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Performance and emissions analysis of diesel engine fuelled with exhaust gas energy preheated ROME biodiesel

The crude oil resources are depleting as the days progress and biodiesel is an emerging substitute. But the usage of biodiesel is associated with fuel atomization problems. The prime cause is the high viscous nature of oils obtained from green matter. As we know that with increase in temperature of oil viscosity decreases. Current work deliberates the influence of preheating of biofuel on the engine output parameters. DI diesel engine fuelled with preheated biofuel blends result in increase in thermal efficiency and drop in HC, CO emissions, but the rise in peak cylinder temperature resulted in increase in NO_x emissions.

Keywords: Green matter, atomization, viscosity, biofuel.

1. Introduction

The rate of usage of crude oil is increasing with every passing second and this also resulted in rise in fuel price and also causes ill effect on atmosphere due to release of greenhouse gases. Biofuels are carbon neutral and its sustainable nature makes it as a promising alternative to power internal combustion engines. The high viscous nature of green fuels has limited its usage in engines, but with technology advancement in decreasing viscosity of bio-oils have given great support for its usage in the engines, one such method is preheating of oil before it enters the fuel injector. In the current work the heat energy required for preheating the biofuel is obtained from exhaust gases. A metered quantity of exhaust gas is used to maintain the temperature of 70ºC at the inlet of fuel injector.

2.0 Description

2.1 Materials used

Experiments are performed on 4 stroke single cylinder DI diesel engine fitted with re-entrant combustion chamber (RTC), at injector opening pressure of 240 bar, injection timing of 27° BTDC and fuel nozzle with 6 holes, the performance and emission characteristics are evaluated [2].

The properties of raw rice bran oil are mentioned in Table 1.

The biofuel is obtained from raw rice bran oil by transesterification, the process of removing free fatty acid content in the presence of catalyst to produce the ethyl ester or methyl esters. The properties of rice bran oil biofuel are evaluated as per ASTM standards [3] are cited in Table 2.

The exhaust gas flow is maintained in such a way to preheat the biofuel to a temperature of 70ºC at the inlet of fuel injector and same is considered as fuel injection temperature for engine [1].

3.0 Experimental results and discussion

The present work focusses on the effect of preheating of biodiesel on the performance and exhaust emissions.

The testing is carried on an engine at optimized engine operating conditions such as IOP of 240 bar, IT 27°BTDC, re-entrant combustion chamber (RTC) and fitted with injector nozzle of 6 holes [5, 8], when the engine is running at a rated speed of 1500rpm.

BTE

The energy content of ROME is less and its viscosity is high in comparison with diesel hence it resulted in poor performance. Preheating of biodiesel enhanced fuel atomization which has resulted in better mixture formation and best performance. [10]

Table 1: Raw castor oil properties

Properties	Raw rice bran oil
Flash point	312˚C
Fire point	338˚C
Kinematic viscosity	41.54 cSt.
Density	918 kg/m^3

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TABLE 2: PROPERTIES OF BIODIESEL

Diesel (%)	Biodiesel (%) ROME	Density (kg/m^3)	Viscosity(cSt)	Calorific value (CV) (kJ/kg)	Specific gravity	Flash point (^{o}C)
100	-	834	2.38	42250	0.834	60
-	B20(Without preheating)	842	2.866	42077	0.842	110
-	B20(With Preheating)	840	2.426	42120	0.840	

TABLE 3: ENGINE SPECIFICATIONS OF TESTED ENGINE

Parameters	Specifications
Engine type	TV1 (Kirloskar make)
Software used	Engine soft
Injector operating pressure	200 to 260 bar
Static injection time	23^{o}BTDC
Governor type	Centrifugal type
No of cylinders	1
No of strokes	4
Rated power	5.2 kW at 1500 rpm
Cylinder diameter (bore)	0.0875 m
Stroke length	0.11 m
Ratio of compression	17.5:1

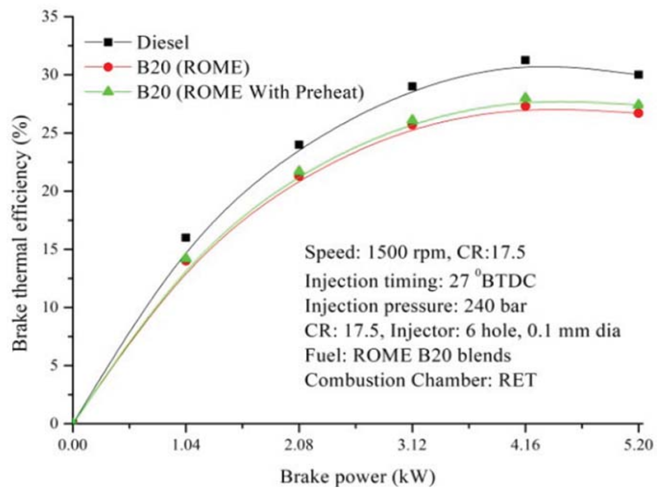

Fig.2: BTE vs. BP

SMOKE EMISSIONS

The FFA in biodiesel leads to formation of poor air fuel mixture and results in incomplete combustion as a result of that smoke emissions are more for pure ROME but the preheating enhances combustion efficiency as a result of this smoke emissions drops [4].

