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Investigation of ceramic coated diesel engine fueled with ricebarn oil biodiesel blends

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The present work investigates on the production of the Rice Bran Oil (RBO) biodiesel and investigation of the bio diesel blends of the RBO in engine performance characteristics, combustion analysis and emission characteristics. The cylinder, piston valves and cylinder heads are coated with ceramic material through atomic spray coating technique. The coating provides improved BTE, brake specific fuel consumption and decreased emission. The heat release rate and the emission analysis during the combustion process is also investigated and it is observed that the heat release rate at the initial stage is higher and it reduces during the further process.

Keywords: Ceramic coating, Diesel engine performance, RBO, Biodiesel, Heat release rate.

Introduction

The biodiesel are highly required in the recent days as an alternative to the conventional neat diesel. High crude oil price, increased emission, pollution threats, threats of global warming are the major sources because of which the requirement for biodiesel are popular in many countries nowadays. The developments of biodiesel fuels are always important and also the properties of the biodiesel fuels should confine with the properties of the neat diesel. Vegetable oil are one such alternative biodiesel identified for the neat diesel and the viscosity of the vegetable oil is more than the viscosity of the neat diesel. In this work, RBO is investigated for its engine performance characteristics and emission characteristics when it is fuelled in compression ignition engine. Since the number of vehicles increases, emissions also get increased. Petroleum reserves are depleting every year and are necessary to find an alternative in the near future. Unsustainable demands for petroleum fuels, increased global warming threats and environmental degradation matters have necessitated for development and adaptation to eco friendly biodiesels. Hence it is necessary to find an alternative fuel having reduced emissions such as rice bran bio diesel blends. Rice bran oil are chosen because of its Easy availability of raw material since Asia is largest in rice cultivation and for large quantity of production, cost of oil is low. The absolute viscosity of the rice bran biodiesel oil at 90 degree Celsius is found to be 7.04 Ns/m^2. The flash and fire point of the rice bran biodiesel are carried out and it is recorded as 161 and 187 degree Celsius respectively. The calorific value is observed to be 41877 KJ/Kg for the pure rice bran biodiesel.

The extraction of biodiesel by transesterification of crude RBO is demonstrated [1]. Transesterification is the process of exchanging the organic group R″ of an ester with the organic group R' of an alcohol. The RBO is tested in engine for studying its performance and emission characteristics and it is reported that the emission of CO, HC are reduced to a higher extent when compared to the neat diesel. The process parameters are optimized during the transesterification process for extracting high quality RBO. It is concluded that optimized conditions favoured the best rice bran bio diesel oil and it performed better with providing higher engine performance characteristics [2]. The RBO is fuelled for a four stroke, single cylinder DI engine to investigate the engine performance characteristics. It is reported that the RBO biodiesel blends will provide greener environment as the CO, HC and NOx emission are decreased. Also the ignition delay are lowered upto 20% at higher loads and in turn increases the rate of vaporization [3]. The rice bran biodiesel blend with the combination of 20% RBO and 80% of pure diesel fuel provides similar fuel properties as that the the neat diesel. Also the biodiesel blend with a combination of 30% bio diesel and 70% diesel fuel provides excellent characteristics. The improved heat release rate is also noticed with this bio diesel blend. [4] RBO biodiesel is apromising alternative fuel for the

