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Experimental Investigation of Performance Characteristics of Pre-Heated Milkscum Oil Bio Diesel Using Exhaust Gas on a Diesel Engine

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Abstract

The primary carbon-neutral and sustainable fuel for compression ignition engines is biodiesel. The high surface tension and high viscosity of different types of biodiesel are the primary causes of technical issues. High viscosity and surface tension in the CI engine lead to incorrect fuel atomization and charge uniformity. Preheating is hence the process used to reduce the biodiesel's viscosity. The Utilizing exhaust gases to pre-heat biodiesel to temperatures of 30°C, 40°C, and 45°C lowers its viscosity and surface tension, improving fuel injection and ultimately enhancing engine performance. Preheating of biodiesel can be made by using special arrangement of exhaust manifold.

Keywords: *Biodiesel preheating, Viscosity*

1.0 Introduction

Petroleum fuel demand is sharply rising as a result of the world's growing industrialization and motorization. Fuels derived from petroleum come from finite reserves. There are undoubtedly finite supplies of raw materials and primary energy in the world. Therefore, it is essential to search for alternative fuels that can be created using domestically accessible resources like vegetable oils, alcohol, and biodiesel. Because biodiesel differs from diesel in terms of injection, ignition, and emission characteristics, its use is restricted[2]. Vegetable oil's high density and viscosity obstruct the injection process and result in inadequate fuel atomization. As a result, there is insufficient fuel and air mixing, which increases the risk of misfire, incomplete combustion, carbonization of the injector tip, and delayed ignition. For this reason, using pure biodiesel in diesel engines is not recommended. To overcome these problems caused by the high viscosity of biodiesel, a number of techniques have been used. These include biodiesel/diesel blends, preheating the biodiesel[1].

About 150 million tons of milk are produced in India annually. This milk is handled by thousands of sizable dairies all over the nation. The present study reveals that bio-diesel from Dairy Waste Scum Oil is a suitable alternative for petro-diesel. The performance parameters evaluated are Break Power (BP), Indicated Power (IP), Mechanical Efficiency (ME), Break Thermal Efficiency (BTE), Brake Specific Energy Consumption (BSEC). The outcomes of an experimental study comparing diesel and biodiesel blends are contrasted[2].

2.0 Literature Review

Norrizal Mustaffaetal[1] studied experimentally the use of the preheated crude palm oil on a Serial 4 cylinder OHC turbo type diesel engine. They tested the fuel under three

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different load conditions (0% load, 50% load, and 100% load) and at three different fuel temperatures (40°C, 50°C, and 60°C). Subsequently, the outcomes obtained from every preheat temperature and load scenario were juxtaposed with the grade 11 diesel fuel. four distinct engine speeds were used to collect the data: 1500, 2000, 2500, and 3000 rpm. The load was varied at 0%, 50% and 100% load conditions. To lessen the heat loss of the heated biofuel, they employed damaged fuel lines. They came to the conclusion that, in contrast to diesel fuel, increasing load conditions and fuel temperature did not appear to have a significant impact on performance parameters. In terms of emissions, it was discovered that HC produced was better at 100% load condition and 40°C preheating temperature. This behaviour could be associated with the higher oxygen content that improves the combustion process and pre-heat decreases the viscosity which improves the oxidation in the cylinder. The preheat fuel temperature was found to produce better CO emissions, but NO formation increased because it is anticipated that the combustion process will be strongly influenced by the rising ambient temperature in the chamber.

Dinesha P et al.,[2] carried out an experimental investigation is on a four stroke single cylinder CI engine to find out the performance and emission characteristics with preheated B40 blend of pongamia biodiesel and B20 biodiesel. The B40 blend is preheated at 60, 75, 90 and 110°C temperature using waste exhaust gas heat in a shell and tube heat exchanger. Trans-esterification process is used to produce biodiesel required for the present research from raw pongamia oil. Experiments were done using B40 biodiesel blend at different preheating temperature and for different loading. They observed a significant improvement in performance and emission characteristics of preheated B40 blend is obtained. B40 blend preheated to 110°C showed maximum 8.97% increase in brake thermal efficiency over B20 blend at 75% load. Also the highest reduction in UBHC emission and smoke opacity values were obtained as 78.12% and 73.54% respectively over B20 blend for B40 blend preheated to 110°C at 75% load. Thus they concluded that preheating of higher biodiesel blend at higher temperature improves the viscosity and other properties sharply and improves the performance and emission.

