Effects of Fuel Injection Pressure, Combustion chambers on Performance and Emissions of a C.I engine using Cotton Seed Oil biodiesel with Additives

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ABSTRACT- *In this competitive and economic world , the diesel engines are largely used for each and every means of transport due to low Specific Fuel Consumption & high brake thermal efficiency due to this large usage the cost of the fuel and the emissions of the fuel are going to be increased greatly. In order to reduce this cost and emissions, the alternate fuels are the best option. Cotton seed oil ethyl ester(CSOEE) is one of the alternate fuels which is used in this investigation. Experimental investigations were made on a 4-stroke single cylinder , naturally aspirated , water cooled direct injection diesel engine. In order to improvise the performance of the engine the combustion chambers are to be changed. Here in this investigation Hemispherical and toroidal were used. During this investigation , engine was fuelled with 3 different proportions of CSOEE-I,II,III with two additives are used. The tests were performed at different fuel injection pressure by rotating the screw which is provided inside the injector, and by changing the combustion chamber. The results of this experiment shows that at 220 bar of F.I.P and CSOEE-III proportion the BSFC , HC, CO_2 , CO were decreased and the mechanical eff. and brake thermal eff. were optimum. The NOx emissions was increasing . The performance was better in toroidal combustion chamber compare to hemispherical.*

KEY WORDS: Cotton seed oil ethyl ester ,CSOEE-I, CSOEE-II, CSOEE-III F.I.P , Hemispherical, toroidal combustion chamber, isobutanol-ethanol

1.INTRODUCTION:

As the non-renewable petroleum oils usages were increasing greatly in our daily life , which leads this usage to increase the cost of non-renewable resources (like oils) and this usage leads to increase in the emissions. These emissions because of higher usage may stimulate the several health problems. Greater usage of non-renewable resources may results to takedown(degrade) the fuels in nature. So in order to minimize the degradability of non-renewable fuel and to minimize the emissions , the usage of alternate fuels are the best option. Some of the alternate fuels are biodiesel, hydrogen, vegetable oil , bioalcohol etc . Here in this investigation Cotton seed oil ethyl ester biodiesel were used with different proportions. The intense problem with the direct usage of cotton seed oil or any non-edible oil in compression ignition engine were the higher viscosity and the lower brake thermal efficiency when compare with diesel fuel, so to surmount this , convert it in to biodiesel (CSOEE).

Most of the non renewable fuels like gasoline, kerosene , diesel and fuel oils have the drawbacks that which we cannot store them for the long term, and that makes difficult for transportation and even for the usage . More than 30 properties of the fuels can be improved by adding the small amount of the chemicals named as fuel additives for getting the new beneficial characteristics. Hence for this investigation CSOEE and its blend with isobutanol-ethanol like CSOEE-I/II/III was prepared.

The various factors that influence the performance of engine are fuel injection pressure , compression ratio , injection timing, intake temperature, air/fuel ratio, combustion chamber design etc. Here in this investigations F.I.P was changed by rotating the screw which is provided inside the injector. For the fuel to mix well atomization, dispersion, vaporization, penetration are to be achieved. These characters can be achieved by increasing the F.I.P. When all these 4 factors are achieved it will also reduce the engine emissions, increases engine power & torque, i.e;) complete burning of fuel will result in power & torque. In addition to change in the F.I.P the combustion chamber was also changed to improvise the performance of the engine.

