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Study of Diesel Engine Performance Using Variations of Dexlite Fuel Mixture and Corn Seed Oil

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ABSTRACT

Due in the world population continues to increase so the need for fossil fuels also increased. This is what requires us to look for other sources beyond oil and gas, or that can be said alternative fuel. Alternative fuel not only to solve the scarcity problem but also a problem of air pollution caused by fossil fuels. This alternative fuel can be obtained from the seeds of the rubber, corn, tobacco, oil seeds, sunflower seeds, and others where at designated for diesel engines. This study aims is to analyze the performance of TD–115. From this Research diesel engine using corn biodiesel mixture Dexlite fuel by using (Dexlite, Dexlite + 5% Biodiesel, Dexlite + 10% Biodiesel, Dexlite + 15 % Biodiesel, Dexlite + 20% Biodiesel, Dexlite + 25% Biodiesel). Found that the Power (P) decrease up to 40, Specific Fuel Consumption (SFC) of the mixture increase up 48 Thermal Actual Brake Efficiency (decrease up to 41%, rate of mass fuel (mf) decreased to 59%, Volumetric Efficiency ( ) decreases to 19%, Heat Losses decrease up to 74%, Air Fuel ratio decreased to 44%.

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1. INTRODUCTION

Indonesia is running low, with an estimated supply of 86.9 billion barrels. This amount is estimated to only be able to meet domestic energy needs for the next 23 years (Pranowo, 2009a). This situation makes the development of energy diversification including bioenergy a top priority that must be done in order to maintain energy security (Rampai, n.d.)The increasing population and the high dependence of the Indonesian people on oil further exacerbate this condition (Arza & Murtala, 2021). The increase in population has an impact on increasing the need for transportation facilities and industrial activities that (Arsandi et al., 2017) resulting in an increase in the need and consumption of national fuel oil (BBM) (Sa'adah et al., 2017). The need for diesel fuel nationally from year to year continues to increase successively (Wijianto et al., 2014).

As a result of dependence on petroleum as a fuel, the impact is very large (Kholiq, 2015). Therefore, in order to reduce dependence on fossil fuels (Meichika et al., 2021), it is necessary to immediately take steps to obtain alternative energy sources (Pranowo, 2009b). The development of bioenergy or biofuels as an alternative energy source is very strategic to overcome these problems (Hambali et al., 2007). Facing the increasing scarcity of petroleum while the need for diesel fuel is increasing along with the increase in the use of diesel engines (Sitorus et al., 2016), it is necessary to look for other sources other than oil and gas. Alternative fuels that are possible are derived from vegetable oils which are (Syah, 2006)found in plants such as coconut, castor seeds, sunflower seeds, soybeans (Sulistiani, 2016), peanuts. In this case, the author has studied and read several studies on the use of alternative fuels derived from plants or from materials originating around our environment (Prihandana et al., 2007). Among them is biodiesel made from a mixture of pertadex and sunflower seed biodiesel (Kristianturi, 2019). Where from these studies affect the performance of diesel engines resulting in a decrease in power of about 1-4% (Kristianturi, 2019), Specific Fuel Consumption increases by about 11-58%, the actual thermal efficiency of the brake decreases by about 2-6%, the mass flow rate of fuel decreases by about 4-14% (Tulus B Sitorus, et al. USU. 2015) (Dwi Bagaskoro, n.d.).

In addition, there are also other biodiesel studies, namely coconut oil biodiesel fuel which has great potential to be applied as a substitute for diesel/diesel oil (Darmanto, 2006). The flash point of coconut biodiesel is lower than that of diesel. The calorific value of coconut oil biodiesel fuel is equivalent to diesel fuel (Aziz, 2010)(Seno Darmanto, Ireng Sigit A. Mechanical Engineering UNDIP.2006). Other biodiesel that can be used as raw material for alternative fuels include sesame seeds (Kuncahyo et al., 2013) (Arthur, et al. USU. 2016), rice husk biodiesel, and biodiesel from plastic waste processing (Insan, 2020). So that the author's idea emerged to conduct research on the use of biodiesel from corn kernels (Masruroh & Pahlawan, 2017). Where we know that corn is one type of plant that can grow easily in almost all parts of Indonesia (Azwir et al., 2019). In addition, corn is a plantation crop whose prices are still affordable (Tak, 2021).

