International Journal of Marine Engineering Innovation and Research, Vol. 9(3), Sept. 2024. 598-603
(pISSN: 2541-5972, eISSN: 2548-1479)

Using Ketapang Seed Oil Biodiesel as an Environmentally Friendly Renewable Alternative Energy to Improve Diesel Motor Performance

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(Received: 16 August 2024 / Revised: 21 August 2024 /Accepted: 2 September 2024)

***Abstract*— The needs of society related to the energy crisis require alternative energy that can replace fossil fuels, such as Ketapang seed biodiesel. Preparation of crude oil by maceration method and making biodiesel through esterification and transesterification process. The research will discuss the performance of diesel engines with biodiesel fuel and Ketapang seed biodiesel with the composition of B0, B10, B20, B30. The test uses a rotation variation of 1200 to 2000 RPM and a load of 1000 to 3000. From the test properties and performance test research, it can be seen that they are related to each other. Biodiesel obtained better performance compared to B10, B20, B30. The lowest Specific Fuel Oil Consumption value is found in biodiesel fuel, where based on the average calculation on the maximum Specific Fuel Oil Consumption graph, B0 fuel produces a lower Specific Fuel Oil Consumption value than B10, B20 and B30 fuels with a difference of 33,759 gr/kWh, 49,661 gr/kWh and 113,694 gr/kWh. In this research process, the results of diesel engine performance using Ketapang seed biodiesel proved to be worse than biodiesel.**

Keywords— Biosolar, Ketapang seed biodiesel, maceration method, performance, diesel engine

I. INTRODUCTION

According to (Atiqi, 2020) states that it coincides with the energy crisis that is currently hitting Indonesia due to the high demand from the public as well as transportation entrepreneurs and industry for fuel oil (BBM) from fossils or minerals is getting higher, meanwhile fossil-based fuels are running low [1]. The impact of worsening air pollution is also caused by emission of fossil fuels [9].

According to (Faizal et al., 2009) states Terminalia Cattapa Linn (Ketapang) is a plant that is often found in coastal areas or lowlands across a fairly wide distribution area [2]. Very many of these plants are found in tropical climates such as in Southeast Asia. Apart from growing widely around the coast, this plant can also be planted in the lowlands as a shade tree. And not a few are planted to decorate the city [10].

Research on the extraction of Ketapang seeds as a raw material for biodiesel was carried out by [3]. This study used experimental methods, namely maceration and distillation. The results prove that the volume of Ketapang oil produced is in accordance with the length of soaking time. The volume of oil produced ranges from 25 mL to 31 mL [27]. The resulting yield conversion shows a number that is also directly proportional to the length of soaking time [24]. The longer the soaking time, the greater the yield created. The yield obtained is 44% to 52%. Then for the % Free Fatty Acid (FFA) content obtained also shows a larger number with the length of soaking time. The FFA content obtained was 28% to 36% [11]. Monitored from the density and yield obtained, the Ketapang oil produced contains a lot of fatty acids and can be used as a raw material for making biodiesel [12]. If viewed from the FFA content which is quite high, it is necessary to do pre-esterification before esterification to reduce FFA levels in Ketapang oil before it is processed into biodiesel [13].

The stirring process did not affect the yield obtained because the results obtained were not too far off in the two experiments [23]. Based on the results of comparisons with other methods, the maceration method is good enough to do because the results obtained are not far enough with the soxhlation method [14]. In the manufacture of biodiesel from Ketapang seed oil, a transesterification and esterification process is required, namely the transesterification process is capable of converting triglycerides/fats into esters which this process is catalyzed by its alkaline nature with the help of methanol and KOH, while esterification is able to convert free fatty acids into alkyl esters through an acid catalyst. with the composition of methanol, sulfuric acid [4].

