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Impacts of Jatropha biodiesel blends on engine performance and emission of a multi cylinder diesel engine

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Abstract- **Recently, non-edible oil based biodiesel fuels have more attractive among all researchers as well as government than edible sources based alternative fuels. The objective of this study is to compare the engine performance and emission results of biodiesel produced from Jatropha oil when applied in different proportions in multi cylinder diesel engine. Results revealed that biodiesel blends produce less CO (up to 52.6%) and lower HC (up to 48%) with an increase in emission of NO (up to 11.82%). Biodiesel also presented a slight increase in brake specific fuel consumption (up to 8.33%) which may be acceptable considering the reduction in exhaust emissions. The experimental results proved that biodiesel blends can be used in compression ignition engines, thereby providing a viable alternative to diesel.**
Keywords**: Jatropha biodiesel; Emissions; Performance.**

I. Introduction

The requirements of energy are increasing rapidly due to fast industrialization and the increased number of vehicle on the road [1-3]. Biodiesel is one of the promising alternative fuels for diesel engine especially from non-edible feedstock [4-6]. However, biodiesel combustion in diesel engine emits less harmful exhaust emissions such as HC, CO and GHG compared to diesel which is proven statement [7-10]. Moreover, many researchers have been used several biodiesel derived from edible and non-edible oils in diesel engine to control the crisis of energy. The search for sustainable and environment friendly fuels are uninterrupted process. However, the use of edible vegetable oils for biodiesel production have given rise to debate of 'food versus fuel' and have also resulted in increase of food price in the recent years [11,12]. In addition, non-edible oils based biodiesel would not be more expensive like edible oils sources biodiesel to use as fuels when compared to conventional diesel fuels. As a result, the use of non-edible oils such as Jatropha (Jatropha curcas) has shown the attention among many countries like Malaysia [13]. In the present study, Jatropha oil has been identified as a potential non-edible vegetable oil for biodiesel production. Biodiesel was produced by using transesterification from this non edible oil and measured some physico-chemical properties then evaluated in accordance with relevant ASTM standards. The performance, emission and combustion studies were carried out on a four cylinder compression ignition engine. The performance and emission data from diesel engine fueled with Jatropha biodiesel blends were compared with base diesel fuel to use it as diesel substitute.

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II. Engine test

The photographic view of the experimental set-up is shown in Fig. 1. The tested engine in this study is a four cylinder inline (Indirect Injection) computerized four stroke radiator type cooling system diesel engine of 55 KW rated power. The details specification of the engine is given in Table 1. The BOSCH BEA-350 exhaust gas analyzer was used to record the data of all exhaust gas emissions.

Fig. 1 Engine test bed set-up.

Table 1 Details specification of the tested engine

Parameter	Specification
Model	Four cylinder inline diesel engine
Type	Four stroke, indirect injection
Displacement (L)	2.5
Cylinder bore x stroke (mm)	92x96
Compression ratio	21:1
Maximum engine speed (rpm)	4200
Maximum power (KW)	55
Fuel system	Distribution type jet pump (Indirect Injection)
Lubrication system	Pressure feed
Combustion chamber	Swirl type
Cooling system	Radiator cooling

III. Results and discussions

The impacts of on engine performance and emission such as NO, HC, and CO fueled with Jatropha biodiesel blends (JB5, JB10, JB15 and JB20) in multi cylinder diesel engine at full throttle position were systematically investigated in this study. All experiments were tested carefully and some were repeated to get perfect results.

A. *Test fuel standardization*

The properties of biodiesel and their blends are compared with ASTM biodiesel standards. The tested properties of methyl ester of Jatropha and their blends are found to be reasonable agreement with ASTM 6751. Table 2 represents the physical properties of Jatropha biodiesel and its blends.

Table 2 Properties of test fuels

Proper-ties	Kine-matic Visco-sity at 40°C (mm^2/sec)	Density (kg/m^3)	Calorific Value (MJ/kg)	Flash Point (°C)	Cloud Point (°C)	Pour Point (°C)
JB0 (Diesel)	3.0699	828	45.265	72.5	8	6
JB100	4.7227	865	39.827	182.5	5	3
JB5	3.1382	829.2	45.023	82.5	6	0
JB10	3.1908	831.5	44.728	85.3	6	1
JB15	3.2288	832.7	44.709	83.5	6	0
JB20	3.2879	834.6	44.191	87.5	6	0

B. *Engine Performance analysis*

Performance parameters such as engine power and BSFC with respect to variable engine speed (1000~4000 rpm) are evaluated for all test fuels and are compared to diesel combustion under 100% throttle condition. Fig. 2 and Fig. 3 represent the change in power and BSFC for different biodiesel blends compared to diesel combustion. The engine power for base diesel fuel at different engine speeds such as 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm are 12.78, 20.53, 26.47, 31.15, 37.89, 36.14 and 33.93 KW respectively.

