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Effect of Injection Pressure on CI Engine Performance Fuelled with Biodiesel and its blends

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Abstract— Use of biodiesel as an alternative to diesel could reduce the dependency on petroleum products and the pollution problem. The physical properties of the fuel such as viscosity, volatility and flash point also affect the combustion process, thereby engine performance. Specifically atomization of the fuel during the injection is attributed to higher viscosity of biodiesel. Injected fuel droplets get smaller as the injection pressure increases which contributes to better atomization of the fuel. Hence the effect of injection pressure (IP) on the performance of compression ignition (CI) engine fuelled with biodiesel and its blends with diesel is evaluated. Tests are conducted on CI engine fuelled with diesel at IP of 200 bar to get base line data for comparing engine performance with various blends of palm oil methyl ester (POME) and diesel as test fuels at different injection pressures. The results indicate that the performance of engine is improved with B60 (60% POME and 40% diesel) at IP of 220 bar compared to other test fuels at different injection pressures. In this paper comparison of test fuel B60 at different injection pressures with diesel at 200 bar is made.It is observed that brake thermal efficiency is improved and brake specific energy consumption is lowered with B60 at 220 bar due to improved atomization. It is also observed that carbon monoxide, unburned hydrocarbons are reduced and Nox emissions increased compared to other test fuels at different injection pressures.

Index Terms— Bio-diesel, Palm Oil Methyl Ester, Compression Ignition Engine, Emissions.

1 INTRODUCTION

THE depletion, increasing demand and price of the petroleum prompted extensive research worldwide on alternative energy sources for internal combustion engines. Use of bio fuels such as vegetable oil could reduce the dependency on petroleum products and the pollution problem. The use of straight vegetable oils (SVO) in diesel engines presents problems primarily due to their high viscosity and lower volatility [1]. SVO can replace diesel oil for short term with lower output [2] but long term and unmodified engine coke up [3]. Tadashi et.al [4] observed higher carbon deposits and piston rings sticking and R Altin et.al [5] observed higher specific fuel consumption, more carbon monoxide emissions due to higher viscosity. Reduction in viscosity of vegetable oil may improve the engine performance, and can be done by converting it to bio diesel.

N.R. Banapurmath [6] found a slight reduction in thermal efficiency, increase in smoke emissions, increased ignition delay and combustion duration with methyl esters of Honge, Jatropha and sesame oil as compared to neat diesel. Lower brake power and torque were observed with bio diesel as compared to diesel [7]. Pradeep and Sharma [8] observed that lower Brake thermal efficiencies & heat release rates and higher combustion duration with biodiesel compared to diesel. Scholl and Sorenson [9] reported that carbon monoxide, oxides of nitrogen (NOX) and smoke emissions were slightly lower for soybean ester than diesel, whereas HC emission showed 50% reduction. Sanjay Patil et.al [10] conducted tests on diesel oil, neat palm oil methyl ester (POME) and its blends with diesel. It was observed that brake thermal efficiency, brake specific energy consumption is improved with POME and its blends with diesel. The peak pressure and rate of pressure rise are lower, smoke and hydrocarbon emissions are reduced with POME and its blends. Authors [6-10] have evaluated the performance of CI engine without changing the injection pres sure. Viscosity of biodiesel is still more than that of diesel at 30°C. Injection of higher viscous fuel results in to larger droplets resulting in poor atomization. By increasing injection pressure smaller fuel droplets will be injected may result in better atomization.

Hence an effort is made to investigate the effect of injection pressure on the CI engine performance fuelled with biodiesel and its blends with diesel.

2 EXPERIMENTAL SETUP

A stationary single cylinder, 4 stroke, water cooled diesel engine developing 5.2 KW at 1500 rpm is used for investigation. Technical specifications of the engine are given in Table 1. The engine is coupled to an Eddy current dynamometer. The major pollutants like smoke and unburned hydrocarbon are measured using smoke meter and four gas analyzer. The fuel flow rate is measured on volumetric basis using burette.

A palm oil methyl ester (POME) is chosen as a potential alternative biodiesel. Viscosity is measured using redwood viscometer, flash and fire points are determined using Martenpenesky closed cup apparatus and calorific value is estimated using bomb calorimeter.