According to (Prasutiyon, 2017) stated that biodiesel used cooking oil with a manufacturing process using the transesterification method as much as 20% mixed with 80% diesel fuel with an additional Iodine number can affect significant damage to diesel engine components [15]. However, no case studies have been found to test the performance of diesel engines using Ketapang seed oil biodiesel because previous research only reached the

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extraction of Ketapang seed crude oil, the manufacture of Ketapang seed biodiesel, and its use as a surfactant base material [5]. Through this final project, a performance analysis of a diesel engine with biodiesel fuel containing biodiesel from Ketapang seed oil will be carried out using an experimental method [24]. This analysis is expected to be able to determine the characteristics of the fuel and its performance that is accurate according to the actual conditions of the diesel engine [22]. This research is considered quite important because the results of the experiment are able to answer various challenges regarding efforts to save fuel by adding biodiesel from Ketapang seed oil [6].

The utilization of biodiesel as an alternative fuel source has garnered attention due to its potential to reduce greenhouse gas emissions and dependency on fossil fuels [20]. Ketapang seed oil, derived from Terminalia catappa, presents a promising feedstock for biodiesel production, and understanding its chemical composition, transesterification processes, and overall feasibility is crucial for enhancing the performance of diesel engines [16,31,32]. In order to comprehensively analyze the biosolar fuel, researchers will delve into the intricacies of biodiesel production from Ketapang seed oil [25]. This entails understanding the optimal conditions for transesterification, catalyst selection, and the impact of varying reaction parameters on the yield and quality of biodiesel [17]. The chemical composition of Ketapang seed oil is a key factor in determining its suitability for biodiesel production, and in-depth analysis and optimization of these processes will contribute to the efficient utilization of this alternative fuel in diesel engines [18].

The integration of biosolar fuel derived from Ketapang seed oil biodiesel into diesel engines necessitates a thorough examination of its compatibility and impact on engine performance [21]. Studies evaluating the combustion characteristics, emission profiles, and overall efficiency of diesel engines running on this biosolar fuel will provide valuable data for optimizing the engine's operational parameters [19]. Additionally, understanding the combustion kinetics and combustion chamber behavior with the use of Ketapang seed oil biodiesel can lead to tailored engine designs and tuning strategies for enhanced performance [28,33].

This research was conducted with an experimental method to test the fuel. There are three variations of the fuel mixture 70% biodiesel 30% biodiesel ketapang seed oil, 80% biodiesel 20% biodiesel ketapang seed oil, 90% biodiesel 10% biodiesel ketapang seed oil [7]. Then carried out several stages of testing . Thus, at the end of the study, it could be proven that the performance of the e - cell motor with bio-diesel fuel could work better and more efficiently after adding ketapang seed cell bio-diesel which was used as a variation of fuel in e-cell motors so as to increase fuel efficiency [8].

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II. METHOD

2.1 Materials and tools

The raw materials used in this study were ketapang seeds in the Surabaya area and its surroundings. N-hexane solvent to extract ketapang seed oil. Sulfuric Acid/H2SO4 and methanol as methoxide solution for esterification process, KOH pellets and methanol as methoxide solution for transesterification process, aquadest.

The equipment used is pipe pliers, oven, blender, sieve balance, glass jars, digital scales, beakers, measuring cylinders, pipettes, a set of rotary evaporators, a set of Buchner funnels, a set of centrifuges, a separating funnel.

2.2. Steps

Production of Ketapang Seed Biodiesel from 03-04-2023 to 22 May 2023 at the Chemistry Laboratory of Hang Tuah University , Surabaya. The first step is to look for ketapang fruit in old and dry conditions, take the seeds using a pipe pliers by cutting the seeds vertically, first weighing the ketapang seeds as needed as much as 4600 grams, heating the ketapang seeds to a temperature of 50 °C for 3-4 days and grind the ketapang seeds and sift them with a size of 50 mesh, then the seeds are soaked by maceration method with n-hexane solution approximately 5 times until the oil content in the seeds is reduced.

Then proceed with the filtering process using a Buchner funnel to separate the powder from the n-hexane solution, after that it is continued with the distillation process with a rotary evaporator which functions to separate the oil and n-hexane solution and then the vapor from the solution is cooled to become liquid again and can be recycled for the maceration process. After that proceed to the centrifuge process to reduce the amount of free fatty acids in the oil. Then the oil is collected and heated before being processed for biodiesel production, approximately 3400 ml of crude oil is obtained from approximately 4600 grams of ketapang seeds.

