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Effect of Injection Pressure and Injection Timing in Performance and Emission Characteristics in DI Engine using Blend of Methyl Esters of Jatropha

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Abstract : The petroleum products play on important role in our modern life. The costs of these products depend on international markets and petroleum reserves. Rising petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated an intense international interest in developing alternative non-petroleum fuels for engines. In recent years, research has been directed to explore plant-based fuels and plant oils and fats as fuels.

Methyl esters of Jatropha (MEJ) are one of the best alternative fuels for diesel engine. In this project combustion, performance and emission characteristics of blends of methyl esters of Jatropha will be studied by varying the injection pressure and injection timing using direct injected constant speed diesel engine.

Performance characteristics such as brake thermal efficiency and brake specific fuel consumption at various loads will be calculated by varying injection pressure and injection timing. Emission characteristics such as NOx, CO, CO2 and HC at various loads will be calculated by varying injection pressure and injection timing. Various blends of methyl esters of Jatropha are b20, b40, b60, b80, b100 and the results will be compared with diesel. Injection pressure will be from 200 to 250 bar .i.e.) 180 bar, 195 bar, 210 psi. Injection timing will be 33° btdc, 30° btdc, and 27° btdc.

Keywords : Methyl esters of Jatropha (MEJ), injection pressure and injection timing, NOx, CO, CO2 and HC.

1 Introduction:

Bioenergy includes solid, liquid, or gaseous fuels, as well as electric power or chemical products derived from organic matter, whether directly from plants or indirectly from plant-derived industrial, commercial or urban wastes, or agricultural or forestry residues. Liquid biofuels, the subject of this paper, include pure plant oil, biodiesel, and bioethanol. Biodiesel is based on esterification of plant oils. Ethanol is primarily derived from sugar, maize and other starchy crops. Global production of biofuels consists primarily of ethanol. Biodiesel comes second.

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Biodiesel is a variety of ester-based oxygenated fuels derived from natural, renewable biological sources such as vegetable oils. Its name indicates, use of this fuel in diesel engine alternate to diesel fuel.

Biodiesel operates in compression ignition engines like petroleum diesel thereby requiring no essential engine modifications. Moreover it can maintain the payload capacity and range of conventional diesel. Biodiesel fuel can be made from new or used vegetable oils and animal fats. Unlike fossil diesel, pure biodiesel is biodegradable, nontoxic and essentially free of sulphur and aromatics. Biodiesel is typically made from vegetable oil though animal fat can also be used. The choice of feed is country specific and depends on availability. It is estimated that the potential availability of such oils in India amounts to about 1 million tons per year, the most abundant oil sources are sal oil (180,000 t), mahua (180,000 t), neem oil (100,000 t) and Pongamia pinnata, also known as Karanja oil (55,000 t).

However, based on extensive research carried out in agricultural research centers, it was decided to use Jatropha oilseed as the major feedstock for India's biodiesel programme. Jatropha was originally developed in Central America and is a tree-borne oilseed which grows in dry, arid land.

2. The Production of Methyl Esters of Jatropha (MEJ).

Jatrophaoil can be further processed through transesterification into biodiesel, which can be blended with diesel or used straight in most engines and generators. The seedcake has a high mineral content and can be used as organic fertilizer.

Oilseeds are crushed to extract oil. The residue cake can be used as a fertilizer or for animal feed. In order to produce MEJ, raw plant oils are filtered and mixed with ethanol or methanol to initiate an esterification reaction. The esterification process separates fatty acid methyl esters, which are the basis for MEJ; the glycerin can be used in soap manufacture. Small-scale cultivation of fuel crops for MEJ is typically more economical if the various by-products are used economically or commercially. Direct use of plant oils for cooking or lighting is possible, but requires modified cook stoves or lamps. In spite of experiments with alternative cook stoves for many years, liquid biofuels are not yet widely used for cooking purposes. MEJ is primarily used in diesel engines which can provide energy for various purposes.

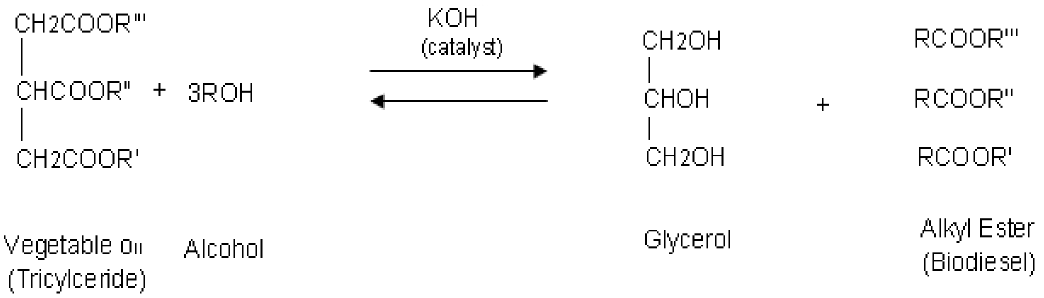

Figure.2.1 Esterification Reaction

The process of converting jatropha oil into biodiesel fuel is called Transesterification and is luckily less complex then it sounds. Chemically, Transesterification means taking a triglyceride molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin, and creating an alcohol ester. This is accomplished by mixing methanol with sodium hydroxide to make sodium methoxide. This liquid is then mixed into the jatropha oil. After the mixture has settled, Glycerin is left on the bottom and methyl esters, or biodiesel is left on top and is washed and filtered. The final product Bio Diesel fuel, when used directly in a Diesel Engine will burn up to 75% cleaner then mineral oil Diesel fuel.

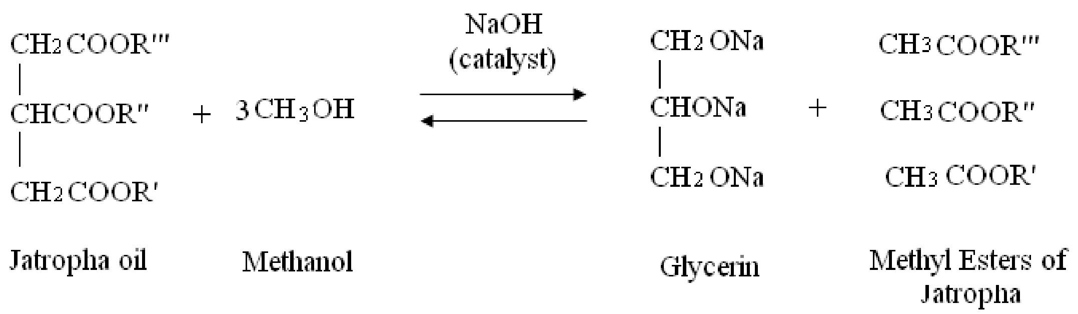

Figure.2.2 Transesterification Reaction

3. Properties of Jatropha Oil

The component analysis of Jatropha seeds (wt. per cent) is as follows: moisture 6.2 per cent, protein 18 per cent, fat 38 per cent, carbohydrate 17 per cent, fiber 15.5 per cent, and ash 5.3 per cent. Jatropha oil mainly consists of tri-glycerides of oleic acid (34-45 per cent), linoleic acid (31-43 per cent) and palmitic acid (14-15 per cent).