V. Mathan Raj, L.R. Ganapathy Subramanian, G. Manikandaraja [1] conducted the experiment on effect of isobutanol on performance, emission characteristics and combustion of a CI engine fuelled with cotton seed oil (CSO) blended with diesel. They have concluded that the addition of CSO in diesel increases its density, viscosity and oxygen content but reduces its calorific value. There is very slight increases in BTE with the use of 5% and 10% of iso-butanol to the biodiesel. B10 + 10% shows the 3% higher BTE as compared to diesel at full load condition. The exhaust gas temperatures with the blends are usually lower than that with diesel fuel. The decrease in NOx emissions is usually proportional to the iso-butanol content in the blends. The HC emission increases on increasing iso-butanol content in the blends, and reaches its maximum value with the use of B20 + 5%.The test result reveals that cottonseed oil and isobutanol can be used as fuel additive and the blend performs better as both the blending materials increase in the blends thus stating that B20 + 10% blend is the most suitable blend which can be used in place of pure diesel without making any changes in the engine system. M. Leenus Jesu Martin, V. Edwin Geo, D. Kingsly Jeba Singh, B. Nagalingam [2] conducted experiment on A comparative analysis of different methods to improve the performance of cottonseed oil fuelled with diesel engine. They have concluded that The brake thermal efficiency of diesel and neat CSO at peak power is 32.3% and 28% respectively. An increase in the brake thermal efficiency to 31.4% is noticed at peak output with cotton seed oil ethyl ester (EECSO). Smoke, CO and HC levels are reduced with EECSO compared to neat CSO. A blend of 60% CSO and 40% of diesel results in good brake thermal efficiency and a significant reduction in smoke level. The preheated blend of 60% of CSO and 40% of diesel at 90 °C shows an increase in brake thermal efficiency, which is close to diesel. Engine performance improves with the addition of orange oil (OO) and DEE with CSO. S. Naga Sarada , M.Shailaja , A.V. Sita Rama Raju , K. Kalyani Radha [3]were conducted experiment on Optimization of fuel injection pressure for a compression ignition engine with alternate fuel as cotton seed oil. They have concluded that 1. Quieter operation of the engine is observed when cotton seed oil is used as fuel. 2. Performance of engine with cotton seed oil as fuel is better at an IP of 210 bar. 3. An increase in the Brake thermal efficiency from 25.02% to 28.02% was observed with increase in injection pressure from 180bar to 210 bar; due to better atomization and improved combustion of the fuel. 4. Lowering of the HC emissions from 1720 ppm to 1480 ppm. 5. Performance of engine with cotton seed oil as fuel at an IP of 210 bar is approximately similar to the operation of engine with diesel.XiangrongLi YanlinChen LiwangSu FushuiLiu [4] were conducted experiments on Effects of lateral swirl combustion chamber geometries on the combustion and emission characteristics of DI diesel engines and a matching method for the combustion chamber geometry and concluded that the combustion performance of the LSCS is primarily affected by the geometries of the split-flow creation, in which θ (the deviation angle of flow-guide) plays a dominant role. When θ was in the range of 15–27°, the combustion chamber created favorable flow guidance for spray and promoted the fuel/air mixture formation. After the geometrical optimization of the LSCS, fuel consumption decreased by 2.8–4.1 g/(kW.h) and soot emission decreased by 69–75% under various engine speeds as compared with the double swirl combustion system (DSCS).Taiping WangBing SunDiLiuJixin Xiang [5] were conducted experiments on Experimental investigation of two-dimensional wall thermal loads in the near-injector region of a film-cooled combustion chamber and concluded that the thermal-structural analysis needed to provide detailed boundary conditions in the hot-gas-side walls of rocket combustion chambers.

2. MATERIALS:

The test fuel taken for this investigation is CSOEE and three blends of CSOEE & isobutanol-ethanol. Various chemical and physical properties of CSOEE and the blends are determined by using standard testing procedure. Viscosity is calculated by redwood viscometer, the calorific value is calculated by bomb calorimeter, the flash and fire point were find out by pensky apparatus.

2.1 FUEL INJECTOR:

Fuel injection is used for the introduction of fuel in an internal combustion engine, most commonly in an automotive engines the injection was by the means of an fuel injector. Fuel injector used in this investigation is shown below.

Fig 2.1 fuel injector

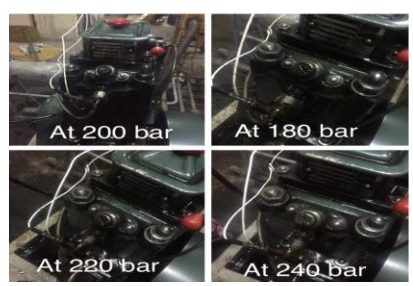

Fig 2.2 screw position in the fuel injector at different pressures

2.3 COMBUSTION CHAMBERS:

A combustion chamber was the part of an internal combustion engine, in which the fuel and air mixture was burned. Here in this investigation two combustion chambers are used to improvise the performance parameters. The two combustion chambers are hemispherical, toroidal. Fig 2.3 shows the shape of two combustion chambers.