From the amount of crude oil obtained as much as 3400 ml will be reduced by 400 ml due to the heating process. After that, proceed to the esterification process by first preparing a methoxide solution with the composition for 150 ml of ketapang oil requiring 60 ml of methanol and 2.5 ml of sulfuric acid /H2SO4, then the stirring process is carried out at 60 °C with a speed of 250 rpm for 90 minutes.

Then proceed with separating the oil and fatty acids by centrifuging for 10 minutes at a speed of 4000 rpm to separate the oil and precipitate followed by the transesterification process by preparing a methoxide solution in the transesterification process by combining 60 ml of methanol and 1.5 grams of KOH pellets. Then the stirring process was carried out at 60°C by mixing ketapang oil after the esterification process with methoxide solution at 250 rpm for 90 minutes.

Then proceed with the settling process of separation between glycerin and biodiesel waiting for 24 hours. In this process, from 150 ml of ketapang seed oil, 50 ml of glycerin and 60 ml of biodiesel are produced, while the

other 40 ml disappears due to evaporation. After that, the biodiesel washing process was carried out more than 5 times. In figure 1. The washed biodiesel is heated to a temperature above 100 °C after the drying process, approximately 1200 ml of ketapang seed biodiesel is obtained in figure 2.
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Figure 1. Purification Process at the Chemistry Laboratory of Hang Tuah University, Surabaya

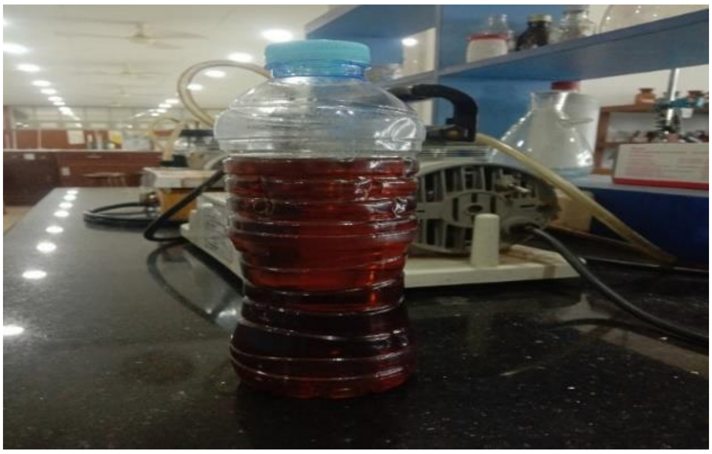

Figure 2. Ketapang seed biodiesel at the Chemistry Laboratory of Hang Tuah University, Surabaya

Before testing the performance of the biodiesel fuel engine, the characteristics of the ketapang seed biodiesel must be tested and the performance test can be seen in (figure 3).

Properties test results 09-06-2023 at the Chemical Laboratory of Sepuluh Nopember Institute Technology in (table 1),

Figure 3. Diesel Motor Performance Test 06-04-2024 at the ship Engine Laboratory, Marine Engineering, Hangtuah University Surabaya

TABLE 1.
PERFORMANCE TEST OF KETAPANG SEED BIODIESEL

No.	Parameter	Method	Spectacle Min	Max	Test results
1.	**Specific gravity**	ASTM D1298	850	890	887.6 kg/m ^{3}
2.	**Color**	ASTM D1500	-	3.0	L 3.0
3.	**Flash Point**	ASTM D93	52	-	182.4 ° *C*
4.	**Viscosity**	ASTM D445	2	6.0	5,926 cSt
5.	**Carbon Content**	ASTM D189	-	0.05	0.017 %Wt
6.	**Ash Content**	ASTM D482	-	0.02	0.012 % Wt
7.	**Moisture and Sediment Content**	ASTM D1796	-	0.05	0.05 % Vol
8.	**Sulfur Content**	Sulfur meters	-	0.35	0.0042 % Wt
9.	**Distillation**	ASTM D86	-	360	351.4 ° *C*
10.	**Acid Number**	ASTM D664	-	0.5	0.34 mg KOH/gr
11.	**Cetane Index**	ASTM D613	45	-	45

III. Results and Discussion

From the analysis and discussion, it can be seen that the fuel is not performing well in the diesel motor performance test at the lowest RPM, namely 1200 with a Specific Fuel Oil Consumption value of B0 fuel at a load of 3000 Watt 639.681 gr/kWh. The Specific Fuel Oil Consumption value for B10 fuel is 695.917 gr/kWh. On B20 fuel, the Specific Value of Fuel Oil Consumption is 735.048 gr/kWh. B30 fuel produces a Specific Fuel Oil Consumption of 793.567 gr/kWh in (figure 4).

