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The Effect of the Use of B30 Biodiesel Fuel on the Design and Construction of People's Shipping Ships

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ABSTRACT

The limited supply of fossil fuels in Indonesia encourages the need for sustainable alternative energy, one of which is biodiesel. This study aims to analyze the effect of the use of B30 biodiesel on the design, construction, and performance of people's shipping ship engines. The research methods used include literature studies, field surveys in several traditional shipyards, and diesel engine performance tests with B30, HSD, and MFO fuels. The analyzed parameters include pressure and temperature at key points of the engine working cycle, indicator and effective power, thermal and volumetric efficiency, and specific fuel consumption. The results showed that the engine performance with B30 was lower than that of MFO, but more economical than HSD at a certain power level. The use of B30 also has an impact on the design aspects of the ship, especially the capacity and layout of the fuel tank, piping system, and the compatibility of materials to the chemical properties of biodiesel. Therefore, the implementation of B30 on people's shipping ships requires adjustments to infrastructure design, fuel quality control, and proper engine maintenance strategies to support energy efficiency and operational sustainability

INTRODUCTION

The energy crisis due to limited fossil fuel supply has become a global issue that has a significant impact on various sectors, including marine transportation. In Indonesia, kapal pelayaran rakyat (Pelra Ship) is one of the vital modes of transportation that supports the distribution of goods and the mobility of people between islands. However, the dependence of pelra ships on fossil fuel poses serious problems, both in terms of availability, operational costs, and environmental impact. To answer this challenge, biodiesel is present as one of the alternative energy solutions that are renewable, environmentally friendly, and can be produced from local resources such as palm oil and other vegetable oils.

Biodiesel has physical and chemical characteristics close to diesel, so it can be used directly or mixed with fossil fuels without requiring major modifications to diesel engines. The Government of Indonesia has implemented a mandatory policy on the use of biodiesel, starting from B20 to currently B30, to support national energy security while reducing carbon emissions. However, the application of biodiesel in the shipping sector, especially people's shipping ships, still faces a number of challenges. Some of them are differences in calorific value, fuel consumption, material compatibility, and implications for ship design and construction, especially on fuel storage and distribution systems.

This research is important to provide a deeper understanding of the influence of the use of B30 biodiesel on the technical aspects of people's shipping ships, including diesel engine performance, fuel tank design and capacity, piping system layout, and material compatibility with biodiesel chemical properties. Thus, the results of this research are expected to contribute to the development of more efficient, environmentally friendly, and sustainable people's shipping technology, in line with Indonesia's national energy policy.

Although biodiesel has many advantages, there are challenges that need to be overcome in its use. One of them is the potential for contamination with water, which can affect the quality of biodiesel. Although biodiesel is hydrophobic, under certain conditions, it can absorb water and cause operational problems. Therefore, proper handling and storage are essential to maintain the quality of biodiesel, especially in humid climates.

The petroleum industry often sets prices in the fuel market, so biodiesel has to compete with cheaper fossil fuel prices. However, with increasing awareness of environmental issues and declining biofuel prices, biodiesel is increasingly in demand. In this context, the development of biodiesel not only helps to address the current energy supply problems, but also becomes a hope for a sustainable future, where renewable energy can meet the needs of society without harming the environment.

METHOD

This study uses a case study approach with a combination of descriptive and experimental analysis methods. The first stage was a literature study on government regulations, international standards, as well as previous research related to the use of B30 biodiesel in diesel engines. Furthermore, a field survey was carried out on several people's shipping ships in the Rembang and Tuban areas to identify aspects of ship design and construction, including the type of material, engine room layout, piping system, fuel tank capacity, engine condition, and availability of safety equipment. The next stage is experimental testing of engine performance using three types of fuel, namely B30, HSD, and MFO. The parameters measured included pressure and temperature at key points of the diesel engine's life cycle, indicator power (Ni) and effective power (Ne), thermal and volumetric efficiency, and specific fuel consumption (sfc and bsfc). The test results were then analyzed comparatively to see the differences in the performance of each type of fuel and the implications for the design and construction of the vessel, including fuel tank capacity, engine room layout, piping system, and material compatibility with biodiesel chemical properties.

RESULTS AND DISCUSSION

B30 fuel as a renewable, sustainable fuel and alternative to internal combustion engines, the use of biodiesel is required to be more adaptable to the development of manufacturing, especially diesel engines. The development and use of biodiesel has been popular since the 2000s, both economically and technically. This has triggered the emergence of new regulations and standards with reference to international regulations.