The author also often sees in the author's living environment that most corn plants are only used as animal feed to milled coffee mixing materials (Piryadi, 2013). So that the author's idea emerged that underlies this research, namely to find out other economic functions of corn plants (Widi, 2018)namely the feasibility of corn kernels as an alternative fuel for mixing, perhaps even a substitute for fossil fuels (Widarti et al., 2016). So that it can be used to reduce the use of fuel oil (fossil) (Serevina et al., 2021). In addition, one of the renewable energies that can be produced with appropriate technology which is relatively simpler and according to the potential in the territory of Indonesia, especially in rural areas is corn kernels which (Indonesia, n.d.) is one type of plant that is easy to cultivate, produces fruit that contains vegetable oil and has the potential to be used as raw material (Tasma, 2017) replacement/mixture of dexlite (biodiesel).

The purpose of the test is to determine the effect of a mixture of dexlite fuel and corn kernel biodiesel on the performance of diesel engine generators (Fadhlullah, 2018). The benefits of testing this research are: (1) To determine the economic function of corn kernels (Risal et al., 2021)(2) To provide support to the government in reducing dependence on fossil fuels, especially diesel (Meilani & Wuryandani, 2010) (3) To determine the advantages and disadvantages of each tested fuel, namely Dexlite (Diesel CN:51), and a mixture of Dexlite with corn kernel biodiesel.

2. RESEARCH METHOD

2.1 Method of Collecting Data

The data used in this test include: (1) Primary data, is data obtained directly from measurements and readings on the instrumentation unit and measuring instruments in each test. (2) Secondary data, is data about the characteristics of the fuel used in the test.

2.2 Data Processing Method

The data obtained from the test results are processed using the existing formula, then the results of the calculations are presented in tabulation and graph form.

Observation and Testing Phase, the parameters to be reviewed in this test are: (1) Motor torque (T), (2) Motor power (N), (3) Specific fuel consumption (sfc), (4) Actual Brake Thermal Efficiency (5) Volumetric Efficiency (6) Heat Loss (7) Percentage of Heat Loss. The test procedure is divided into several stages, namely: (1) Testing a diesel engine using dexlite fuel. (2) Testing diesel engine using dexlite fuel + Corn Biodiesel 5% (3) Testing diesel engine using dexlite fuel + Corn Biodiesel 10% (4) Testing diesel engine using dexlite fuel + Corn Biodiesel 15% (5) Engine testing diesel using dexlite fuel + 20% Corn Biodiesel (6) diesel engine testing using dexlite + Corn Biodiesel fuel 25%.

3. RESULTS AND DISCUSSIONS

3.1. Calorie Meter Bomb Test Results

Bomb calorimeter testing to get the calorific value of the fuel. The calorific value of the fuel is obtained by looking at the difference in water temperature before and after the fuel calorie bomb process takes place, can be calculated using equation 2.2. The results obtained are still the gross calorific value of the fuel, so for the net calorific value of the fuel we use, we use the LHV (Low Heating value) value of the fuel which is calculated using equation 2.4. The following table shows the results of the bomb calorimeter test, along with the HHV and LHV values of the fuel:

Table 1. Bomb Calorimeter Test Results

Bahan Bakar	Pengujian	T1	T2	HHV	LHV	LHV Rata-Rata
Dexlite	1	25.15	26.03	61029.568	57789.568	
	2	26.23	27.06	57353.088	54113.088	
	3	27.42	28.29	60294.272	57054.272	56171.9168
	4	25.27	26.12	58823.68	55583.68	
	5	26.22	27.08	59558.976	56318.976	
M.Jagung 5%	1	26.06	26.85	54411.904	51171.904	
	2	26.93	27.8	60294.272	57054.272	54701.3248
	3	27.83	28.72	61764.864	58524.864	
	4	25.7	26.51	55882.496	52642.496	1470,592
	5	26.54	27.37	57353.088	54113.088	
M.Jagung 10%	1	28.43	29.25	56617.792	53377.792	
	2	26.07	26.91	58088.384	54848.384	53818.9696
	3	26.96	27.81	58823.68	55583.68	2352.947
	4	27.83	28.63	55147.2	51907.2	
	5	25.65	26.47	56617.792	53377.792	
M.Jagung 15%	1	25.7	26.55	58823.68	55583.68	
	2	26.64	27.46	56617.792	53377.792	52936.6144
	3	27.53	28.28	51470.72	48230.72	3235.302
	4	28.49	29.3	55882.496	52642.496	
	5	25.66	26.5	58088.384	54848.384	
M.Jagung 20%	1	25.91	26.79	61029.568	57789.568	
	2	27.02	27.8	53676.608	50436.608	52642.496
	3	27.83	28.62	54411.904	51171.904	3529.42
	4	28.56	29.31	51470.72	48230.72	
	5	25.77	26.62	58823.68	55583.68	
M.Jagung 25%	1	25.79	26.61	56617.792	53377.792	
	2	26.78	27.63	58823.68	55583.68	52054.2592
	3	27.68	28.49	55882.496	52642.496	4117.65
	4	25.45	26.21	52206.016	48966.016	
	5	26.27	27.04	52941.312	49701.312	
M.Jagung 100%	1	25.12	25.89	52941.312	49701.312	
	2	26.43	27.22	54411.904	51171.904	49260.1344
	3	27.32	28.07	51470.72	48230.72	6911.782
	4	28.09	28.86	52941.312	49701.312	
	5	25.23	25.97	50735.424	47495.424	

