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PERFORMANCE AND EMISSION CHARACTERISTICS OF CI DI ENGINE USING BLENDS OF TWO BIODIESEL (SIMAROUBA BIODIESEL AND JATROPHA BIODIESEL) AND DIESEL FUEL

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***Abstract— T*he increase in fossil fuel depletion has noticed in the present days due to the dependence increase in number of automobiles and in the agricultures, power generation and domestic sector etc. Hence the bio-diesels takes place a part in replacing diesel fuel. Straight use of vegetable oils may affect the engine, which can be overcome by transesterification process to reduce the viscosity of oils. With these objectives, the current work has carried out on vertical single cylinder 4-stroke compression ignition (CI) diesel engine, to investigate the performance and emission characteristics of diesel engine using two bio-diesels namely Jatropha bio-diesel and simarouba bio-diesel in the ratio of (S50+J50) and (S75 +J25). In this study blends B0, B20, B40, B60, B80 and B100 at an engine speed of 1500rpm has tested. It has shown that the is a marginal increase in BSFC and decrease in BTE, in blending bio-diesel at all injection pressures namely 190, 205 and 220 bar respectively. Emission of CO, UBHC and NO_x are lowered in bio-diesel and diesel blends. The blend (S50+J50) has shown the superior performance than (S75 +J25) blend.**

***Index Terms-* Bio-diesels, Simarouba, Jatropha, CI engine.**

I. INTRODUCTION

In the era of e-commerce, e-world, e-digitization, and techno-commercial living and lavish living behaviour of human's day to days lifestyle, it has been noticed a constant and symbiotic growth in the rate of the fossil fuel consumption, consequent upon the population explosion and the smart urbanisation of cities in the world.

In the present scenario, most and major of agriculture, auto motives and transportation vehicles are enhanced by compression ignition engines, which often use the diesel as the main fuel. The instantaneous growth in fuel supply is due to extraordinary use of petroleum based fuel for automobile application and to maintain the social metabolism in the present situation, resulting in consolidated depletion of fossil fuels.

It has also been came into the scene that the "According to the literature survey's on the World Economical Energy forum by the various countries have been illustrated that the universal supply of fuel oil may reach its final end up to 2019-20. It has also reported that the cost of diesel supply can be reduced by mixing with biodiesel.

In the several studies many of researchers are investigated about human health hazardous associated with the diesel exhaust emissions. The invention and research work is carried out thought the universe to build the high fuel efficient and lower emission engines, as well as the development of renewable fuels. So that bio fuels have taken as another source for fuel supply.

II. OBJECTIVES

In this paper, Simaoruba and Jatropha biodiesels are used in interaction with the diesel fuel. In this paper, the importance of (IP) injection pressure has given to the best performance and lower emission from the diesel engines. However the main objectives are highlighted as follow.

1. Investigation of the biodiesel properties and also the diesel
2. Experimental investigations on the performance of the vertical single cylinder 4-stroke direct ignition (DI) & compression ignition (CI) diesel engine using two biodiesels namely Simarouba & Jatropha in the ratios namely (S50+J50) and (S75+J25) at different fuel injection pressures i.e. 190, 205 and 220 bar.
3. Measurement of smoke and various emittents using smoke meter and gas analyzer
4. Evaluation of the optimum performance parameters for maximum efficiency & minimum pollution.

III. BIODIESEL EXTRACTION

Direct use of vegetable oils can clogs diesel engines due to its high viscosity; the oil needs to be chemically modified into mono-alkyl esters whose properties resemble those of fossil fuels. Cracking / pyrolysis. Transesterification process is the universal method used for extraction of biodiesel.

Table 1.1 And 1.2 Properties of Diesel and Simarouba and Jatropha blends

Blends S50+J50	Density in (Kg/m3)	Heating value in (Kj/Kg)
S0	810	44100
S20	822	43391
S40	834	42702
S60	846	42032
S80	858	41382
S100	870	40750

Blends S75+J25	Density in (Kg/m3)	Heating value (Kj/Kg)
S0	810	44100
S20	823	43361
S40	836	42645
S60	849	41951
S80	862	41278
S100	875	40625

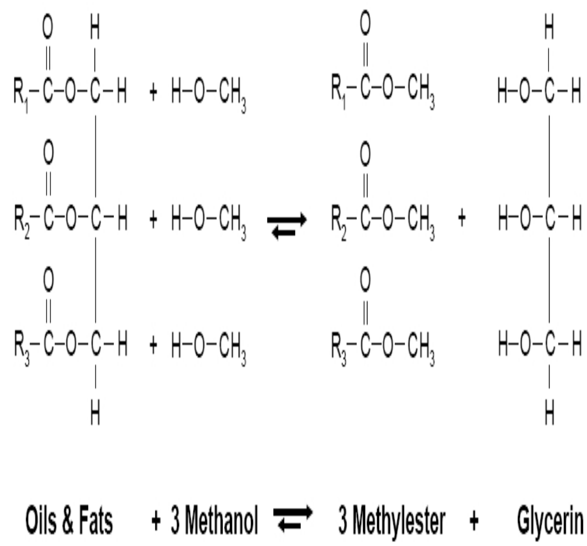

Fig. Transesterification process.

