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PERFORMANCE AND EMISSION CHARECTERISTICS OF A SINGLE CYLINDER DIESEL ENGINE OPERATED WITH METHYL ESTER MANGO SEED BIODIESEL

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ABSTRACT

The present study is to investigate the performance and emission characteristics of methyl ester mango seed biodiesel fueled single cylinder four stroke diesel engine. The engine was operated for 210, 225 and 250 bar injection pressures for B00, B10, B20 and B30 biodiesels. The experiments were carried out on water cooled diesel engine to determine the brake thermal efficiency, specific fuel consumption and emission charecteristics for different injection pressures. The experimental result shows that the brake thermal efficiency of the biodiesel was slightly lower than the brake thermal efficiency of diesel fueled engine. The specific fuel consumption of biodiesel was more compared to diesel. The CO emissions and NOx emissions are lower at the 225 bar injection pressure for all types of biodiesels. The NOx emissions increases and CO_2 emissions decreases as methyl ester mango seed oil blend boosts in the pure diesel.

Keywords: Biodiesel, Diesel engine, Emissions, Nox emission

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1. INTRODUCTION

The services of the automotives are superior in the daily life of the human beings. Nowadays, human beings are more depend on the automotives for common purposes like purchasing of food products from the nearest stores and for travelling from on one place to other place which leads to more utilization of petroleum products. The petroleum products are needed to generate thermal energy in the combustion chamber of the automotives for smooth operation. Only 30% of the thermal energy generated by the engine is renewed into useful work and remaining energy is dissipated through cylinder walls, engine head, and piston head by direct heat loss and exits through exhaust gasses. The overall efficiency of the internal combustion engine is only about 40% - 42%. This efficiency may be due to a number of issues like; deficient in employing latest methods for design of combustion chamber, meager oxygen furnishing to the combustion chamber, lack of creating turbulence in the combustion chamber, deficient in optimizing the injection pressure of the fuel and compression ratio of the engine. The efficiency of the engine can be improved in one or the other way to save fuel energy and oils. In recent days, there is a maximum demand for fuels and oils leads to higher cost and non availability. This demand can be reduced by improving the efficiency of the internal combustions engines which is the challenge for the engineers [1-2]. The biodiesels are the alternate fuels can be used in automotives to reduce the use of petroleum products [3-4]. Many researchers were studied the influence of injection pressure in improving the thermal efficiency of the biodiesel fueled internal combustion engines with declined pollutants and some of the literatures were reviewed [5-9]. N.R.Banapurmath et al., [10] have performed the experiment on a single cylinder, four stroke, direct injection, water cooled CI engine operated using the biodiesels like; Honge, Neem and Rice bran oils. The fuel economy increases and enhances the combustion temperature of the diesel engine compared to the engine operated using the diesel fuel. The emission characteristics are decreased and CO emission is slightly enhanced. Z H Huang et al., [11] have experimented to reduce the exhaust gas emissions in the diesel engine operated by using dimethyl ether. The various parameter like thermal efficiency, specific fuel consumption BSFC and emission characteristics are determined. The fuel economy increases and enhances the combustion temperature of the diesel engine compared to the engine operated using the diesel fuel with decreased emission characteristics. GVNSR Ratnakara Rao et al., [12] have conducted the experiments in a diesel engine using mahua oil as a fuel by varying the compression ratio at a steady engine speed of 1500 rpm. The result indicates that the performance is improved by 15.7 is finest compression ratio with the mahua oil. The emission characteristics are decreased and CO emission is slightly enhanced. Sukumar Puhan, N et al., [13] in this investigation, mahua oil methyl ester was transesterified with methanol via sodium hydroxide as catalyst by reaction duration of 120min. The fuel economy increases and enhances the combustion temperature with moderate performance the diesel engine compared to the engine operated using the diesel fuel. Similar results are indicated by Sharanappa Godiganur et al., [14]. S.K.Haldar yiet et al., [15] they are studied the performance of the diesel engine by using the putranjiva oil blends as the biodiesel fuels. The 30% blend of puntranjiva oil gives the same power out as that of diesel oil fuel power out in the diesel engine. Thus 30% blend of puntranjiva oil can be employed as an substitute fuel for diesel engine with better emission characteristics. Y C Bhatt et al., [16] have conducted the experiments in a diesel engine using mahua oil as a fuel by varying the compression ratio at a stable engine speed of 1500 rpm. The calorific value of the mahua oil is 96.3 % of the calorific value of the diesel oil. The 20% blend is prepared and used as biodiesel fuel. The result indicates that the performance is improved with enhances in the compression ratio with the mahua oil [17-18]. Some of the investigations were carried out by many researchers on biodiesels [19-24]. A thorough evaluation of the literature survey shows that there are incredibly little investigations have reported on the consequences on the performance of methyl ester mango seed biodiesel fueled single cylinder 4 stroke diesel engine. Thus, the present investigation is carried out to study the performance and emission characteristics of MEMS biodiesel fueled single cylinder 4-stroke diesel engine.

2. PREPARATION OF METHYL ESTER MANGO SEED OIL

The mango seeds are first collected from the local area, mango juice centers and mango pickle industries. The collected mango seed were dried for two weeks and the outer shell of mango seeds were broken down after drying. Mango seed kernels were dried for a week and then crushed in local oil mill to obtain mango seed oil. The MSO is converted to biodiesel by transesterification process. It is the process of reacting the oil with methanol in the presence of catalyst (KOH). During the process, the molecule of raw mango seed oil is chemically broken to form the ester and glycerol. Mango seed ester is filtered to separate from glycerol. The mango seed oil was mixed with methanol and the mixture is heated at a temperature of 65^{o} C to 75^{o} C.

The mixture is stirred occasionally and then kept aside for about 16 hrs. Similar process was adopted for production of biodiesels by M.P. Dorado et al., [25].

Table 1: The properties of biodiesels

Property	**Diesel**	**MSBD10**	**MSBD20**	**MSBD30**
Kinematic viscosity at 40° C (m^2/s)	3.9×10^{-6}	1.810×10^{-6}	3.62	4.8
Density (kg/m^3)	830	807.16	812.83	825
Calorific value (kJ/kg)	43000	40958.3	39801.64	34516.9
Flash point (°C)	56	48	54	58
Fire point (°C)	65	53	60	63

3. EXPERIMENTAL PROCEDURE

The experiment was conducted to determine the consequence of injection pressure on performance on methyl ester mango seed biodiesel fuelled CI engine. The experiments were carried out at steady speed of 1500 rpm for comparing the performance of C.I engine by varying its injection pressure for pure diesel and for blend of bio-diesel. The biodiesel blend is prepared by adding 10%, 20% and 30% of methyl ester mango seed biodiesel to the pure diesel for testing. A single cylinder computerized diesel engine is used for the conduction of experimentations which is an electrically loaded, water cooled engine directly interfaced with computer as shown in figure. This engine having a facility to varying the parameters like; load on the engine, speed and injection pressure of the engine. The piezo-electric pressure transducer is fitted at the crown of the engine head to measure the pressure at each cycle for different constraints. The indicated mean effective pressure values of the cycles are considered based on the repetitiveness in the readings. This is also provided the sensors to gauge the temperature of inlet and exhaust gas, jacket water and calorimeter water temperature. The engine was operated for 210, 225 and 250 bar injection pressures for B00, B10, B20 and B30 biodiesels. The thermal efficiency, specific fuel consumption and emission characteristics were discussed.