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TABLE 1. SPECIFICATIONS OF ENGINE

SL.NO	PARAMETER	SPECIFICATION
1	TYPE	FOUR STROKE DIRECT INJECTION SINGLE CYLINDER DIESEL ENGINE
2	SOFTWARE USED	ENGINE SOFT
3	NOZZLE OPENING PRESSURE	200 BAR
4	RATED POWER	5.2KW @1500 RPM
5	CYLINDER DIAMETER	87.5 MM
6	STROKE	110 MM
7	COMPRESSION RATIO	17.5:1
8	INJECTION TIMING	23 DEGREE BEFORE TDC

3 PROCEDURE

An engine is operated on diesel at IP of 200 bar and various blends of POME and diesel as test fuels at IP of 200 bar, 220 bar and 240 bar. The test fuels are namely B20, B40, B60, B80 and B100 prepared with 20%, 40%, 60%, 80% and 100% POME with petroleum diesel respectively. The blends are stirred using magnetic stirrer. Various physical and chemical properties of the test fuels are determined and tabulated in table No 2.

TABLE.2. PROPERTIES OF DIESEL AND POME

PROPERTIES	DIESEL	POME(B100)
VISCOSITY IN CST (AT 30°C)	4.25	40.25
FLASH POINT(°C)	79	190
FIRE POINT(°C)	85	210
CARBON RESIDUE (%)	0.1	0.64
CALORIFIC VALUE(KJ/KG)	42700	36000
SPECIFIC GRAVITY(AT 25°C)	0.830	0.880

Cylinder pressure data is recorded by using piezoelectric transducer for 80 cycles, averaged and processed within the framework of first law of thermodynamics [11] to compute net heat release.

4 RESULTS AND DISCUSSIONS

4.1 Performance Parameters

4.1.1 Brake thermal efficiency

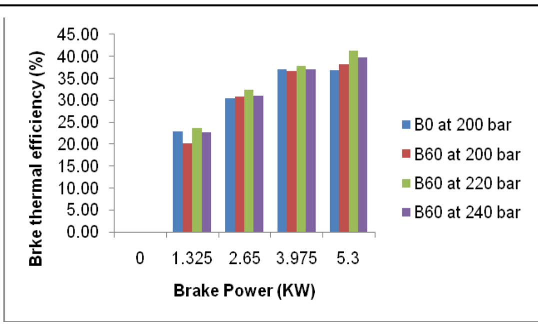

Fig.1. Variation of Brake Thermal Efficiency

4.1.2 Brake Specific Fuel Consumption

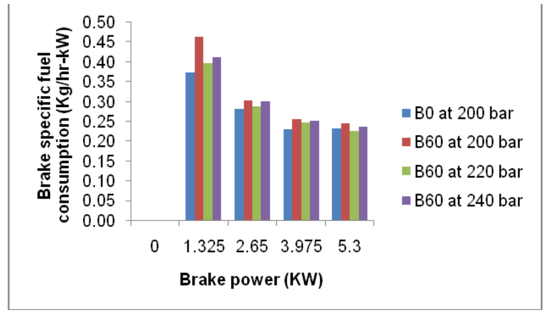

Fig.2. Variation of Brake Specific Fuel Consumption

4.1.3 Exhaust gas temperature

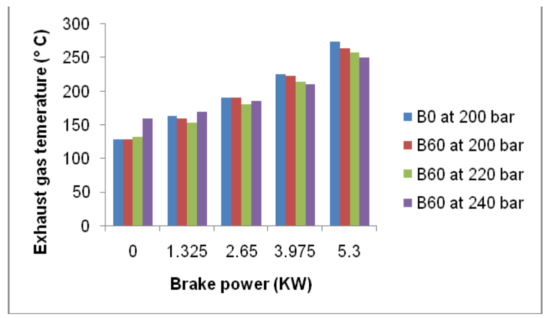

Fig.3. Variation of Exhaust Gas Temperature

From above figures (1-3) it is observed that the brake thermal efficiency with B60 at injection pressure 220 bar is increased due to better atomization. At injection pressure 240 bar brake thermal efficiency is lowered due to lower momentum of very fine droplets which reduces the droplet penetration in combustion chamber. As the injection pressure increases bsfc decreases due of complete combustion of fuel. Increase in injection pressure assists in better mixing of fuel with air. The exhaust gas temperature is decreased with increase in injection pressure as a result of better combustion.

