Experimental Investigation of Engine Characteristics of Di Diesel Engine using Rapeseed Biodiesel

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Abstract— Being renewable in source of energy the vegetables oils can be use as fuel for CI engine. However, poor volatility and high viscosity lead to increased emissions and reduced performance. Hence the properties of vegetable oils need to be modified. The most commonly used method for this modification is converting into biodiesel by transesterification process and blending with diesel are considered in this work. The scope of present work includes, characterization of Rapeseed oil, examining the suitability of this oil as fuel by evaluating performance, combution and emission characteristics and comparing the same with that of diesel.

Key words: Rapeseed Oil, Engine Performance, Feasibility Study

I. Introduction

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative to sustain the growth rate. Bio-diesel is a promising alternative for our Diesel needs. With vast vegetation and land availability, certainly bio-diesel is a viable source of fuel for Indian conditions. Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. The blend of Bio-diesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher Cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. It can be seen that the efficiency of the engine increases by the utilization of Bio-diesel. This will have a great impact on Indian economy.

Diesel fuels have deep impact on the industrial economy of a country. These are used in heavy trucks, city transport buses, locomotives, electrical generators, farm equipments, underground mine equipments etc. The consumption of diesel fuels in India for the period 2007-08 was 28.30 million tons, which was 43.2% of the consumption of petroleum products. This requirement was met by importing crude petroleum as well as petroleum products. The import bill on these items was 17,838 crores. With the expected growth rate for diesel consumption more than 14% per annum, shrinking crude oil reserves and limited refining capacity, India is likely to depend more on imports of crude petroleum and petroleum products

II. Literature review

Shyam Kumar Ranganathan, et.al [1] conducted experiment on the Performance Evaluation of C.I. Engine with Rapeseed Oil. Rapeseed Oil methyl ester was produced by means of trans-esterification process using Rapeseed Oil, which can be described as a biomass based and renewable energy source. The viscosity of Rapeseed Oil was reduced by preheating it before supplied to the test engine. Kinematics viscosity of oil is higher than those of diesel fuel. The heating value of oil lower while its flash point is higher than diesel fuel.

S.Kirankumar, et al [2] conducted experiment on the Experimental Investigation On Performance, Combustion Characteristics Of Diesel Engine By Using Cotton Seed Oil. The brake thermal efficiencies are obtained32.82%, 32.33%, 33.71% and 34.08% for the fuels diesel, C10, C20 and C30 respectively, among the three blends of cotton seed oil the maximum BTE is 34.08% which is obtained for C30. The BTE of cotton seed oil is increases up to 0.46% as compared with Diesel at full load condition. Exhaust emissions like smoke density, unburned hydrocarbons, carbon monoxide and NOx are decreases of cotton seed oil blends as compared to diesel fuel.

Maharaja Gasti, et al [3] conducted experiment on the Comparative Experimental Investigation Of Performance And Combustion Characteristics In A Single Cylinder Thermal Barrier Coated Diesel Engine Using Diesel And Castor Biodiesel. The following conclusions were drawn from these investigations carried out on normal engine and LHR engine for different loads, Using insulation to reduce the heat loss to the cooling system of the engine causes the cylinder walls to become hotter and increases exhaust gas energy. Thermal efficiency is not improved to the same extent that heat rejection is reduced by combustion chamber insulation.

S Naga Sarada1**,** et al [4] conducted experiments on the Optimization of injection pressure for a compression ignition engine with cotton seed oil as an alternate fuel. Increased injection pressure has a significant effect on enhancing engine performance and lowering emissions. Increase in the injection pressure from 180 bar to 240 bar with cotton seed oil as fuel lead to. Quieter operation of the engine is observed when cotton seed oil is used as fuel. Performance of engine with cotton seed oil as fuel is better at an IP of 210 bar. 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. Lowering of the HC emissions from 1720 ppm to 1480 ppm. 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.

