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Performance Study of Single Cylinder Diesel Engine Using Pertadex Mixed Fuel with Rice Bran Biodiesel

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ABSTRACT

Increasing population, and limited resources of oil into so many things that encourage us to do the research and development of alternative fuels, one of which is the use of rice bran to produce biodiesel. Indonesia as the world's third largest grain, bran produced in large quantities. The content of free fatty acids (Free Fatty Acid (FFA)) is high, rice bran can be converted into Biodiesel. This study aims to analyze the performance of diesel engines using alternative fuel mixture Pertadex with 5%, 10%, 15%, 20%, 25%, 30% biodiesel rice bran. Stages of work done in this study, the manufacture of biodiesel by transesterification process, blending biodiesel with Pertadex, testing calorific value in a bomb calorimeter, and performance testing of diesel engines. From the analysis, it is concluded, greater the addition of a mixture% biodiesel Rated Power, volumetric efficiency, the actual Thermal Efficiency and Heat Loss tended to decline, while the rate of material flow baar (mf) and specific fuel consumption (SFC) Tend to increase.

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1. INTRODUCTION

The increasing number of rapidly growing population in Indonesian society has led to an increase in transportation facilities and industrial activities (Harahap, 2013) which results in an increase in the need and consumption of fossil fuels (BBM) (Nababan, 2017) Meanwhile, Indonesia's oil reserves are running low, which is estimated to be available at 86.0 billion barrels (Kholiq, 2015). This amount is estimated to only be able to meet domestic energy needs for the next 23 years (Ministry of Energy and Mineral Resources, 2005) (Nasional, 2014). The current high price of world oil sourced from fossils is making the situation even worse (Prihandana et al., 2007). This situation makes the development of energy diversification, including bioenergy, a top priority that must be done in order to maintain energy security (Pranowo, 2009). Indonesia is a country that is very rich in resources that can be used as biofuels (Qiqmana, 2014), Utilization of biofuel as an alternative energy mixture of fossil fuels is one of the right steps that can save the need for national diesel oil which continues to increase from year to year (Wahyuni & MP, 2013). Efforts to develop the biofuel industry are not only meant to reduce dependence on fossil fuels (BBM), but are also expected to create jobs, thereby reducing unemployment (pro job) (Rampai, n.d.); and the level of poverty (pro poor); strengthening the national economy (pro growth); and improve the environment (pro planet). In regards to that (Lako, 2015), as an effort to find other raw materials in the form of potential vegetable oil-producing plants to be developed as raw materials for prospective biofuel production (Wijaya et al., 2012).

One of the renewable energies that can be produced with appropriate technology that is relatively simpler and according to the potential of the region in Indonesia is rice bran (Mediastika, 2021), which is a very appropriate raw material to be used as a substitute for diesel fuel (biodiesel) without affecting the ups and downs of economic growth (Wahyuni, 2013). Indonesia as the third largest grain producer in the world produces bran in large quantities as much as 3.5 million tons per year (Directorate General of Crop Production Development 2005) abundant supply of raw materials, the production of biodiesel from bran oil is very promising (Dharsono & Oktari, 2010). Depending on the rice variety and degree of milling, rice bran contains 16%-32% by weight of oil (Putrawan 2006). About 60%-70% of rice bran oil cannot be used as food (non-edible oil) due to the stability and different storage methods of rice bran (Maharani & Zuliyana, 2011). Rice bran oil is one type of oil with high nutritional content due to the presence of fatty acids, biologically active components, and antioxidant components such as: oryzanol, tocopherols, tocotrienols, phytosterols, polyphenols and squalene (Iqbal, 2016). But with sufficient storage time, the free fatty acid content can increase by more than 60%. The rapid increase in free fatty acids occurs due to the presence of lipase enzymes which are active in rice bran after the rice milling process (Mukhlis, 2017). The free fatty acids can be converted into biodiesel (methyl ester) by esterification using alcohol. Therefore, it can be ascertained that bran is a potential raw material for biodiesel production. In addition, the increasing number of motorized vehicles currently has an impact on poor air quality in urban areas, which requires motorcycle manufacturers to innovate, one of which is the catalytic converter found in current cars. This tool serves to reduce the intensity of exhaust gas air pollution due to the combustion process of motorized vehicles.