HC EMISSIONS

Preheating decreases, the viscosity of ROME hence better atomization occurs in comparison with ROME without preheating. The preheated biodiesel produces less UHC emissions in comparison with ROME without preheating [9].

CO EMISSIONS

CO emissions are less due to complete combustion of preheated biodiesel and are in comparison with emission when operated with diesel fuel. [7]

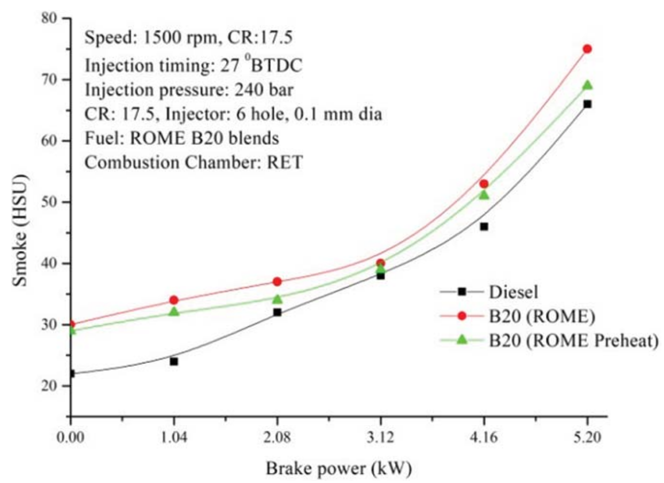

Fig.3: Smoke opacity vs. BP

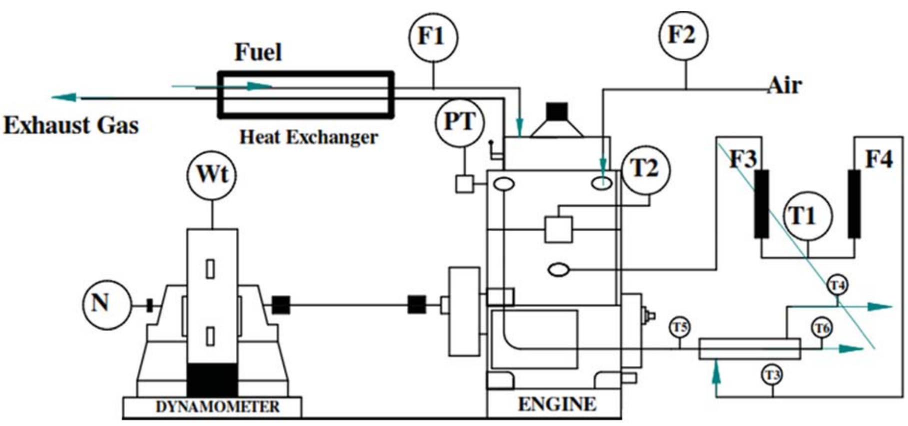

Fig.1: Illustration of engine test set up

NO_x EMISSIONS

NO_x emissions of ROME (Both without preheating and with preheating) are comparatively low because the peak cylinder temperature for diesel. Lower cetane number of ROME attributes to less peak in cylinder temperature. [5]