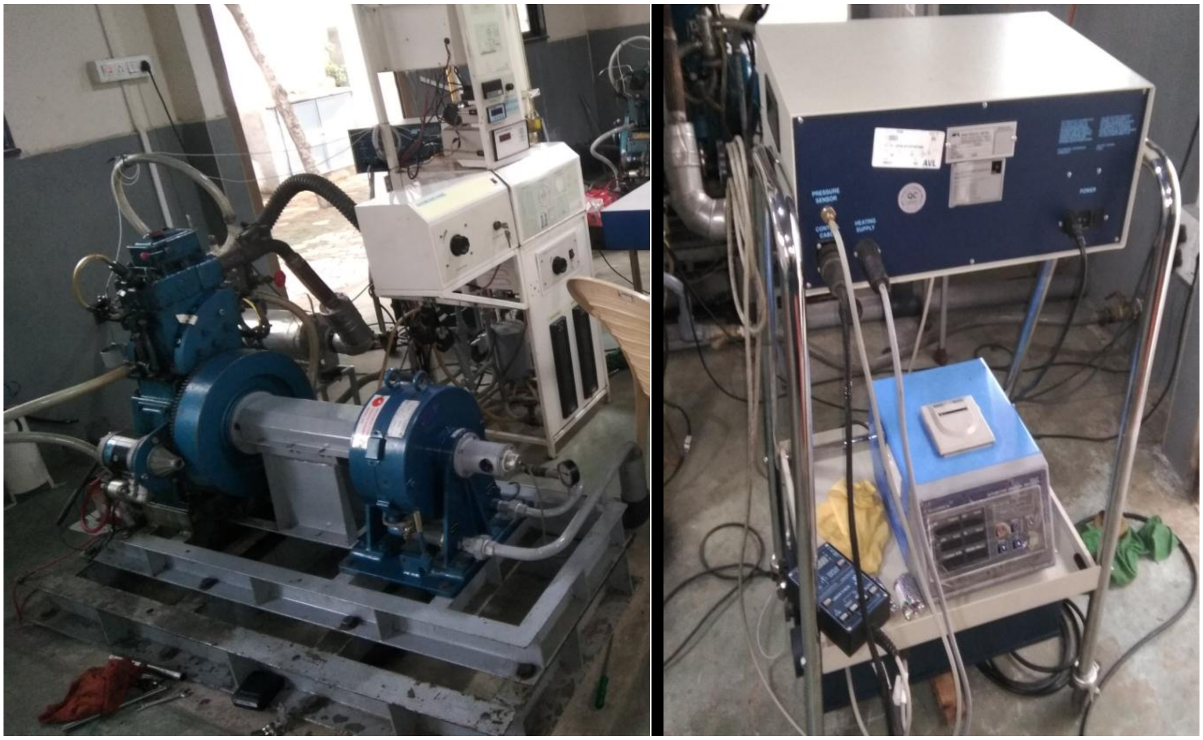

Fig 1: Single cylinder 4-stroke diesel engine test rig with emissions testing instrument

Table 2: Engine Specification

Parameters	**Specification**
Manufacture	Kirloskar oil engines Ltd. India
Engine	IC Engine set up under test is Research Diesel engine (TV1)
Bore/stroke	87.5mm/110mm
C.R	12:1 to 18:1
Speed	1500 RPM
Rated power	3.50 kW
Working cycle	Four stroke
Response time	4 micro seconds
Type of sensor	Piezo electric
Crank angle sensor	1-degrere crank angle
Injection pressure	250bar/23 def TDC
Resolution of 1	360 deg with a resolution

4. RESULTS AND DISCUSSION

This section presents the experimental results and its discussions on the influence of injection pressure on the specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emission characteristics of the biodiesel fueled diesel engine.

4.1 Influence of Load and injection pressure on Indicated power

Figure 2 illustrates the influence of load on the indicated power at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The indicated power is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The indicated power increases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the development of the indicated power decreases.

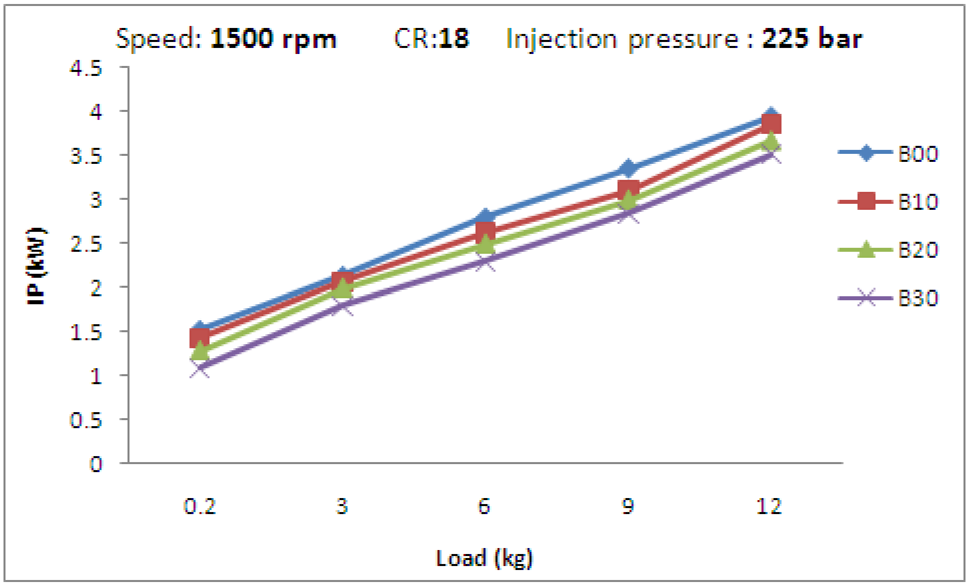

Figure 2: Influence of Load on Indicated power

Figure 3 illustrates the influence of injection pressure on indicated power of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The indicated powers are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The indicated power decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The indicated power of B20 biodiesel decreases by 10.49% and the indicated power of biodiesel B30 decrease by 12.43% when compared to the indicated power of B00 diesel at 225 bar injection pressure.

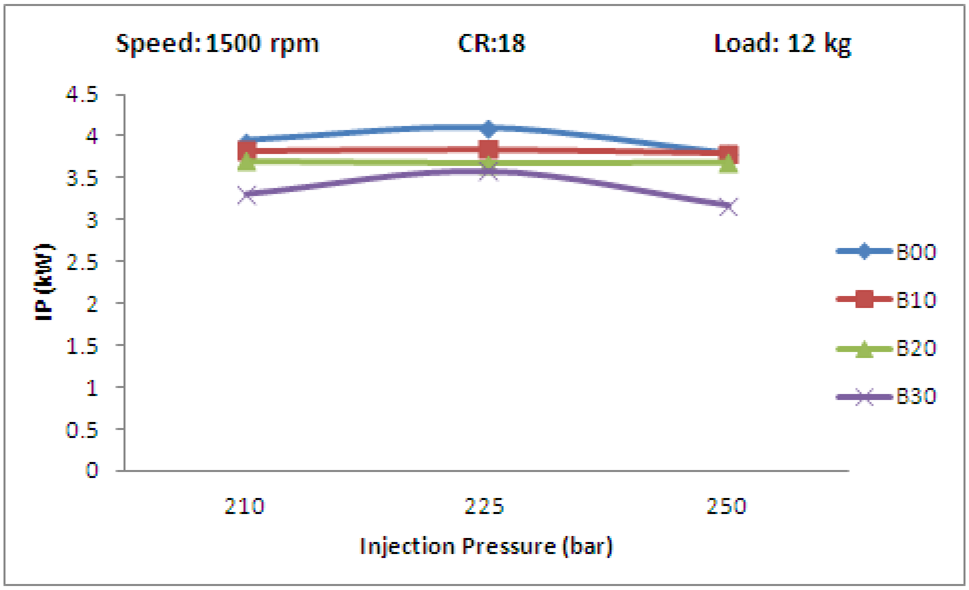

Figure 3: Influence of injection pressure on Indicated power

4.2 Influence of Load and injection pressure on Brake power

Figure 4 illustrates the influence of load on the brake power at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The brake power is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The brake power increases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the development of the brake power decreases.