3.0 Design and Fabrication of A Pre-Heating Chamber

Materials used:- Outer container – Zinc sheet metal, Fuel pipe – Copper tube, Exhaust pipe – Galvanized iron flexible pipe (Figure 1).

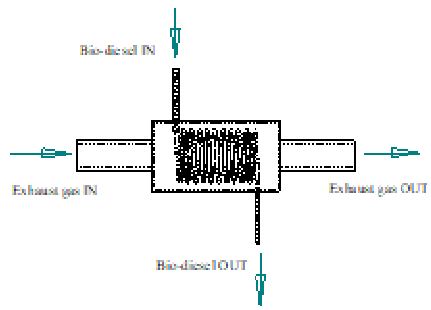


Figure 1. 2D view of a pre- heating chamber.

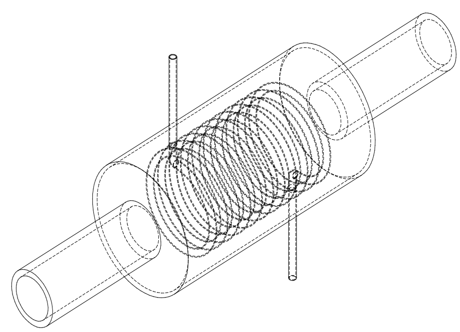


Figure 2. Isometric view of a pre-heating Chamber.

Figure 3. Fabricated pre-heating chamber.

4.0 Experimental Procedure

- Step 1: Turn on the control panel's main lights and adjust the servo stabilizer's supply voltage to 220 volts.
- Step 2: The main gate valve is opened, the pump is turned on, and the water flow to the dynamometer, calorimeter, sensors, and engine cylinder jacket (300 liters per hour) is adjusted.
- Step 3: Fuel can be heated to different temperatures inside the container before being transferred to the engine at the proper temperature.
- Step 4: To reach steady state, the engine is started by hand cranking and run for 20 minutes.

Figure 4. Engine setup.

Utilized is the engine VCR software. The governor regulates the engine's normal speed of 1600 rpm, with a compression ratio of 17.5. Prior to taking readings, the engine is run with neat diesel under loading conditions of 0%, 25%, 50%, 75%, and 100%. This is done twice during a load trial. After five minutes, the engine is allowed to stabilize Performance metrics, such as peak pressure, brake power, exhaust gas temperature, and speed, are measured under steady state conditions at each loading scenario. The tests are conducted again using different blends of biodiesel and diesel. Parameters like total fuel consumption, brake-specific fuel consumption, brake-specific energy consumption, and brake thermal efficiency are calculated using the experimental results. Lastly, a plot of brake thermal efficiency and brake specific fuel consumption for diesel and biodiesel is presented in relation to loading conditions. The engine's performance characteristics are ascertained from these plots.

5.0 Results

5.1 Performance Characteristics

5.1.1 Fuel: Diesel, Pressure = 200bar, C.R = 17.5

Table 1. Performance Characteristics for Diesel

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/ Kw- hr)	BTE (%)	ME (%)	ITE (%)
1	0	0.069	2.423	5.162	1.515	2.866	52.840
2	2.5	0.588	3.536	0.703	11.115	16.620	56.878
3	5	1.216	4.004	0.419	18.639	30.362	61.389
4	7.5	1.817	4.613	0.332	23.527	39.391	63.727
5	10	2.347	5.268	0.301	25.991	44.556	68.332

5.1.2 Fuel: Milkscum oil (B-10) Pressure = 200bar, Temperature = 30^{0}C, C.R = 17.5

Table 2. Performance Characteristics for Milkscum oil (B-10), 30^{0}C

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw- hr)	BTE (%)	ME (%)	ITE (%)
1	0	0.074	2.506	4.891	1.752	2.941	59.33
2	2.5	0.594	2.683	0.734	11.67	22.150	52.74
3	5	1.175	3.249	0.382	22.39	31.497	51.11
4	7.5	1.882	3.950	0.306	27.95	47.637	58.67
5	10	2.428	4.828	0.273	31.34	50.296	52.32

5.1.3 Fuel: Milkscum oil (B-10) Pressure = 200bar, Temperature = 40^{0}C, C.R = 17.5

Table 3. Performance Characteristics for Milkscum oil (B-10), 40^{0}C

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw)	BTE (%)	ME (%)	ITE (%)
1	0	0.076	2.293	4.197	1.863	3.305	59.865
2	2.5	0.628	2.630	0.616	12.684	23.887	57.337
3	5	1.273	3.315	0.363	23.901	35.990	55.250
4	7.5	1.776	4.082	0.317	24.635	43.500	56.521
5	10	2.479	4.437	0.217	33.807	53.611	53.213