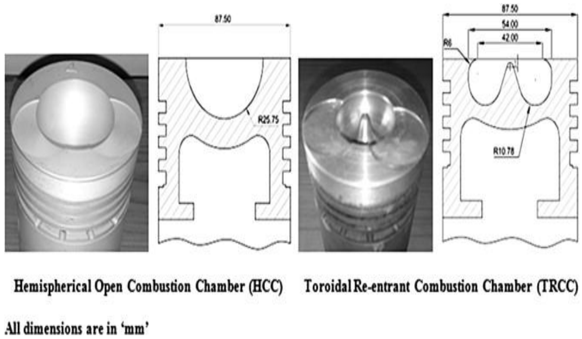

Fig 2.3 Hemispherical , toroidal combustion chambers.

Table 1: Properties of cotton seed oil (CSO), CSOEE, diesel

Properties	CSO	CSOEE	Diesel
Density(g/cc)	0.965	0.929	0.85
B.P(°c)	321	266	248
C.V(Kj/Kg)	39500	31400	42500
K.V @20°C	29.4	7.5	3.3

3.EXPERIMENTAL SETUP:

The experimental setup comprise of 4 stroke single cylinder diesel engine which was water cooled coupled to eddy current dynamometer with the help of flexible rubber coupling and is mounted on a centrally balanced base frame made of mild steel channels. Schematic diagram is shown in Fig 3.1. The set up had stand alone panel box consisting of air box, fuel flow measurements, process indicator and engine indicator, manometer, fuel tank, fuel measuring unit, transmitters for air and. Rotameters are provided for "cooling water" and "calorimeter water" flow measurement. A single cylinder four stroke, naturally aspirated, direct injection and water cooled diesel engine with a displacement volume of 661 cc, compression ratio (CR) of 17.5:1 and rated power output of 5.2 kW at 1500 rpm is used for conducting experiments. The technical specifications of the test engine are given in Appendix-I. The engine is running at its rated speed of 1500 rev/min. Engine is directly coupled to an eddy current dynamometer that permit engine motoring either fully or partially. The engine and the dynamometer are interfaced to a control panel. A computerized diesel engine test rig supplied by Apex innovations is used in this investigation. An Exhaust gas analyzer is used measure the emissions.

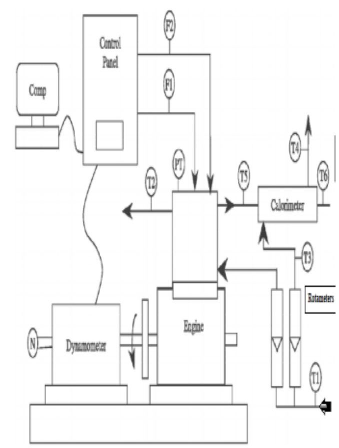

Fig3.1: Schematic diagram of experimental set up

Table 2: Specifications of Engine

Engine power	5.2KW
Engine Max Speed	1500 rpm
Cylinder bore	87.5mm
Stroke length	110mm
Connecting rod length	234mm
Compression ratio	17.5
Stroke Type	Four
No. of cylinders	One
Cooling type	Water
Dynamometer type	Eddy current
Indicator used type pressure	Cylinder

4.EXPERIMENTAL PROCEDURE:

Ensure that the sufficient amount of fuel in fuel tank. Remove air if present in fuel line, if any. Turn on electric supply and ensure that PPU (Piezo powering unit), DLU (Dynamometer loading unit), Load indicator and Voltmeter were in switched on position. By hand cranking start the engine and allow it to run at an idling condition for 20 minutes. Initially the pressure is to be at 180 bar. Increase the load on the engine by rotating knob which is present on the DLU. eg: 12.5%, 25%,37.5%, 50%, 62.5% loads. Note the readings, manometer , time taken for the fuel consumption of 10ml, temperatures and emissions. The emissions are noted by the fuel gas analyzer. Change (increase) the load and wait for 5-6 minutes , take the readings which are mentioned above for this load too. Release the load to "0%" or 0 kg , increase the pressure to 200 bar and then note the readings for this 200 bar pressure. Increase pressure to 220 bar and 240 bar in next stages and note the readings for this pressures. These reading are taken for the two combustion chambers that is for the hemispherical and toroidal, First it was to be performed for diesel fuel and then note the readings. Secondly it has to be fuelled with 80 % biodiesel (cotton seed oil) , 10% iso butanol , 10% ethanol , for this case change the fuel injection pressure , loads , combustion chamber and then note the readings . Next it has to be fuelled with 75% biodiesel , 15% isobutanol , 10% ethanol and then note the readings. Then it has to be fuelled with 70% biodiesel , 20% isobutanol , 10% ethanol and then note the readings. Finally it has to be fuelled with pure biodiesel here it is pure cotton seed oil. Then calculate the performance parameters. Compare the performance parameters and emissions characteristics at each pressure , load and for the proportions with diesel ,and performance for the different combustion chambers.

5. RESULTS AND DISCUSSION:

5.1 PERFORMANCE PARAMETERS:

The Compression ignition engine performance , emissions are discussed with Cotton seed oil Ethyl Ester (CSOEE) and with isobutanol-ethanol blends by changing the fuel injection pressure, and changing the combustion chambers.

5.1.1 BRAKE SPECIFIC FUEL CONSUMPTION:

From fig. 2 it is observed that for the CSOEE-III the BSFC is less than the other two proportions and B100 we can also compare at different FIP, and for the different combustion chambers.

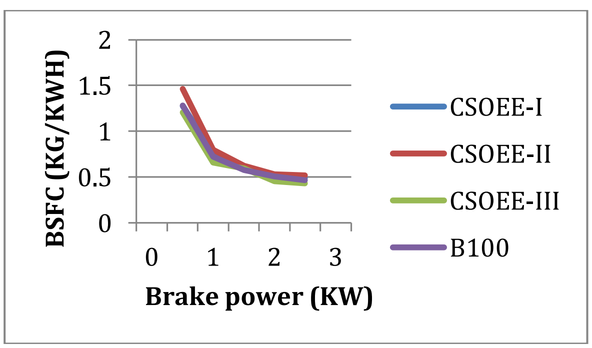

Fig 2: BSFC at different brake power for the three proportions and B100.

So BSFC can be observed for the CSOEE-III at three different F.I.P and compare it with pure biodiesel(B100) .Fig 3 shows the F.I.P for 3rd composition at different F.I.P and with hemispherical combustion chamber. From fig. 4 it was observed that the B.S.F.C decreases when the increase in brake power or the additive % . It was seen that for the CSOEE-III at 220 bar F.I.P and for the toroidal combustion chamber the B.S.F.C is much lower. As the fuel injection pressure increases , the fuel will become more and more atomized when compare to normal F.I.P, which increases the combustion rate and this leads to decrease in the B.S.F.C.

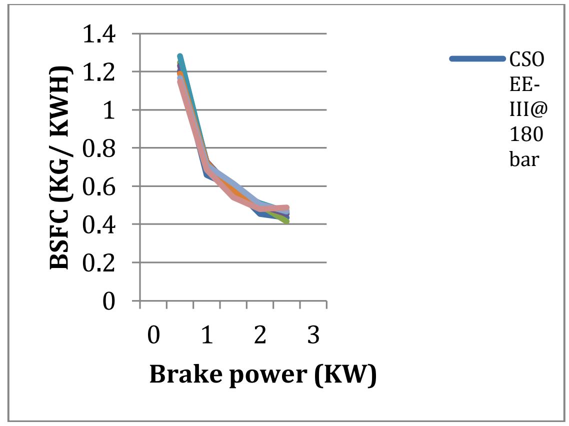

Fig. 3: B.P vs. BSFC for CSOEE-III & B100 at different fuel injection presures with hemispherical combustion chamber.