Figure 5 illustrates the influence of injection pressure on brake power of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The mechanical efficiencies are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The brake power decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The brake power of B10 biodiesel decreases by 0.3% and the brake power of biodiesel B30 decreases by 1.22% when compared to the brake power of B00 diesel at 225 bar injection pressure.

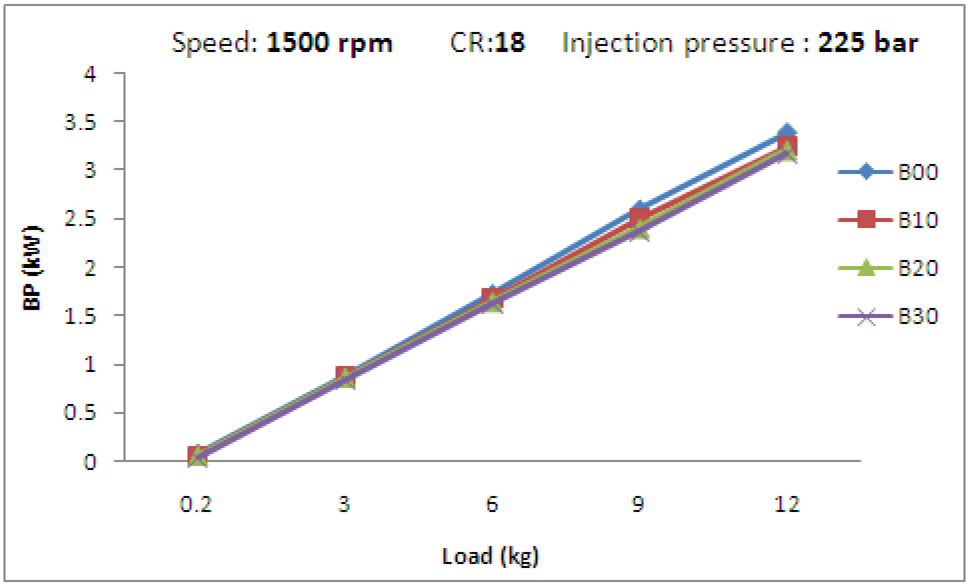

Figure 4: Influence of Load on Brake power

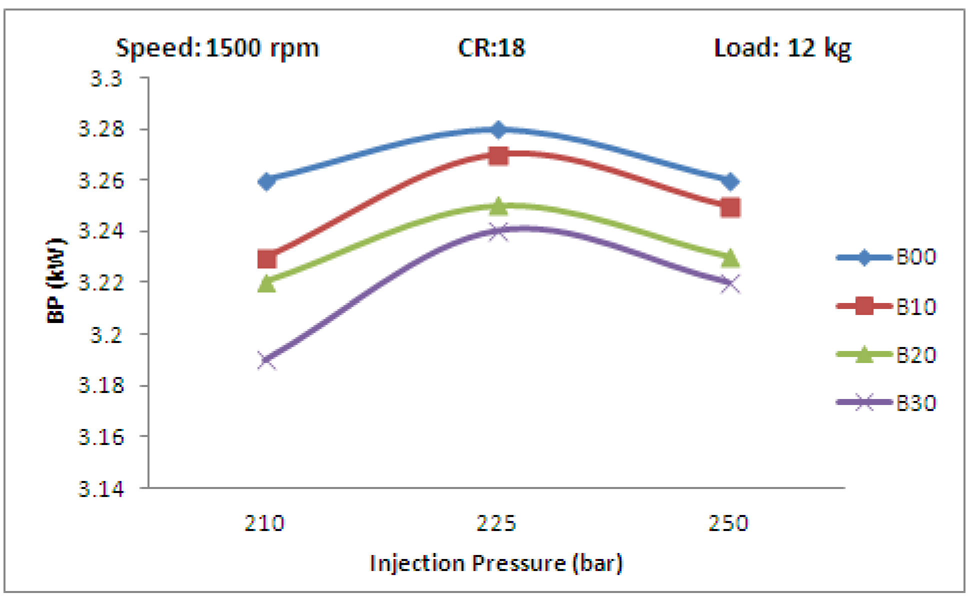

Figure 5: Influence of injection pressure on Brake power

4.3 Influence of Load and injection pressure on Indicated mean effective pressure

Figure 6 illustrates the influence of load on the indicated mean effective pressure at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The indicated mean effective pressure is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The indicated mean effective pressure increases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the development of the indicated mean effective pressure decreases.

Figure 7 illustrates the influence of injection pressure on indicated mean effective pressure of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The indicated mean effective pressures are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The indicated mean effective pressure decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The indicated mean effective pressure of B20 biodiesel decrease by 8.38% and the indicated mean effective pressure of biodiesel B30 decreases by 10.2% with that of the indicated mean effective pressure of B00 diesel at 225 bar injection pressure.