The purposes of this test are: (1) To determine the performance of a diesel engine using pertadex fuel and a mixture of pertadex with rice bran biodiesel. The benefits of this test are: (1) As a consideration for the government to save foreign exchange on the pertadex fuel subsidy budget (2) To provide support to the government in reducing dependence on fossil fuels, especially pertadex. (3) To find out the advantages and disadvantages of each tested fuel, namely a mixture of pertadex with rice bran 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 (Supriyatmojo et al., 2018). (2) Secondary data, is data about the characteristics of the fuel used in the test (Negara et al., 2009).

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 (Otto, 2016).

2.3 Observation and Testing Phase

The parameters that will be reviewed in this test are: (1) Motor power, (2) Fuel Flow Rate (Mf), (3) Specific fuel consumption (sfc), (4) Actual Thermal Efficiency, (5) Volumetric efficiency, (6) Heat Loss. The test procedure is divided into several stages, namely: (1) Testing diesel engines using Pertadex fuel (Cappenberg, 2017), (2) Testing diesel engine using Pertadex fuel + 5% rice bran (3) Testing diesel engine using Pertadex fuel + 10% rice bran (Sirait, 2016) (4) Testing diesel engine using Pertadex fuel + 15% rice bran (5) Testing diesel engine using Pertadex fuel + 20% rice bran (6) Testing diesel engine using Pertadex fuel + 30% rice bran (Wafir, n.d.).

2.4 Diesel Engine Performance Testing Procedure

The procedure for testing the performance of the motor is carried out with the following steps: (1) Instrumentation calibration of the diesel engine before use (2) Operates the engine by turning the engine crankshaft, then heating the engine for 10 minutes (3) Adjusting the engine speed at 1800 RPM using a lever speed and view analog data on the instrument (4) Determine the fuel consumption to be tested (5) Weigh the fuel that runs out after 5 minutes of testing (6) Repeat the test using different rotation variations (1800 RPM, 2000 RPM, 2200 RPM, 2400 RPM, 2600 RPM, 2800 RPM). To be more concise, the performance testing procedure carried out can be seen through the flow chart in Figure 3.11 below.