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petroleum products. The volume combination of 20% RBO and 80% petrodiesel fuel provides most effective composition for the combustion analysis of a diesel engine.RBO based biofuels finds applications on the aspects of lubricating oil degradation, deposition formation, etc. [5]. The use of RBO enriched with diesel fuel on compression ignition engine with the use of the rice bran biodiesel blend is discussed [6]. Experiments are conducted with turbocharger fitted with the engine and optimization is carried out to select the suitable biodiesel blend that will give effective performance for the engine and effective compression ratio [7]. The effect of nano particles on the droplet combustion of rice bran bio diesel is discussed. It is reported that the rice bran biodiesel blend with 20% of RBO and 80% of pure diesel with 75 ppm exhibits lesser threats towards combustion. The importance of understanding the droplet combustion of biodiesel fuels are also discussed [8]. The advanced injection timing and higher injection pressure increase the NOx emission.the engine performance is studied for three different engine cylinder injection pressures and it is noted that the biodiesel blend with RBO with volume concentration of 10% emits lower CO and HC emissions [9] Hydrogen enriched rice bran biodiesel fuel in investigated and it is proved that the combustion characteristics and the BTE of the engine is improved. RBO is compared with karanja biodiesel fuel and it is observed that the performance of the rice bran biodiesel is efficient when compare to the other biodiesels [10]. The engine performance analysis and emission analysis is carried out for the rice bran oil bio diesel blend with camphor addtivies [11].

Materials and Methods

Experimental test are conducted on a VCR diesel engine with 80 mm bore diameter and stroke length of 110 mm. The speed of the engine is maintained at 1500 rpm; compression ratio is 16:1 with injection pressure of 200 bar. Exhaust gas analyzer is used to investigate the exhaust gas emission and smoke opacity is investigated using the smoke opacity meter. The fuel tank is attached nearby the engine to confirm the supply of the fuel is continuous to the engine and initially the engine is started with diesel. The engine parts such as cylinder, piston, valve heads are coated with ceramic material. This coating will improve the engine performance characteristics and reduce the emission characteristics. Then the same engine is fuelled with the RBO biodiesel and tested. The engine test conducted at five different load conditions at a constant speed of 1500 rpm. The combustion parameters such as net heat release rate, maximum heat release rate are measured and discussed.

A brown layer between the rice and the outer husk of paddy is the Rice Bran and RBO is the byproduct of the rice. RBO contain higher free fatty acids and it is non-edible. The rice bran are cleaned in clear water and maintained at 50 degree Celsius. The sulphuric methoanol solution is added RBO and it is stirred continuously for about few minutes. This is then poured in to a separate funnel to facilitate transesterficiation process and the rice bran biodiesel are produced. Different blends of biodiesel from Rice bran with diesel varying from 0 to 50% on volume basis are prepared and designated as shown in Table.1. Camphor is prepared from the steam distillations of chipped wood and branches under vacuum and it is used as an additive to the fuel used in this work. Camphor that are prepared are used as the filter products and they are pressed, distilled and rectification under vacuum. Finally the filtered oil is collected at 3 fractions as white, yellow, and brown camphor. The brown and yellow camphor is toxic, also used in the treatment for muscular aches and pains and the white camphor is used as an additive in this work.

Results and Discussion

Engine characteristics

Table 2 represents performance values of pure diesel at compression ratio 16. The frictional power, brake power, indicated power, brake mean effective pressure, indicated mean effective pressure, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, specific fuel consumption and volumetric efficiency are calculated. The performance analysis for the rice barn oil bio-diesel blends for the combinations of B20-2 grams camphor as additive, B20-4 grams camphor as additive, B30-2 grams camphor as additive and B30-4 grams camphor as additive are also determined and presented in the Tables 3-6 respectively. The mechanical efficiency and the BTE of the diesel engine fuelled with the various blends of the rice barn

Table 1. Nomenclature of RBO biodiesel blend with diesel fuel.

Rice bran Bio-diesel blend Proportion	% of Biodiesel	% of Diesel	Camphor-Additive (grams)
B20-2	20	80	2
B20-4	20	80	4
B30-2	30	70	2
B30-4	30	70	4

Table 2. Performance values of pure diesel at CR16.

Speed (rpm)	Load (kg)	Torque (nm)	BP (kw)	FP (kw)	IP (kw)	BMEP (bar)	IMEP (bar)	BTE (%)	ITE (%)	Mech eff. (%)	SFC (kg/kwh)	Vol Eff. (%)
1500	0	0.48	0.08	3.81	3.88	0.09	4.55	1.28	63.98	2	7.05	80.31
1500	3	5.64	0.91	3.79	4.7	1.07	5.53	13.74	71	19.35	0.66	80.24
1500	6	11.11	1.77	3.96	5.73	2.11	6.82	21.44	69.24	30.96	0.42	79.87
1500	9	16.65	2.63	3.86	6.49	3.16	7.79	26.52	65.33	40.59	0.34	78.93
1500	12	21.94	3.44	3.73	7.18	4.17	8.69	29.7	61.91	47.98	0.3	77.72

Table 3. Performance values of B20-2 at CR16.

