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A Study of diesel engine fuelled with Madhuca Indica biodiesel and its blend with Diesel fuel

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Abstract: *The engine emission characteristics of Mahua (Madhuca Indica) biodiesel (Mahua Oil Methyl Ester) and its blends with diesel is presented. The thermo-physical properties of all the fuel blends have been measured and presented. The engine tests are conducted on a 4-Stroke Tangentially Vertical (TV) single cylinder kirloskar 1500 rpm water-cooled direct injection diesel engine with eddy current dynamometer at different brake power of 1.021133, 2.072299, 3.093431, 4.144597, 5.195763 kw with modified Static Injection Timing of 22° bTDC and standard Nozzle Opening Pressure of 220 bar maintained as constant throughout the experiment under steady state conditions at full load condition. From the test results, it could be observed that the higher brake power of 5.195763 kw (full load) with nozzle opening pressure of 220 bar and static injection timing of 22° bTDC gives lower emissions for brake power 5.195763 kw for B0 and B25 when compared to other blends. Also there is significant percentage reduction in* NO_x *emission with brake power of 5.195763 kw for B0 when compared with B100. It could be found that lower in CO, HC emissions with brake power 5.195763 kw for B25 when compared to B0.*

Keywords: *Mahua Oil; Biodiesel; Nozzle Opening Pressure; Static Injection Timing; Performance; Emission*

I. Introduction

In recent years, agrowinginterestisevincedconcerningrenewableandalternativefuels.The mahua biodiesel and fossil diesel study was done and discussed extensively with the engine performance obtained by blend with different volumetric ratios. The diesel engine sector forms a vital part of transportation systems in all the developed and developing countries of the world. However, diesel engine exhaust emissions are a major contributor to environment pollution. The conventional fossil fuel (diesel) used in diesel engines contains higher amounts of aromatics and sulphur, which cause environment pollution. As an example, higher amount of particulate matter (PM), unburned hydrocarbon (HC), oxides of nitrogen (NO_x), carbon di-oxide (CO_2) and Oxides of Nitrogen (NO_x) are produced from fossil-fuelled diesel engine exhaust emissions. Moreover, NO_x and CO_2 are the green house gases and NO_x causes acid rain. Bio-fuel contains less aromatic content an impractically sulphur-free, and produces complete combustion due to its oxygen content in comparison with conventional diesel fuel. Secondly, the environmental benefit is another motivation factor due to a lesser green house effect, less local air pollution, less contamination for water and soil and a reduced health risk. In this paper an analysis of 4S TV1 DI with static injection timings of 22° bTDC and with a constant brake power at full load condition of the diesel engine with eddy current dynamometer using B0, B25, B50, B75 and B100 as fuel is presented.

Table 1: Specification Details of the Engine

Name of the Description	Details / Value
Make	Kirloskar TV –I
Type	Single Cylinder, DI Diesel Engine
Bore x Stroke	(87.5x110) mm
Compression ratio	17.5:1
Speed	1500 rpm
Rated Brake Power	5.2 kW
Cooling System	Water Cooled
Nozzle Opening Pressure	220 bar (Standard)
Static Injection Timing	22˚ bTDC (Modified) at full load

Table 2: Properties of Mahua biodiesel and its Diesel Blends

S. No	Name of the properties	B0	B25	B50	B75	B100
1	Gross calorific value in MJ/kg	45.59	43.98	43.27	42.52	41.82
2	Kinematic viscosity at 40ºC in cSt	2.6	3.49	4.17	4.98	6.04
3	Flash Point in ºC	65	71	78	112	170
4	Fire Point in ºC	70	79	88	123	183
5	Cloud Point in ºC	-15	4	8	11	13
6	Specific gravity	0.82	0.83	0.85	0.87	0.88
7	Cetane number	46	51.6	51.7	51.8	52.4
8	Acidity	0.065	0.067	0.070	0.083	0.26

