ANALYSIS ON PERFORMANCE AND EMISSION CHARACTERISTICS OF DIRECT INJECTION DIESEL ENGINE USING BIODIESEL MIXTURES

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Abstract - *As Conventional fuels are going to deplete soon, we need a alternative fuel. Bio-diesel is such a renewable alternative fuel. Many studies conducted on biodiesel showed that biodiesel blending with diesel up to 20% can give good performance and emission characteristics on diesel engines, the drawback is the higher NOx emission. Here we are blending rubber seed and jatropha biodiesel with diesel to improve its properties we are adding cetane improver 2- ethyl hexyl and we expect better performance and emission characteristics. We are doing the experiment on a V C R engine so the optimum compression ratio for a diesel engine can also be determined from our experiment. The experimental results are compared with the results of Diesel RK software.*

Key Words: Bio-diesel, variable compression ratio (VCR), Diesel RK

1. INTRODUCTION

Diesel fuel dominates the vehicle field due to its higher fuel economy so consumption of diesel oil is several times higher than that of petrol. Due to shortage of fuels there is a need for other alternative. Vegetable oils is another alternative but the viscosity of vegetable oils is high otherwise it is having high energy density, cetane number. Blending, emulsification, thermal cracking and transesterification are the commonly adoptable methods to use the vegetable oil as fuel in diesel engines. Recent years biodiesel has received significant attention both as a possible renewable alternative fuel and as an additive to the existing petroleum-based fuels. Biodiesel exhibits several merits when compared to that of the existing petroleum fuels. Many researchers have shown that particulate matter, unburned hydrocarbons, carbon monoxide, and sulfur levels are significantly less in the exhaust gas while using biodiesel as fuel. However, an increase in the levels of oxides of nitrogen is reported with biodiesel. Presently, considerable research has been undertaken to understand the performance characteristics of biodiesel-fueled engine as well as the biodiesel production technology. Biodiesel is produced commercially by the transesterification of vegetable oils with alcohol. Methanol or ethanol is the commonly used alcohols for this process.
The experimental results of various researchers support the use of biodiesel as a viable alternative to the diesel oil for use in the internal combustion engines. It is also important to note that most of the experiments conducted on biodiesel are mainly obtained from refined edible type oils only. The price of refined oils such as sunflower, soybean oil and palm oil are high as compared to that of diesel. This increases the overall production cost of the biodiesel as well. Biodiesel production from refined oils would not be viable as well as economical for the developing countries like India. Hence, it is better to use the nonedible type of oils for biodiesel production. In India, non-edible type oil yielding trees such as linseed, castor, Karanja, neem, rubber, jatropha and cashew are available in large number. The production and utilization of these oils are low at present, because of their limited end usage. Utilization of these oils/biodiesel as fuels in internal combustion engines are not only reducing the petroleum usage, but also improve the rural economy. If we are using forest area to cultivate oil crops to produce biodiesel it will ultimately lead to increase in pollution than decrease since forest can absorb more greenhouse gases than farm land.

This experimental work investigates the performance, combustion and emission characteristics of a single cylinder direct injection (DI) diesel engine with fuel blend: jatropha-rubber seed oil- cetane improver diesel. 2 ethyl hexyl nitrate is used as the cetane improver. The performance and emissions of diesel engine is investigated theoretically by using the simulation software Diesel-RK.

2. MODELLING AND SIMULATION

Diesel-RK is a modeling and simulation software specifically developed for thermodynamic engine simulation. DIESEL-RK software is developed in the department of Internal Combustion Engines (Piston Engines), Bauman Moscow State Technical University. It is mainly designed for simulating and optimizing the working processes of internal combustion engines with all types of boosting. This software is used for torque curves, engine performance predictions, fuel consumption predictions, emission analysis and optimization of fuel injection profile including multiple injection, sprayer design and location as well as piston bowl shape optimization in models of DI Diesel engines. In the present simulation study, Diesel-RK software is used for calculation of performance and emission values for hemispherical piston bowl in which Diesel is used as fuel. In figure 1 shows hemispherical piston bowl modelled with Diesel- RK.

