Analysis of Diesel Generator Fuel Quality on the Sultan Hasanuddin Training Ship

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Abstract. The KL Sultan Hasanuddin training ship utilizes biodiesel (B30) for its main engine and generator to support energy sustainability. Effective fuel management is critical on board to maintain fuel quality and quantity. This involves careful procedures for loading, storage, and purification. In this study, three fuel samples (A, B, and C) were analyzed in a certified laboratory using ASTM standards. Generally, fuel quality in these samples was within normal limits or below maximum thresholds. However, sample A (from the supplier) differed significantly from samples B and C, notably with a high water content of 239 mg/kg. Additionally, samples B and C showed a reduction in FAME (fatty acid methyl ester) content, suggesting sediment buildup, possibly within the fuel tank. This finding indicates the need for attention to sediment control, which can impact fuel performance and longevity, requiring specific maintenance measures for the tank to prevent contamination and maintain optimal engine function.

Keywords: First Keyword, Second Keyword, Third Keyword.

1 Introduction

In recent years, domestic oil production has continued to decline, while demand has always increased. Currently, Indonesia can no longer rely on non-renewable energy sources. Oil reserves are predicted to run out in a relatively short time. Efforts to deal with the energy crisis have been made, one of which is by using renewable alternative energy, namely FAME, which comes from two vegetable oil transesterification processes. Currently, PT Pertamina (Persero) has used FAME to reduce the use of diesel fuel, which is marketed under the name Biosolar. Biosolar is used for diesel engines with high engine speeds, namely more than 1000 rpm.

The Training Ship (KL) Sultan Hasanuddin, owned by the Makassar Maritime Polytechnic (PIP), is one of six 1200 GT cadet training vessels built by the Ministry of Transportation in 2017. This vessel was designed to enhance the training capabilities of maritime cadets, particularly those at the Makassar Maritime Polytechnic, and to prepare future sailors. In its daily operations, KL Sultan Hasanuddin is powered by two main engines and three generators. All engines on board run on Biosolar fuel, supplied directly by PT. Pertamina, to support the ship's commitment to environmentally sustainable practices.

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Proper fuel handling on board is essential to maintain both the quality and quantity of fuel, ensuring that the ship operates safely and efficiently. This process requires meticulous attention at each stage—from loading, filtering, and processing to purifying and storing fuel in dedicated tanks. Each step is carefully managed to meet the specified standards and fuel characteristics, reducing the risk of contamination and ensuring that the fuel's integrity is preserved throughout its use on board. By following these stringent fuel handling procedures, the vessel can achieve optimal performance and safety.

Fuel produced and marketed to consumers meets established quality standards, as outlined in the Decree of the Director General of Oil and Gas No. 146.K/10/DJM/2020, which specifies the standards and quality of diesel fuel for the domestic market. However, when fuel is received on board, it cannot be immediately used in the engines. Instead, it must first be stored in a double-bottom tank, during which its quality may change due to environmental factors within the tank. As a result, the fuel requires an additional purification process to remove any contaminants that may have accumulated, ensuring it meets the necessary standards for safe and efficient engine use.

2 Research Purposes

This research aims to find out how the quality of fuel changes due to water and dirt in the fuel system. It will identify where the biggest changes happen, and measure the percentage of fuel that improves after going through the purification process. The goal is to understand how well the purification process works to make the fuel safer and better for use in the ship's engines.

3 Research Method

This research uses a quantitative approach with experimental methods. It involves laboratory testing and sampling from various fuel storage locations, including samples from suppliers, storage tanks (double bottom tanks), setting tanks, and service tanks (purified fuel from clarifiers). The study also includes qualitative analysis to assess changes in fuel quality for each sample, which will then be compared with fuel specifications from Pertamina.

Sampling is done to obtain representative fuel samples from the entire contents of the storage tanks, both on land and on the ship, following established procedures and methods. The sampling process occurs upon receipt to ensure that the product meets the required standards and specifications, and it continues during storage and distribution to monitor the condition and consistency of product quality. The sampling methods for fuel (BBM) and biodiesel (BBN) follow the ASTM guidelines.

Table 1. Fuel sample

Sample	Description
A	Supplier
B	Double Bottom Tank
C	Services Tank

Data analysis starts by reviewing the laboratory test results from certified fuel testing institutions. These results are then compared with established standards to identify any differences in the fuel content values. The comparison will focus on the values of the tested samples to determine if there are any deviations from the expected fuel quality standards.