The highest average Low Heat Value (LHV) occurs in dexlite oil, which is 56171,9168. Meanwhile, the lowest average Low Heat Value (LHV) occurs in Corn Seed Oil Biodiesel, which is 49260,1344. So that the decrease in LHV is 12.30%. Meanwhile, the highest decrease in LHV that occurs between Dexlite mixed with biodiesel, corn kernels is in a mixture with a 25% content, which is 7.33%.

3.2. Diesel Engine Performance Test

The data obtained from the direct reading of the 4 stroke 1 cylinder TD-111 diesel engine test device through the TD-115 reader will then be processed and calculated to get the performance of the diesel engine.

3.2.1. Power

The amount of power from each test and each load variation is calculated using equation 2.5. For testing with Dexlite fuel: Load: 3.5 Kg Engine speed: 1800rpm.

$$P_b = \frac{2 \; x \; \pi \; x \; 1800}{60} x \; 8.1 \tag{1}$$

Pb = 1.52kW

With the same calculation, it can be seen the amount of power generated from each test both in all variations of the percentage of biodiesel, and loading conditions and engine speed as shown in Table 4.9 below:

Table 2. Calculation Data For Power

Beban	Putaran	Daya (kW)					
		Dexlite	Dexlite +M.Jagung 5%	Dexlite +M.Jagung 10%	Dexlite +M.Jagung 15%	Dexlite +M.Jagung 20%	Dexlite +M.Jagung 25%
3.5	1800	1.52604	1.43184	1.37532	1.26228	1.18692	1.11156
	2000	1.7793333	1.6537333	1.57	1.46533333	1.402533333	1.3188
	2200	2.0263467	1.8881867	1.81910667	1.68094667	1.634893333	1.542786667
	2400	2.31104	2.16032	2.11008	1.93424	1.85888	1.7584
	2600	2.61248	2.4219867	2.34034667	2.20428	2.095426667	2.013786667
	2800	2.90136	2.7548267	2.60829333	2.46176	2.344533333	2.256613333
4.5	1800	2.355	2.24196	2.14776	2.0724	1.99704	1.92168
	2000	2.6794667	2.5748	2.4492	2.3864	2.281733333	2.198
	2200	2.9934667	2.90136	2.7632	2.69412	2.578986667	2.509906667
	2400	3.34096	3.24048	3.11488	3.03952	2.91392	2.81344
	2600	3.7010133	3.59216	3.45609333	3.37445333	3.238386667	3.129533333
	2800	4.0736267	3.9564	3.83917333	3.75125333	3.634026667	3.487493333

At a loading of 3.5 kg the lowest power occurred in tests using 25% biodiesel fuel at 1800 rpm engine speed of 1.11156 kW while the highest power occurred in tests using Dexlite fuel at 2800 rpm engine speed of 2.90136 kW. So that the power loss that occurs is 61.68%.

At a loading of 4.5 kg the lowest power occurred in tests using 25% biodiesel fuel at 1800 rpm engine speed of 1.92168 kW while the highest power occurred in tests using Dexlite fuel at 2800 rpm engine speed of 4.0736267 kW. So that the power loss that occurs is 52.82%. The comparison of the amount of power for each test at each load and rotation variation can be seen in Figures 4.3 and 4.4 below:

Figure 1. Graph of Power Vs Engine Speed For 3.5 Kg . Load

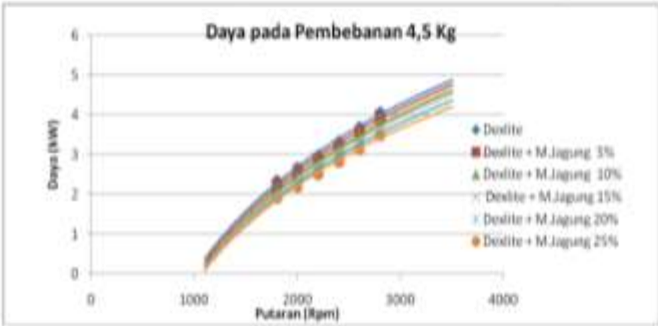

Figure 2. Graph of Power Vs Rotation For 4.5 Kg . Load

Graphics 4.3 and 4.4 show that the greatest power occurs in the use of Dexlite fuel because the highest calorific value (LHV) is found in Dexlite, in addition to the use of Dexlite also produces the highest torque so that the power produced is the highest, which is equal to 54113.08 kJ/kgoC Graphs 4.3 and 4.4 show that the highest power occurs in the use of Dexlite while the lowest power occurs in the use of Dexlite + Biodiesel Corn 25%. This is due to the higher torque obtained with Dexlite fuel than using biodiesel blended fuel.

3.2.2. Specific Fuel Consumption (SFC)

The specific fuel consumption of each test at each variation of load, rotation and fuel can be calculated using equation 2.14. With the large fuel flow rate obtained in section 4.4.2, for testing using Dexlite material with a load of 3.5 kg there is an engine speed of 1800 rpm, the SFC value is obtained:

$$SFC = \frac{0{,}184 \times 10^3}{1{,}52}$$

$$Sfc = 121{,}05 \text{ (gr/kWh)} \tag{2}$$

By using the same method for variations in load, fuel, and engine speed, the SFC calculation results are obtained as shown in Table 4.15 below:

Table 3. Calculation Data for Specific Fuel Consumption

Beban	Putaran	Konsumsi Bahan Bakar Spesifik (gr / kWh)					
		Dexlite	Dexlite +M.Jagung 5%	Dexlite +M.Jagung 10%	Dexlite +M.Jagung 15%	Dexlite +M.Jagung 20%	Dexlite +M.Jagung 25%
3.5	1800	120.81116	150.44918	155.32676	167.83797	183.0323406	198.8109907
	2000	111.85335	146.2379	156.99951	166.611725	177.4519893	192.4557679
	2200	110.83353	147.57016	158.137257	167.585316	174.2205404	182.5929561
	2400	106.9963	139.60285	159.852256	169.91289	168.1767988	184.5383029
	2600	104.11563	144.98954	161.080209	171.023431	172.3060289	169.7292
	2800	104.16571	143.16065	161.118356	167.955368	158.4622384	164.6360918
4.5	1800	78.749276	97.727675	102.013977	107.562247	110.6589477	114.9985142
	2000	76.77434	97.608495	102.614059	109.612977	111.2359141	115.4734727
	2200	75.025775	99.274947	105.423225	113.27526	112.9534551	117.3963148
	2400	74.767707	101.42087	106.880689	115.532301	115.7550834	121.4877161
	2600	73.493386	106.51256	109.077937	118.699226	118.1483833	124.1102846
	2800	76.068193	106.21877	109.462089	117.822138	115.6414008	124.5850386

At the loading of 3.5 kg the highest SFC occurred in the use of biodiesel 25% at 1800 rpm, which was 198,8109907 gr/kWh and the lowest SFC occurred in the use of Dexlite fuel at 2800 rpm, which was 104,16571gr/kWh. So that the increase in SFC that occurred was 47.60%. At the loading of 4.5 kg the highest SFC occurred in the use of biodiesel 25% at 2800 rpm, which was 124.5850386 gr/kWh and the lowest SFC occurred in the use of Dexlite fuel at 2600 engine speed, which was 73.493386 gr/kWh. So that the increase in SFC that occurred was 41,009%. Comparison of SFC values for each fuel test can be seen in Figures 4.15 and 4.16 below.

Figure 3. SFC vs Engine speed at 3.5 Kg . loading

Figure 4. SFC vs Engine speed at 4.5 Kg . loading

Figures 4.15 and 4.16 show that the largest SFC occurs in the 1800 round 25% biodiesel because this cycle has a low mf value. In addition, this is influenced by the calorific value of the fuel which is small compared to the available fuel. The low calorific value results in fuel consumption that occurs every hour the higher the power unit it generates because the fuel does not burn completely.

3.2.3. Injector Condition

To know the results of combustion in the combustion chamber it is necessary to know the condition of the injector.