Analysis of Ship Construction and Equipment; In terms of construction, the entire ship uses whole wood with a variety of different types of wood without any clear standards. Types of wood for bones or for leather and other parts of construction. The determination of the type of wood adjusts the availability of materials and the experience of the shipbuilder. It is very difficult to assess the construction strength or quality of the construction of ships that are traditionally produced because the quality and size of the wood used are very varied and not measurable. Accommodation space at the rear above the main deck. Meanwhile, the cargo space is under the main deck which is covered with boards arranged on top of the coaming. Engine rooms and loading rooms mostly do not have partitions between the loading room and the engine room in order to optimize the loading space, but this is actually quite dangerous for the safety of the ship. For flat loading and unloading tools rely on a derick boom mounted on the ship's mast

Analysis of Machinery Systems and Safety Equipment; All ships surveyed in Rembang and Tuban use diesel engine main drives without sail drive alternatives. The engines used are used engines from trucks or drive engines for generators connected to propeller shafts. However, these engines are not actually intended for ship engines because land engines have the weakness of their durability to the angle of inclination. Marine engines are designed to remain operating when subjected to an inclination of more than 40 degrees. In addition, marine engines are designed to operate with a seawater cooling system while land engines are with an air conditioning system. All machines used have generally been modified to cool seawater. But unfortunately modifications like this will damage the engine material which is not intended for seawater. Safety equipment on the ship is almost non-existent. Some may have multiple life jackets. But stop there. The main requirements of safety equipment such as life rafts or extinguishers are not found on the ship.

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Figure 1. The Author (Consultant) and the Hubla Team During a Field Survey

Therefore, the development of biodiesel is expected to also help control air pollution and reduce pressure on scarce resources without significantly sacrificing engine power and being economically economical. It is therefore necessary that much further research on optimization and modification of engines, engine performance, instrumentation and new methodologies for measurement, etc., must be carried out when diesel oil is completely replaced by biodiesel. The following is an overview of energy potential in Indonesia.

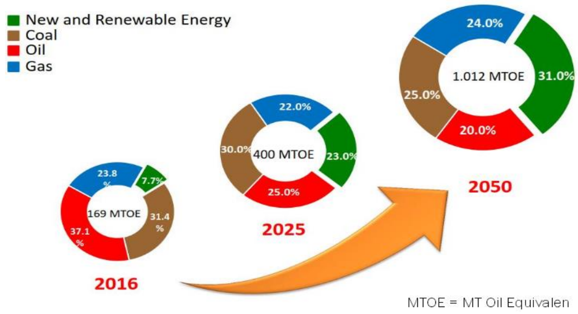


Figure 2. Indonesia Energy Mix
Source : www.pertamina.com

In early September 2018, all diesel for diesel engine fuel must be mixed with biodiesel. The portion of biodiesel in diesel fuel is set at 20% (B20) and on January 1, 2020 B20 fuel was increased to B30. So far, the obligation to use diesel mixed with biodiesel only applies to Public Service Obligation (PSO) connoisseurs. Currently, the obligation is extended to all types of diesel engines, both public vehicles, private cars, heavy equipment industries to ship transportation. Regarding the mandatory policy of using B30 in the ship and power plant industries, multiflier has a positive effect on the shipping industry and heavy industry. Ship engines with the latest technology that use fuel injectors with a selenoid system are more sensitive to fuel quality. So the ship industry needs to consider all aspects of performance, maintenance costs, durability and other aspects to change the type of fuel to be used. As an alternative, the solution can be done by modifying the fuel supply system, the modification is carried out with B30 treatment before entering the daily fuel tank, as well as treatment before entering the engine combustion chamber. In the future, the government will launch the use of B100, only for this policy, an additional fuel supply system is needed with the addition of a fuel storage tank equipped with a heater, a fuel supply pump, a fuel separator and a filter. This modification is a market opportunity for the repair and maintenance business. The preparation of B30 has been carried out for a long time and there are no problems in its application to heavy equipment or in the shipping industry. Comparison of the use of B30, HSD, MFO fuel to thermodynamic parameters at the main points of the diesel engine working cycle based on the results of the analysis mentioned above can be seen the difference in pressure and temperature achieved, as stated in table 1 below;

Table 1. Comparison of Engine Pressure and Temperature on B30, HSD, MFO Fuel Consumption Based on Mean Values

Parameter	B30	HSD	MFO
Suction step final pressure (Pa), kg/cm2	0.999139	1.05	1.10
Suction step end temperature (Ta), K	363.3249	381.82	380.75
Compression step end pressure (Pc), kg/cm2	27.76654	29.18	30.52
Compression step end temperature (Tc,K	875.2835	919.84	917.26
End pressure of combustion step (Pz),kg/cm2	49.97596	52.52	54.94
End temperature of combustion step (Tz), K	1587.451	1668.26	1704.66
Expansion step final pressure (Pb), kg/cm2	2.055371	2.16	2.26
Expansion step final pressure (Pb), kg/cm2	0.999139	881.57	901.18