4 Result And Analysis

KL Sultan Hasanuddin is equipped with 2 main propulsion engines, 3 diesel generator engines, and 1 harbor diesel engine. All of these engines use Biosolar B30 fuel, which contains a 30% biodiesel mixture, following the fuel quality standards outlined in the Decree of the Director General of Oil and Gas No. 146.K/10/DJM/2020, which specifies the standards and quality of domestically marketed diesel fuel.

Table 2. Biosolar Specifications (B30)

No	Karakteristik	Satuan	B30 Solar 48		B30 Solar 51		Metode Uji
			Min	Max	Min	Max	
1	Bilangan Setana:		48		51		ASTM D 613
	Angka Setana atau Indeks Setana		45		48		ASTM D 4737
2	Berat Jenis pada 15°C	kg/m[a]	815	880	810	850	ASTM D 4052 / ASTM D1298
3	Viskositas pada 40°C	mm2/s	2,0	4.5	2.0		ASTM D 445
4	Kandungan Sulfur	% m/m		0,25 0,2 [1)] 0,05 [2)] 0.005 [3)]		0,05 0,005 [1)]	ASTM D 4294 ASTM D 5453 / ASTM D2622

No	Karakteristik	Satuan	B30 Solar 48	B30 Solar 51	Metode Uji
5	Distilasi: 90 % vol. Penguapan	°C	370		ASTM D 86
6	Titik Nyala	°C	52	55	ASTM D 93
7	Titik Kabut, atau	°C	18		ASTM D 2500 / ASTM D 5771 / "ASTM D 5773 /
	Titik Tuang	°C	18	18	ASTM D 7683"
8	Residu Karbon	"% m/m	"0,1	"0,1	"ASTM D 189 /
9	Kandungan Air	mg/kg	425	425	ASTM D 4530
10	Kandungan FAME	% v/v	30 [4)]		ASTM D 6304
11	Korosi Bilah Tembaga	merit"	Kelas 1	Kelas 1	ASTM D 7371 /
12	Kandungan Abu	% m/m	0,01	0,01	"ASTM D 482 /
13	Kandungan Sedimen	% m/m	0,01	0,01	ISO EN 6245"
14	Bilangan Asam Kuat	"mg	0	0	ASTM D 473
15	Bilangan Asam Total	KOH/gr"	0,6	0,3	ASTM D 664
16	Penampilan Visual	"mg	Jernih dan Terang	Jernih dan Terang	ASTM D 664
17	Warna	KOH/gr"	3	1	Visual
18	"Lubrisitas (HFRR wear	-	460 [5)]	460	ASTM D 1500

The fuel system on the Sultan Hasanuddin training ship begins with receiving fuel from the supplier, typically via a tanker truck, which is connected to the ship's fuel bunker manifold for pumping. The fuel is then stored in the designated storage tank, known as the FO Storage Tank. On KL Sultan Hasanuddin, the tanks used for storing fuel before it is used are located in tank no. 2 Port and Starboard (No. 2 FO TK PS). During the fuel reception process, the supplier provides a fuel sample to the ship, which serves as a reference for the quality of the received fuel.

Fuel sampling at KL Sultan Hasanuddin was carried out using transparent plastic mica bottles. Sampling was carried out/taken from several sampling points, namely:

1. Sample A

For fuel sample A, the ship receives the sample directly from the supplier, which is marked with an official supplier company sticker, confirming it as a standard sample from PT. Pertamina. However, the fuel samples provided during the bunkering at KL Sultan Hasanuddin did not include specific fuel specification documents (biosolar). Instead, the documentation only listed the general specifications of the fuel type, the amount received, and the transport means used for delivery (sample A).

Fig. 1. Sample bottle A

2. Sample B

The fuel received by KL Sultan Hasanuddin is initially stored in tank no. 2 port and starboard (storage tanks) for a certain period, depending on the amount or capacity of the fuel received. From these storage tanks, the fuel is then drawn by the fuel pump/transfer pump to be sent to the settling tank. However, KL Sultan Hasanuddin does not have a settling tank, so the fuel is directly transferred from the storage tank (sample B).

Fuel Sample B is taken directly from the storage tank through the fuel transfer pump. On commercial vessels, the typical process involves the fuel being drawn from the storage tank and then sent to a settling tank. However, for KL Sultan Hasanuddin, the fuel bypasses the settling tank and goes directly to the purification process before being transferred to the daily tank.

Fig. 2. Sample bottle B

3. Sample C

Fuel sample C is a fuel sample taken from the daily tank (day tank) where this tank is a storage tank for the results of the purification process so that the fuel quality is expected to be better than before.