M.Harinathareddy, et al[5] conducted experiment on the Experimental Investigation of Compressed Ignition Engine Using Cotton Seed Oil Methyl Ester as Alternative Fuel. At constant speed of 1500 rpm it is observed that brake thermal efficiency (η bth) with use of CSO methyl ester is slightly greater in comparison with Jatropha

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biodiesel and petroleum diesel. It is also observed that indicated thermal efficiency (η ith) with use of CSO methyl ester is considerably greater (i.e. 20.70%) in comparison with Jatropha biodiesel and petroleum diesel. Thus, in developing nations CSO is available in ample quantity, if it is processed as per the fuel requirements in mass production then there is a chance for reducing its overall cost. Then it will become a renewable source of energy in the case of diesel fuel scarcity

N.Venkateswara Rao, et al.[6] conducted experiment on Effect of Injector Opening Pressure and Injection Timing on Exhaust Emissions and Combustion Characteristics of Diesel Engine with Tobacco Seed Oil Based Biodiesel then they concluded that When compared with conventional engine, with biodiesel operation, at recommended and optimized injection timings, LHR engine at peak load operation- decreased smoke levels, increased NO_x levels, increased peak pressure and increased maximum rate of pressure rise. Increase of injection pressure with both versions of the engine with test fuels. Smoke levels decreased, NO_x levels increased and peak pressure increased. With preheating of biodiesel with both versions of the engine, smoke levels decreased and NO_x levels

III. Experimental Set Up

The various components of experimental set up are given below. Fig shows the photograph of the experimental set up. The important components of the system are

A. *The Engine*

The engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, direct injection computerized Kirloskar make CI Engine. This engine can withstand higher pressures encountered and also is used extensively in agriculture and industrial sectors. Therefore this engine is selected for carrying experiments.

Fig. 1: Experimental setup

B. *Dynamometer*

The eddy current dynamometer shown in fig is connected to the engine which is used to control the load on the engine. The working principle of eddy current dynamometer is shown in fig It consists of a stator on which number of electromagnets is fitted and a rotor disc is made of copper or steel and coupled to the output shaft of the engine. When the rotor rotates eddy currents are produced in the stator due to magnetic flux set up by the passage of field current in the electromagnets. These eddy currents oppose the rotor motion, thus loading the engine. These eddy currents are dissipated in producing heat so that this type of dynamometer also requires some cooling arrangement. The torque is measured with the help of moment arm. The load is controlled by regulating the current in the electromagnets.

Fig. 2: Dynamometer

C. *Exhaust Emissions Testing Machine*

fig shows the exhaust gas testing machine. It is designed with sophisticated measurement modules. The product has additional features to save a vehicle and customer database, radio-connected diesel measuring chamber up to the option of designing the protocols individually. Due to the robustness and intuitive application of the device, the tester can be used to get sophisticated and accurate emission measurements.

Fig. 3: Exhaust Testing Machine

IV. Result and Discussion

A. *Performance Characteristics*

1) *Variation of brake thermal efficiency with brake power*

The fig shows comparison between the break thermal efficiency and the brake power output for various blends of diesel and Rapeseed oil .For all cases with the increase of engine load, the thermal efficiency increases. The maximum thermal efficiency is achieved at 90% of load of the engine in all modes of operation. It is evident from the graph that the diesel (D100) has the highest brake thermal efficiency followed by the Rapeseed blends of B20, B40, B60, B80 and B100.The BTE of Rapeseed blend was lower than that of diesel throughout the entire range. The BTE 20% blend of Rapeseed oil compared with diesel exhibits the highest

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value of , For 75% of load all fuels show the maximum brake thermal efficiency. At full load the brake thermal efficiency decreases. For diesel at 75% load the brakre biodiesel is 25.47%. the drop in thermal efficiency is attributed to the poor combustion chacterstics of the vegitable oils due to their high viscosity and poor volatility.