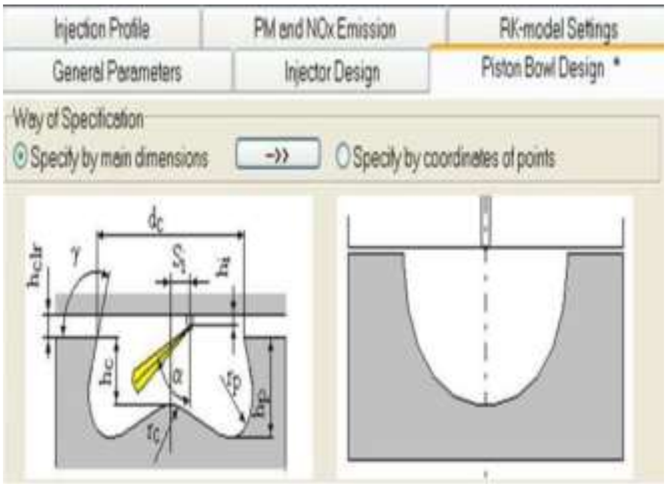

Fig-1: Hemispherical piston howl modelled with Diesel

Table -1: Specification of engine (VCR)

Engine Make	Legion Brothers
Engine Type	4-Stroke, Diesel Engine
Number of Cylinder	1
Bore × stroke	85×110 mm
Compression ratio	Variable (12-19)
Rated power	3.7 kW, 1500 rpm
Dynamometer	Electric AC-generator
Orifice diameter	0.15 mm
Injection pressure	(200-220) bar
Cooling system	Water cooling
Combustion chamber	Hemispherical

3. EXPERIMENT

In the present study is based on the experimental analysis of diesel, bio-diesel, on a single cylinder internal combustion engine at five different loading conditions.

The performance and emission characteristics of the engine test rig depends on the fuel used. The engine is warmed up initially and stabilized before taking all the readings. All the readings recorded are replicated thrice to get a reasonable value. The performance parameters such as Brake Thermal Efficiency (ηB.Th.), Brake Specific Fuel Consumption (bsfc), Exhaust Gas Temperature (EGT) and Volumetric Efficiency (ηVol.) and emission parameters such as Carbon Monoxide (CO), Carbon Dioxide (CO2) and Nitrogen Oxides (NOx) are evaluated.

Table-2: Fuel properties

Property		**Diesel**	**Bio-diesel**
Mass composition of fuel	C	0.87	0.766
	H	0.126	0.121
	O	0.004	0.113
Sulphur fraction in the fuel		0.025	0.0024
Low heating value (MJ/kg)		42.5	30.5
Cetane number		48	53
Fuel density (kg/m^3)		830	862
Surface tension (N/m)		0.028	0.0344
Dynamic viscosity (Pa.s)		0.003	0.00368
Molar mass (kg/kmol)		190	282
Apparent Activation energy (kJ/mol)		23	14.73

4. RESULT AND DISCUSSION

The test is conducted at 1500 rpm with compression ratio of 15:1. The fuel supplied per cycle is changed from 0.005-0.03g/cycle and done the simulation for the above engine to obtain different NOx, soot, particulate matter, specific fuel consumption, output power, torque.

4.1 Cylinder pressure vs crank angle

In a compression ignition engine, the peak cylinder pressure depends on the burned fuel fraction during the premixed burning phase, i.e. the initial stage of combustion. The variation of the cylinder pressure with crank angle for diesel and bio-diesel are shown in Fig.2 &Fig.3. Bio-diesel shows lower peak cylinder pressure because of the longer ignition delay for bio-diesel.