Fig. 3. Sample bottle C

All fuel samples collected are stored in sterile bottles, free from water and dirt, with a capacity of approximately 1 liter. These bottles are kept in a dry, secure location to protect them from weather conditions until they are delivered for testing. Each bottle is labeled clearly to avoid any mix-up of samples. The fuel samples are then sent to a certified laboratory for testing. In this study, the laboratory tests were conducted at PT. Sucofindo, located at Jl. Urif Sumiharjo No. 90 A, Makassar. The testing follows the ASTM (American Standard Testing Material) methods, a globally recognized organization that develops technical standards for materials, products, systems, and services.

Based on the laboratory results of the B30 fuel samples from KL Sultan Hasanuddin, which were tested according to ASTM methods at PT. Sucofindo, the following results were obtained:

Table 3. Comparison of Laboratory Test Results of KL Sultan Hasanuddin Fuel

Parameter	Unit	B30 Specifications		Sample A	Sample B	Sample C	Information
		Min Limit	Max Limit				
Calculated Cetan Index		48		48.5	47.6	47.9	Normal
Density at 15 °C	Kg/m³	815	880	862.3	853.0	852.7	Normal
Viscosity at 40°C	mm²/s	2.0	5.0	3,831	3.604	3.320	Normal
Sulfur Content	% m/m		0.25	0.088	0.101	0.099	Normal
Pour Point	°C		18	+12	+15	+15	Normal
Carbon Residue	% m/m		0.1	0.02	0.01	0.03	Normal
Water Content	Mg/kg		425	239	144	139	Normal
FAME Content	% v/v	30		31.32	15.24	14.64	Down
Sediment Content	% m/m		0.01	0	0	0	Normal
Ash Content	% m/m		0.01	0.002	0.002	0.002	Normal

From the results of the comparison of the Laboratory Test of KL Sultan Hasanuddin fuel, it is generally normal or below the maximum limit. However, from the results of the laboratory test of the three fuel samples for sample A (sample from the provider/supplier), the laboratory test results are quite significantly different from the laboratory test results of samples B and C, especially in certain parameters such as;

- index print (48.5),
- density (862.3 Kg/m³) ,
- pour point (12 °C) ,
- water content (239 Mg/kg)
- FAME content (31.32% v/v)

Based on the results of laboratory tests of these fuel samples, it was found that the fuel samples provided by the supplier had a fairly high water content compared to the fuel received by the ship, according to the laboratory test results table above.

Comparison of laboratory test results between samples B and C in general did not experience significant changes. However, from the laboratory test results there was a change in the fuel quality value from the storage tank (sample B) with the quality of the fuel material after going through the furufication/clarifier process (sample C).

Table 4. Comparison of Fuel Quality Results from Laboratory Tests

Parameter	Unit	Sampel B	Sampel C	nilai	keterangan
Calculated Cetan Index		47.6	47.9	0.3	naik
Density at 15 °C	Kg/m³	853.0	852.7	0.3	turun
Viscosity at 40°C	mm²/s	3.604	3.320	0.284	turun
Sulfur Content	% m/m	0.101	0.099	0.002	turun
Pour Point	°C	+15	+15	0	tetap
Carbon Residue	% m/m	0,01	0.03	0.02	naik
Water Content	Mg/kg	144	139	5	turun
FAME Content	% v/v	15.24	14.64	0.6	turun
Sediment Content	% m/m	0	0	0	tetap
Ash Content	% m/m	0.002	0.002	0	tetap

5 Conclusions

Based on the laboratory test data from the tested samples, it can be concluded that the fuel sample submitted by the provider (sample A) showed notable differences, particularly with a water content of 239 mg/kg and FAME (biodiesel) content of 31.32% v/v. When comparing the fuel quality before and after the purification process (samples B and C), the water content decreased by 5 mg/kg, indicating that the purification process effectively reduced water contamination. Since the reference fuel sample A received by the ship did not fully meet the expected quality standards, the fuel quality on KL Sultan Hasanuddin, after purification, is considered to be in good condition and within normal limits.

The fuel quality on KL Sultan Hasanuddin is categorized as normal, based on the comparison of the laboratory test results of samples B and C with the fuel specification data (B-30) outlined in the Decree of the Director General of Oil and Gas No. 0234.K/10/DJM.S/2019, dated November 11, 2019. This decree sets the standards and quality (specifications) for diesel fuel mixed with 30% biodiesel (B30) marketed domestically, confirming that the fuel onboard meets the required specifications.

1. The need to ensure fuel sampling from the fuel supplier. This is intended to ensure the quality of fuel received by KL Sultan Hasanuddin.
2. Periodically, the storage tank is cleaned, referring to the results of laboratory tests that identify the presence of deposits at the bottom of the tank with a decrease in FAME levels in the fuel.

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