5.1.4 Fuel: Milkscum oil (B-10) Pressure = 200bar, Temperature = 45^{0}C, C.R = 17.5

Table 4. Performance Characteristics for Milkscum oil (B-10), 45^{0}C

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw)	BTE (%)	ME (%)	ITE (%)
1	0	0.053	2.872	5.956	1.313	1.860	70.573
2	2.5	0.598	3.256	0.653	11.965	18.363	65.157
3	5	1.286	3.931	0.313	24.949	37.181	62.786
4	7.5	1.842	4.088	0.304	25.894	45.053	55.254
5	10	2.526	4.437	0.205	36.538	54.432	54.615

5.1.5 *Fuel: Milkscum oil (B-20) Pressure = 200bar, Temperature = 30^{0}C, C.R = 17.5*

Table 5. Performance Characteristics for Milkscum oil (B-20), 30^{0}C

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw)	BTE (%)	ME (%)	ITE (%)
1	0	0.071	2.174	5.186	1.508	3.254	46.326
2	2.5	0.586	3.012	0.735	10.638	19.467	54.647
3	5	1.312	3.451	0.465	17.343	33.004	51.137
4	7.5	1.910	4.542	0.328	23.853	42.057	56.715
5	10	2.345	4.970	0.308	25.383	47.196	53.783

5.1.6 *Fuel: Milkscum oil (B-20) Pressure = 200bar, Temperature = 40^{0}C, C.R = 17.5*

Table 6. Performance Characteristics for Milkscum oil (B-20), 40^{0}C

SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw)	BTE (%)	ME (%)	ITE (%)
1	0	0.070	2.617	5.004	1.562	2.658	58.771
2	2.5	0.613	2.852	0.701	11.144	21.506	51.821
3	5	1.499	3.583	0.429	18.222	36.530	53.881
4	7.5	1.897	4.457	0.324	24.102	42.564	56.625
5	10	2.398	4.876	0.307	25.459	47.957	57.087

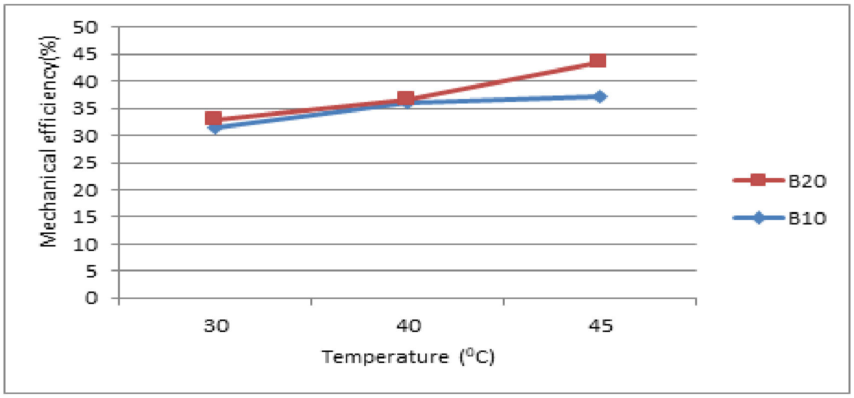
5.1.7 *Fuel: Milkscum oil (B-20) Pressure = 200bar, Temperature = 45^{0}C, C.R = 17.5*

Table 7. Performance Characteristics for Milkscum oil (B-20), 45^{0}C

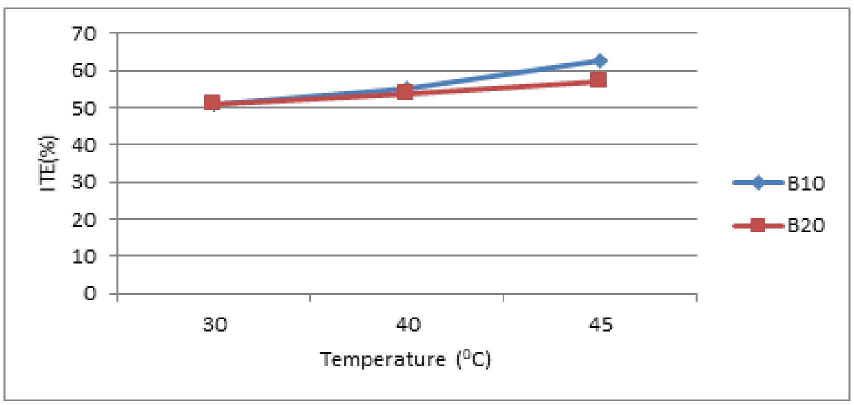
SI.NO	LOAD (Kg)	B.P (kW)	I.P (kW)	BSFC (Kg/Kw)	BTE (%)	ME (%)	ITE (%)
1	0	0.071	2.309	4.769	1.639	3.069	53.421
2	2.5	0.601	3.368	0.703	11.124	17.837	62.363
3	5	1.543	3.718	0.412	18.995	43.436	56.810
4	7.5	1.813	3.993	0.323	24.216	45.407	53.330
5	10	2.544	5.287	0.293	26.667	48.343	60.138