Under full throttle condition, the use of all biodiesel blends in four cylinder diesel engine the reduction in power is investigated as reasonable range (+2.2 to -4.50) at lower engine speed as 1000 rpm to 2500 rpm. The average reductions in engine power for JB5, JB10, JB15 and JB20 compared to JB0 are 0.83, 3.49, 1.57 and 4.15% respectively. The value of BSFC for base diesel fuel at different engine speeds such as 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm are 335.1, 331, 333, 354, 390, 432 and 488 g/KWh respectively. The average increases in BSFC for JB5, JB10, JB15 and JB20 compared to JB0 are 6.79, 8.33, 6.19 and 7.62% respectively. The reason for the reduction in engine power and increase in BSFC are possibly due to slight reduction of cylinder pressure as well as lower heating value of biodiesel [14].

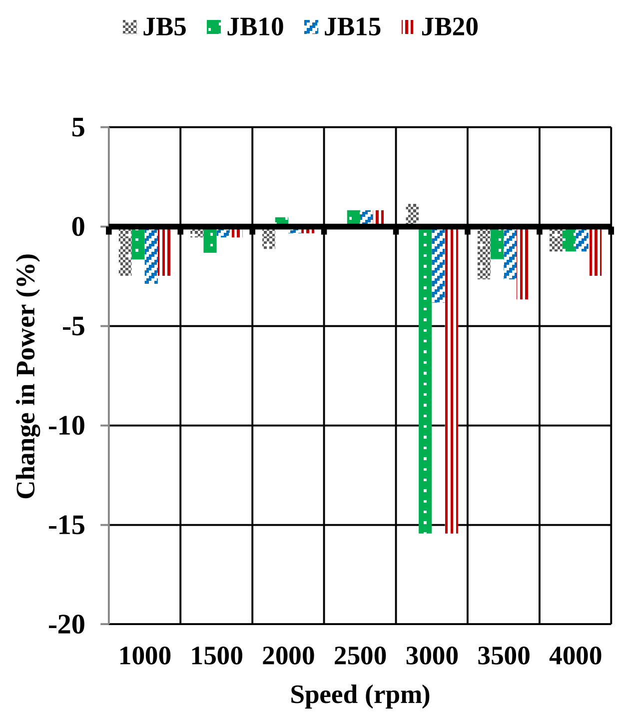

Fig. 2 Change in Power (%) of different blends of Jatropha biodiesel compared to diesel combustion.

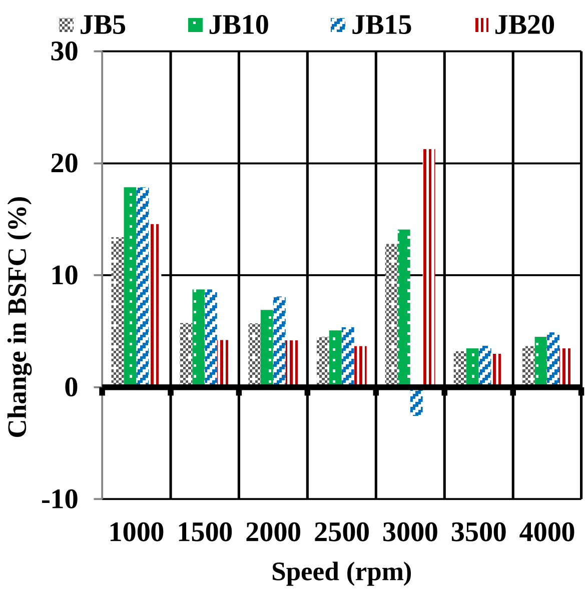

Fig. 3 Change in BSFC (%) of different blends of Jatropha biodiesel with compared to diesel combustion.

C. *Effect of speed and blending ratio on NO emission*

Fig. 4 shows the variation of NO emission for all tested biodiesel blends compared to diesel combustion. The values of NO emission for base diesel fuel at different engine speeds such as 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm are 119, 174, 190, 217, 235, 232 and 229 ppm. It is observed that using all biodiesel blends of Jatropha increase the NO emission compared to diesel combustion. The average increase the NO emission for JB5, JB10, JB15 and JB20 compared to JB0 are 11.82, 8.74, 9.89 and 10.74% respectively. Several researchers investigated and found that higher NO_x emissions are produced for biodiesel combustion which influenced by several factors such as physicochemical properties and molecular structure of biodiesel, adiabatic flame temperature, ignition delay time, injection timing etc. However, some studies have pointed out that higher biodiesel NO_x emissions occur mainly due to increase in the formation of prompt NO_x in biodiesel combustion in diesel engines. Fenimore suggested that the reactions of hydrocarbon radicals (CH, CH_2, C_2, C, and C_2H) with molecular nitrogen are the main contributors to produce prompt NO_x. The production rates of HCN, N and NO increases with increasing the concentration of free radicals. Garner et al. [15] investigated and found that the formation rate of CH radicals is high for biodiesel combustion in diesel engine. As a result it could be pointed that the higher formation rate of free radicals is prime reason for biodiesel fuel higher NO_x emissions.