4.2 Combustion parameters

4.2.1 Net heat released

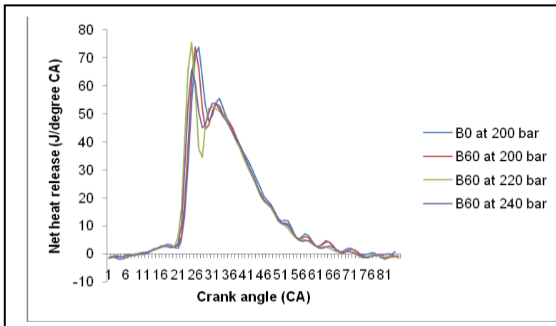

Fig.4. Variation of net heat released

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4.2.2 Peak pressure

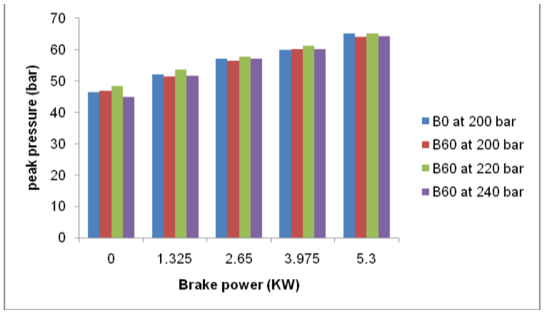

Fig.5 Variation of peak cylinder pressure

Above figures (4-5) indicates that at IP of 220 bar B60 shows increased heat release during premixed combustion due to improved atomization and mixing of fuel with air resulting in increased rate of combustion. The peak pressure for B60 is 64.21 bar, 65.29 bar and 64.25bar at IP of 200 bar, 220 bar and 240 bar. Whereas the peak pressure for B0 at IP 200 bar is 65.31bar. This indicates that peak pressure with B60 varies marginally with change in injection pressure and it is comparable with diesel.

4.3 Emission parameters

4.3.1 Hydrocarbon emissions

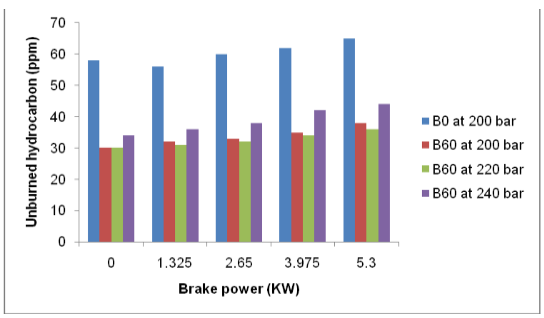

Fig.6. Variation of hydrocarbon emissions

4.3.2 Smoke emissions

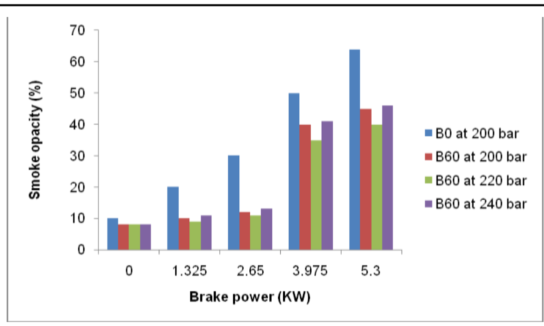

Fig.7. Variation of smoke

4.3.3 Carbon monoxide

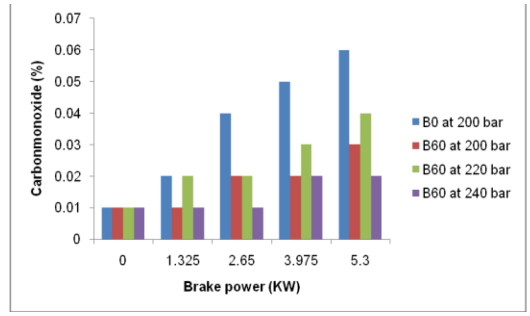

Fig.8. Variation of carbon monoxide

4.3.4 Oxides of nitrogen

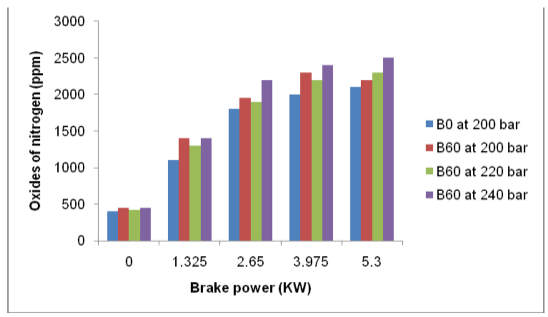

Fig.9. Variation of oxides of nitrogen

Figures (6-9) shows effect of injection pressures on emission of various emitants. Unburnt hydrocarbon, carbon monoxide and smoke emissions are lower at IP of 220 bar for B60 as compared to diesel at 200 bar. The reason may be higher oxygen content and better atomization of fuel. The Nox are highest with B60 at IP of 220 bar due to higher mean gas temperature.

5 Conclusion

In this study POME is selected as potential biodiesel and various blends of POME and diesel have been prepared. Engine is operated with each blend at different injection pressure and the performance parameters were computed and the following conclusions are drawn

Engine performance is improved with B60 at IP of 220bar due to improved atomization of fuel. Brake specific fuel consumption is decreased with increase in load for all the test fuels. For test fuel B60 at IP of 220 bar the bsfc is lowest. Emissions are lower with biodiesel blends at 220 bar but Nox emissions are more. At 240 bar emissions are increased.

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