6.0 Graphical Representation

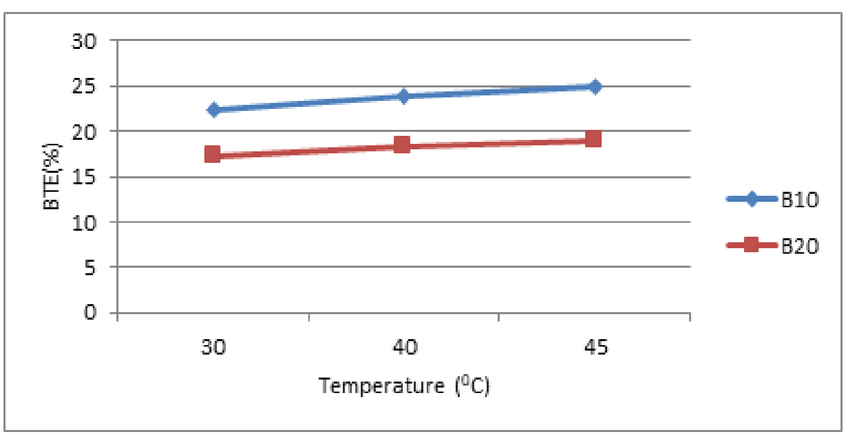
6.1 Fuel: Milkscum oil Pressure = 200bar, Load = 5 Kg



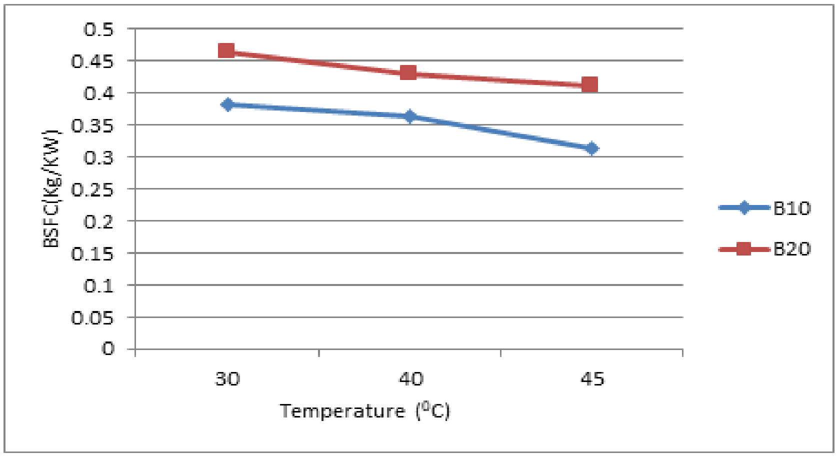
Graph 1. Mechanical efficiency (%) vs Temperature (^{0}C).



Graph 2. ITE (%) vs Temperature (^{0}C).



Graph 3. BTE (%) vs Temperature (^{0}C).



Graph 4. BSFC (Kg/KW) vs Temperature (^{0}C).

7.0 Conclusion

- By improving fuel atomization at the elevated temperature of the biodiesel, pre-heating the fuel significantly reduces its kinematic viscosity and density property, which in turn improves injection of the fuel.
- Additionally, preheating shortens the ignition delay time during an engine's cold start, which lessens the ignition problem.
- For B10 blend as the temperature increases the specific fuel consumption will decrease by 5.23% and 5.85% for 5Kg and 10Kg.
- For B20 blend as the temperature increases the specific fuel consumption will decrease by 8.39% and 4.77% for 5Kg and 10Kg.
- For B10 blend as the temperature increases the mechanical efficiency will increase by 3.2% and 6.18% for 5Kg and 10Kg.
- For B20 blend as the temperature increases the mechanical efficiency will increase by 9.65% and 2.37% for 5Kg and 10Kg.

8.0 Reference

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