2) Variation of Specific fuel consumption with Brake power

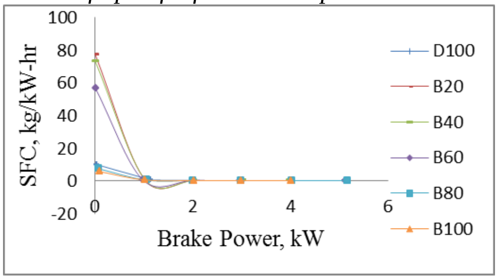

Fig. 4: variation of brake power to SFC

The fig shows the variation of brake specific fuel consumption with brake power output for Rapeseed oil and its blends with diesel in the test engine are shown in above figure. diesel has lower SFC Value compared with all other blends: however 20% blend of Rapeseed oil has lower SFC values. The lowest SFC of bio diesel Rapeseed oil is 0.43 kg/kw-hr, whereas it is 0.45kg/kw-hr for diesel. The increase in BSFC of rapeseed oil and their blends may be due to their lower calorific value. For the fuels tested, BSFC decreased with increase in load. One possible explanation for this reduction could be due to higher percentage of increase in brake power.

3) Variation of Volumetric efficiency with Brake power

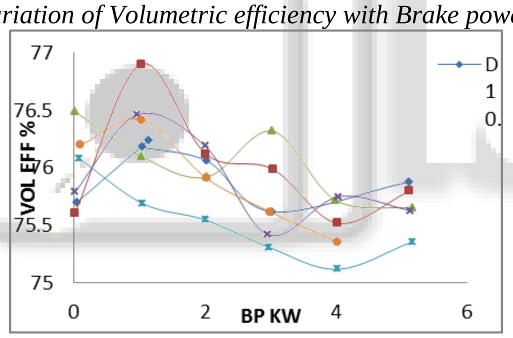

Fig. 5: variation of brake power to volumetric

Fig shows the variation of volumetric efficiency with brake power for different oil blends. For all the fuel tested the volumetric efficiency goes on decreasing as the load increases. The increase in exhaust gas temperature may be responsible for reduction in volumetric efficiency. The maximum volumetric efficiency for diesel oil is 19.78% at no load. At rated load the volumetric efficiency for diesel is 18.35% against 20% of pure biodiesel. It may be due to larger differences in calorific value, viscosity, specific gravity and volatility between diesel and CSB.

4) Variation of Exhaust Gas Temperature with Brake power

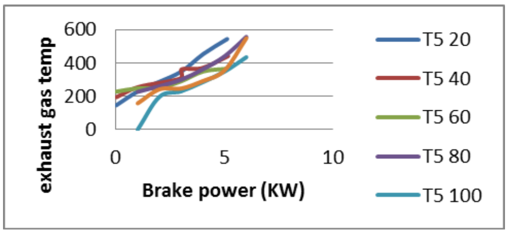

Fig. 6: Variation of Exhaust Gas Temperature with Brake power

Fig shows the variation of Exhaust Gas Temperature (EGT) with brake power output for cotton seed biodiesel and its blends with diesel in the test engine. The EGT of 20% blend of cotton seed *biodiesel* has lower values compared with all other blends and is well comparable with diesel. The EGT of all blends and diesel increases with increase of operating loads. . The maximum EGT occur at full load. Maximum EGT of pure biodiesel is 565^{0} C against 541^{0} C for that of diesel on normal engine. By increasing percentage of biodiesel in diesel increases the EGT. The EGT for cotton seed biodiesel in 20%, 40%, 60% and 80% blend with diesel is 0.27%, 1.22%, 2.3% and 3.3% higher than that of diesel respectively. This may be due to the fact that the higher viscosity and poor volatility of Cottonseed oil lead to poor mixture formation and hence diffusion combustion phase is more dominant which prolongs the heat release process. This may lead to higher exhaust gas temperature. The reasons for lower exhaust gas temperatures for blends are due to lower viscosity which results a lesser penetration of the fuel into the combustion chamber and the lesser amount of heat is developed.