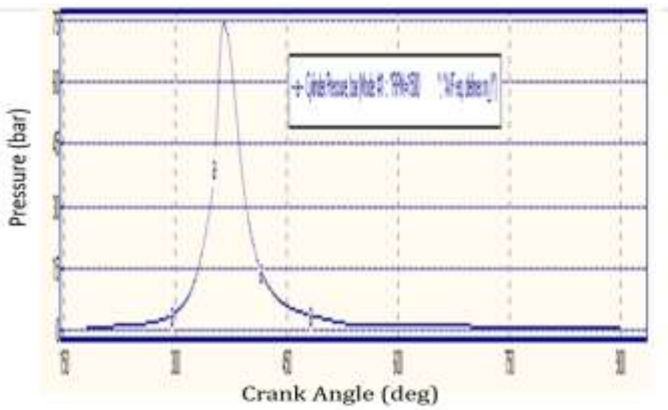

Fig.2 Cylinder pressure vs Crank angle for Diesel

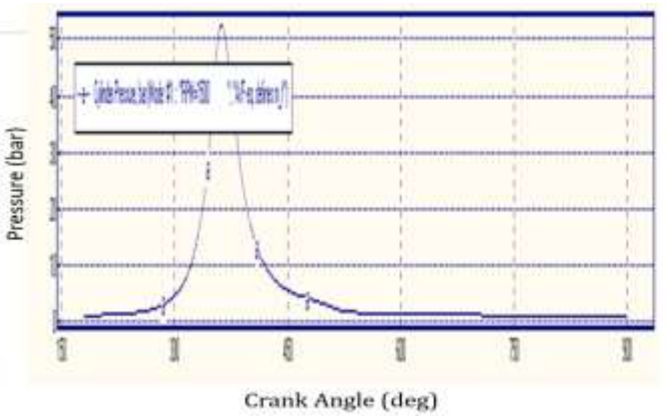

Fig.3 Cylinder pressure vs Crank angle for Bio-diesel

4.2 Cylinder temperature vs crank angle

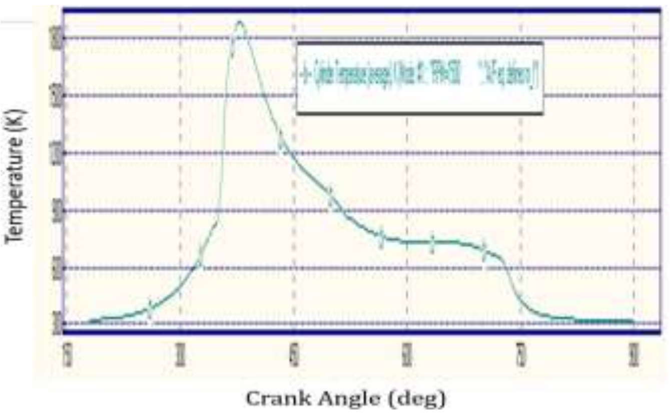

Fig.4 Cylinder temperature vs Crank angle for Diesel

In a compression ignition engine, the peak cylinder temperature depends on the burned fuel quality. The variation of the cylinder temperature with crank angle for diesel and bio-diesel are shown in Fig.4 & Fig.5. Bio-diesel shows lower peak cylinder temperature because of the lower calorific value and poor atomization for bio-diesel.