Table 3.1 Properties of Methyl Esters Jatropha Oil Compared with Diesel Fuel

Properties	**Diesel**	**Jatropha biodiesel**				
		B20	**B40**	**B60**	**B80**	**B100**
Density at 15^0C,kg/m^3	840	850	865.9	889	907.5	927.5
Kinematic viscosity at 40ºC, cSt	2.6	3	4.1	6.56	9.97	16
Higher calorific value, kJ/kg	44420	44372.1	43282.7	42612.3	41941.9	41271.5
Flash point, ºC	51	56	61	68	74	172
Carbon residue, %	0.12	0.17	0.18	0.3	0.4	0.46
Cetane Number	50	52.4	52.4	52	51	50
Water content	Nil	Nil	Nil	Nil	Nil	Nil
Sulphur	0.012	0.017	0.021	0.027	0.031	0.038
Sediments	0.0018	0.0028	0.0041	0.015	0.018	0.023
Pour point		-14	-10	-7	-4	4
85% Distillation point, ^{0}C	300	315	340	324	338	352
95% Distillation point, ^{0}C	303	317	342	330	345	370

4. Engine Setup

The Speedwel Engine is connected to an Eddy current Dynamometer and to an Exhaust gas analyzer. The engine is started using diesel as fuel, after completion of the warm-up procedure, the engine was run on no-load condition and the speed was adjusted to 1500 rpm.

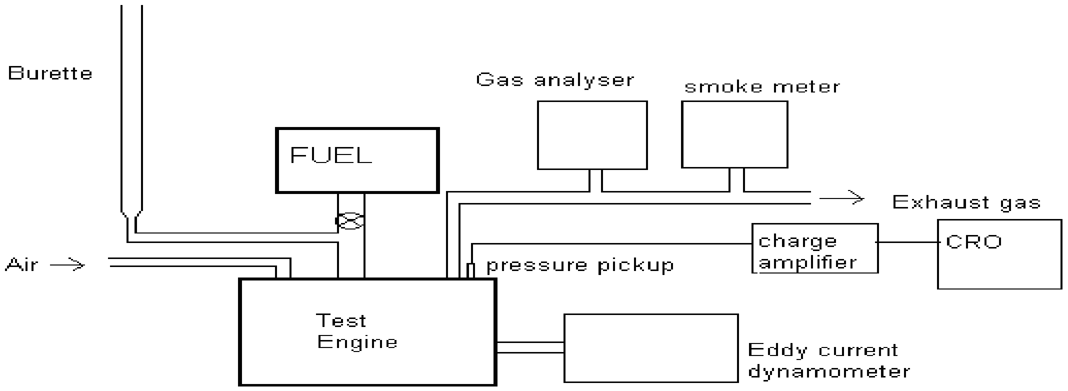

Figure 4.1 Engine Setup

The engine was accelerated to gain uniform speed after which it was gradually loaded. The experiments were conducted for eight engine torque levels viz, 0, 4, 8,12,16,20 Nm. Using this values, performance and emission characteristics are calculated

For each load condition the engine was run for a minimum of 5 minute and test datas were collected. Simultaneously, engine exhaust emission (NO_x, CO, HC) values were noted down.

Then injection pressure and injection timing are changed and the experiment is repeated and the readings are tabulated.

4.2 Specification of Speedwell Engine

Table 4.1 Specification of Speedwell Engine

MANUFACTURER	GUJARAT FORGING LTD.
TYPE	TRB-DIESEL INJECTION
MODEL	SW-3B
FUEL	HIGH SPEED DIESEL
NUMBER OF CYLINDER	1
BORE x STROKE	88 x 110
CYCLE	FOUR STROKE
COMPRESSION RATIO	15.6 : 1
SPEED	1500 RPM

5. Results and Discussion

5.1Performance Testing For Various Injection Timing and Injection Pressure

5.1.1. Brake Specific Fuel Consumption (BSFC)

The specific fuel consumption of engine was increased with increase in amount of biodiesel blends is shown in Figure.5.1Figure.5.2 & Figure.5.3. When injection timing is increased the BSFC also increases. When injection pressure is increased the BSFC also increases. The percent increase in specific fuel consumption was increased with decreased amount of diesel fuel in the blended fuels. This may due to lower heating value of the fuels and higher mass of fuel flow to meet the engine loads. AT 180 psi as injection pressure and 33˚ btdc as injection timing the BSFC is minimum for B20.