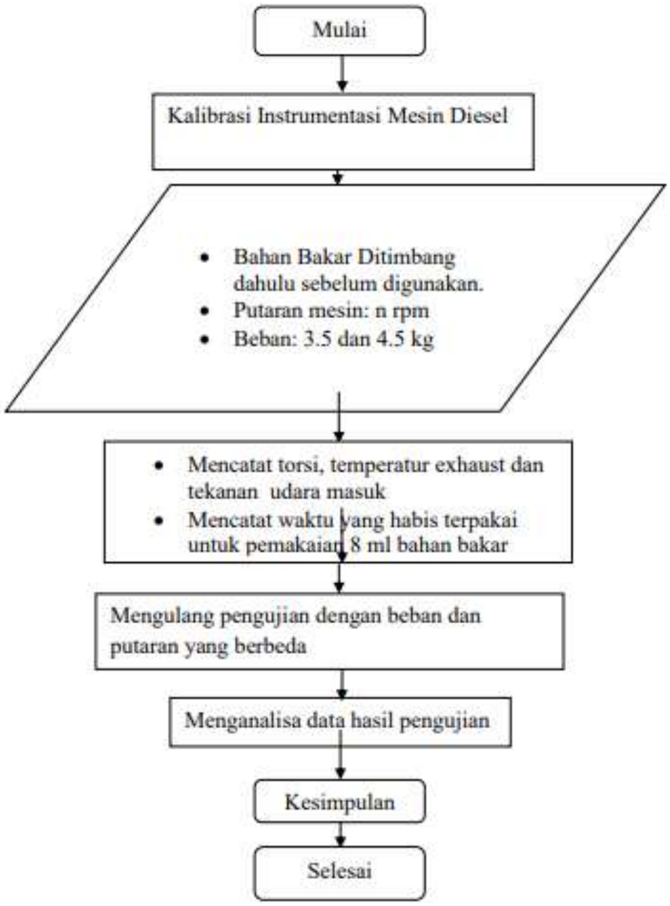

Figure 1. Engine Performance Testing Flowchart

3. RESULTS AND DISCUSSIONS

3.1. Rice Bran Biodiesel

Bran contains 17%-23% fat which can be used as edible oil. In the bran there are also several minerals, among others: calcium (0.13%), phosphorus (2.39%), tassium (0.14%), sodium (0.24%), magnesium (0.14%) and silica (4.07%). In addition, there are also 224 ppm iron), aluminum, copper, manganese, tin and chloride (SBP Board of Consultants and Engineers 1998). Following are the results of extraction, transesterification and comparison with SNI (Indonesian National Standard):

3.2. Calorie Meter Bomb Test Results

Bomb calorimeter testing is done 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 bombing process takes place, or it can be written in the equation:
HHV= (t2- t1-tkp) x Cv (1)
where:
HHV = High Heating Value, t2 = Water temperature after ignition (oC), t1 = Water temperature before ignition (oC), tkp = Temperature increase due to ignition wire (0.05oC), Cv = Specific heat of bomb calorimeter (73529.6 kJ/kg oC).

The results obtained are still the gross calorific value of the fuel, so for the net calorie value of the fuel we use, we use the LHV (Low Heating value) value of the fuel, namely:
LHV = HHV – 3240 kJ/kgoC.

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(°C)	T2(°C)	HHV(Kj/kg)	LHV(kJ/kg)	LHV Rata-Rata(Kj/kg)
Pertamina dex	1	25.21	26.09	61029.57	57789.57	56466.04
	2	26.29	27.12	57353.09	54113.09	
	3	27.52	28.39	60294.27	57054.27	
	4	28.5	29.38	61029.57	57789.57	
	5	25.25	26.1	58823.68	55583.68	
Pertamina dex + 5 % biodiesel	1	25.54	26.33	54411.904	51171.904	50289.549
	2	26.42	27.18	52206.016	48966.016	
	3	27.24	28.05	55882.496	52642.496	
	4	27.38	28.2	56417.792	53177.792	
	5	28.27	28.98	48529.536	45289.536	
Pertamina dex + 10% biodiesel	1	27.99	28.79	55147.2	51907.2	52789.556
	2	25.62	26.47	58823.68	55583.68	
	3	26.62	27.42	55147.2	51907.2	
	4	27.51	28.3	54411.904	51171.904	
	5	26.45	27.25	56417.794	53177.794	
Pertamina dex + 15% Biodiesel	1	25.84	26.77	64708.048	61468.048	56171.917
	2	26.91	27.73	56417.792	53177.792	
	3	27.76	28.53	51470.72	48230.72	
	4	26.23	27.24	70588.416	67348.416	
	5	27.31	28.09	53676.608	50436.608	
Pertamina dex + 20% Biodiesel	1	26.02	26.78	52206.016	48966.016	47789.543
	2	26.86	27.56	47794.24	44554.24	
	3	27.6	28.35	51470.72	48230.72	
	4	26.36	27.12	52206.02	48966.02	
	5	27.25	28	51470.72	48230.72	
Pertamina dex + 25% Biodiesel	1	25.78	26.53	51470.72	48230.72	46024.832
	2	26.65	27.39	50735.424	47495.424	
	3	27.45	28.11	44853.056	41613.056	
	4	26.12	26.88	52206.016	48966.016	
	5	27.01	27.7	47059.944	43819.944	
Pertamina dex + 30% Biodiesel	1	26.66	27.42	52206.016	48966.016	45730.714
	2	27.47	28.15	46323.648	43083.648	
	3	28.17	28.87	47794.24	44554.24	
	4	26.15	26.89	50735.424	47495.424	
	5	27.04	27.74	47794.24	44554.24	