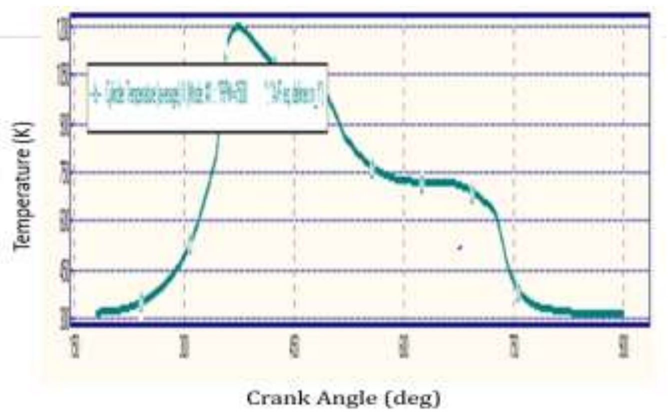

Fig.5 Cylinder temperature vs Crank angle for Bio-diesel

4.3 Heat release rate vs crank angle

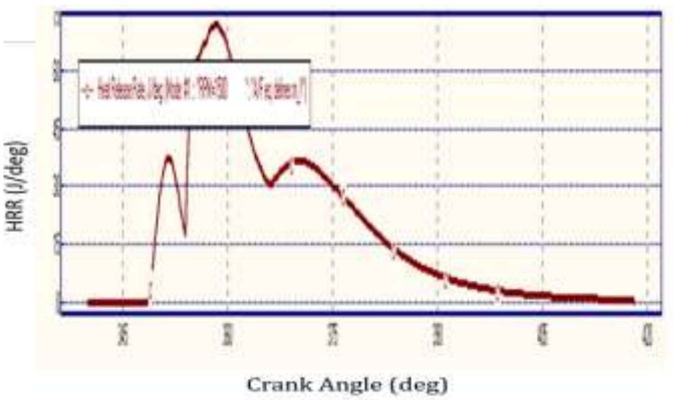

Fig.6 Heat release rate vs Crank angle for Diesel

Fig.6 & Fig.7 shows the variation of heat release rate with the crank angle, it is observed that the bio-diesel have lower heat release rate than diesel due to less energy released in premixed phase and also probably due to the lower volatility of biodiesel. The early start of combustion was caused by the advancement in the injection timing and shorter ignition delay.

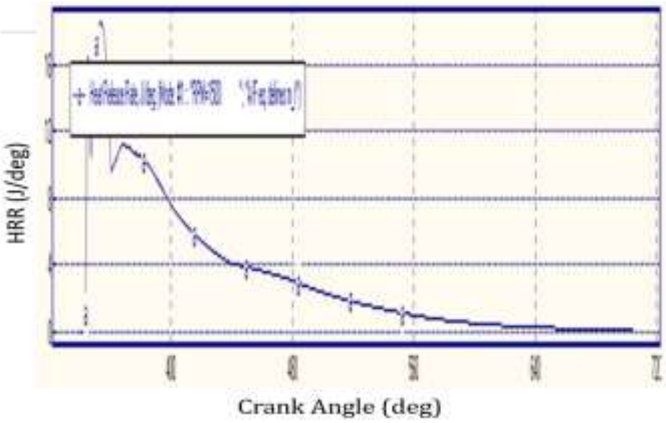

Fig.7 Heat release rate vs Crank angle for Bio-diesel

4.4 Nox vs crank angle

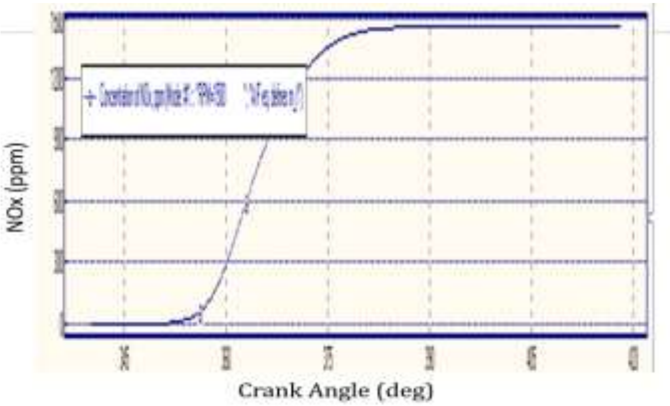

Fig.8 NOx vs Crank angle for Diesel

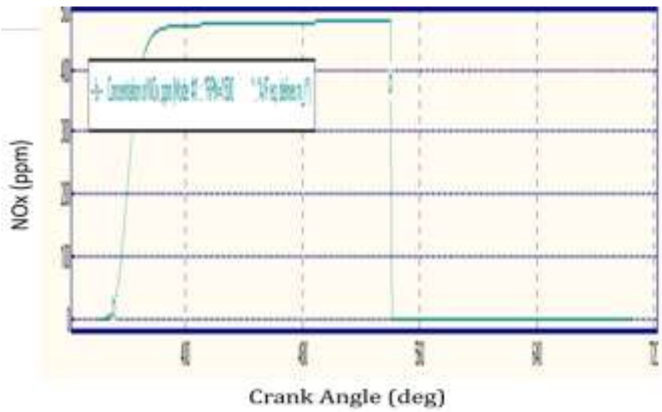

Fig.9 NOx vs Crank angle for Bio-diesel

Fig.8 & Fig.9 shows the variation of NOx with the crank angle for diesel and bio-diesel respectively. It is observed that bio-diesel have lower NOx emission than diesel. This is due to lower combustion temperature and lower reaction rate