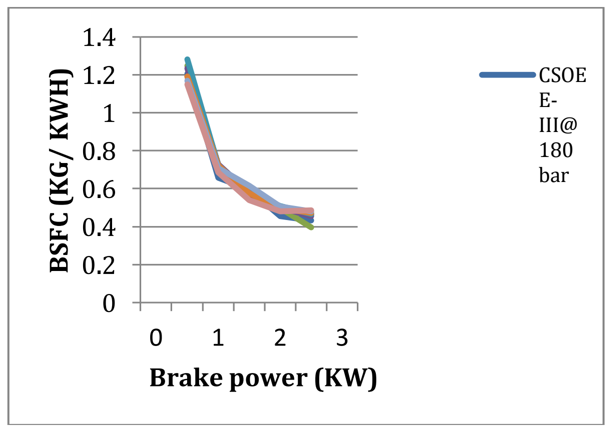

Fig 4: B.P vs. BSFC for CSOEE-III & B100 at different fuel injection presures with toroidal combustion chamber.

5.1.2 : MECHANICAL EFFICIENCY:

From fig.5 it was observed that mechanical efficiency is maximum at 220 bar for pure biodiesel (B100) . the maximum mechanical efficiency was observed at 180 bar only if the additives are added. The mechanical efficiency was an optimum at 200 bar by an observation. Dispersion is more because of the fuel atomization , which shows that there is an effective mixture of fuel & air, leads to increases the combustion rate. Fig 6 shows the variation for the 3 proportions and with the toroidal combustion chamber. The mechanical efficiency is more with the toroidal combustion chamber.

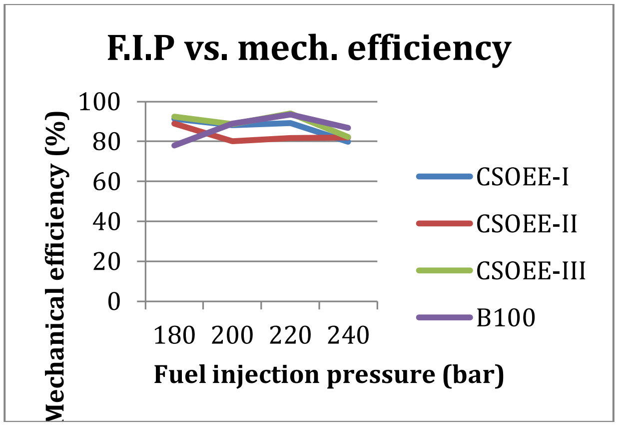

Fig. 5: F.I.P vs. η_{mech} for three proportions & B100 with hemispherical combustion chamber.

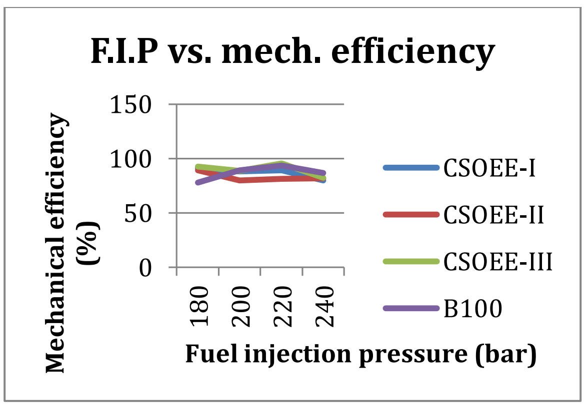

Fig 6: F.I.P vs. mechanical efficiency for the 3 proportions & B100 with toroidal combustion chamber

5.1.3: BRAKE THERMAL EFFICIENCY:

From fig.7 it was observed that, change in fuel injection pressure doesn't affect much on brake thermal efficiency for the pure biodiesel where as for proportions, it affects. The brake thermal efficiency is lower than B100 for all the proportions. Except for the CSOEE-III. Optimum value of brake thermal efficiency is for the CSOEE-III at 220 bar. At the high fuel injection pressure the mixture in the engine converts effectively the heat from a fuel to mechanical energy. Fig 8 shows the F.I.P vs. brake thermal efficiency for the 3 proportions &B100 with the toroidal combustion chamber , compare to hemispherical here the performance (brake thermal efficiency) is more.