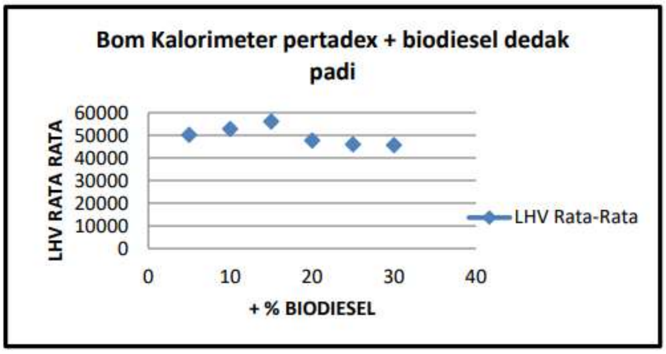

Figure 2. LHV vs %Biodiesel Chart

From the results of the Bomb Calorimeter test, the highest average LHV value for pertadex fuel is 56466.04 and the lowest LHV value for pertadex fuel + 30% iodine.

3.3. TD Bed Test Engine Test Results -111

From the engine test bed TD -111, testing was carried out and the test results were observed on the TD-115 reader instrumentation. The test was carried out with 5 variations of fuel, 6 variations of engine speed, and 2 variations of static load, namely 3.5 kg and 4.5 kg.

3.4. Diesel Engine Performance Test

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

3.4.1. Power

The comparison of the amount of power for each test at each load and rotation variation can be seen in Figures 4.2 and 4.3 below:

Figure 3. Power vs engine speed graph for 3.5 kg beban load

Figure 4. Power vs Speed Graph for 4.5 kg . load

From the graph it can be seen that the highest power occurs in the use of Pertamina dex while the lowest power occurs in the use of Pertamina dex + 20% rice bran biodiesel

3.4.2. Fuel Flow Rate (mf)

The comparison of each mf value at each loading with variations in fuel and variations in engine speed can be seen in graphs 4.4 and 4.5 below:

Figure 5. Graph of mf vs. engine speed for a load of 3.5 kg

Figure 6. Graph of mf vs. engine speed for a load of 4.5 kg

It can be seen from the graph trend above that the fuel flow rate is high at the use of 20% bodysel with a 3.5 kg load, while the lowest fuel flow rate occurs when the 25% biodiesel is used at a 4.5 kg load.

3.4.3. Specific Fuel Consumption (SFC)

By using the same method for variations in load, fuel, and engine speed, the SFC calculation results are obtained as shown in table 4.16 below:

Table 2. SFC Specific Fuel Consumption (g/Kwh)

Beban	Putaran	Pertadex	Biodiesel 5%	Biodiesel 10%	Biodiesel 15%	Biodiesel 20%	Biodiesel 25%	Biodiesel 30%
	1800	141.635	163.601	159.254	158.488	191.105	171.874	169.054
	2000	130.816	164.965	153.189	169.634	177.260	173.503	156.544
	2200	143.850	161.896	182.334	155.996	192.312	171.713	171.304
3.5	2400	144.586	155.792	173.381	174.421	174.421	166.999	188.374
	2600	131.731	169.180	205.722	159.596	186.647	187.683	181.129
	2800	132.472	154.829	203.868	170.629	179.404	186.304	165.887
	1800	104.132	103.812	110.308	111.747	118.634	117.294	112.741
	2000	89.317	106.341	118.973	110.850	112.382	120.605	114.951
	2200	96.028	113.853	116.559	106.840	126.539	118.103	108.768
4.5	2400	93.298	110.747	120.753	106.546	126.450	118.156	128.520
	2600	98.065	123.833	128.867	118.173	120.514	130.264	118.866
	2800	102.887	120.137	121.532	116.440	127.856	122.321	114.166

The comparison of SFC prices for each fuel test can be seen in Figures 4.14 and 4.15 below.