4.5 Soot vs crank angle

Fig.10 & Fig.11 shows the variation of soot with the crank angle for diesel and bio-diesel respectively. It is observed that bio-diesel have lower soot emission than diesel. This is due to the oxygen within the fuel decreases the tendency of a fuel to produce soot. Another reason for smoke reduction when using biodiesel is the lower carbon to hydrogen (C/H) ratio as compared to pure diesel fuel.

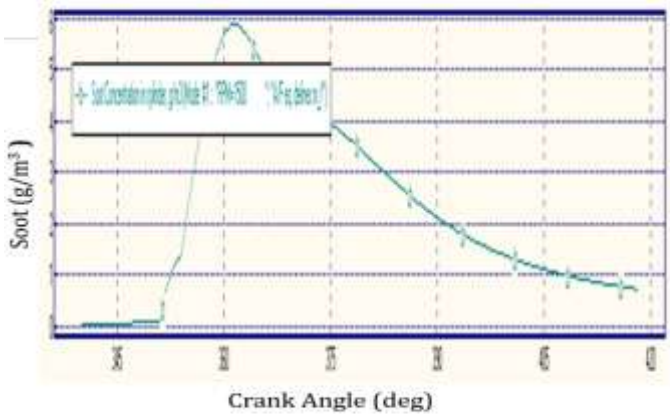

Fig.10 Soot vs Crank angle for Diesel

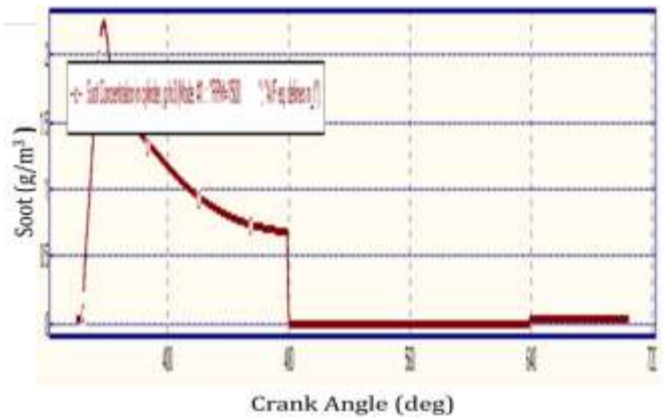

Fig.11 Soot vs Crank angle for Bio-diesel

4.6 Pm vs mass of fuel supplied per cycle

Fig.12 & Fig.13 shows the variation of PM with the mass of fuel supplied for diesel and bio-diesel respectively. It is observed that bio-diesel have higher PM emission than diesel. This is due to lower combustion temperature and lower reaction rate for bio-diesel.