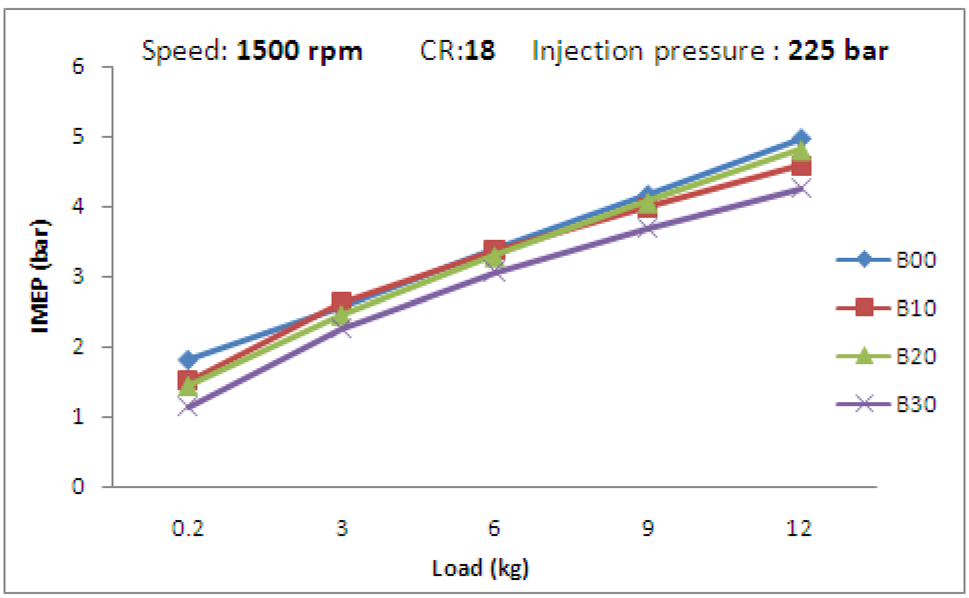

Figure 6: Influence of Load on Indicated mean effective pressure

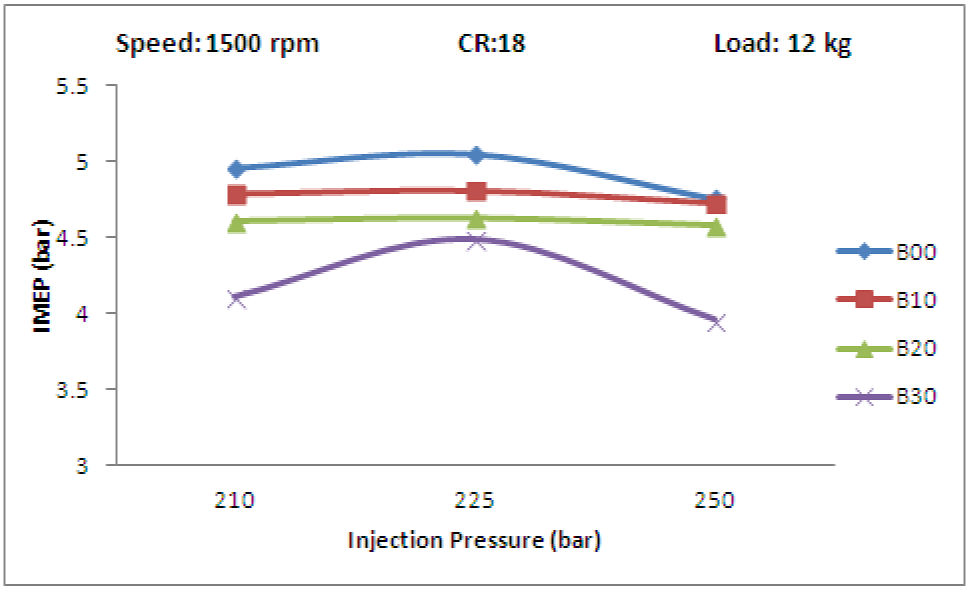

Figure 7: Influence of injection pressure on Indicated mean effective pressure

4.4 Influence of Load and injection pressure on Indicated Thermal efficiency

Figure 8 illustrates the influence of load on the indicated thermal efficiency at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The indicated thermal efficiency is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The indicated thermal efficiency decreases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the indicated thermal efficiency decreases.

Figure 9 illustrates the influence of injection pressure on indicated thermal efficiency of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The indicated thermal efficiency are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The indicated thermal efficiency decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The indicated thermal efficiency of B20 biodiesel decreases by 10.38% and the indicated thermal efficiency of biodiesel B30 decreases by 15.5% when compared to the indicated thermal efficiency of B00 diesel at 225 bar injection pressure.

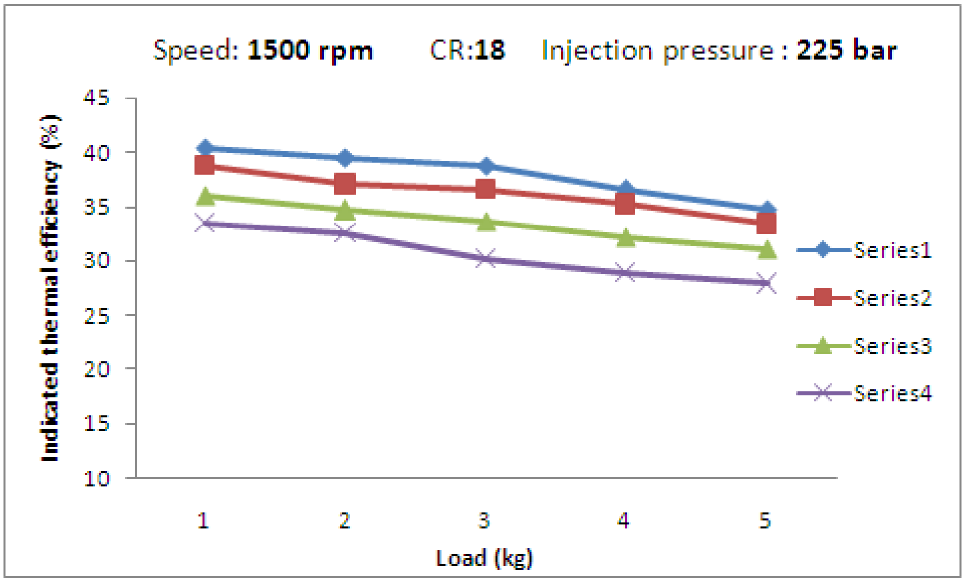

Figure 8: Influence of Load on Indicated Thermal efficiency

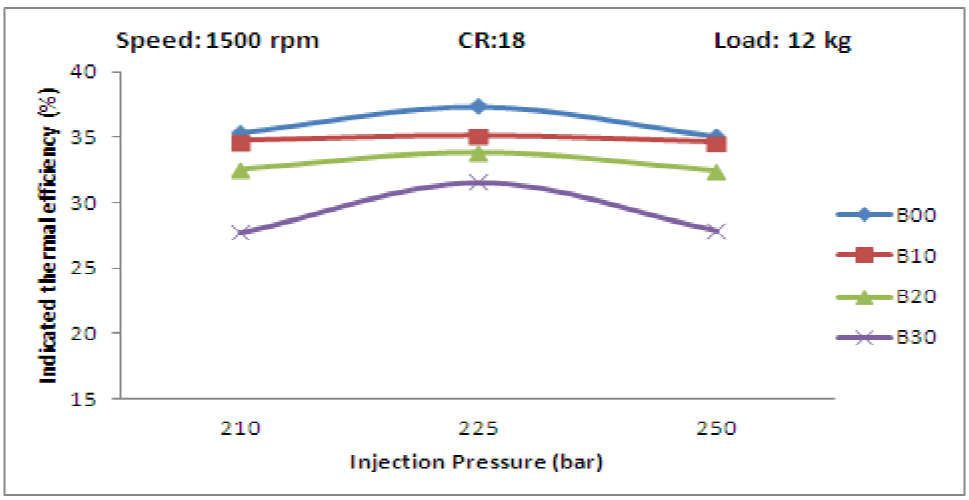

Figure 9: Influence of injection pressure on Indicated Thermal efficiency

4.5 Influence of Load and injection pressure on Brake Thermal efficiency

Figure 10 illustrates the influence of load on the brake thermal efficiency at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The brake thermal efficiency is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The brake thermal efficiency increases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the brake thermal efficiency decreases.

Figure 11 illustrates the influence of injection pressure on brake thermal efficiency of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The brake thermal efficiency are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The brake thermal efficiency decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The brake thermal efficiency of B20 biodiesel decreases by 4.9% and the brake thermal efficiency of biodiesel B30 decrease by 8.33% when compared to the brake thermal efficiency of B00 diesel at 225 bar injection pressure.

