Performances of Engines Fueled with Biodiesel of Rapeseed and Jatropha Oil

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Abstract. This paper objective is to study and analyze two different alternative green fuels (biofuels) obtained from rapeseed oil, a plant which grows in Romania and jatropha oil that grows and is commonly used in Pakistan. The experimental test regarding the (on) engine performances and the level of pollutant emissions of the studied mono cylindrical diesel engine was conducted in the laboratory on Thermodynamics and Thermal Machines of the Faculty of Mechanics of Craiova. Various instruments were used to acquire pollutant emissions and corresponding data as well as the performances of the engine for each case. Nowadays, purposes for the diesel engines are a fuel product more efficient and a greater flexibility regarding the fuels with attention over the level of pollution.

Keywords: biodiesel; rapeseed oil; jatropha oil; emissions.

1 Introduction

Biodiesel is considered one of the primary attractive alternative fuels due to the increasing petroleum prices and to the depleting of fossil sources. This is produced by a process of transesterification of vegetable oils and animal fats with an alcohol in presence of a catalyst. Currently biodiesel and bioethanol are seen as solutions and almost every country of European Union have prepared a policy on production and use of biodiesel in the sector of transportation and heating. Biodiesel has some advantages as a higher cetane number, biodegradability, lower sulfur and aromatic content, and lower emissions of carbon monoxide, unburned hydrocarbons and particulate matter. One of the main problems with biodiesel and biodiesel blends is the high viscosity of the fuel. Among the biodiesel properties, density, viscosity and heating value affect the engine performance and emission characteristics. Orkun et al. [1] studied biodiesel produced from soybean oil and its blends (B10, B20, and B50) in a single-cylinder direct injection diesel engine over the entire rpm range (1200–3000 rpm). They found that biodiesel provided an 1–4% decrease in the torque and an approximately 2–9% increase in the brake-specific fuel consumption (BSFC). Conversely, they found that NOx emissions increased by 6.95–17.62% and CO_2 by 1.46–5.03%. Sanjid et al [2] experimented with four-stroke, direct injection diesel engine fueled with blends of

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palm and jatropha biodiesel and measured the engine performance and emission. CO was reduced by 9.53-20.49%, HC by 3.69-7.81% while NOx emission increased for all the tested biodiesels. In a previous study by Abedin [3] in a four-cylinder diesel engine fuelled with B5, 10%, and 20% blends of palm and jatropha biodiesel), it is reported that the brake power decreased by 2.3- 10.7% and BSFC is lower than diesel fuel. 10% blends reduce emissions of CO by 20% and HC by 17,5%. In another set of experiments Rahman et al [4] in a four cylinder diesel engine fueled with 10% and 20% (JB10 and JB20) blends of Jatropha CO emissions were reduced by 16.7-41.46%, HC by 31-42.7% and NO_X increased by 11.7-21.36%. With the previous studies examined it was seen that there were no studies on the comparative analysis of biodiesel of rapeseed, jatropha oil and diesel fuel. In the present study, the effects of two different biodiesels fuel obtained through transesterification on engine power and torque performance and emissions and fuel combustion characteristics of these fuels compared to diesel fuel were studied.

2 Material and Methods

2.1 Details of fuel properties

In this study jatropha oil was supplied from Pakistan from a local vendor and rapeseed oil was purchased from a local supplier from Craiova. Both oils were processed in the laboratory of Thermodynamics and Thermal Machines of Faculty of Mechanics using a transesterification reaction in a 30 L installation for biodiesel production. The properties of all tested fuels are tabulated in Table 3.

Table 1. Properties of the fuels and standards

Properties	Units	Method	Diesel	Biodiesel of rapeseed	Biodiesel of jatropha	Limits for ASTM and EN biodiesel standards
Kinematic viscosity at 40 °C	mm^2s^{-1}	ASTM D445	3.078	4.37	4.82	1.9-6
Cloud Point	°C	ASTM D2500	-18	-4.1	-2	-
Pour Point	°C	ASTM D97	-32	-12	-6	-
Calorific value	MJ/kg	ASTM D4809	44	43.2	42.1	-
Flash point	°C	ASTM D93	68	164	162	130 Min.
Density at 40 °C	kg/m^3	EN ISO 3675	816	882	878	860-900
Cetane number	-	ASTM D613	49	53.4	53.8	47 Min.