Speed (rpm)	Load (kg)	Torque (nm)	BP (kw)	FP (kw)	IP (kw)	BMEP (bar)	IMEP (bar)	BTE (%)	ITE (%)	Mech eff. (%)	SFC (kg/kwh)	Vol Eff. (%)
1500	6	11.22	1.8	3.67	5.46	2.13	6.49	20.13	61.2	32.9	0.42	79.2
1500	9	16.83	2.66	3.81	6.47	3.2	7.77	26.31	64	41.1	0.32	78.1
1500	12	22.02	3.45	3.75	7.2	4.18	8.73	26.37	55	48	0.32	77.4

Table 4. Performance values of B20- 4 at CR16.

Speed (rpm)	Load (kg)	Torque (nm)	BP (kw)	FP (kw)	IP (kw)	BMEP (bar)	IMEP (bar)	BTE (%)	ITE (%)	Mech eff. (%)	SFC (kg/kwh)	Vol Eff. (%)
1500	6	11.21	1.8	3.47	5.26	2.13	6.24	20.44	59.9	34.1	0.44	78.9
1500	9	16.44	2.61	3.72	6.33	3.12	7.58	26.41	64.1	41.2	0.34	78
1500	12	21.8	3.43	3.74	7.17	4.14	8.67	28.36	59.4	47.8	0.32	76.8

Table 5. Performance values of B30- 2 at CR16.

Speed (rpm)	Load (kg)	Torque (nm)	BP (kw)	FP (kw)	IP (kw)	BMEP (bar)	IMEP (bar)	BTE (%)	ITE (%)	Mech eff. (%)	SFC (kg/kwh)	Vol Eff. (%)
1500	6	11.29	1.81	3.56	5.38	2.15	6.36	21.72	64.43	33.72	0.38	78.34
1500	9	16.44	2.61	3.66	6.26	3.12	7.5	25.72	61.78	41.62	0.32	77.7
1500	12	21.81	3.43	3.72	7.15	4.14	8.64	27.4	57.1	47.98	0.3	77.14

Table 6. Performance values of B30 -4 at CR16.

Speed (rpm)	Load (kg)	Torque (nm)	BP (kw)	FP (kw)	IP (kw)	BMEP (bar)	IMEP (bar)	BTE (%)	ITE (%)	Mech eff. (%)	SFC (kg/kwh)	Vol Eff. (%)
1500	6	11.12	1.78	3.53	5.32	2.11	6.3	22.48	67.05	33.53	0.42	78.4
1500	9	16.65	2.66	3.71	6.37	3.16	7.58	27.96	66.96	41.75	0.34	77.78
1500	12	21.72	3.42	3.84	7.26	4.13	8.75	30.83	65.39	47.15	0.31	76.66

biodiesel blends are analysed. The highest mechanical efficiency is found to occur at B30-4 biodiesel blend. However the BTE is found to be much consistent for all the values of the bio diesel blends. It is seen that as the loading of the engine increases, the BTE also increases and the highest value of the BTE is observed at B30-4 biodiesel blend and the lowest is observed at B20-2 biodiesel blend. Also the variations of the SFC while using Rice barn oil biodiesel bends under different loadings are analysed. It is observed that the SFC decreases with increase in loads for all biodiesel blends of the rice barn oil. The highest BSFC is observed for the biodiesel blend of B20-4 biodiesel blend and at higher engine loads the BSFC is found to be very closer for all the biodiesel blends of rice barn oil.