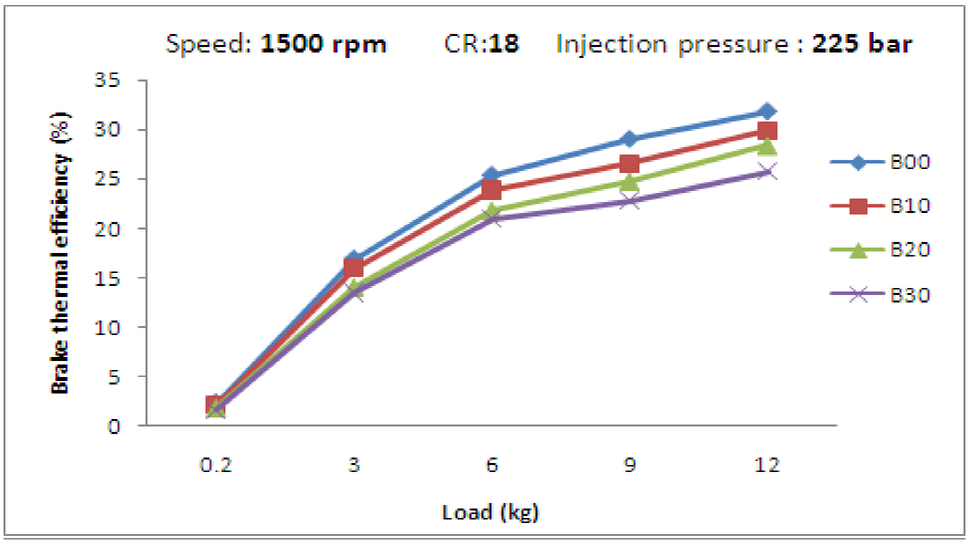

Figure 10: Influence of Load on Brake Thermal efficiency

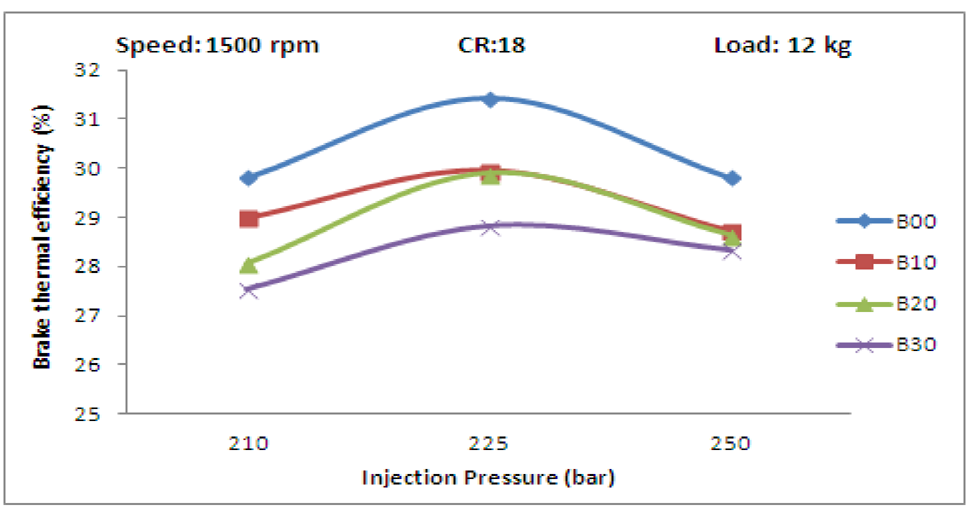

Figure 11: Influence of injection pressure on Brake Thermal efficiency

4.6 Influence of Load and injection pressure on specific fuel consumption

Figure 12 illustrates the influence of load on the specific fuel consumption at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The specific fuel consumption is lower for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The specific fuel consumption decreases as the load on the engine increases for all the fuels.

Figure 13 illustrates the influence of injection pressure on specific fuel consumption of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The specific fuel consumption was lower at 225 bar injection pressure for B10, B20 and B30 biodiesels. The specific fuel consumption increases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The specific fuel consumption of B20 biodiesel increases by 6.67% and the specific fuel consumption of biodiesel B30 increases by 10% when compared to the specific fuel consumption of B00 diesel at 225 bar injection pressure.

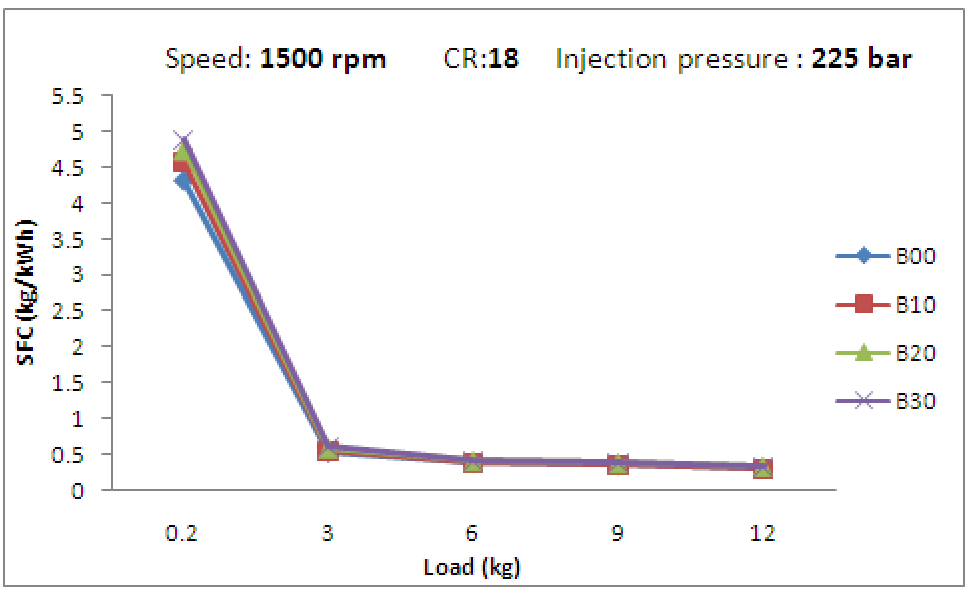

Figure 12: Influence of Load on specific fuel consumption

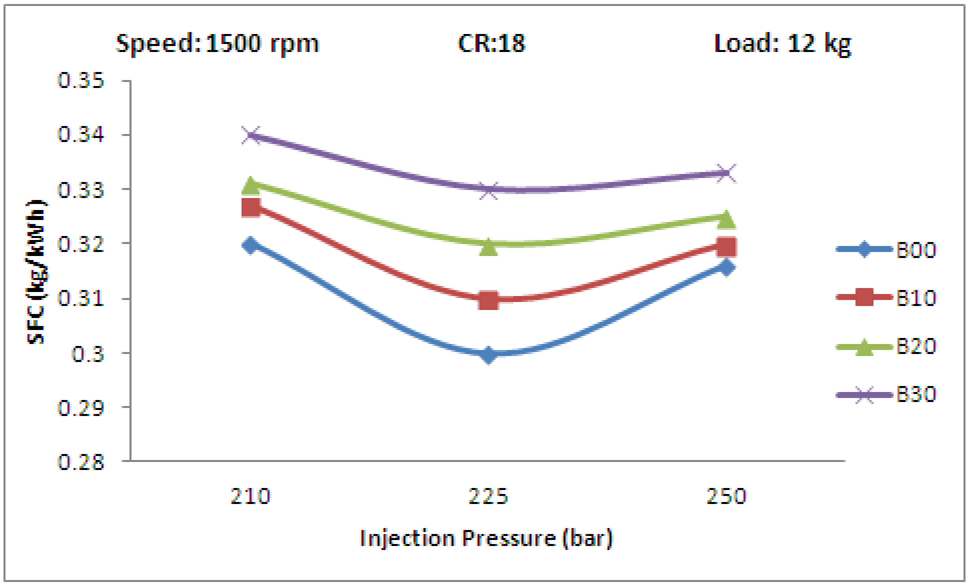

Figure 13: Influence of injection pressure on specific fuel consumption

4.7 Influence of Load and injection pressure on Mechanical efficiency

Figure 14 illustrates the influence of load on the Mechanical efficiency at speed of 1500 rpm, compression ratio of 18 and the injection pressure of 225 bar. The Mechanical efficiency is lower for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The Mechanical efficiency increases as the load on the engine increases for all the fuels. The concentration of the biodiesel increases, the Mechanical efficiency decreases.