Figure 7. SFC vs Engine speed at 3.5 kg load

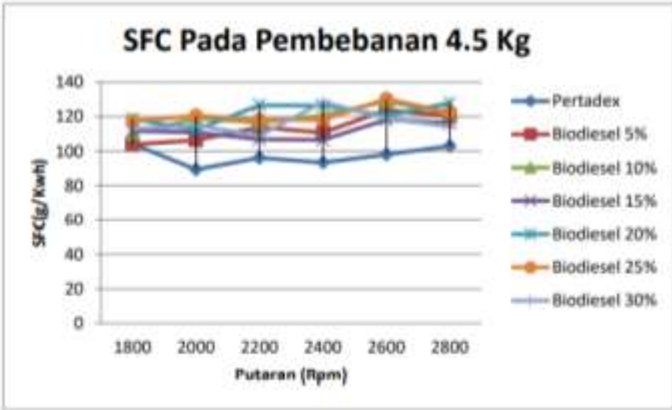

Figure 8. SFC vs Engine speed at 4.5 kg loading

3.4.4. Heat Loss

Furthermore, with the same calculation for loading, variations in LHV value according to the percentage of biodiesel, and varying rotations, heat losses are obtained as shown in table 4.17 below.

Table 3. Heat Loss Heat Loss (w)

Beban	Putaran	Pertadex	Biodiesel 5%	Biodiesel 10%	Biodiesel 15%	Biodiesel 20%	Biodiesel 25%	Biodiesel 30%
	1800	951.362	1001.30	805.184	806.35	788.02	862.72	745.15
	2000	1217.69	1281.39	1002.028	1460.14	1461.75	1159.54	1369.10
	2200	1592.00	1463.14	1269.175	1720.94	1857.63	1550.31	1822.98
3.5	2400	2157.36	1930.30	1985.017	2232.15	2149.82	2114.43	2295.24
	2600	2467.65	2391.55	2635.147	2524.65	2624.74	2365.01	2457.78
	2800	2798.49	3170.12	3359.381	3028.06	3362.48	2870.73	2622.47

Beban	Putaran	Pertadex	Biodiesel 5%	Biodiesel 10%	Biodiesel 15%	Biodiesel 20%	Biodiesel 25%	Biodiesel 30%
	1800	951.362	1001.30	805.184	806.35	788.02	862.72	745.15
	2000	1217.69	1281.39	1002.028	1460.14	1461.75	1159.54	1369.10
	2200	1592.00	1463.14	1269.175	1720.94	1857.63	1550.31	1822.98
3.5	2400	2157.36	1930.30	1985.017	2232.15	2149.82	2114.43	2295.24
	2600	2467.65	2391.55	2635.147	2524.65	2624.74	2365.01	2457.78
	2800	2798.49	3170.12	3359.381	3028.06	3362.48	2870.73	2622.47

Figure 9. Heat Loss vs. Engine speed at 3.5 kg load

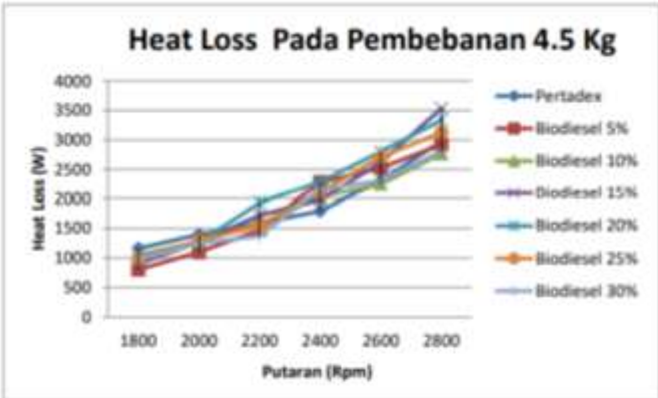

Figure 10. Heat Loss Vs Engine Speed At 4.5 Kg . Loading

3.4.5 Percentage of Heat Loss

The results of the percentage of heat loss for each fuel, loading can be seen in the graphs 4.18 and 4.19 below.