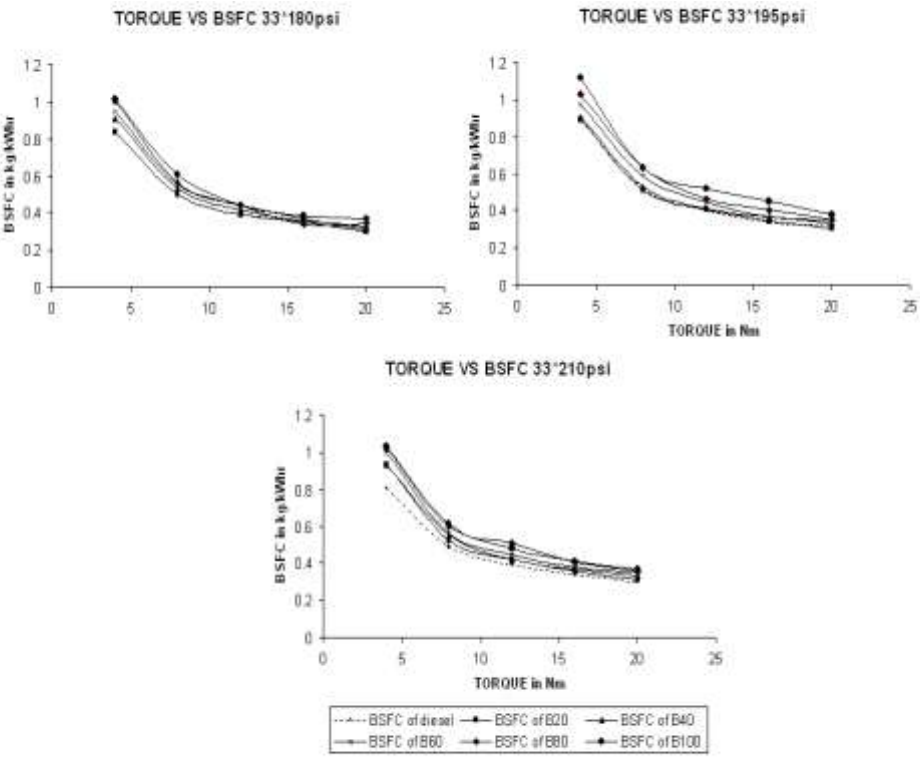

Figure 5.1. BSFC For Injection Timing 33°

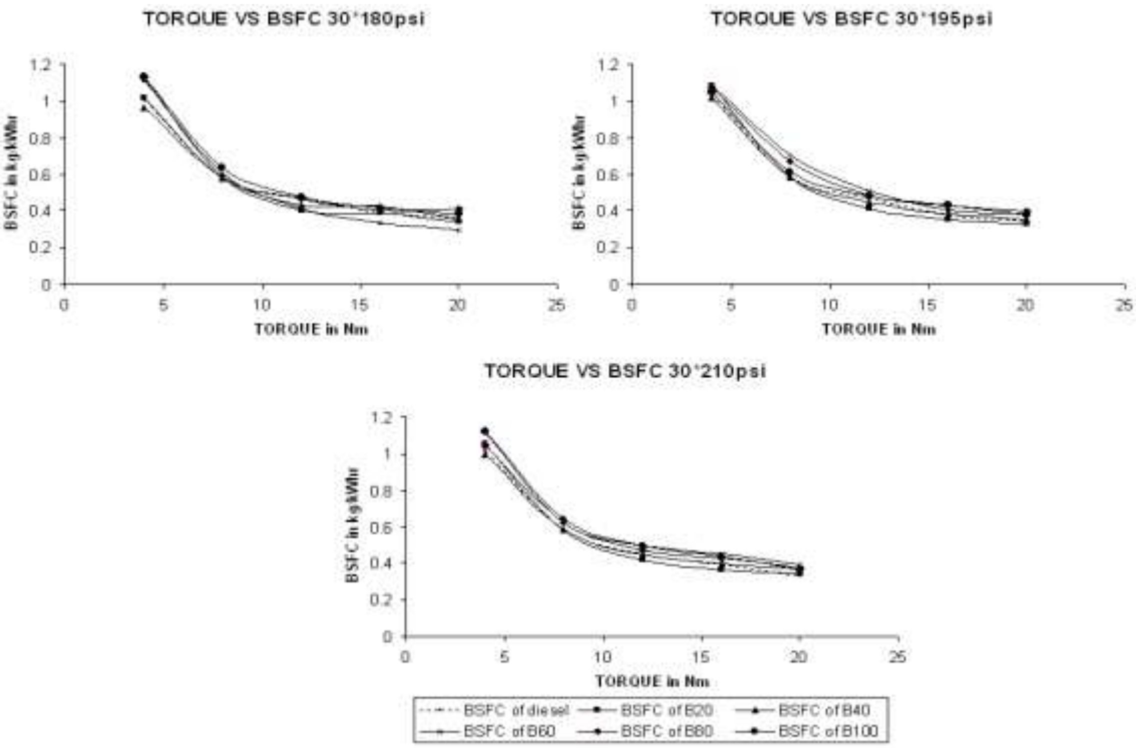

Figure 5.4 BSFC For Injection Timing 30°

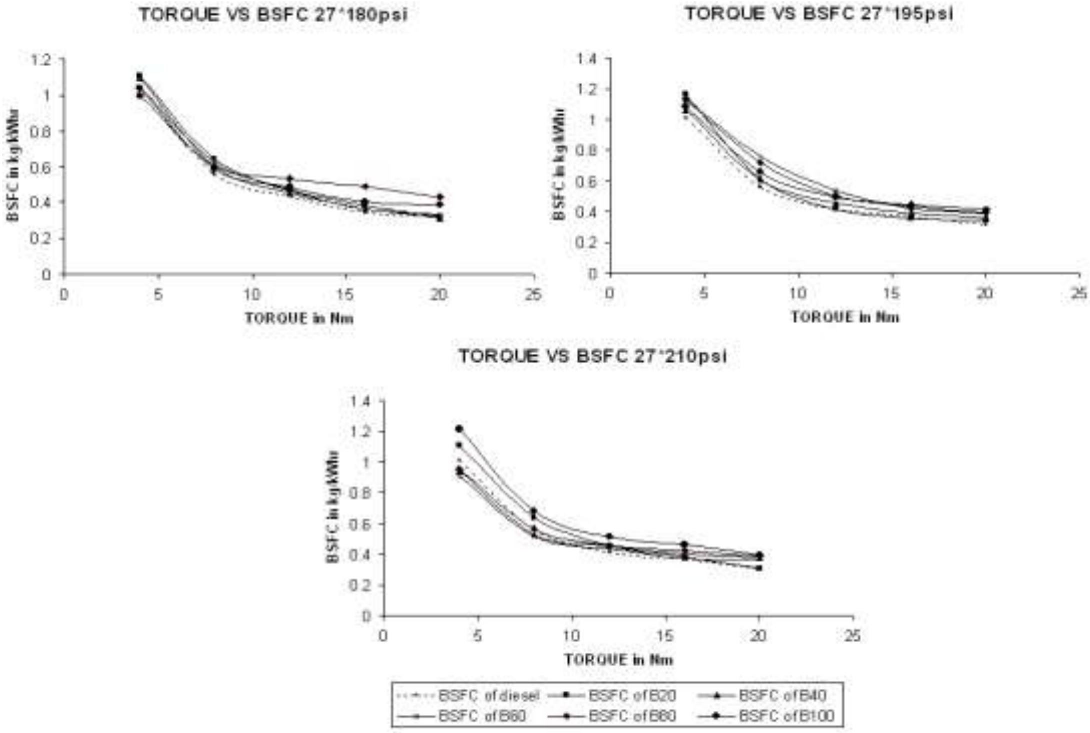

Figure 5.3 BSFC For Injection Timing 27˚

5.1.2Brake Thermal Efficiency (η_{BT})

The Brake Thermal Efficiency (η_{BT}) of engine was decreased with increase in amount of biodiesel blends is shown in Figure.5.4, Figure.5.5 & Figure.5.6.When injection timing is increased the efficiency also increases. When injection pressure is increased the efficiency also increases. AT 180 psi as injection pressure and 33˚ btdc as injection timing the efficiency is maximum for B20.