II. Experimental Setup And Procedure

Experiments have been conducted on a 4 stroke TV1 direct injection (DI) diesel engine developing power output of 5.2 kw at 1500 rpm connected with water cooled eddy current dynamometer. The specifications of the engine are placed in Table 1. The static injection timing of 22° bTDC and standard Nozzle opening pressure of 220 bar are used for the entire experiments at full load condition of the diesel engine. AVL 444 di-gas analyzer is used for the measurement of exhaust emission of HC, CO, CO_2, O_2 and NO_x. Smoke level is measured using standard AVL 437 smoke meter. All the experimental readings are taken at full load and steady state conditions of the engine.

III. Results And Discussion

3.1 Carbon Monoxide

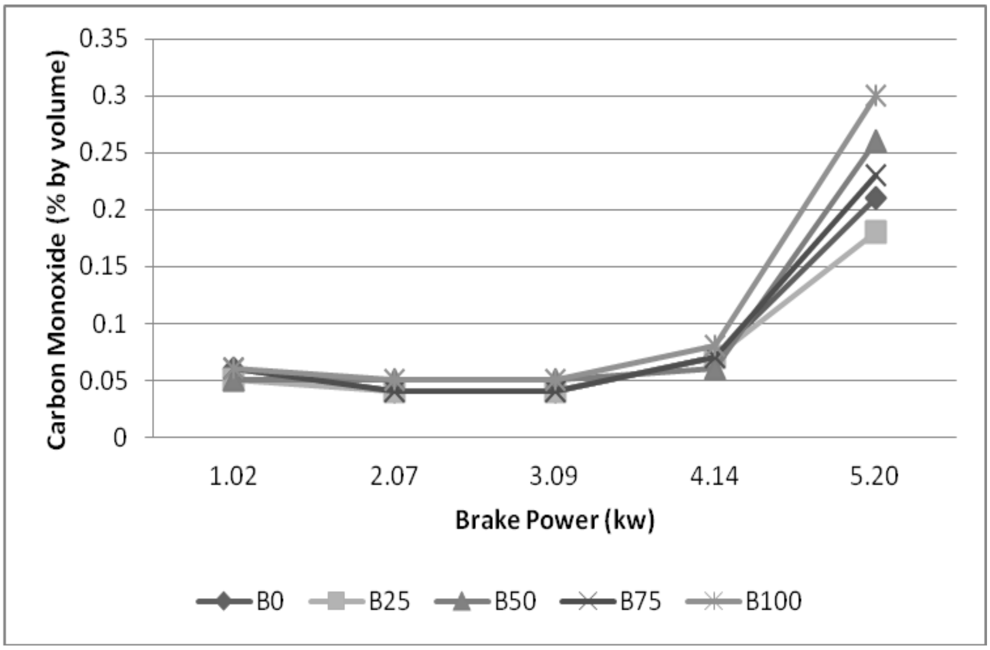

Figure 1: Carbon Monoxide vs Brake Power

The variation of carbon monoxide with respect to brake Power of 1.021133 (no load), 2.072299, 3.093431, 4.144597 and 5.195763 (full load) kw for different blend ratios are shown in figure 1. From the graph results, it is observed that the brake power with 2.072299 and 3.093431 kW give lowest carbon monoxide as compared to all other brake power for all blends of fuel. The percentage increase in carbon monoxide for brake power with full load for B0, B25, B50, B75 and B100 is 50%, 51%, 51.5%, 51.33% and 52% respectively as compared to brake power with no load condition. The percentage increase in CO emission is more for B50. Some of the CO produced during combustion of biodiesel might have converted in to CO by taking up extra oxygen molecule present in the biodiesel chain and thus reduces CO formation.