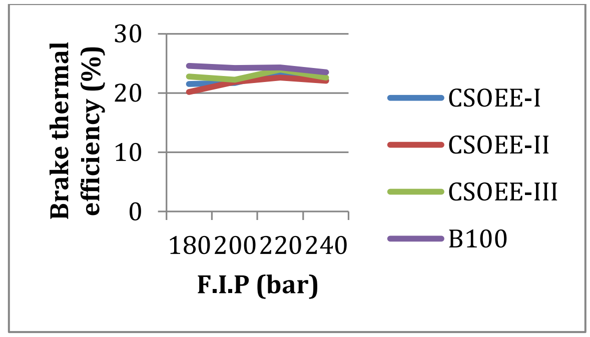

Fig. 7: F.I.P vs. η_{bth} for three proportions & B100 with hemispherical combustion chamber.

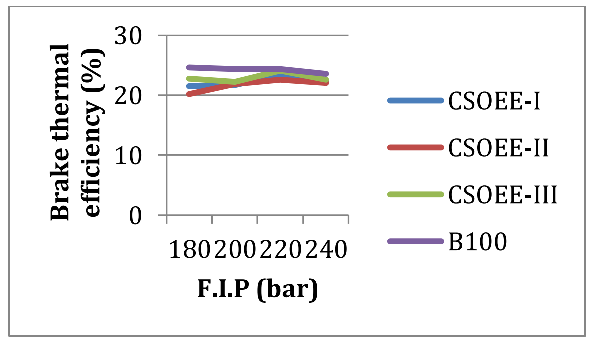

Fig 8: F.I.P vs. η_{bth} for three proportions & B100 with toroidal combustion chamber.

5.2 EMISSIONS:

5.2.1: NOX EMISSIONS:

From fig.9 it was observed that the NOx emissions were seen to be minimum at 240 bar F.I.P whether it was a proportion or for a B100. But for the taken proportions rather than B100 the NOx emissions are increased. The NOx emissions were lower when compared with CSOEE-I,CSOEE-III for CSOEE-II.

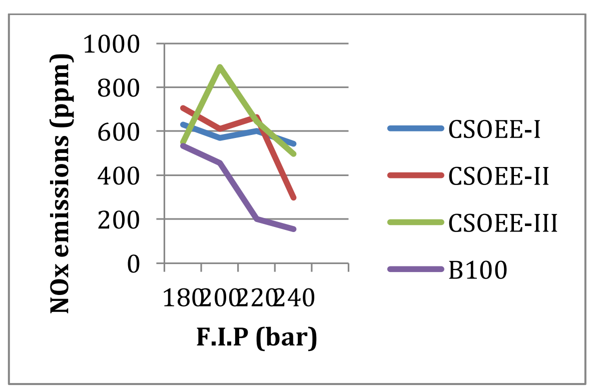

Fig. 9: F.I.P vs. NOx emissions for three proportions & B100.

5.2.2: CO EMISSIONS:

From fig.10 it was observed that when compared with B100 the CO emissions for all the three proportions have lesser emissions at 220 bar. For the third proportion(CSOEE-III) the CO emissions are much lower , which is safe for the environment because the carbon emissions may damage health and the environment. And it was also observed that the CO emissions decreases as the increase in additive(isobutanol + ethanol) percent.

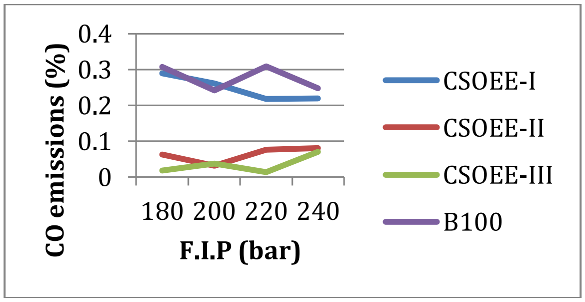

Fig.10: F.I.P vs. CO emissions for three proportions & B100.