Based on the acquisition of the values shown in the table above, it can be seen that there is a significant difference, when it is at the point of combustion until the end of expansion. This is indicated by the difference in the content of the combustion value, the calorific value (Qb) of the three types of fuel. Based on the results of the engine performance analysis, the value of several performance parameters can be seen, as shown in table 2 below;

Table 2. Diesel Engine Performance Achievement When Fueling B30, HSD, MFO Based on *Mean Value*

Parameter	B30	HSD	MFO
Daya indicator (Ni), PS	2928.979	3078.079	3244.7064
Effective power (Ne), PS	2489.632	2616.367	2758.0004
Thermal efficiency (ηth), %	29.89803	31.42	44.58
Volumetric efficiency (ηv). %	72.14733	75.82	57.40
Fuel consumption specific indicator (*sfc*), kg/HP-Hour	0.401654	0.4221	0.3075
Effective specific fuel consumption (*bsfc*), kg/HP-H	0.472545	0.4966	0.3618

The difference in the performance of the ship's engine in terms of power, efficiency and fuel use according to the table above, the engine power produced when using MFO fuel is proven to be higher than when using HSD and B30 fuel. It can also be seen that the use or consumption of fuel is greater when the engine operates using HSD fuel than when using B30 and MFO fuels. Regarding the level of efficiency, it is proven that the heat utilization of the engine system, the use of MFO fuel is greater than the use of HSD and B30 fuel. Therefore, from some of the analyses above, we can assess the parameters of the main points of the diesel engine work cycle and their performance according to their fuel consumption, as shown in table 3 below;

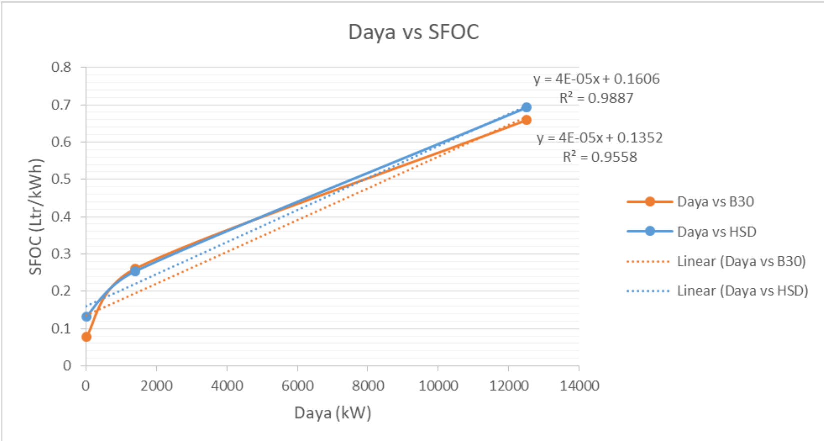
Table 3. Differences in the Use of B30, HSD, MFO Fuel on the Parameters of the Main Points of the Working Cycle and the Performance of Diesel Engines

Measurement Parameters		Fuel Type		
Main Point of Ship Engine Cycle		**B30**	**HSD**	**MFO**
Condition	**Suction step final pressure (Pa)**	0.999139	1.05	1.1
Pressure	**Compression step final pressure (Pc)**	27.76654	29.18	30.52
Siklus	**Compression step final pressure (Pc)**	49.97596	52.52	54.94
Working (kg/cm2)	**Compression step final pressure (Pc)**	2.055371	2.16	2.26
Condition	**Suction step end temperature (Pa)**	363.3249	381.82	380.75
Temperature	**Compression step end temperature (Pc)**	875.2835	919.84	917.26
Siklus	**Compression step end temperature (Pc)**	1587.451	1668.26	1704.66
Work (K)	**Compression step end temperature (Pc)**	838.8673	881.57	901.18

Ship Engine Performance		Fuel Type		
		B30	HSD	MFO
Daya	**Indicator power (Ni)**	2928.979	3078.079	3244.706
Engine (PS)	**Effective power (Ne)**	2489.632	2616.367	2758
Efficiency Engine (%)	**Thermal efficiency (ηth)**	29.89803	31.42	44.58
	Volumetric efficiency (ηv)	72.14733	75.82	57.4
Fuel consumption (kg/hp-hour)	**Fuel Consumption Specific Indicator (*SFC*)**	0.401654	0.4221	0.3075
	Effective use of specific fuel (*bsfc*)	0.472545	0.4966	0.3618

The results showed that the engine performance when using MFO fuel was better than when using B30 and HSD fuel. Therefore, if you want to use B30 fuel in the operation of ship engines, especially engines used in People's Shipping , it is necessary to conduct more in-depth research to get better results.