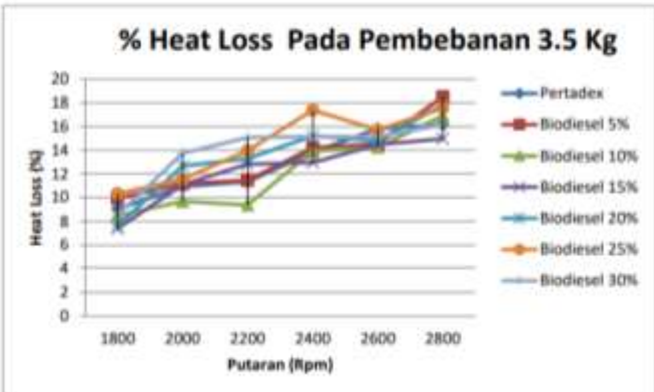

Figure 11. Percentage of Heat Loss vs. Engine speed at 3.5 kg load

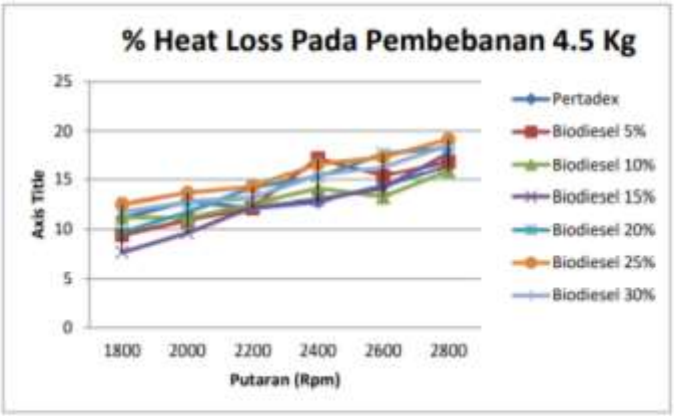

Figure 12. Percentage of Heat Loss Vs Engine Speed At 4.5 Kg . Loading

4. CONCLUSION

The conclusions in this study are: (1) The greater the addition of the % biodiesel mixture, the power value, volumetric efficiency, actual thermal efficiency and heat loss tend to decrease, while the fuel flow rate (mf) and specific fuel consumption (SFC) tend to increase. (2) Mixing rice bran biodiesel with pure pertadex as an alternative fuel is feasible to use where the comparison between the performance of pertadex and the pertadex mixture of rice bran biodiesel is not very significant. (3) The highest power was obtained in the Pertadex Fuel Test with a load of 4.5 kg at 2800 rpm, which was 3.1358 kW. While the lowest power was obtained in the Pertadex fuel test + 25% Biodiesel rice bran at 1800 rpm engine speed of 1.05504 kW. (4) The highest Mf was obtained in the Pertadex fuel test + 20% rice bran biodiesel at 2800 engine speed with a load of 3.5 kg, which was 0.3943 kg/hour while the lowest Mf was obtained in the Pertadex fuel test + 25% biodiesel at 1800 rpm engine speed with a load of 4.5 kg. that is equal to 0.17015 kg/hour. (5) The highest SFC was obtained in the Pertadex fuel test + 10% Biodiesel rice bran with a load of 3.5 engine speed at 2600 rpm, which was 205.72 gr/kWh. The lowest SFC was obtained in the Pertadex fuel test at 2000 engine speed and a load of 4.5 kg, which was 89.3175gr/kWh. (6) The maximum Volumetric Efficiency value was obtained in the test of Pertamina dex fuel mixture + 30% Biodiesel, rice bran, engine speed of 2600 rpm and load of 3.5 kg, which was 89.84171%. while the minimum Volumetric Efficiency Value obtained in the test of the Pertadex fuel mixture + 20% Biodiesel rice bran load of 4.5 kg engine speed of 2800 rpm, which is 47.8628%. (7) The maximum actual Thermal Efficiency value was obtained in the Pertadex + 30% Biodiesel fuel mixture test with a load of 4.5 kg engine speed of 2200 rpm, which was 30.1267%, while the minimum actual Thermal Efficiency Value was obtained in the Pertadex + 20% Biodiesel fuel mixture test. rice bran load 3.5 kg engine speed of 2200 rpm that is equal to 6.050898%. (8) The highest heat loss value was obtained from the use of Pertamina Dex fuel + 15% rice bran biodiesel with a load of 4.5 kg at 2800 rpm engine speed, which was 3538,675 W. The lowest heat loss value was obtained from the use of Pertamina Dex fuel + 30% biodiesel biodiesel, rice bran load 3.

Suggestions in this study are: (1) Completing the measuring instrument 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 by using different fuel mixture variations, wherein the addition of % biodiesel is more accurate to obtain the maximum calorific value.

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