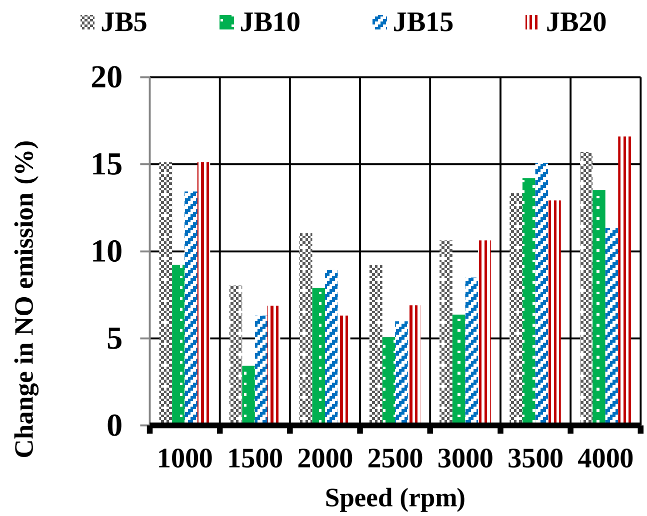

Fig. 4 Change in NO emission (%) of different blends of Jatropha biodiesel compared to diesel combustion.

D. *Effect of speed and blending ratio on HC and CO emissions*

Fig. 5 and Fig. 6 represent the variation of HC and CO emissions for JB5, JB10, JB15 and JB20 Jatropha biodiesel blends compared to diesel combustion at full throttle position. The values of HC emission for reference diesel fuel at different engine speeds such as 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm are 23, 16, 10, 7, 7, 6 and 6 ppm. It is found that with biodiesel combustion reduces the HC emission significantly compared to neat diesel combustion. The average reductions of HC emission for JB5, JB10, JB15 and JB20 compared to JB0 are 33.3, 28, 34.66 and 48% respectively. The values of CO emission for diesel combustion at different engine speeds such as 1000, 1500, 2000, 2500, 3000, 3500 and 4000 rpm are 0.925, 0.595, 0.304, 0.35, 0.451, 0.703 and 0.848 respectively. From Fig. 6, it is observed that with biodiesel combustion reduces the CO emission significantly compared to diesel combustion. The average reduction of CO emission for JB5, JB10, JB15 and JB20 compared to JB0 are 50.4, 10.75, 39.29 and 52.61% respectively. The main reason for lower HC and CO emissions with biodiesel combustion is that, biodiesel fuel contains high oxygen leads to complete combustion [16].

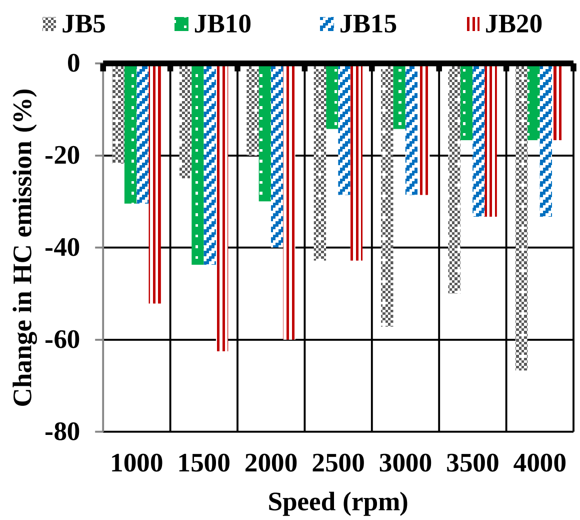

Fig. 5 Change in HC emission (%) of different blends of Jatropha biodiesel compared to diesel combustion

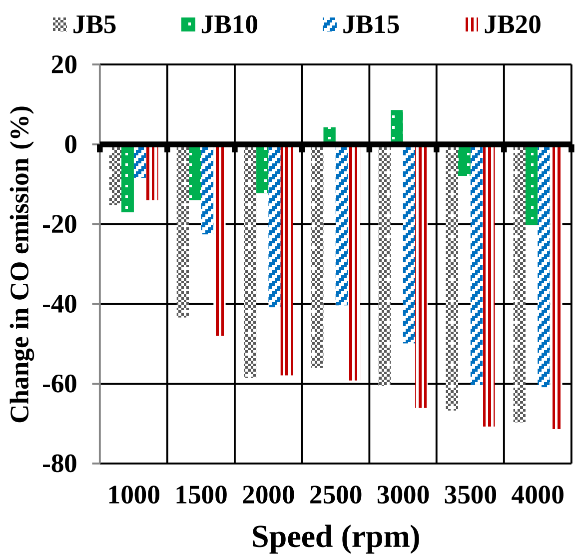

Fig. 6 Change in CO emission (%) of different blends of Jatropha biodiesel compared to diesel combustion.

IV. Conclusion

The aim of this experimental work was to investigate the impacts Jatropha biodiesel blends on engine performance and emissions of multi cylinder diesel engine. The blends of Jatropha biodiesel with diesel produce less HC (up to 48%) and CO (up to 52.6%), but higher NO emission (up to 11.82%). From the results presented above, it can be concluded that Jatropha biodiesel blends up to 20% can be applicable in diesel engine without any engine modification.

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