Meanwhile, the influence of the use of B30 on the design and construction of people's shipping ships is (a). Fuel tank volume; At the same sailing distance, the consumption level of B30 will be greater when compared to MFO, but smaller when compared to HSD, therefore the design and construction of the fuel tank volume will have an impact, it can be larger or smaller. (b). Fuel tank layout and supporting system; The supporting system will also have an effect, such as the piping system, whether the oil heater is needed or not, the pumping system and the valve and the fuel checking system. Likewise, the layout of the tank design and these systems will change. (c). The volume and layout of the room around the fuel tank and the ship's engine room, need to be careful because the fuel tank shrinks or enlarges, will change the room around it. Likewise, fuel support systems will change the system around them, both the use of space and the layout.



Graph 1. power linear regression vs SPOC of B30 and HSD

Table 4. Engine Power and SFOC use HSD and B30

Daya (kW)	**SFOC (Ltr/kWh)**	
	HSD	B30
12498	0.692587	0.659038
1400	0.2536	0.2606
16	0.13191	0.077327

Where Y is the SFOC value in Ltr/KWh and X is the power imposition in KW units, then the linear regression equation for HSD is Y=4E-05x + 0.1606, and for B30 is Y= 4E-05x + 0.1352. For People's Shipping ships, assuming an engine with a power of 80 HP or equivalent to 58 Kw, then SFOC when using HSD is 0.162927 and B30 is 0.137527. It can be concluded that the use of B30 is more economical compared to HSD for the same engine power.

The readiness of engine munufacture, regulators and supply chains, in enforcing the use of B30 fuel and paying close attention to MFM, it is hoped that there will be no more objections and problems arising from all stakeholders, especially users, to claim problems. The implementation of MFM must really be a guarantee of the effectiveness of the implementation of this regulation. So that the implementation of the use of B30 is a national energy saving solution and really becomes a renewable energy whose continuity is maintained.

The Oxygen Content in Compounds in Biodiesel in increasing the number of setane so as to increase the perfection of fuel combustion in the combustion chamber of the engine.The composition of fatty acid ester compounds in biodiesel has an effect on oxidation stability**;** Regarding the amount of unsaturated in biodiesel, it can reduce the quality of biodiesel: the acid number, moisture content and the occurrence *of sludge* over a long period of time, can be increased with antioxidant additives. Polar compounds that bind water**;** Affects the clarity of biodiesel, causing rust on certain metals. Solvency / solvent is an ester compound; *mild solvent* type ester for descaling / *sludge* in *storage tanks*, Affects some elastomer materials, Expands some rubber materials due to *the process of 'cross-linking*' by ester compounds (biodiesel). Organic compounds that can be contaminated by microbes; occurs when biodiesel is stored for a long time and arises due to the influence of water accumulation at the bottom of the tank as well as biodiesel can be degraded by microbes. Material compatibility includes; metal types: carbon steel, stainless steel, aluminum, reactive materials (oxidative catalysts): brass, bronze, copper, lead, tin and zinc, not good for tank materials or pipelines through which they pass; Also the type of elastomer that is often used as: seal, gasket, tubing, o-ring, etc., biodiesel can cause the elastomer to become "swelling", some elastomers are compatible with biodiesel: viton, teflon, nylon

The main requirement for maintaining the quality of B30 to consumers is to ensure the quality of fuel materials: biodiesel, diesel oil, and biodiesel blends. Fuel handling techniques at the sampling, testing, receiving, mixing, storage, and distribution stages, including compliance with established operating standards. Monitoring fuel quality in sampling, testing, and data processing of test results that can be accounted for. Choosing infrastructure materials that are compatible with biodiesel.

CONCLUSION

The results of the study show that B30 biodiesel is suitable for use as an alternative fuel in diesel engines of people's shipping ships with some technical notes. In terms of performance, the B30 produces lower power and efficiency than MFO, but is more economical than HSD at certain engine power. B30's fuel consumption is comparatively greater than that of MFO, but it remains competitive in terms of energy efficiency and environmental friendliness. The use of B30 also affects aspects of ship design and construction, particularly in the capacity and layout of fuel tanks, piping systems, and engine rooms. In addition, the chemical properties of biodiesel need to be considered because it has the potential to affect tank materials and elastomer components. Therefore, the implementation of B30 in people's shipping requires fuel quality control, proper engine maintenance, and adjustment of the ship's infrastructure design so that the sustainability of its use can be guaranteed.

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