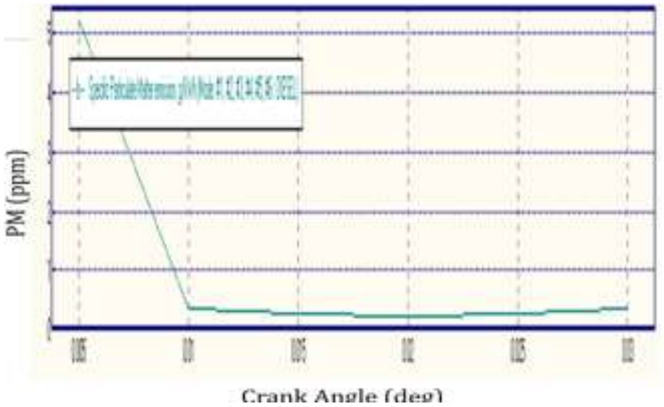

Fig.12 PM vs Mass of fueled supplied per cycle for Diesel

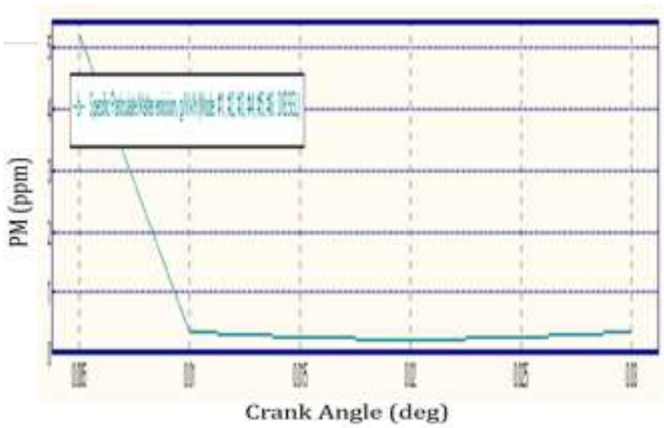

Fig.13 PM vs Mass of fueled supplied per cycle for Bio-diesel

4.7 Torque vs mass of fuel supplied per cycle

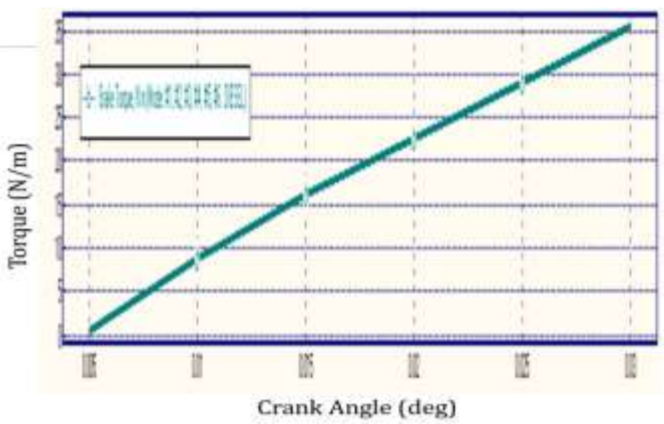

Fig.14 Torque vs Mass of fuel supplied per cycle for Diesel

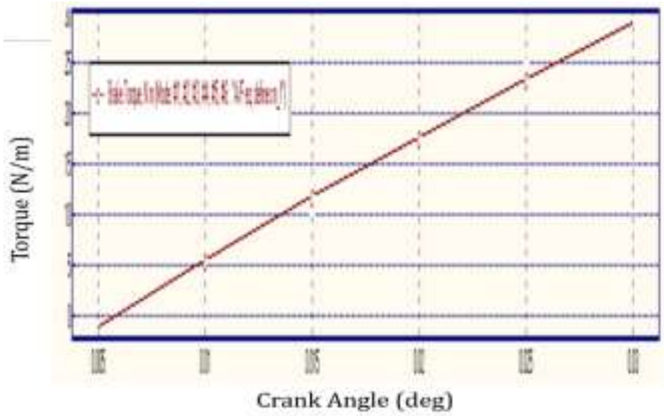

Fig.15 Torque vs Mass of fuel supplied per cycle for Bio-diesel

Fig.14 & Fig.15 shows the variation of Torque with the mass of fuel supplied for diesel and biodiesel respectively. It is observed that bio-diesel have lower torque than diesel. This is due has lower heating value than diesel and hence produces slightly less torque.

4.8 Engine power vs mass of fuel supplied per cycle

Fig.16 & Fig.17 shows the variation of Torque with the mass of fuel supplied for diesel and biodiesel respectively. It is observed that bio-diesel have lower torque than diesel. This is due has lower heating value than diesel and hence produces slightly less torque.