Figure 15 illustrates the influence of injection pressure on mechanical efficiency of the diesel engine when the engine was operated at 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The mechanical efficiency are higher at 225 bar injection pressure for B10, B20 and B30 biodiesels. The mechanical efficiency decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The mechanical efficiency of B20 biodiesel decreases by 9.74% and the volumetric efficiency of biodiesel B30 decreases by 11.1% when compared to the volumetric efficiency of B00 diesel at 225 bar injection pressure.

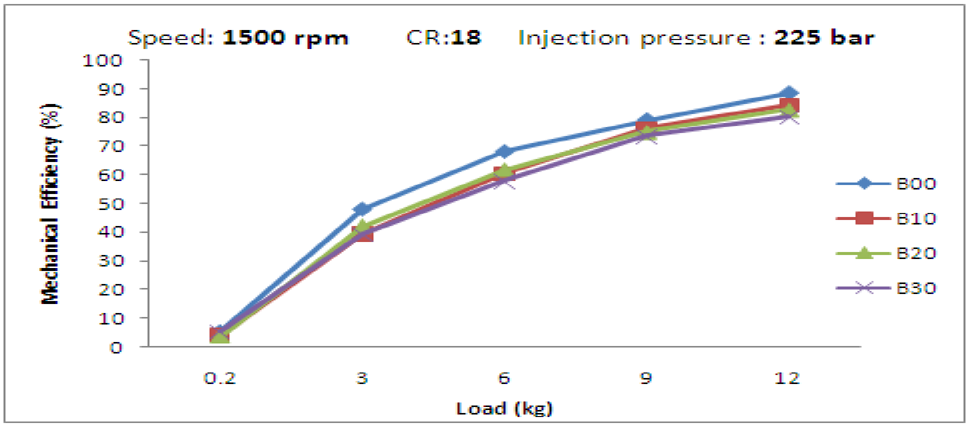

Figure 14: Influence of Load on Mechanical efficiency

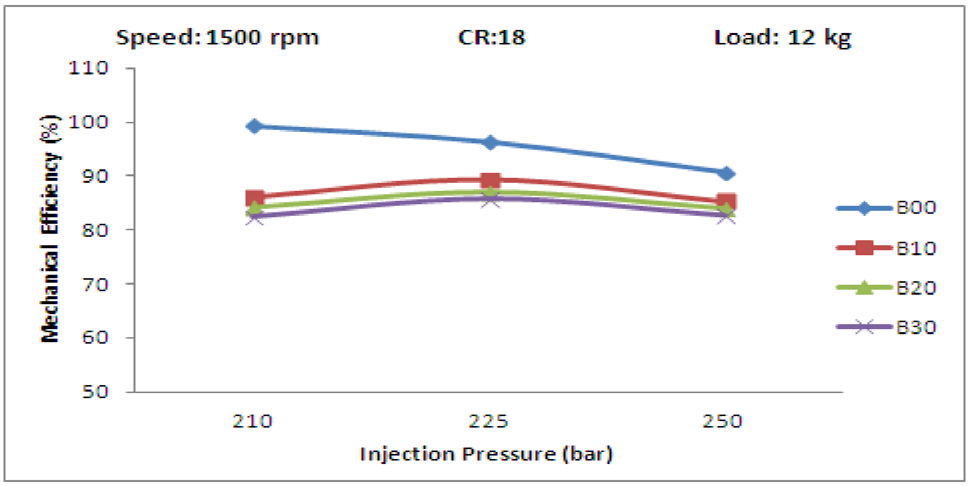

Figure 15: Influence of injection pressure on Mechanical efficiency

4.8 Influence of Load and injection pressure on CO emissions

Figure 16 illustrates the influence of load on CO emissions of the diesel engine when the engine was operated for 225 bar injection pressures, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The CO emissions are lower at the 6 kg load for all types of biodiesels. The CO emissions increases as methyl ester mango seed biodiesel blend boosts in the pure diesel.

Figure 17 illustrates the influence of injection pressure on CO emissions of the diesel engine when the engine was operated for 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The CO emissions are lower at the 225 bar injection pressure for all types of biodiesels. The CO emissions increases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The CO emissions of B10 biodiesel were lower and the CO emissions of biodiesel B30 was higher when compared to the CO emissions of B20 biodiesel at 225 bar injection pressure [32-34].

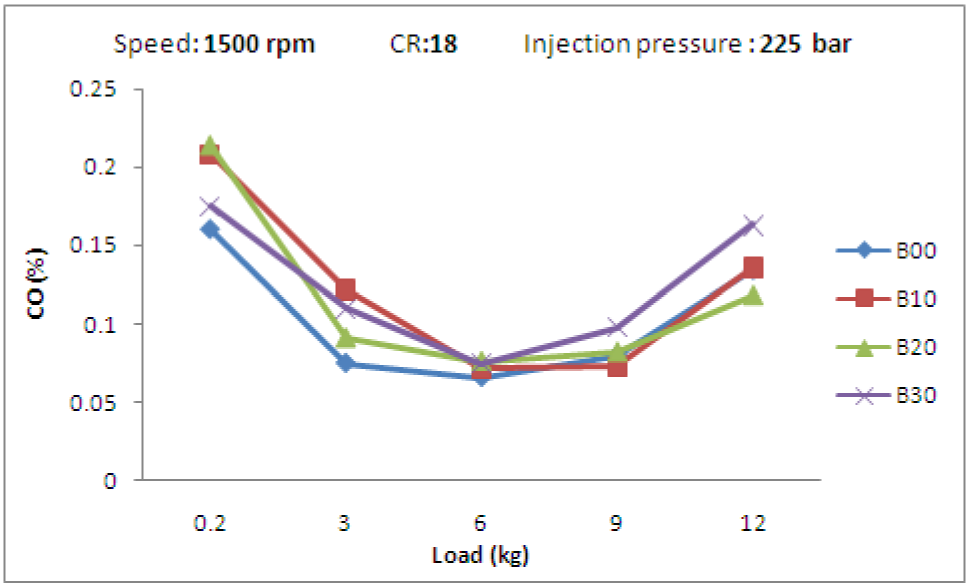

Figure 16: Influence of Load on CO emissions

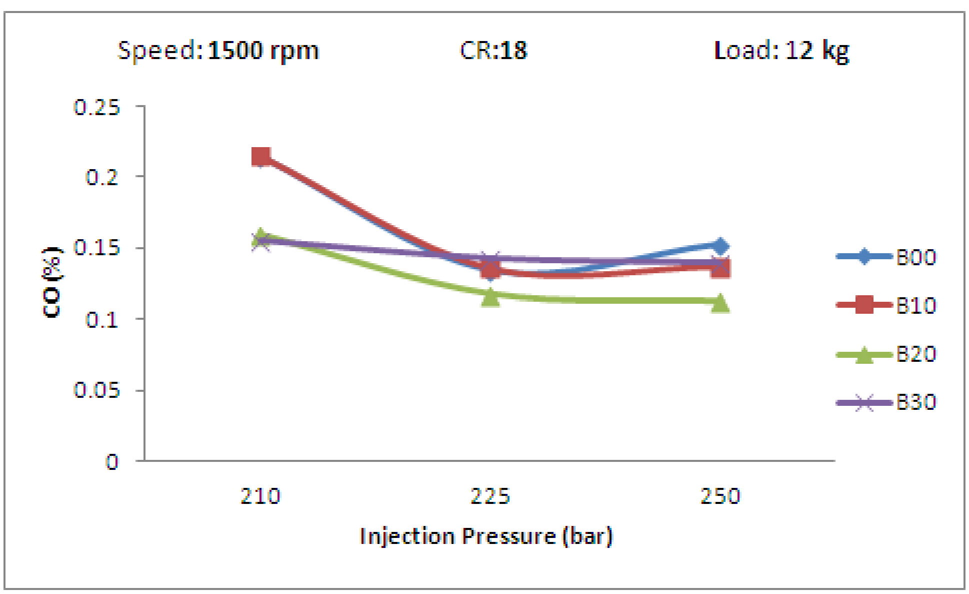

Figure 17: Influence of injection pressure on CO emissions

4.9 Influence of Load and injection pressure on HC emissions

Figure 18 illustrates the influence of load on HC emissions of the diesel engine when the engine was operated for 225 bar injection pressures, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The HC emissions are higher at 12 kg load for all types of biodiesels. The HC emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The HC emissions were higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The HC emission increases as the load on the engine increases for all the fuels.