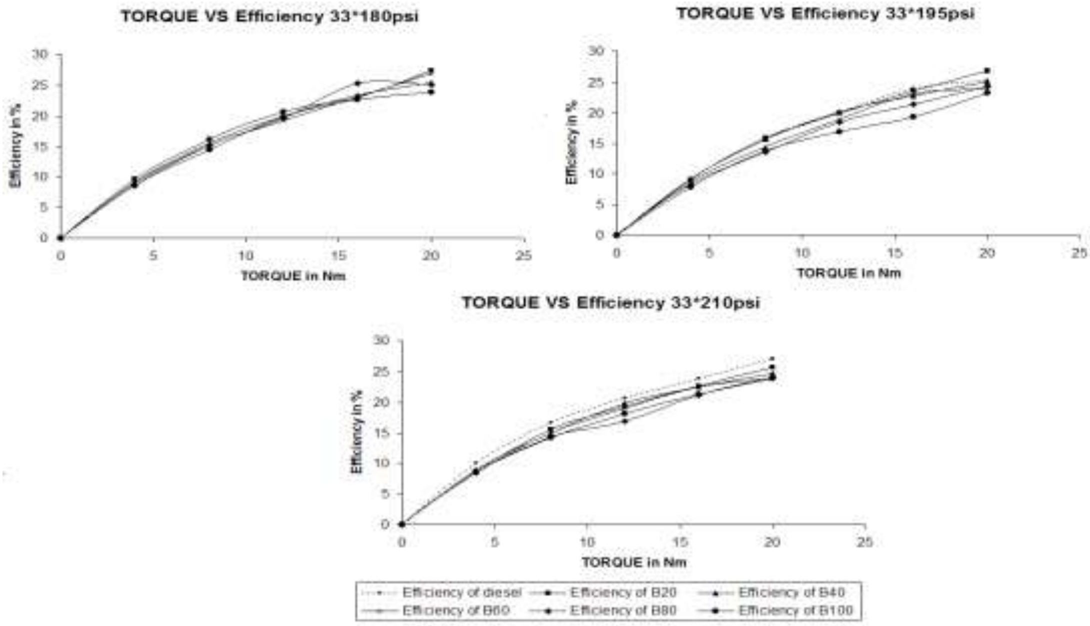

Figure 5.4 BTE (η_{BT}) For Injection Timing 33˚

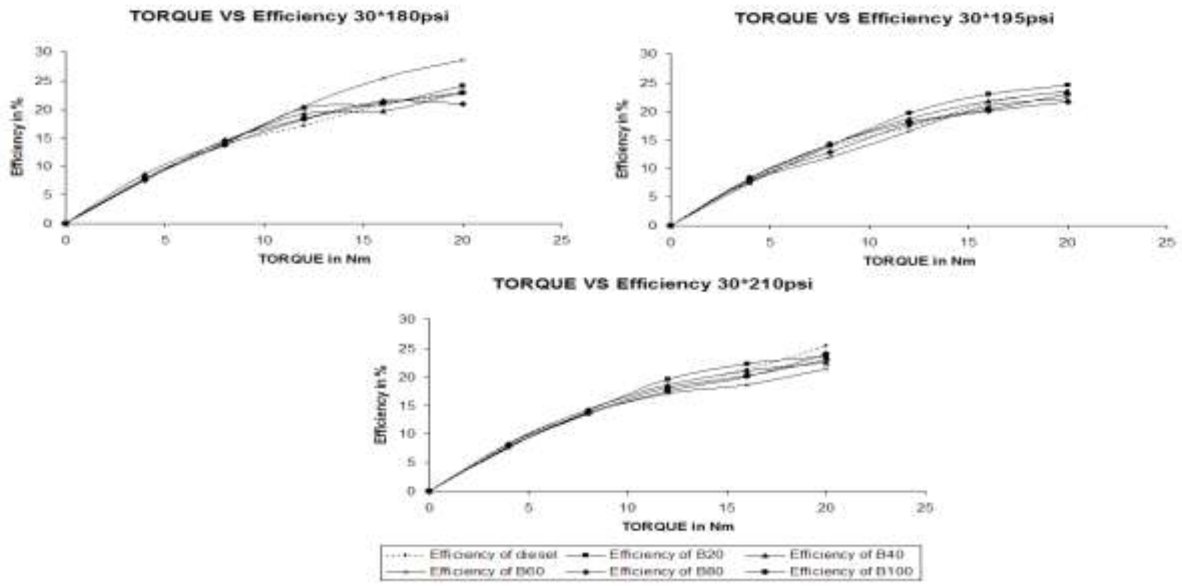

Figure 5.5 BTE (η_{BT}) For Injection Timing 30˚

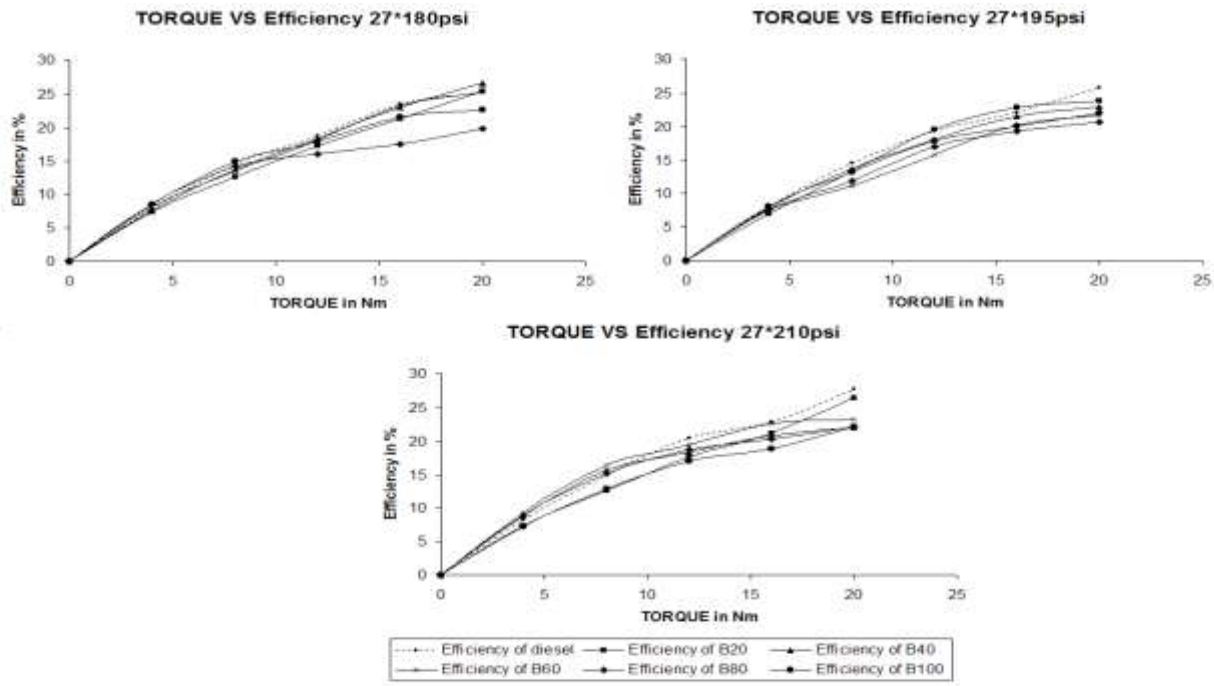

Figure 5.6 BTE (η_{BT}) For Injection Timing 27˚

5.2 .Emission testing for Various Injection Timing and Injection Pressure.