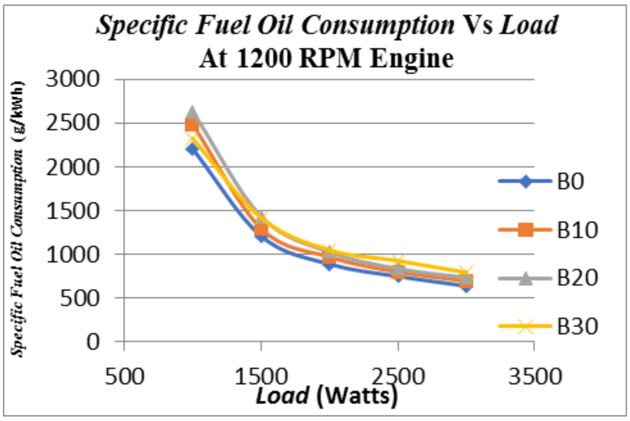

Figure 4. Graph comparison between Specific Fuel Oil Consumption to Load with Fuel Type B0, B10, B20, B30 at 1200 Engine Speed.

From the analysis and discussion of the figure below, it can be seen that fuel consumption was not good in the diesel motor performance test at the highest RPM, namely 2000 with a Specific Fuel Oil Consumption value of B0 fuel at a load of 3000 Watt 627.039 gr/kWh. The Specific Fuel Oil Consumption value for B10 fuel is 683.003 gr/kWh. For B20 fuel, the Specific Fuel Oil Consumption value is 598.833 gr/kWh. B30 fuel produces a Specific Fuel Oil Consumption of 753.892 gr/kWh in (figure 5).

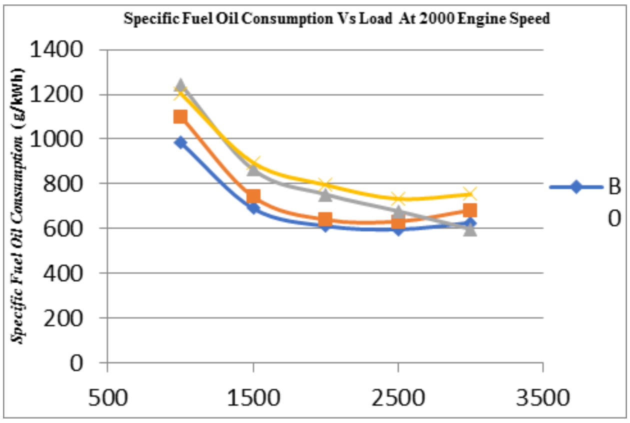

Figure 5. Comparison graph between Specific Fuel Oil Consumption to Load with Fuel Type B0, B10, B20, B30 at 2000 Engine Speed

From the analysis and discussion, it can be seen that the best fuel in the diesel motor performance test is B0 fuel which has the best Specific Fuel Oil Consumption value at 1600 RPM engine speed at 3000Watt load of 485.688 gr/kWh. The best Specific Fuel Oil Consumption value of B10 fuel is found at 3000Watt loading with 1600 RPM engine rotation of 519.447 gr/kWh. For B20 fuel, the best Specific Fuel Oil Consumption value is at 1600 RPM engine speed with a 3000 Watt loading of 569.108 gr/kWh. B30 fuel produces the best Specific Fuel Oil Consumption at 1600 RPM rotation with a 3000 Watt loading of 633.141 gr/kWh in (figure 6).