Figure 5. Injector Condition

Description: (1) Initial condition of the injector, (2) Condition of the injector after burning Dexlite fuel (3) Condition of the injector after burning Dexlite fuel + 5% Corn Biodiesel (4) Injector condition after burning Dexlite fuel + 10% Corn Biodiesel (5) Condition of injector after burning Dexlite fuel + Corn Biodiesel 15% (6) Condition of injector after burning Dexlite fuel + Corn Biodiesel 20% (7) Condition of injector after burning Dexlite fuel + Corn Biodiesel 25%.

From these conditions, it can be seen that the dirtiest condition of the injector is the combustion of Dexlite fuel + 25% Corn Seed Biodiesel, this indicates that the combustion of Dexlite + 25% biodiesel fuel is incomplete so that it leaves combustion residue in the combustion chamber which causes the injector to be dirty.

3.2.4. Economic Value of Fuel Mix

The economic value of the fuel mixture is calculated as a consideration of whether this fuel mixture is feasible to be marketed. The following details the calculation of the selling price of mixed fuel: Corn oil price : Rp. 63.000,-/Liter Dexlite fuel price: Rp. 8.400,-/Liter The percentage of mixed content to be calculated is 15%. The amount of corn oil at 15% content in the mixture for the use of 1 liter of corn biodiesel is 15% x 1000 mL = 150 mL / liter of fuel mixture. So that obtained for 1 liter of corn oil can produce as much mixture.

$$\frac{1000\text{ mL}}{150\text{ mL}} = 6{,}7 \text{ Botol campuran} \quad (3)$$

Meanwhile, Dexlite fuel content in 1 liter of fuel mixture is 85% x 1000 mL = 850 mL/liter mixture. So that it is obtained, the amount of Dexlite fuel for the use of 1 liter of corn oil is: 6.7 mixture X 850 mL = 5,695 mL. Cost for Dexlite 5,695 L x Rp. 8.400,- = Rp. 47,838,- The amount of mixture obtained is 6,695 Liters / liter of corn oil. So the price of the mixture of Dexlite and corn oil biodiesel is:

$$\frac{\text{Rp. } 63.000, + \text{Rp } 47.838,-}{6{,}695 \text{ liter}} = \textbf{Rp. 16.435},\text{-/ Liter Campuran}$$

The effect of diesel engine performance between the use of dexlite and dexlite + 15% biodiesel is as follows: Power produced by the engine on fuel consumption: (1) Dexlite, Speed: 1600 rpm, Load: 3.5 Kg, Power: 1,5260 kW. (2) Biodiesel 15%, Speed: 1600 rpm. Load: 3.5 Kg. Power: 1.2622 kW. The decrease in power that occurs is 26.38%.

4. CONCLUSION

From the test results based on the amount of biodiesel used (Dexlite, Dexlite + 5% Biodiesel, Dexlite + 10% Biodiesel, Dexlite + 15% Biodiesel, Dexlite + 20% Biodiesel, Dexlite + 25% Biodiesel) it is obtained that: (1) The highest torque on the use of dexlite at 2800 rpm at a loading of 4.5 kg while the lowest torque is at the use of 25% biodiesel at 1600 rpm at a loading of 3.5 kg. So that the torque decreases by about 26-40%. (2) The highest power is at the use of dexlite at 2800 rpm at a loading of 4.5 kg while the lowest power is at the use of biodiesel 25% at 1600 rpm at a loading of 3.5 kg. So that the power decreases by around 52 – 62%. (3) The lowest fuel flow rate on the use of dexlite at 1600 rpm rotation at loading 3, 3.5 kg Volumetric Efficiency decreased by 18 - 19%. (5) The lowest specific fuel consumption (SFC) is at the use of dexlite at 2600 rpm at a loading of 4.5 kg while the highest SFC is at the use of biodiesel 25% at 1600 rpm at a loading of 3.5 kg.) increased by about 41-47%. (6) The highest actual brake thermal efficiency was applied to dexlite at 2600 rpm at a loading of 4.5 kg, while the lowest actual brake thermal efficiency was at 25% biodiesel at 1600 rpm.rpm at 3.5 kg load The actual thermal efficiency of the brakes decreases by about 22-40%. This is influenced by the calorific value which decreases when the use of biodiesel increases.

Suggestions in this study are: (1) Completing and studying measuring instruments at the time of testing to obtain better test results. (2) Waiting for stable engine speed when raising and lowering the speed in order to get the right engine speed when testing at different speeds through readings on the TD-115 reading instrumentation. (3) Develop this test using a variety of different fuel mixtures that are more promising. (4) Prioritize work safety in testing.

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