5.2.1Carbon Monooxide(CO)

Thecarbon monoxide (CO)emission of engine was increased with increase in amount of biodiesel blends is shown in Figure.5.7, Figure.5.8& Figure.5.9.When injection timing is increased the CO also increases. When injection pressure is increased the CO also increases. AT 180 psi as injection pressure and 30˚ btdc as injection timing the CO emission is maximum for B80. AT 180 psi as injection pressure and 27˚ btdc as injection timing the CO emission is minimum for B20, which is even less than diesel.

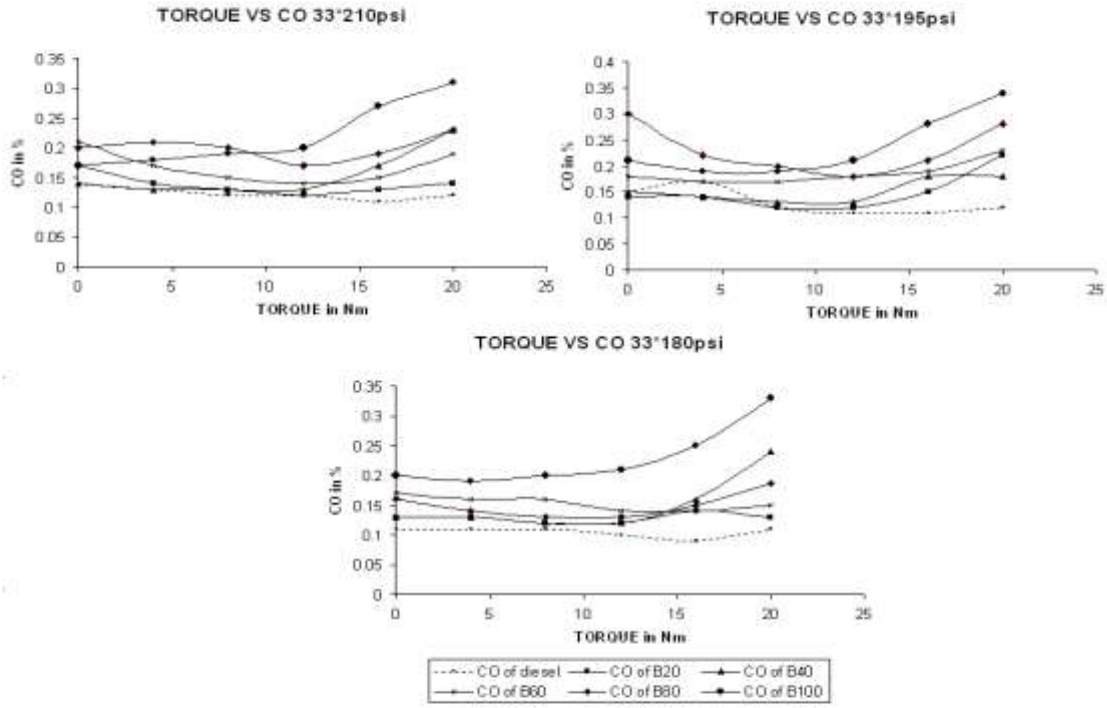

Figure 5.7 CO For Injection Timing 33°

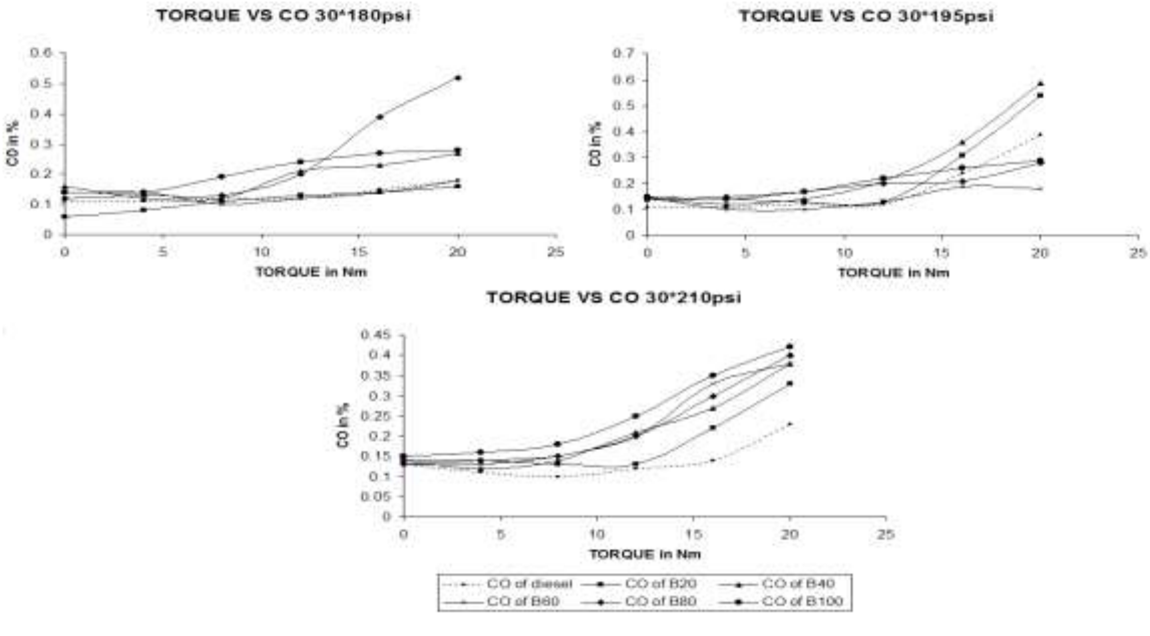

Figure 5.8 CO For Injection Timing 30°

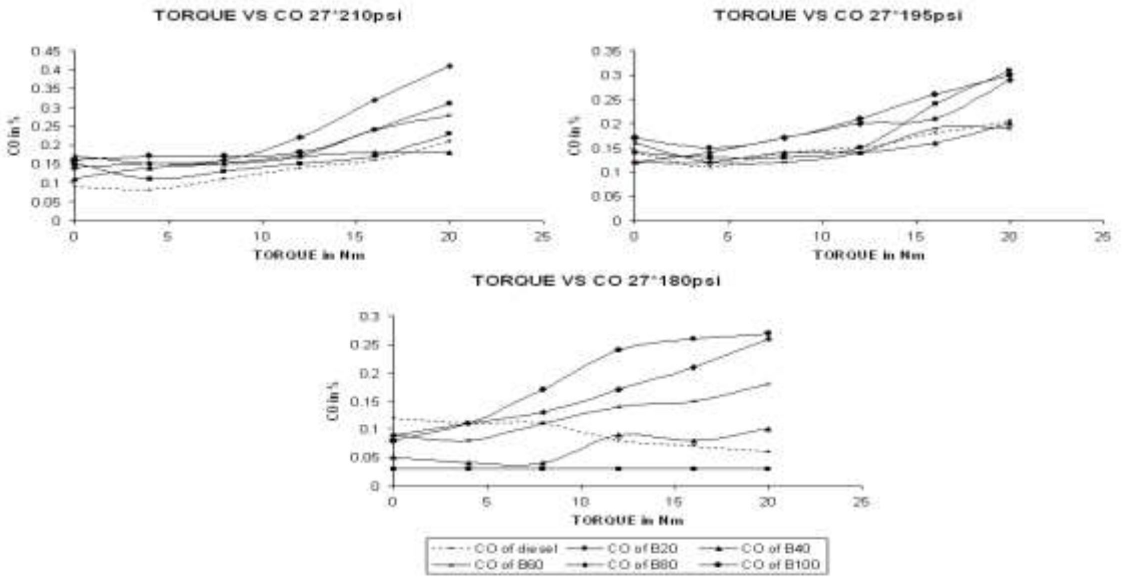

Figure 5.9 CO For Injection Timing 27˚

5.2.1Oxides of Nitrogen (NO_X)

The NOx emission increased with increase in biodiesel amount in the blended fuels and also found that NOx emission from the biodiesel fuel was higher than that of diesel. Probable reasons for increase in NOx concentration by about 2 to 10 per cent from biodiesel fuelled engine was due to higher oxygen level in the fuel. TheNOxemission of engine was increased with increase in amount of biodiesel blends is shown in Figure.5.10, Figure.5.11 & Figure.5.12.When injection timing is increased the NOx increases. When injection pressure is increased the NOx also increases. AT 210 psi as injection pressure and 33˚ btdc as injection timing the NOx emission is maximum for B80.