Figure 19 illustrates the influence of injection pressure on HC emissions of the diesel engine when the engine was operated for 12kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The HC emissions are higher at the 210 bar injection pressure for all types of biodiesels. The HC emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The HC emissions of B30 biodiesel declines by 9.33% and the HC emissions of biodiesel B20 diminish by 15.83% when compared to the HC emissions of B00 diesel at 225 bar injection pressure [35-36].

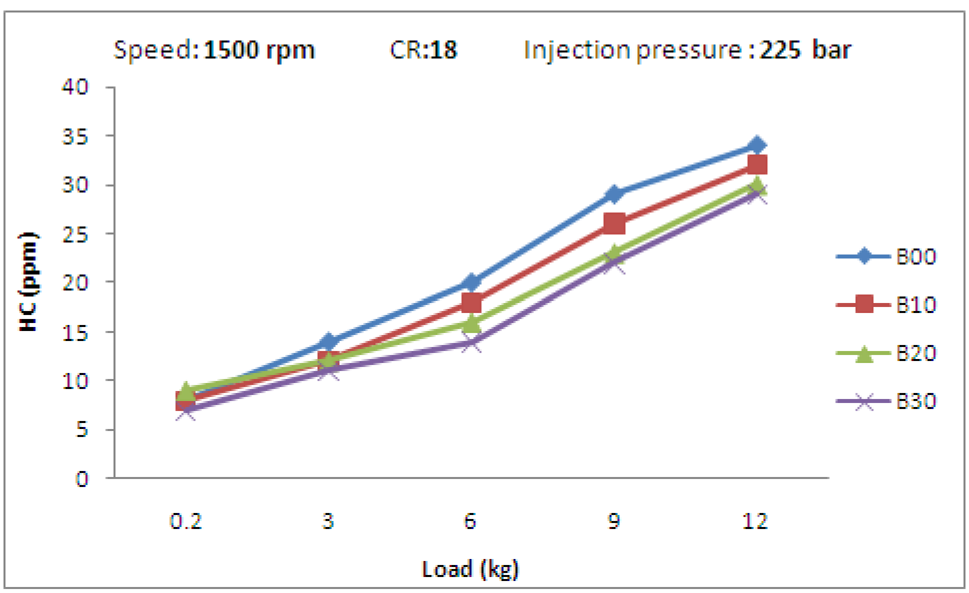

Figure 18: Influence of load on HC emissions

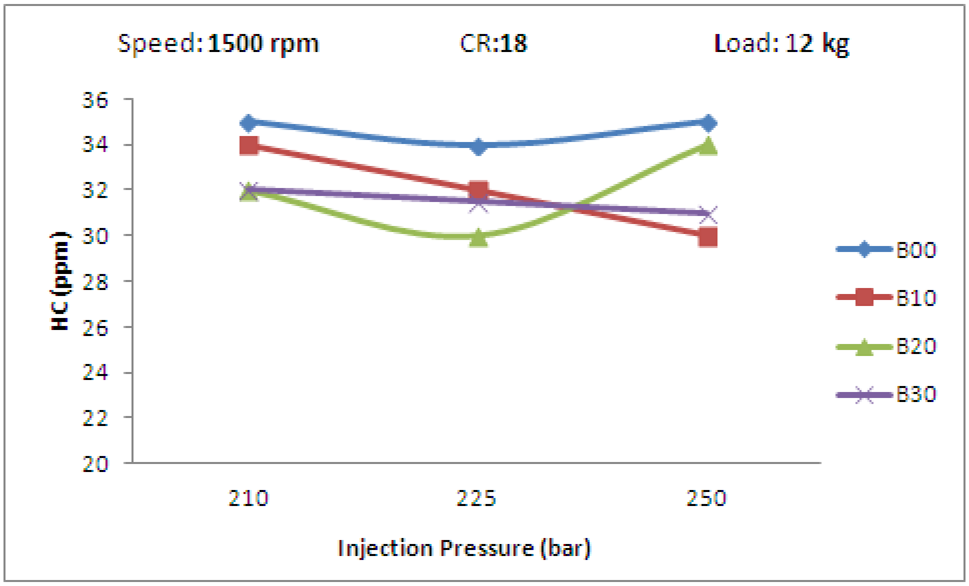

Figure 19: Influence of injection pressure on HC emissions

4.10 Influence of Load and injection pressure on NOx emissions

Figure 20 illustrates the influence of load on NOx emissions of the diesel engine when the engine was operated for 225 bar injection pressures, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The NOx emissions are higher at 12 kg load for all types of biodiesels. The NOx emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The NOx emissions were higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The NOx emission increases as the load on the engine increases for all the fuels.

Figure 21 illustrates the influence of injection pressure on NOx emissions of the diesel engine when the engine was operated for 12kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The NOx emissions are lower at the 225 bar injection pressure for all types of biodiesels. The NOx emissions of B30 biodiesel was lower by 8.86% and the NOx emissions of biodiesel B10 decreases by 20.18% when compared to the NOx emissions of B00 diesel at 225 bar injection pressure [37].