3.2 Hydrocarbon

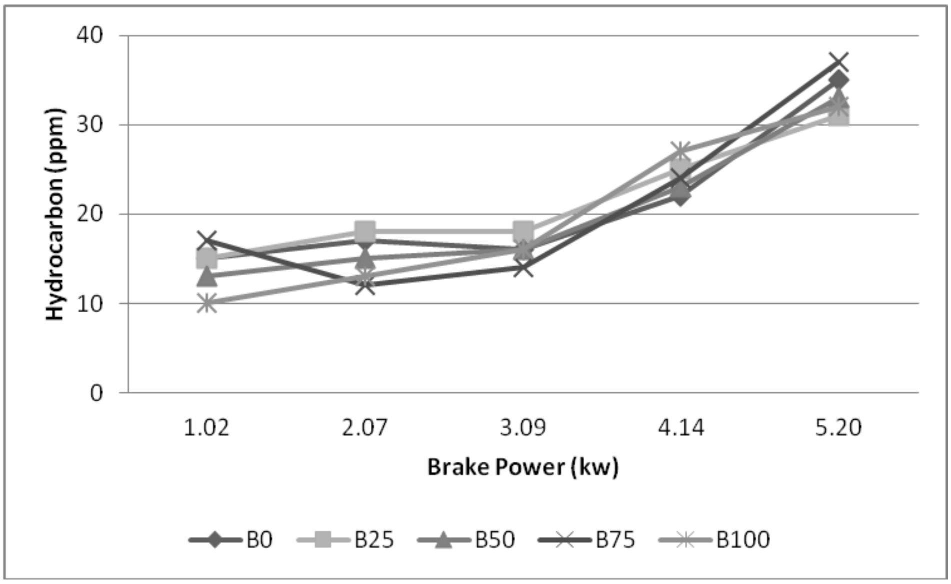

Figure 2: Hydrocarbon vs Brake Power

The variation of hydrocarbon with respect to various brake power of 1.021133 (no load), 2.072299, 3.093431, 4.144597 and 5.195763 (full load) kw for different blend ratios are shown in figure 2. From the test results, it is observed that the brake power with no load gives lowest hydrocarbon as compared to other brake power for all blends of fuel except for the blend B75.The percentage increase in hydrocarbon for the brake power with full load for B0, B25, B50, B75 and B100 is 33.33%, 36.66%, 36.84%, 37.84% and 38.02% respectively as compared with brake power no load. Among all the blends, the B100 gives highest hydrocarbon of 38.02% in terms of percentage increase in hydrocarbon.