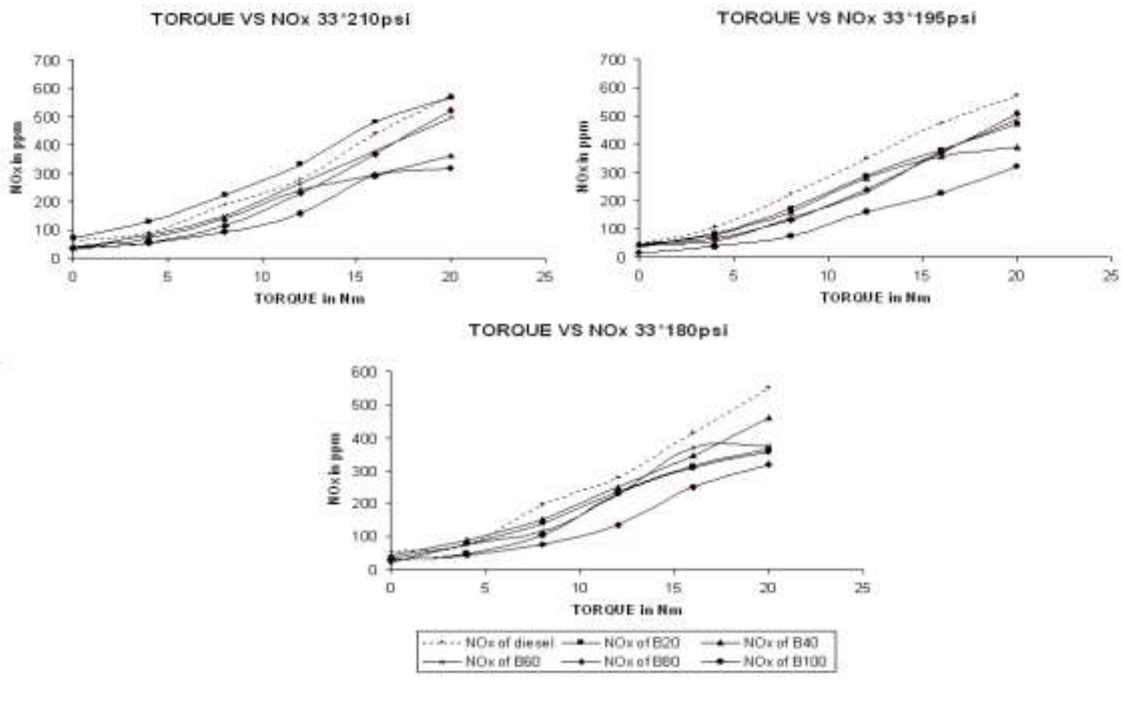

Figure 5.10NOx For Injection Timing 33˚

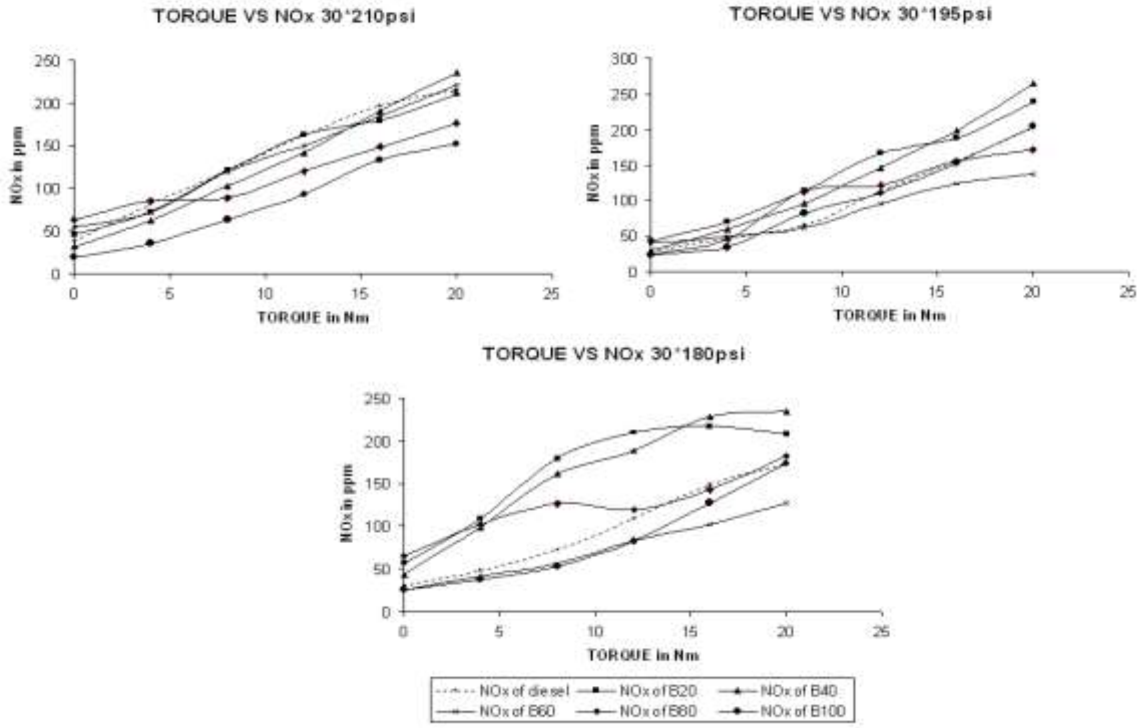

Figure 5.11 NOx For Injection Timing 30°

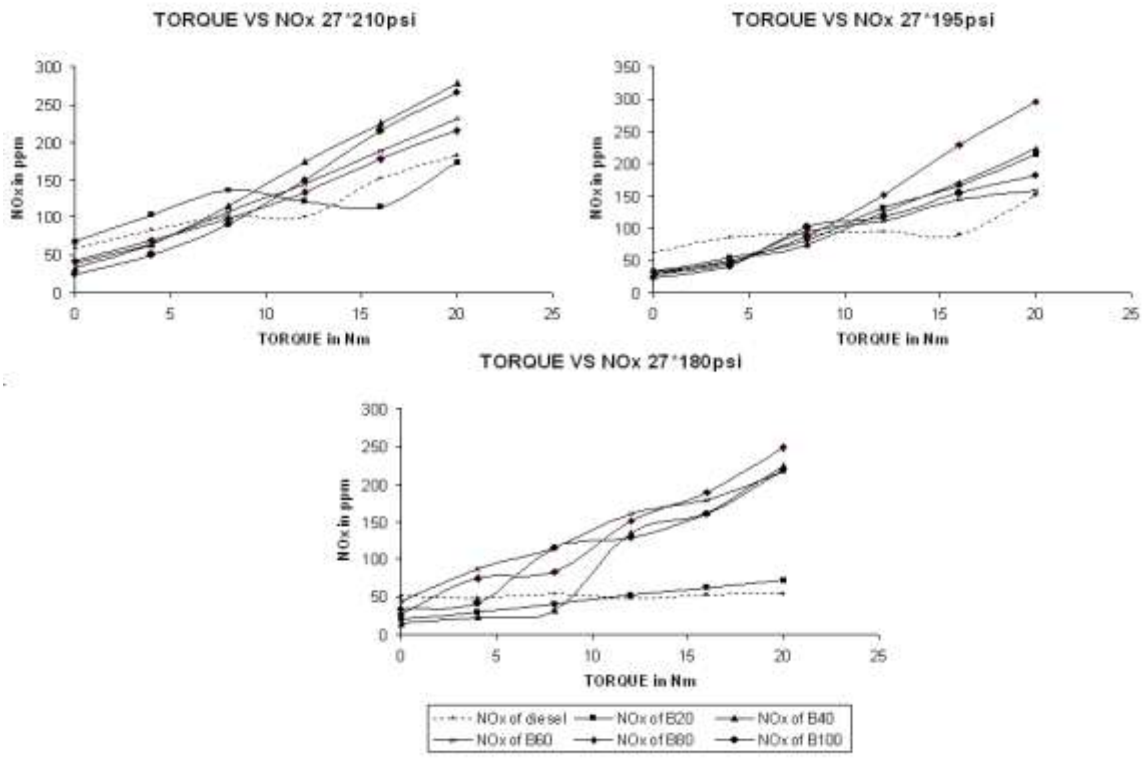

Figure 5.12 NOx For Injection Timing 27°

5.2.3Hydrocarbon (HC)

TheHydrocarbon (HC)emission of engine was increased with increase in amount of biodiesel blends is shown in Figure.5.13, Figure.5.14 & Figure.5.15. The HC emission increased with increase in biodiesel amount in the blended fuels and also found that HC emission from the biodiesel fuel was higher than that of diesel. When injection timing is increased the HC increases. When injection pressure is increased the HC also increases.