2.2 Diesel engine

In the Laboratory of Thermodynamics of Faculty of Mechanics of Craiova was built an experimental stand for measuring the exhaust emission for diesel engine. The engine used in experiments is presented in Table 2 and the experimental stand in Fig.1.

Table 2. Engine specifications [5]

Manufacturer	Ruggerini
Model	RY 50
Configuration	Single cylinder vertical
Type	Direct injection diesel
Displacement	224 cc
Bore	69 mm
Stroke	60 mm
Compresion ratio	21:1
Power	3.5 kW
Speed	3600 rpm
Type of cooling	Air cooling
Max. torque	10,4@2400 rpm
Weight	28 kg

For the test was used a gas analyzer STARGAS 898 which measure different burning gases products: (CO – monoxide of carbon; 0 ¸ 15,000 % Vol.; CO2 – dioxide of carbon; 0 ¸ 20, 00 % Vol.; HC – unburned hydrocarbons; 0 ¸ 30000 p.p.m. Vol.; O2 – oxygen; 0 ¸ 25, 00 % Vol. ;), NO_X; temperature of oil of the engine and the speed of crankshaft.

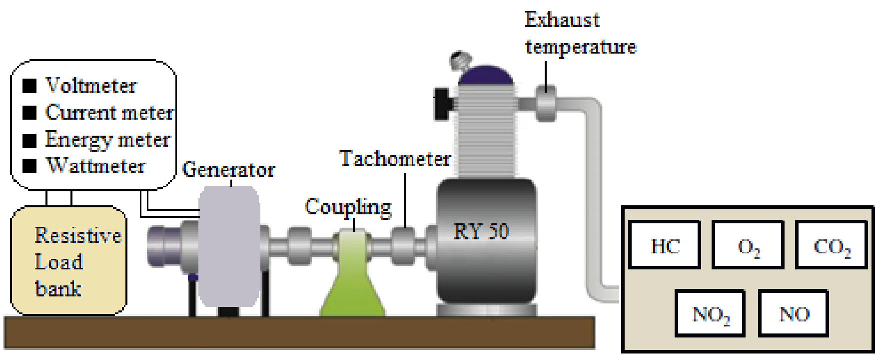

Fig. 1. Experimental stand for measuring biodiesel performances and emissions

2.3 Experimental testing

The experiments are conducted for variables loads at rated speed. Three fuel samples were tested and evaluated. The emission parameters of biodiesel of rapeseed and jatropha are compared to those of diesel fuel. The engine is first started with diesel fuel until a steady operating condition was obtained (cooling water and lubricating oil and have reached 85°C). The experiments were repeated five times and the average values of emission and performance were taken for examination and interpretation of the results.

3 Results and discussion

The diesel engine was used without any modification and emissions result were collected and discussed below. From the Fig.2 it is seen that Brake Thermal Efficiency increases with the load for all fuels tested. The decrease in BTE in biodiesel fuels is associated with the high value of viscosity which influences atomization of the fuel in the combustion chamber. Fig.3 presents the variation of brake specific fuel consumption and is seen that biofuels have higher value due to the lower calorific value of biodiesel. The Exhaust Gas Temperature (EGT) seen in Fig.4 has higher values for biodiesel due to the higher content of oxygen which improve combustion. CO emission presented in Fig.5 show a reduction for biodiesel fuels compared to diesel fuel and is explained by the improved combustion. CO_2 emissions increase for biodiesel fuels due the higher oxygen content (Fig.6). The emission of unburned hydrocarbon (HC) will decrease for biodiesel fuel especially due to the higher cetane number and oxygen content (Fig.7). The NOx will increase for biodiesel fuels and is caused by the viscosity, density, oxygen content, higher specific fuel consumption in the case of biodiesel compared with fossil diesel.