3.3 Carbon di-oxide

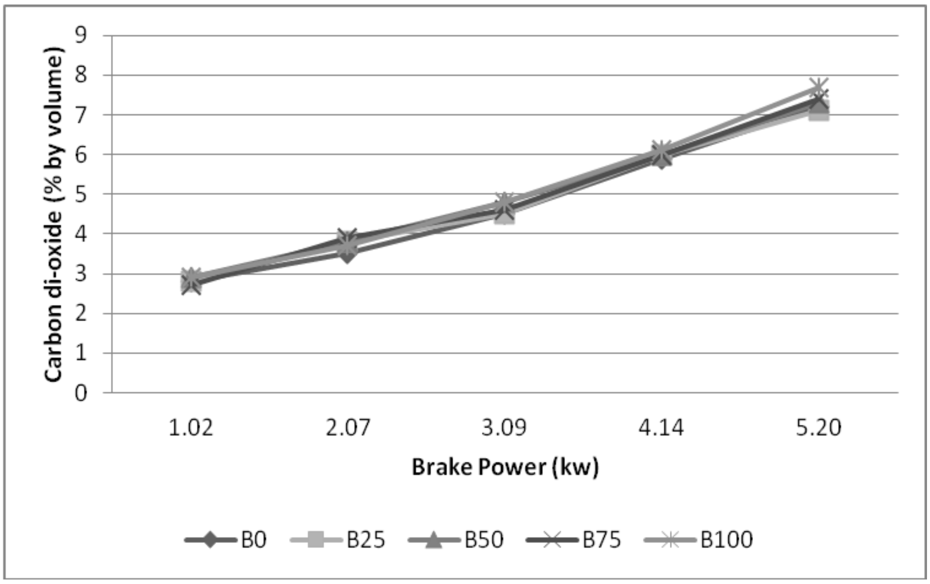

Figure 3: Carbon di-oxide vs Brake Power

Figure 3 shows variation of carbon di-oxide with respect to brake power for different blend ratios. From the test results, it could be stated that the brake power of 5.195763kw (full load) gives highest CO_2 as compared to all other brake power. The percentage increase in CO_2 for brake power with full load for B0, B25, B50, B75 and B100 is 57.49%, 57.57%, 56.7%, 56.07% and 56.67% respectively as compared with brake power with no load. From figure 9, it is observed that B0 and B25 give highest CO_2 in terms of percentage reduction for brake power with full load. The CO_2 emission from a diesel engine indicates how efficiently the fuel is burnt inside the combustion chamber. The ester based fuel burns more efficiently than neat diesel.

3.4 Oxides of Nitrogen

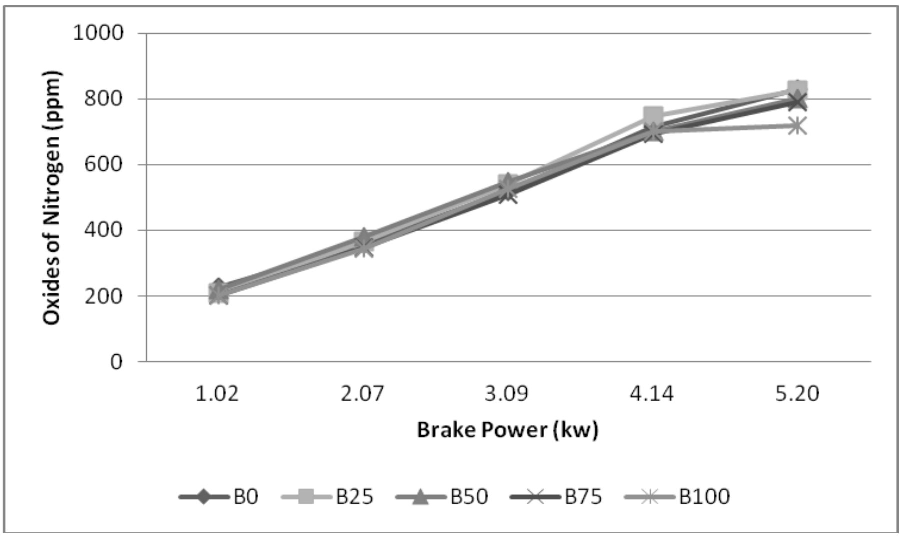

Figure 4: Oxides of Nitrogen vs Brake Power

Figure 4 shows variation of oxides of nitrogen (NO_x) with respect to different brake power of 1.02113 (no load), 2.072299, 3.093431, 4.144597 and 5.195763 (full load) kw. From the test results, it is seen that the brake power of 1.021133 kw (no load) gives lowest NO_x as compared to all other brake power for all blends of fuel. The percentage increase in NO_x for brake power with full load for B0, B25, B50, B75 and B100 is 67.2%, 67.8%, 65.29%, 61.58% and 66.28% respectively as compared with brake power with no load. Among all the blends, the B25 gives highest NOx of 63.8% in terms of percentage of increase in NO_x.

IV. Conclusions

From these readings, it could be concluded that the Mahua biodiesel blend B25 used as an alternative fuel for operating four stroke tangentially vertical single cylinder kirloskar direct injection water cooled constant speed diesel engine with modified static injection timing of 22° bTDC and standard nozzle opening pressure of 220 bar at full load. As compared to all brake power, the brake power with full load gives lower emissions for all loads. In situations of shortage of availability of fossil diesel (B0), it could be suggested that B25 could be used as alternative fuel to operate the diesel engine without any modification in the existing design of the diesel engine.

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