5.2.3: CO_2 EMISSIONS:

Fig.11 shows that the CO_2 emissions were lower at 240 bar F.I.P. The CO_2 emissions were lower at 240 bar for the CSOEE-III. There is possibility of complete combustion with more combustion rate. If the CO2 emissions are more there will be more environmental pollution.

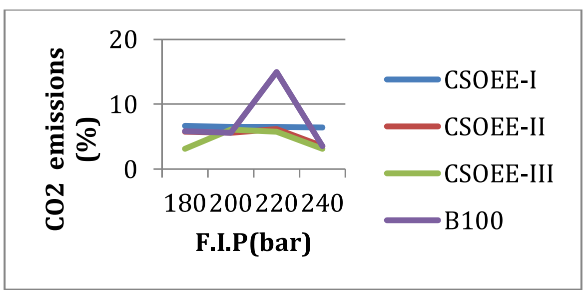

Fig.11: F.I.P vs. CO_2 emissions for three proportions & B100.

5.2.4 UNBURNT HYDROCARBONS:

From fig.12 it was observed that the H.C emissions were lower for the proportions than B100 , and they were lower at 240 bar pressure. For the CSOEE-III from 220-240 bar pressure there was no much variation . HC emissions decreases as the combustion rate is more there was a possibility of complete combustion because of this there were less unburnt gases. Finally we can say that for CSOEE-III the unburnt hydrocarbons were lower.

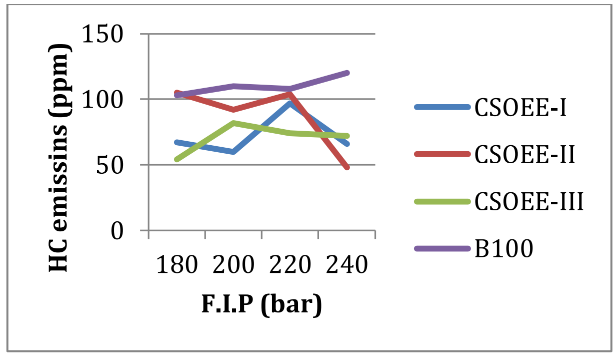

Fig .12 : F.I.P vs. HC emissions for three proportions & B100.

6. CONCLUSIONS:

The BSFC is decreased by 7.1% at 180 bar ,4.3% at 200 bar, 14.6% at 220 bar, 7.6% at 240 bar.So from this we can say that BSFC is lower at 220 bar F.I.P and decreased by 14.6% than that of B100. Mechanical efficiency is optimum at 220 bar F.I.P for all the three proportions taken in this investigation. η_{mech} is increased by 20.54% when compared with B100Brake thermal efficiency is optimum at 220 bar pressure. Here in this the brake thermal efficiency is decreased slightly when compared with B100. Among the three proportions the Brake thermal efficiency is little more for the CSOEE-III at 220 bar pressure. η_{bth} for CSOEE-III at 220 bar is decreased by 2.53% when compared with B100.NOx emissions were increased slightly when compared with B100 for all the three proportions. It is increased by 31.05 when compared with B100.As the % of additive increases CO emissions decreased so for CSOEE-III is decreased by 5.86% at 180 bar F.I.P, 15.70% at 200 bar F.I.P, 4.22% at 220 bar F.I.P, 28.34% at 240 bar F.I.P. From this we can say that CO emission were decreased at 220 bar F.I.P.The CO_2 were decreased by 0.529% at 180 bar F.I.P, increased by 0.088% at 200 bar F.I.P , decreased by 0.387% at 220 bar F.I.P, 0.905% at 240 bar F.I.P for CSOEE-III. From this it is concluded that at 220 bar F.I.P the CO2 emissions were lower.HC emissions for CSOEE-III at 180 bar F.I.P is decreased by 0.524%, at 220 bar it is decreased by 0.685%, at 240 bay it is decreased by 0.6%, at 200 bar CSOEE-I was decreased by 0.5454%. From this it is concluded that for CSOEE-III the HC emissions are lower at 220 bar F.I.P.

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