B. Emission Characteristics

1) Variations of Unburnt Hydrocarbon Vs Brake power

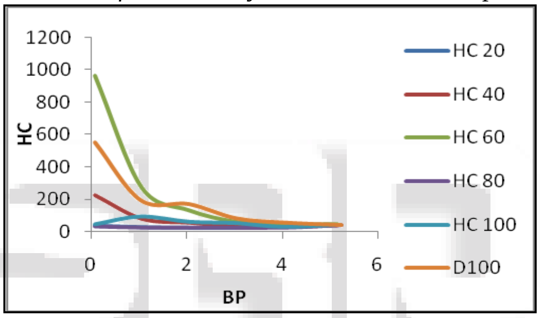

Fig. 7: Variations of Unburnt Hydrocarbon Vs Brake power

Fig shows that variation of emission of hydriocarbon with break power for different blends of rapeseed biodiesel and pure diesel. The emission of HC is decrease in with increase of loads, but the blend B20 exhibits emission of HC similar to diesel. And we observe that the B100 has the least emission of HC compaired to other blends. Thus it can be conformerd that both conventional diesel and biodiesel had the same functional group of C_H. however, the conventional diesel had no oxygen group , whereas biodiesel showed oxygen functional group. Therefore the biodiesel with the existence of oxygen could be promoted cleaner and complete comburstion on the other hand convetional diesel without any oxygen produced more bock smoke and incomplete comburstion during burning.

We can conclude that Hydrocarbon Emissions are significantly lower with Diesel Fuel than the Blends of rapeseedOil. One is that the fuel spray does not propagate deeper into the combustion chamber and gaseous hydrocarbons remain along the cylinder wall and the crevice volume and left unburned . Hydrocarbon content of the fuel not equally distributed in the cylinder area and thus some particles remains unburned which creates higher Hydrocarbon Emissions.

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2) Variations of Carbon dioxide Vs Brake power

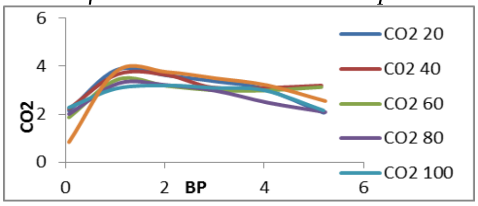

Fig. 8: Variations of Carbon dioxide Vs Brake power

The fig shows the variation of brake power with CO2. It is observed that the level of CO_2 is decreased by replacing the higher amount of diesel, the graph shows that the diesel and 40% blend of rapeseed oil has higher percentage of CO2 compared to other blends. And 80% of biodiesel (B80) has least CO2 emission. The percentage of CO2 decreases with increase in load this due to late burning of the mixture with higher diesel replacement of natural gas ,had caused more fuel to remain partially unburned, increasing the formation of Carbonmonoxide and decreasing the proportion of CO_2 similarly all blends (B20,B40,B60,B100) also corbon dioxide emmissions are decreasing with increasing load .

3) Variations of Carbon monoxide Vs Brake power

The comparison of brake power with corbon monoxide for different biodiesel blends. The CO emission depends up on the strength of the mixture, availability of oxygen and viscosity of fuel. It is observed that the CO emission initially decreases at lower loads sharply increases after 4kw of power for all test fuels. And the diesel and rapeseed oil with 80% blend has more emission of CO compared with blends of rapeseed oil like B20, B40, B60, B80 and B100. This due to incomplete combustion at higher loades which results in higher CO emissions. It is also seem that the CO emission decreases with increase in percentage of attetive in the blendes. From above graph it is revealed that B100 (pear rapeseed oil) shows lowest CO emission.the reason for this is the fuel air mixture filled inside the cylinder is very lean and some of the mixtures nearer to the wall and crevice volume, the flame will not propagate. Therefore, they do not find time to undergo combustion which results higher CO emission However, the CO emissions for D100 blends lie below 0.9% which is a maximum value of CO emission from diesel engines.