Rate of Heat release

Figure 1 shows the rate of heat release for the biodiesel blends of rice barn oil acting at the full load conditions. The phases of combustion are clearly seen in the figure and two peaks in heat release are seen in

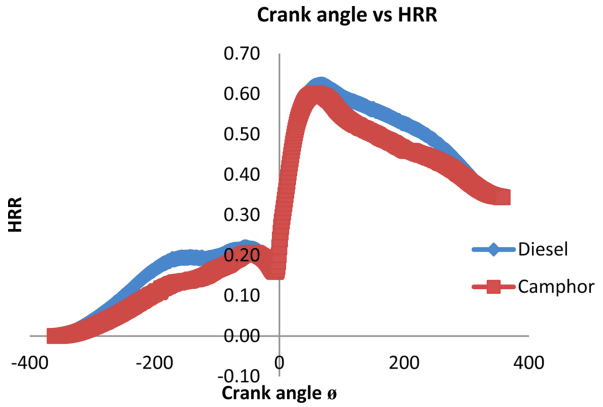

Fig. 1. Heat release rate.

combustion, pre-mixed and mixing- controlled. Due to the vaporization of the fuel during the ignition delay at the beginning, a negative heat release is observed. Once the combustion process is initiated, the heat release becomes positive. The stages of combustion in diesel fuel are also similar to the stages of combustion observed in biodiesel blends. The rate of heat produced in the initial stages of the combustion is higher due to poor atomization and vaporization and results to lower heat release rate during this stage.

Emission analysis

The 5-gas analyser is used to investigate the emission analysis of the engine and it is noted that the emissions of carbon monoxide, hydrocarbons are highly reduced and it favours to the pollution free environment when compared to the pure diesel engine. Also the nitrogen oxide emission is found to be having very little changes when compared with the pure diesel. The emission test is carried out using diesel blends B20-2; B20-4; B 30-2 and B30-4. The CO, HC, CO2, O2 and NO emission are analysed and compared with the neat diesel fuel working under the same characteristics. The engine with compression ratio 16 and load 6 kg is tested for the emission analysis and the 5 gas analyser is used for testing the emission. The results are recorded as shown in the Table 7 and it is observed that the biodiesel blend B30-4 is found to give satisfactory resuts when compared with the other biodiesel blends.

Conclusion

The engine performance characteristics and combustion analysis of diesel engine fuelled with rice bran oil biodiesel with camphor as additive is investigated. It is observed that the brake thermal efficiency, mechanical efficiency and brake specific fuel consumption are improved when compare to the engine performance when fuelled with the pure diesel. Also the heat release rate during the combustion process in analysed and investigated and it is seen that the amount of combustion is high at the initial stage and it decreases as the engine performance at a higher speed. The maximum brake thermal efficiency is found to be 30.83% and it is observed at the engine fuelled with B30-4 biodiesel blend. The specific fuel consumption is found to be highest with the value 0.44 kg/kwh while using the

Table 7. Emission analysis.

Compression ratio	Load	Emissions	Exhaust emission					Unit
			Diesel	B20 -2	B20 -4	B30-2	B30 -4	
16	6	CO	0.32	0.28	0.27	0.24	0.24	% VOL
		HC	65	63	62	56	54	PPM HEX
		CO2	3.4	3.3	3.3	3.3	3.3	% VOL
		O2	15.64	15.65	15.79	15.74	15.83	% VOL
		NO	136	200	227	266	246	PPM VOL
16	9	CO	0.21	0.19	0.19	0.17	0.18	% VOL
		HC	61	62	62	64	65	PPM HEX
		CO2	4.3	4.5	4.5	4.5	4.5	% VOL
		O2	14.21	14.08	13.99	14.06	14.02	% VOL
		NO	505	564	626	761	645	PPM VOL
16	12	CO	0.18	0.19	0.19	0.19	0.18	% VOL
		HC	56	74	56	86	77	PPM HEX
		CO2	5.7	5.8	5.8	5.8	5.9	% VOL
		O2	12.36	12.2	12.08	12.15	11.95	% VOL
		NO	894	992	1035	1071	1121	PPM VOL

B20-4 biodiesel blend.

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