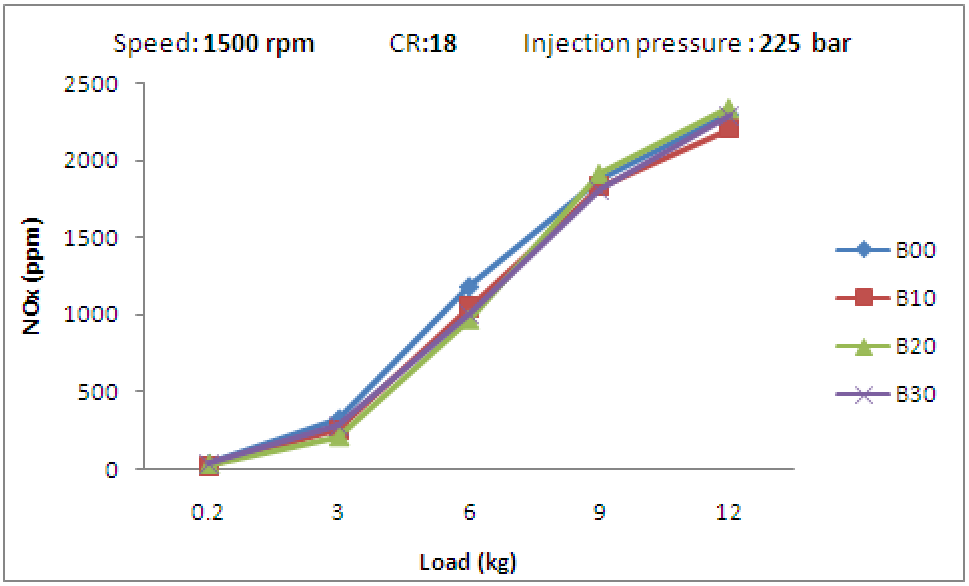

Figure 20: Influence of load on NOx emissions

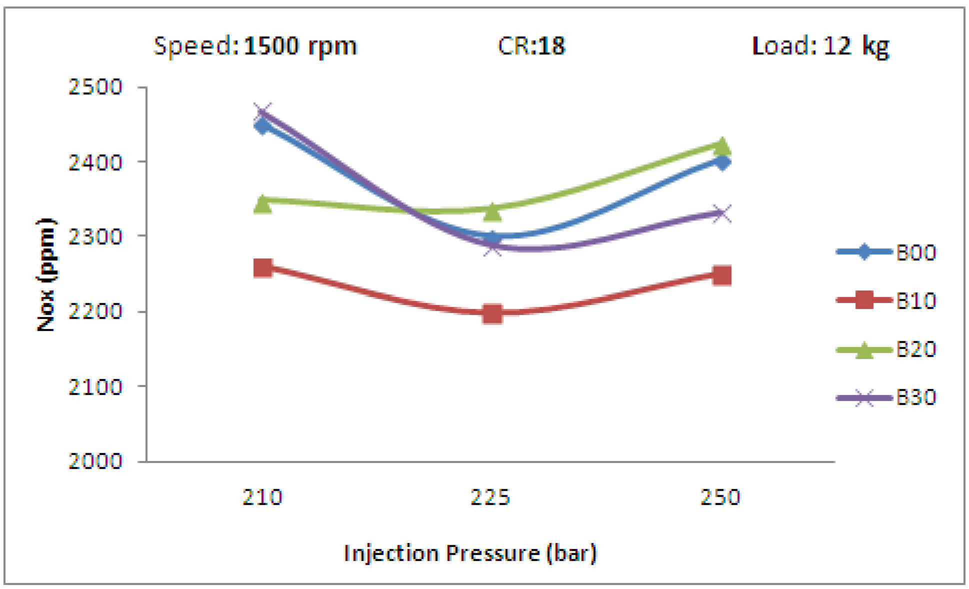

Figure 21: Influence of injection pressure on NOx emissions

4.11Influence of Load and injection pressure on CO_2 emissions

Figure 22 illustrates the influence of load on CO_2 emissions of the diesel engine when the engine was operated for 225 bar injection pressures, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The CO_2 emission increases as the load on the engine increases for all the fuels.

Figure 23 illustrates the influence of injection pressure on CO_2 emissions of the diesel engine when the engine was operated for 12 kg load, compression ratio of 18 and speed of 1500 rpm for B00, B10, B20 and B30 biodiesels. The CO_2 emissions are lower at the 225 bar injection pressure for all types of biodiesels. The CO_2 emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The CO_2 emissions of B20 biodiesel declines by 5.6% and the CO_2 emissions of biodiesel B30 diminish by 10% when compared to the CO_2 emissions of B00 diesel at 225 bar injection pressure.

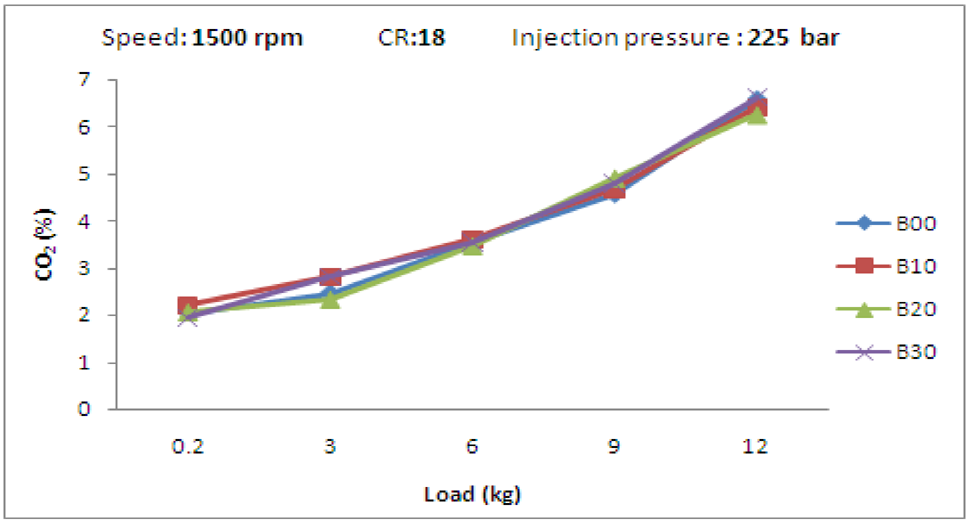

Figure 22: Influence of load on CO_2 emissions

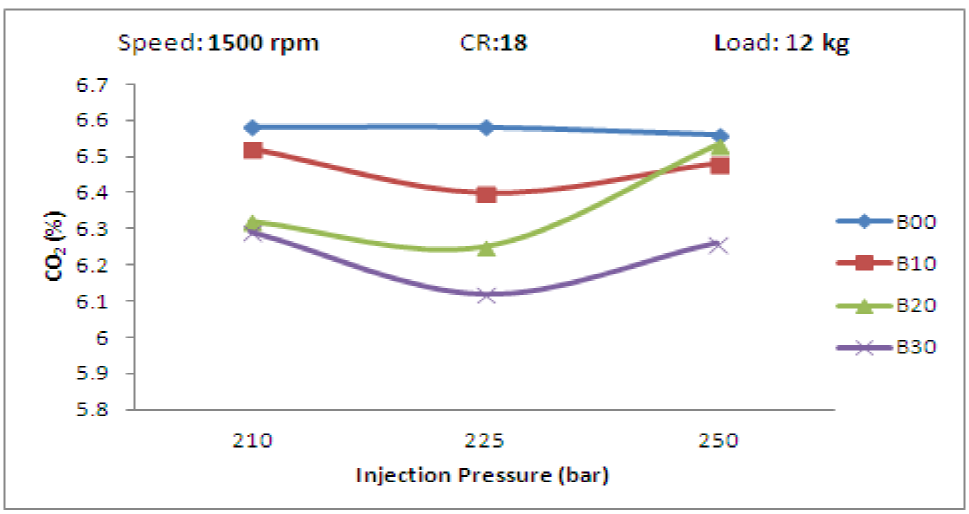

Figure 23: Influence of injection pressure on CO_2 emissions

5. CONCLUSIONS

The performance and emission characteristics of methyl ester mango seed biodiesel fuelled CI engine were determined. The mango seed oil was extracted from the mango seeds collected from the local area, mango juice centers, and mango pickle industries. The indicated power, brake power, and indicated mean effective pressure is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The indicated thermal efficiency is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The indicated thermal efficiency decreases as the load on the engine increases for all the fuels. The brake thermal efficiency is higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The brake thermal efficiency increases as the load on the engine increases for all the fuels. The specific fuel consumption increases as methyl ester mango seed biodiesel blend augments in the pure diesel. The CO emissions are lower at the 6 kg load for all types of biodiesels. The CO emissions increases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The HC emissions and NOx emissions are higher at 12 kg load for all types of biodiesels. The HC emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel. The NOx emissions were higher for the diesel B00 as compared to the B10, B20 and B30 biodiesels. The CO emissions are lower at the 225 bar injection pressure for all types of biodiesels. The NOx emissions are lower at the 225 bar injection pressure for all types of biodiesels. The NOx emissions increases and CO_2 emissions decreases as methyl ester mango seed biodiesel blend boosts in the pure diesel.

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