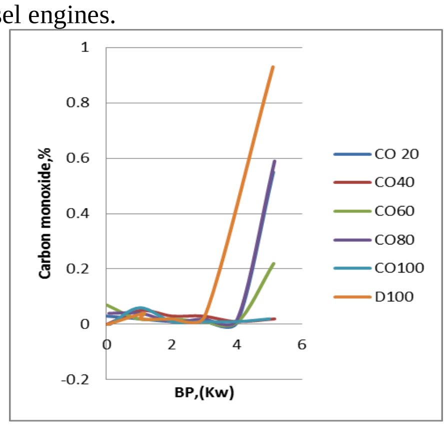

Fig. 9: Variations of Carbon monoxide Vs Brake power
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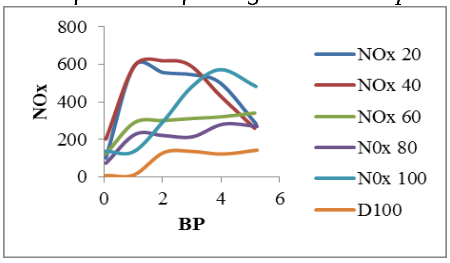
4) Variations of Oxides of nitrogen Vs Brake power

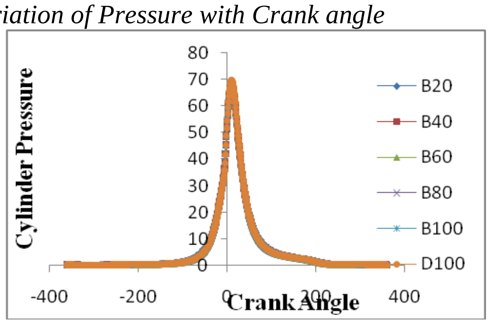


Fig, 10: Variations of Oxides of nitrogen Vs Brake power

The fig shows Variation of NO_x emission with brake power. The average percentage of change in NOx emission for B20, B40, B60, B80 and B100 are shown in the graph. This shows that NOx emission increased with the increase of percentage ratio of biodiesel. NOx emission is primarily a function of total oxygen inside the comburstion chamber, temperature, pressure, compressibility and velocity of sound. Invariably biodiesel has S level of oxygen bound to its chemical structures. Thus, oxygen concentration in biodiesel blends fuel might have caused the formation of NOx. furthermore ,the increase of NOx emission is due to the higher cetane number of biodiesel which will reduce the ignition delay .the increase of NOx emission is a result of the reduced ignition delay .however, the NOx emission can be reduced through engine tuning or using exhaust catalytic converter. At any rate, the NOx still can be reduced with the advanced technologies such as catalytic converter. The NOx emission for biodiesel and its blend is higher then that of diesel except B20 at lower loads. It is increased with the increase in engine load. The maximum NOx values were obtained at full load conditions. The reason for higher NOx emission for blends is due to the higher peak temperature and the biodiesel had S oxygen content in it, which facilated NOx formation

C. Combustion Characteristics

1) Variation of Pressure with Crank angle



Fig, 11 Variation of Pressure with Crank angle

Figure 11 shows the variation of Hydrocarbon (HC) emissions for the plastic pyrolysis oil with diesel fuel at different loads. HC emissions for PO-DF are higher compared to DF at full load. Part load values for PO-DF are marginally closer to DF. HC varies from 28 ppm to 66 ppm for DF. It can be observed that for B20, it varies from 31 ppm to 52 ppm, for B40 from 28 ppm to 61 ppm , for B60 from 39 ppm to 121 ppm, for B80 and B100 varies from 30ppm,42ppm to118ppm, 93ppm respectively. Higher HC emissions are probably due to higher viscosity, density, poor volatility and fuel rich mixtures at higher loads. Part load values for PO-DF are marginally closer to DF.