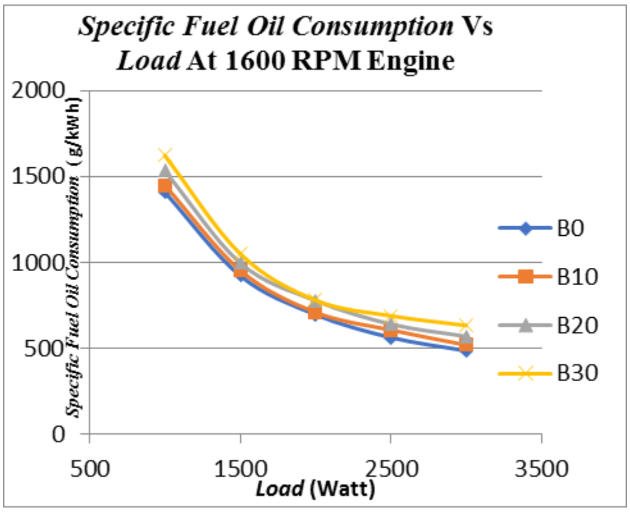

Figure 6. Comparison graph Between Specific Fuel Oil Consumption and load on fuel types B0, B10, B20, B30 at 1600 RPM.

Based on the results of the characteristic test analysis of ketapang seed biodiesel, the results obtained meet the B100 biodiesel standard. It can be seen that ketapang seed biodiesel has a fairly high viscosity value compared to biodiesel of 5.926 cSt, flash point value which is still much higher than biodiesel of 182.4 ° C , while density value is 887.6 kg/m ^{3} . The cetane index value of 45 in ketapang seed biodiesel tends to make the fuel more wasteful, Ketapang seed biodiesel affects the power value. The greater the percentage of biodiesel composition given, the less power will be generated [26)]. However, this effect is not significant because it only reduces the power by 0.03 - 0.08 kW. Ketapang seed biodiesel affects the torque value. At maximum power, the greater the percentage of biodiesel composition given, the less torque will be generated, decreasing in value by 0.1 – 0.3 Nm [29)]. Ketapang seed biodiesel affects the value of Specific Fuel Oil Consumption. At low rpm, the higher the percentage of biodiesel composition, the higher the Specific Fuel Oil Consumption value. Likewise at high speed, the higher the biodiesel composition, the higher the Specific Fuel Oil Consumption value [30)].

IV. Conclusion

The addition of Ketapang seed biodiesel composition to biodiesel will increase fuel consumption to become more wasteful. due to this high value, it is possible that Ketapang seed biodiesel will cause diesel motors and their components to work harder and can even cause damage to diesel motors

Ketapang seed biodiesel affects the value of Specific Fuel Oil Consumption. Where is based on the average calculation on the maximum Specific Fuel Oil Consumption chart. B20 fuel produces a lower Specific Fuel Oil Consumption value than B0, B10 and B30 fuel, the difference is 28.426 gr/kWh, 84.121 gr/kWh and 155.009 gr/kWh, but at 1600-1800 RPM the Specific Fuel Oil Consumption value increased with each increase in load.

According to BKI Volume III Engine Installation Regulations. In the performance test of diesel motors with biodiesel fuel and ketapang seed oil biodiesel using the parameter rated speed of medium speed engines and high-speed engines, with speeds of 1200-2000 RPM. This fuel is not suitable for high-speed engines with larger diesel engine dimensions, both trucks and ships. Because according to the overall graph it can be seen when there is a tendency to decrease in power and a significant increase in fuel consumption occurs because the percentage of the composition of the ketapang seed biodiesel increases at certain RPM. This is possible due to high fuel consumption, then poor combustion which results in clogged injector channels and eventually causes problems with diesel engines.

When making ketapang seed oil, it is best to carry out a continuous heating process and the filtering process repeatedly in order to reduce the fatty acids in ketapang seed oil. During the process of making biodiesel, you should be more careful in mixing the methoxide solution to get better biodiesel yields. Because ketapang seed biodiesel is not yet very popular, if it is to be used as an alternative fuel to replace fossil fuels, the availability of ketapang trees must be maintained. In order for this research to be developed, it is suggested to carry out further research using variations in load and composition of ketapang seed biodiesel compared to biodiesel.

Acknowledgements

Our gratitude goes to LPPM Hangtuah University, which has supported the implementation of this research. Hopefully the results of this research will be useful for the advancement of science and technology and dear readers.

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