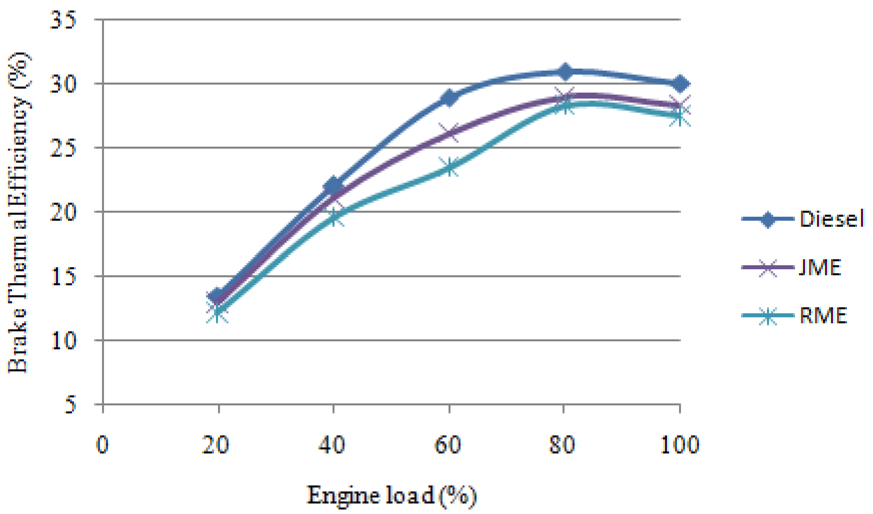

Fig. 2. Variation in brake thermal efficiency with load

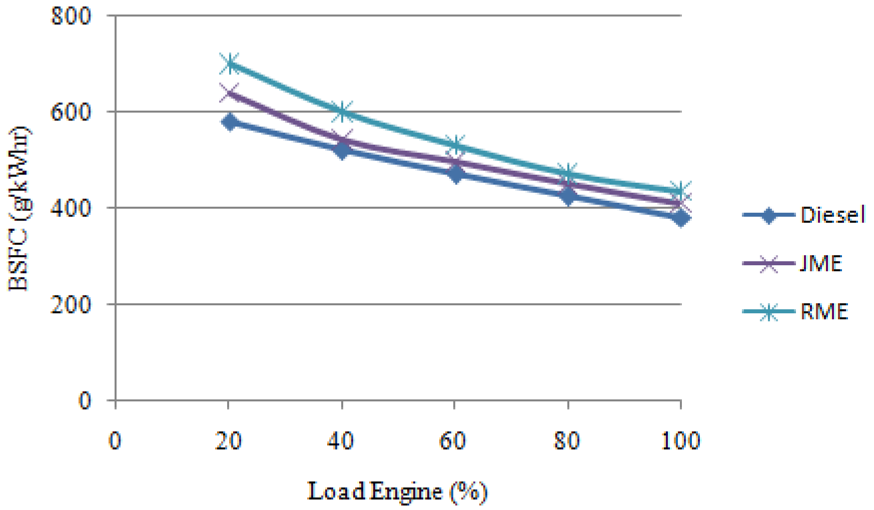

Fig. 3. Variation in brake specific fuel consumption with load

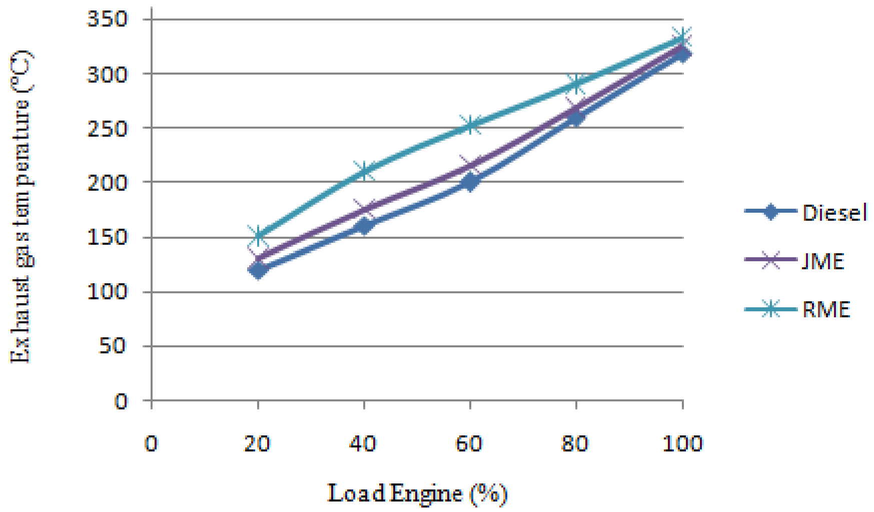

Fig. 4. Variation in exhaust gas temperature with load

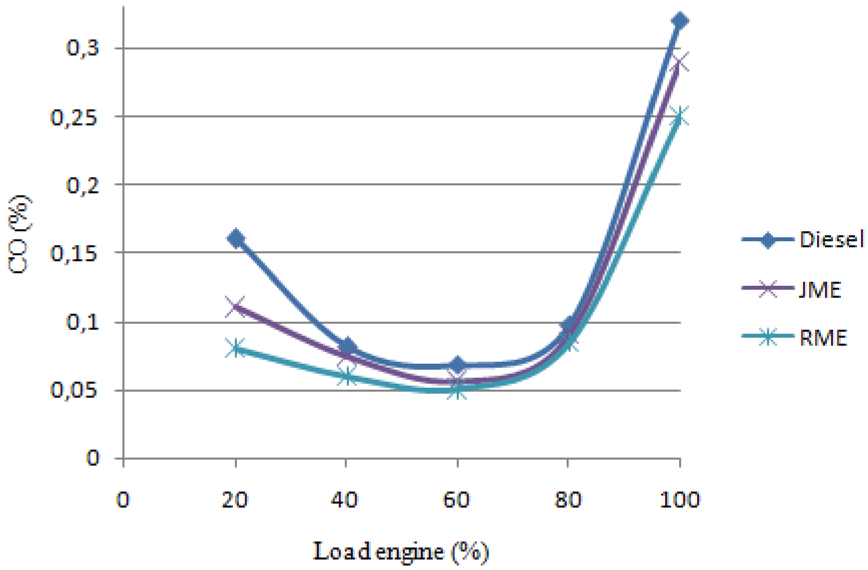

Fig. 5. Variation in CO emission with load

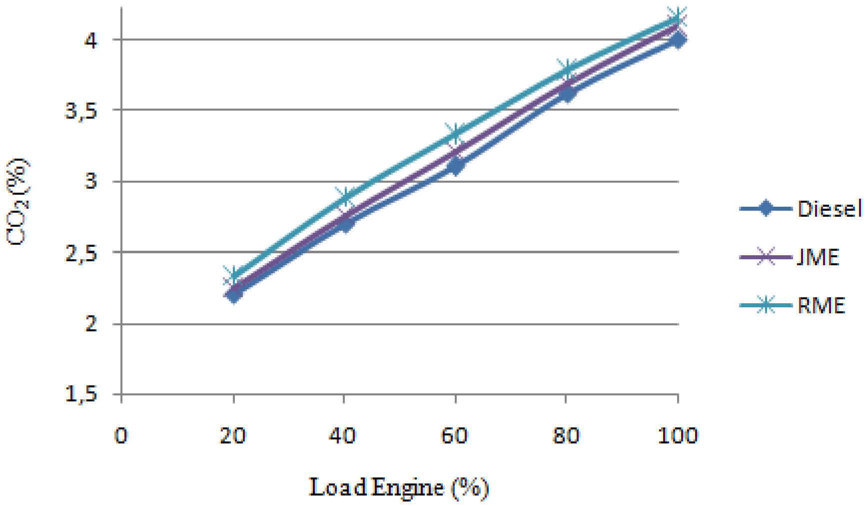

Fig. 6. Variation in CO2 emission with load

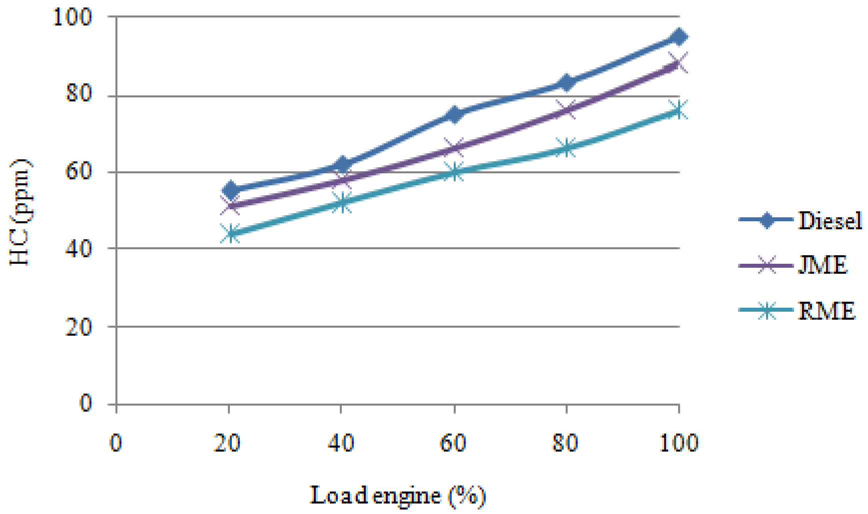

Fig. 7. Variation in HC emission with load

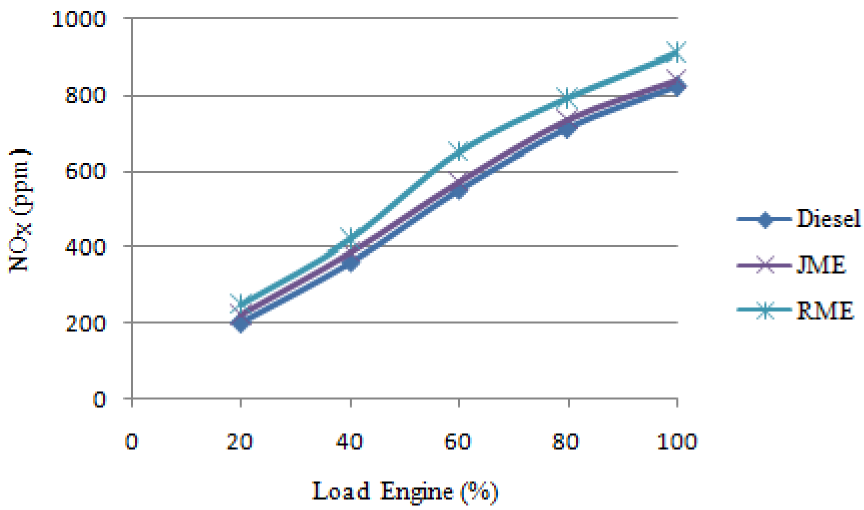

Fig. 8. Variation in NOx emission with load

4 Conclusion

The results of the study presented above offer an insight about the field of green alternative fuels that can be used as an alternative of diesel taking in consideration the performances of the engines and in the same time the level of pollutant emissions.In the second figure it could be observed the evolution of the brake thermal efficiency of the engine fueled alternative with the two types of biodiesel proposed, related to the classic diesel fuel where we can observe a slightly lower value of the RME.The following graphic expresses the variation of the brake fuel consumption when the engine is loaded from 20 to 100% of load. From the results it can be seen that the jatropha oil based biofuel could be considered an alternative of the diesel.Analyzing the value of the exhaust gas temperature for all the three fuels used in the study, the results indicate that a solution can be found in the jatropha biodiesel where it can be seen that there is the smallest increase of temperature regarding the diesel for almost 90% of the presented range. The CO and CO_2 graphics indicate that the lowest variation of the emissions is obtained for the JME blend. Another important aspect that indicates the efficiency of JME fuel is the variation of the NOx emissions, one of the most important in order to establish whether another fuel it could be considered and it is fitted as an alternative.

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