularly within the fuel monitoring system during the commissioning phase. These findings are consistent with reports from Eon Chemicals, which state that biodiesel tends to form deposits and create operational disturbances during early use [10]. Similarly, Paryanto et al. emphasize the necessity of implementing a fuel monitoring system during commissioning to mitigate filter clogging risks during the transition to biodiesel fuels [11]. One of the most visible issues was observed in the filter housing, which serves to clean the fuel before injection (see Figure 7).

Figure 7. Clogged Fuel Filter After B35 Use

Figure 7 shows a severely clogged fuel filter. The filter surface is covered by deposits and impurities carried by the fuel. When clogging occurs, the fuel flow to the injection system is restricted, resulting in incomplete combustion and unstable engine operation. In certain conditions, when the engine is shut down and fuel flow ceases, trapped deposits around the filter may undergo oxidation, further deteriorating the filter and related components. This directly contributes to engine power reduction and unstable performance due to obstructed clean fuel delivery.

As a response to these challenges, new operational standards now require tugboats to be equipped with preheaters. This requirement is aligned with IMO Tier II regulations, which mandate the use of preheaters on marine engines to maintain stable fuel and lubricant temperatures during operation [12].

3.4 Solutions for B35

To improve the performance of the fuel system in tugboats operating on B35 fuel, a series of corrective measures were implemented, particularly targeting the filtration system. The main issue encountered was frequent filter clogging, which resulted in the accumulation of deposits and corrosion in injector components.

After research and technical adjustments, a new type of filter was introduced. This improved filter design is capable of separating particles and impurities in B35 fuel more effectively. Although the filter still cannot be replaced while the vessel is in operation, its service life has been extended, reducing replacement frequency and minimizing operational disruptions (see table 4).

Issue	Before Improvement	After Improvement
Blocked Filter	Presence of impurities adhering to the filter, causing clogging.	- Removal of solid particles such as oxides and other contaminants from the fuel system. - Reduced filter waste due to less frequent replacement.

Cold Condition	Only specific tugboats (e.g., PML) used preheaters.	- Standardized requirement for all tugboats to use preheaters during operation.
Safety Operation	Filters could not be replaced while the vessel was in operation.	Filters remain non-replaceable during operation, but longer service life reduces the replacement frequency. [13].

Tabel 4. Filter Replacement Information

Figure 8. Recommended Filter

Figure 8 shows the Fleetguard FH236 Series, a modern water-separating filter recommended as a replacement for conventional filters. This type is suitable for engines using biodiesel, as it reduces clogging risk and maintains stable fuel pressure.

Gambar 09. ***Housing filter***

Figure 9 presents the filter housing after system improvement. Unlike earlier conditions, no excessive accumulation of solid particles or sludge was observed. Only minor deposits from the combustion process remained, indicating that the upgraded filtration system performs adequately in handling B35 fuel.

4 Kesimpulan

This study on the impact of B35 fuel on the fuel system of a 26-meter tugboat has shown notable differences compared to the use of B0 (pure diesel). Field test results confirmed that fuel supply pressure under B35 operation was more stable and within acceptable ranges. Engine speed also demonstrated improvements, indicating that B35 can be functionally applied in tugboat operations. Nevertheless, several technical challenges were identified. The most significant was fuel filter clogging, primarily caused by the higher monoglyceride content and the hygroscopic nature of B35, which promote deposit formation and water absorption. These deposits may trigger oxidation, injector disturbances, and reduced engine performance over time. To mitigate these issues, improvements were made to the vessel's filtration system by adopting a higher-capacity filter design capable of reducing clogging frequency and extending service life. In addition, the adoption of preheaters, now standardized under IMO Tier II requirements, ensures stable fuel and lubricant temperatures during operation. In conclusion, although B35 fuel demonstrates operational benefits, it also introduces technical risks that may interfere with vessel performance if not properly managed. The implementation of enhanced filtration systems and preheaters are key measures to ensure reliable operation. This research contributes to supporting renewable energy adoption and carbon emission reduction, while providing practical recommendations to address performance challenges in marine diesel engines using biodiesel blends.

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