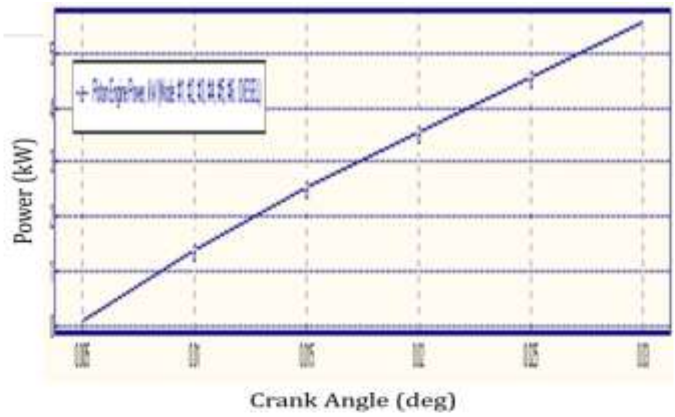

Fig.16 Engine power vs Mass of fuel supplied per cycle for Bio-diesel

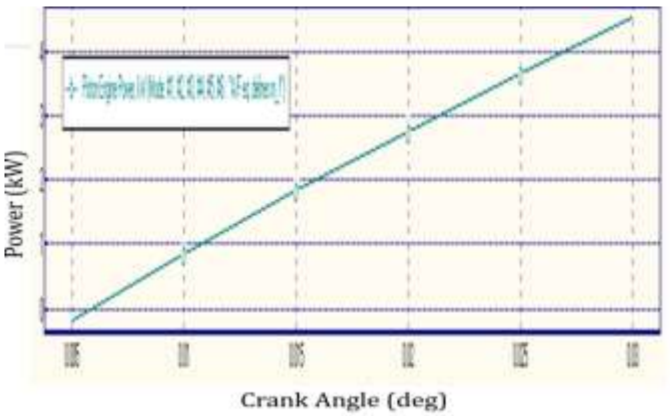

Fig.17 Engine power vs Mass of fuel supplied per cycle for Bio-diesel

4.9 Sfc vs mass of fuel supplied per cycle

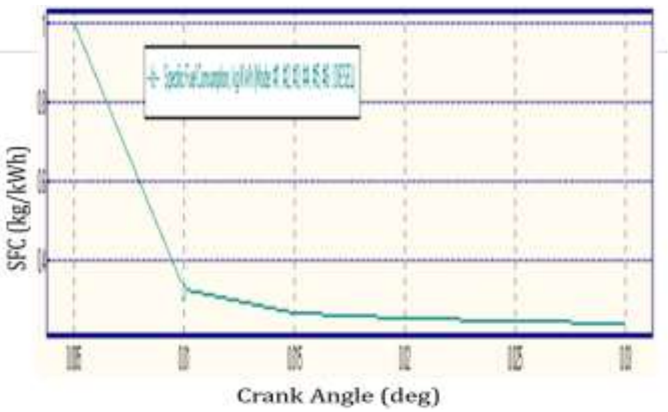

Fig.18 SFC vs Mass of fuel supplied per cycle for Diesel

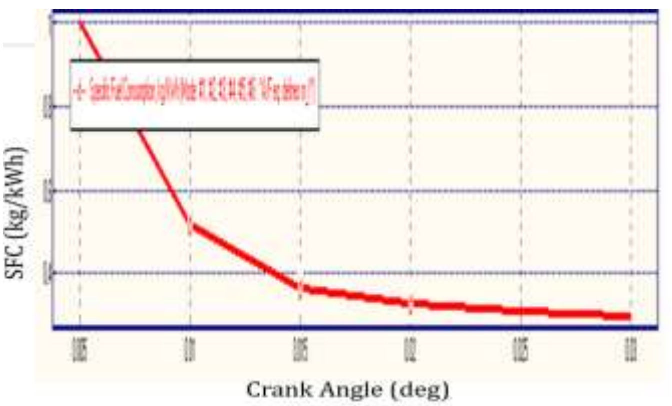

Fig.19 SFC vs Mass of fuel supplied per cycle for Bio-diesel

5. CONCLUSION

Based on observation of numerical simulation the cylinder pressure, temperature and heat release rate for the biodiesel is low. Engine power, torque is also found to be slightly lower but SFC for bio-diesel is slightly higher than diesel. It is also found that for emission like NOx and soot are lower for biodiesel but particulate emission is observed to be higher Experimental values are to be compared with simulated values & performance and emission characteristic are to be observed. Combination of fuels with additives improves combustion properties and hence better performance and emission characteristics are expected.

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