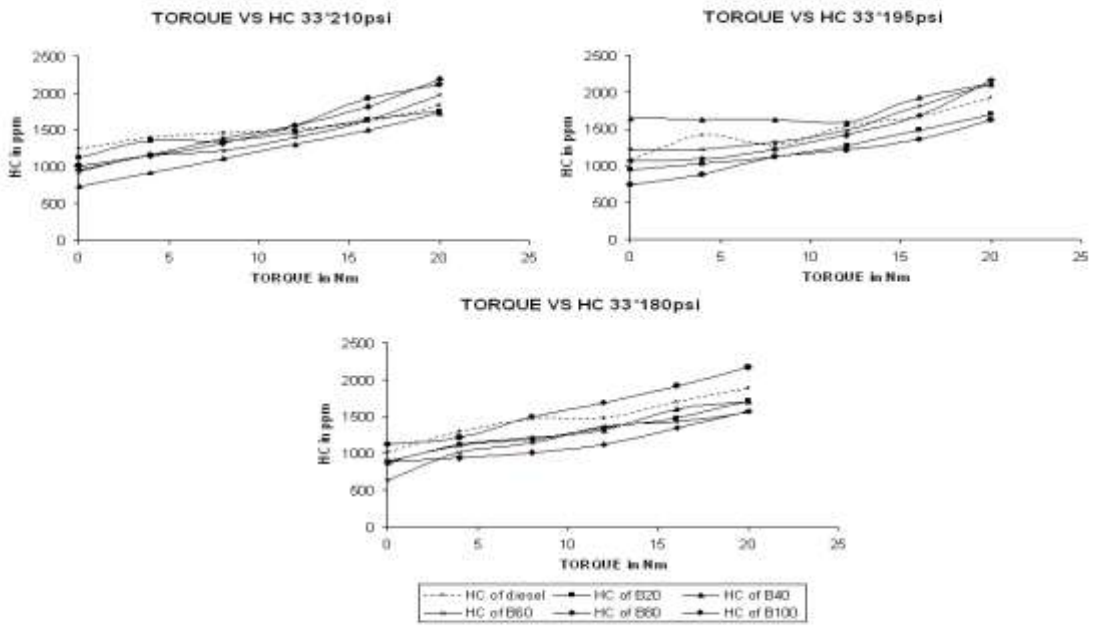

Figure 5.13 HC For Injection Timing 33˚

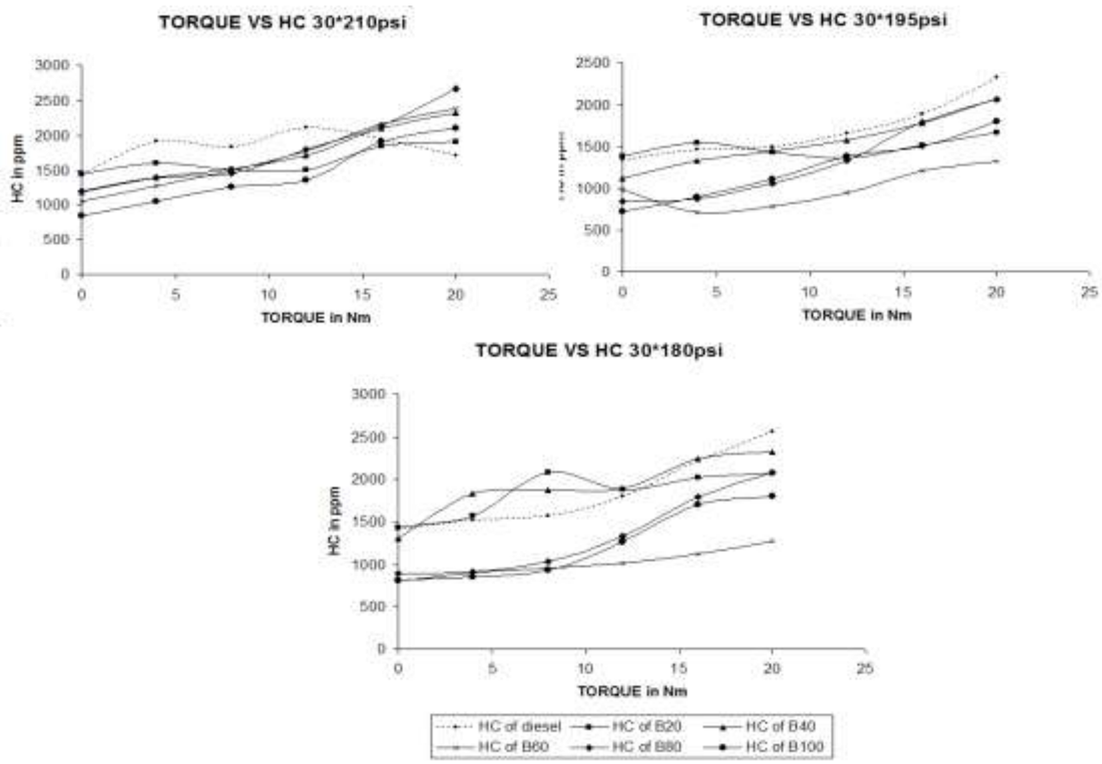

Figure 5.14 HC For Injection Timing 30˚

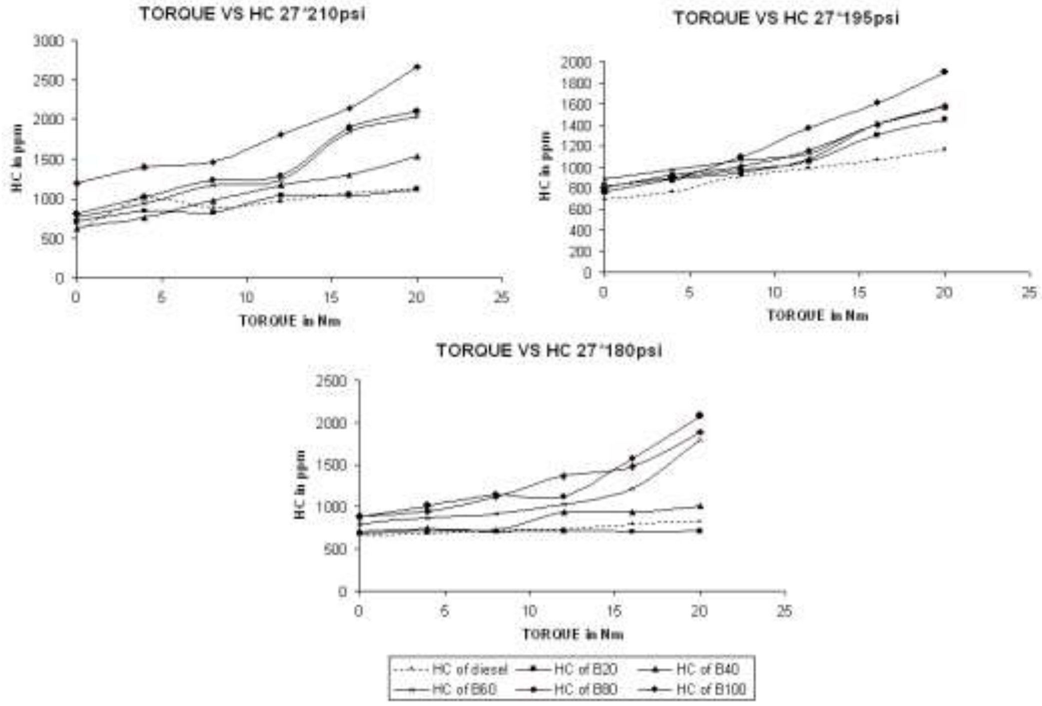

Figure 5.15 HC for Injection Timing 27°

6. Conclusion

The Speedwel Engine was used to test Methyl Esters Jatropha oil (MEJ) and its blends and compared with conventional commercial diesel fuel. The brake thermal efficiency for biodiesel and its blends was found to be slightly less than that of diesel fuel at tested load conditions and the carbon monoxide (CO)emission of engine was increased with increase in amount of biodiesel blends. When injection timing is increased the efficiency and CO increases. When injection pressure is increased the efficiency n CO also increases. The NOx and HC emission increased with increase in biodiesel amount in the blended fuels and also found that NOx and HC emission from the biodiesel fuel was higher than that of diesel.

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