IGNITION DELAY

Ignition delay for ROME tend to decrease with preheating due

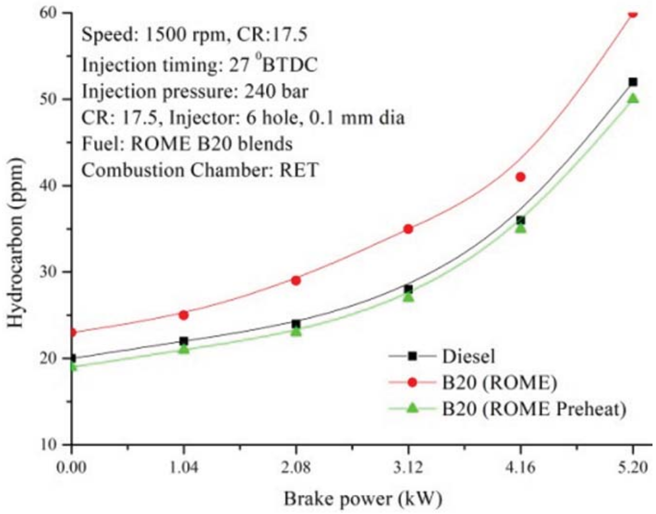

Fig.4: UBC vs. BP

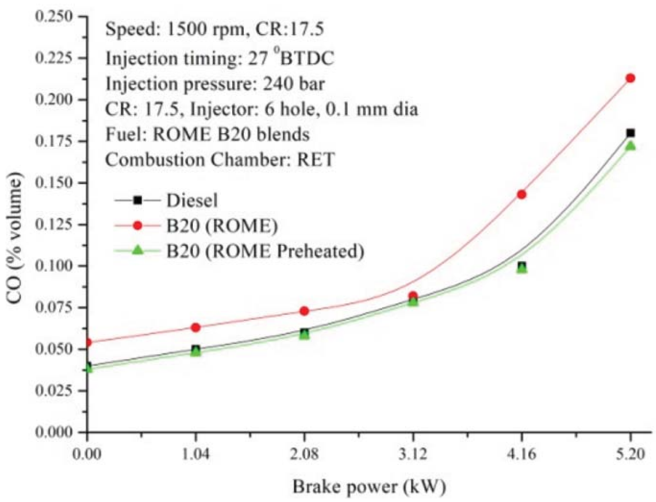

Fig.5: CO vs BP

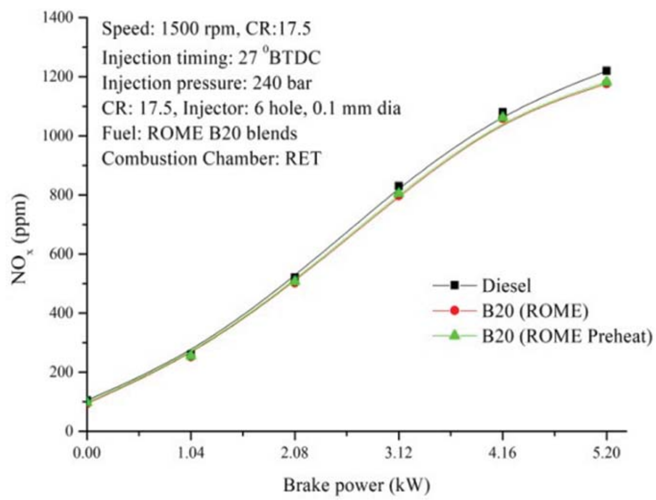

Fig.6: NOx vs. BP

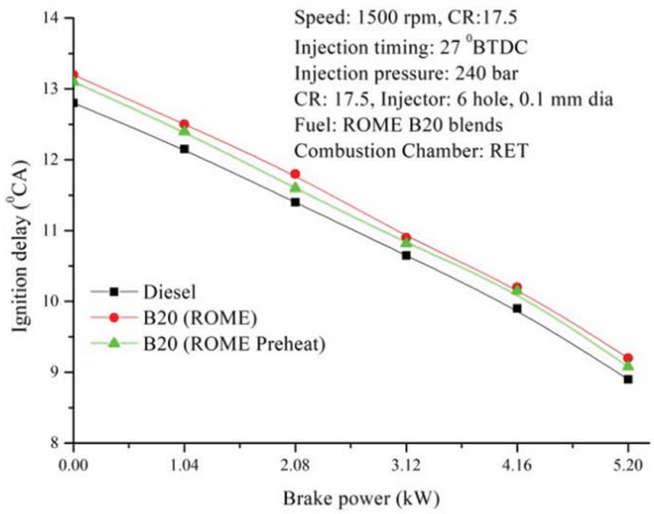

Fig.7: Ignition delay vs. BP

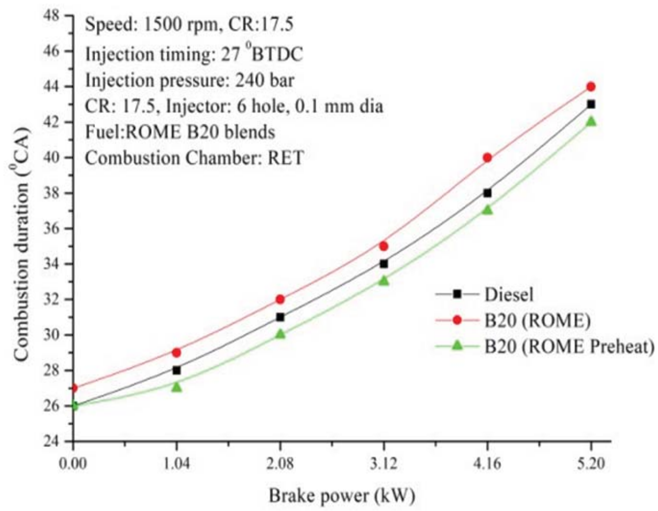

Fig.8: Combustion duration vs. BP

enhanced fuel atomization as the viscosity is less for preheated biodiesel [6].

COMBUSTION DURATION

Combustion duration is less for preheated ROME and the same is presented in the plot [8].

Conclusion

The high viscous nature of biodiesel can be reduced by preheating the fuel before it enters the fuel injector. Preheated ROME biodiesel operation resulted in increase in thermal efficiency by 2.52% in comparison with engine operation with regular ROME. CO, HC, smoke emission are reduced with preheated ROME operation but gives rise to NO_x emissions. The ignition delay and combustion duration are less due to better fuel atomization of preheated biodiesel.

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