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2) Variation of Cumulative heat release with Crank angle

Shows the variation in the mass fraction burned to the brake power in KW, An IC engine gains its energy from the heat released during the combustion of the biodiesel and fuel mixture .engine leading to the conversion of the chemical energy obtained in the fuel are reliable evaluation of these processes is the key to engine optimization .from graph it is clear that the pure biodiesel is as accurate as the diesel 100%, that is biodiesel 20%is very close to the diesel 100% at a load. From 28 ppm to 66 ppm for DF. It can be observed that for B20, it varies from 31 ppm to 52 ppm, for B40 from 28 ppm to 61 ppm, for B60 from 39 ppm to 121 ppm, for B80 and B100 varies from 30ppm,42ppm to118ppm, 93ppm respectively. Higher HC emissions are probably due to higher viscosity, density, poor volatility and fuel rich mixtures at higher loads. Part load values for PO-DF are marginally closer to DF. .

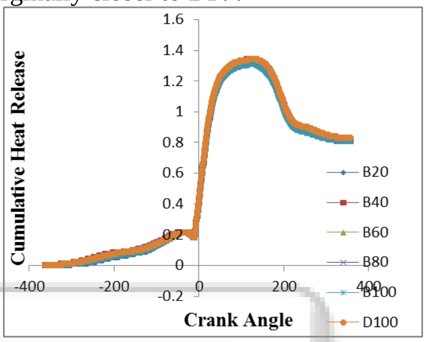

Fig. 12: Variation of Cumulative heat release with Crank angle

3) Variation of Net heat release with Crank angle

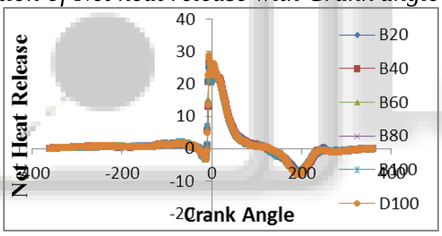

Fig. 13: Variation of Net heat release with Crank angle

Fig shows the variation of net heat release rate with crank angle at maximum load for D100, B100 and some other is shown in figure the maximum hear release rate for D100, B20 and B60 are respectively 180.4, 197 and 172 KJ/CA in diesel premixed burning is more pronounced. B100 shows lower heat release rate compare to ND during premixed burning phase. The poor automisation and poor fuel air mixing is attributed to high viscosity and poor volatility of vegetable oils. This consequently leads to higher exhaust gas temperature and loss of power, because burning occurs in diffusion phase.

V. CONCLUSION

In this project Experimental investigations were conducted on a Kirloskar make single cylinder water cooled naturally aspirated Rapeseed biodiesel and diesel were fuel considered in experimentation. Experimental setup is prepared for EGR to reduce the concentration of NO_x in the exhaust gas. The experiments were conducted for pure biodiesel diesel on normal engine. The performance, combustion and emission characteristics without EGR using neat biodiesel are evaluated and the results compared with that of neat diesel in normal diesel engine. The conclusion of this experiment is as follows.

- The biodiesel is prepared using Rapeseed neat vegetable oil using transesterification process. Density, viscosity of biodiesel found to be higher than that of diesel and the calorific value of biodiesel is lower than that of the diesel.
- Neat biodiesel on engine starts burning before than that of diesel, due to inbuilt oxygen content in Rapeseed biodiesel. However rates of pressure increase for diesel is more than that of neat biodiesel on engine.
- The smoke emission for biodiesel increases with increase in smoke emission is more than that of diesel in normal engine.
- CO and HC emission is lower for Rapeseed biodiesel without EGR than that of normal diesel engine for entire load of operation. The increase in % of EGR increases the CO and HC emission.
- The NO_x emission increases with increase in load and reaches maximum at 60-70% of load and then decreases. NO_x emission is almost all comparable with diesel except a narrow band of part load..
- The results obtained in this experiment are compared with the results of similar work available in literature and the comparison validates my experiment.

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