Make	:	Kirloskar Engine
Bore & stroke	:	87.5mm x110mm
Type of cooling	:	Water cooled
Speed	:	1500 rpm
Compression ratio	:	17.5.1
Number of cylinder	:	1
Rated power	:	5.2 kW
Start of injection	:	23˚ bTDC
Injection pressure	:	205 bar

Table 1.1 Engine specifications

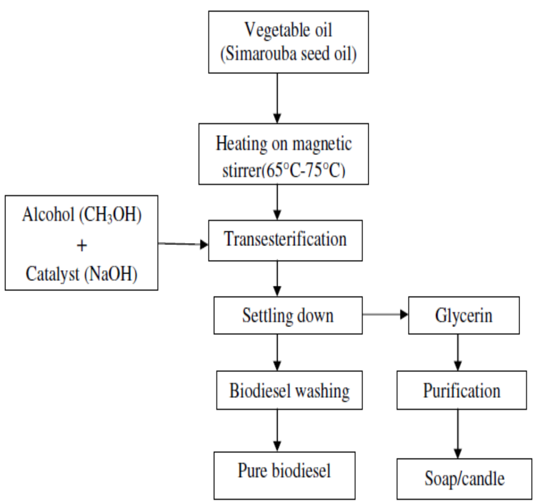

Fig. Flow chart of Biodiesel production

IV. EXPERIMENTAL SETUP AND METHODOLOGY

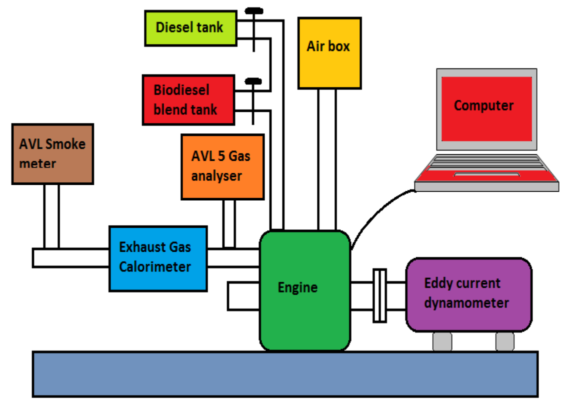

Fig. 1. Line diagram of experimental Setup

The experiments are conducted on compression ignition direct injection; single cylinder 4-stroke Kirloskar diesel engine. The layout of experimental test rig and its instrumentation is shown in fig. 1. It is a water cooled engine with a rated power of 5.2 kW at 1500 rpm having bore 87.5 mm and stroke 110 mm, compression ratio of 17.5, and constant injection pressure of 205bar at 23˚bTDC injection time. It consists of a test bed, a diesel engine with an eddy current dynamometer, a computer with a software called engine soft, an AVL 444 make (5-gas analyzer) exhaust gas analyzer, AVL437 make smoke meter, a pressure sensor to measure the cylinder pressure, TDC sensor records pressure for every two degrees of crank rotation, with which P - θ curve is plotted.

The eddy current dynamometer is mounted on base frame and connected to engine. The engine is subjected to different loads with the help of dynamometer. A rotameter is provided for engine cooling water flow measurement. A pipe in pipe type calorimeter is fitted at the exhaust gas outlet line of the engine. The calorimeter cooling water flow is measured and adjusted by the rotameter. Temperature sensors are fitted at the inlet and outlet of the calorimeter for temperature measurement. The pump is provided for supplying water to eddy current dynamometer, engine cooling and calorimeter. A fuel tank is fitted inside control panel along with fuel measuring unit. An air box is powered for damping pulsation in airflow line. An orifice meter with manometer is fitted at the inlet of air box for flow measurement. Piezo-electric type sensor with water cooled adapter is fitted in cylinder head for combustion pressure measurement. This sensor is connected to an engine indicator fitted in control panel, which scans the pressure and crank-angle data is interfaced with computer through COM port. An encoder is a device, circuit, transducer, software program, algorithm that converts information from one format to another. Rotary encoder is an optical sensor used for speed and crank angle measurement. The sensor is mounted on dynamometer shaft and connected to engine indicator. Thermocouple type temperature sensors measure cooling water inlet, outlet and exhaust temperatures. These temperatures are digitally indicated on indicator situated on control panel. Smoke opacity meter is distributary sample type. It equips gas temperature pressure and distributor control cell in order to ensure metrical stability and repeat. It measures the whole burthen opacity smoke degree continuously and free speed up opacity smoke degree. The exhaust gas analyzer is used to measure the relative volumes of gaseous constituents in the exhaust gases of the engine. Indicators on the test bed show the following quantities which are measured electrically: engine speed, brake power and various temperatures. The computer is interfaced with engine. The PCI 1050 IC card is connected to COM port of CPU. Engine soft is the software used to control the entire engine readings. It is lab view based software. The engine is tested at constant rated speed of 1500 rpm throughout its power range using B0, B20, B40, B60, B80 and B100 blends.

Experiments are conducted on the engine at different loads from 0 kg to 18.3 kg at an interval load of 2.5kg (rated load). Blends B0, B20, B40, B60, B80 and B100 are tested for 23˚bTDC and at an injection pressure of 190, 205 and 220bar (advance, normal and retarded) respectively.

V. RESULTS AND DISCUSSIONS

Thermal performance on vertical single cylinder, 4-stroke direct ignition (DI) and compression ignition (CI) Kirloskar diesel engine is carried out using the blends of two biodiesel namely Jatropha and Simarouba biodiesels with diesel for their varied different volume fraction at 190, 205 and 220 bar injection pressures (IP) are presented below.

1. Thermal performance parameter characteristics for (S75+J25) blend at 190bar IP:

1.1.1 (BSFC) Brake specific fuel consumption for (S75+J25) blend at 190bar IP:

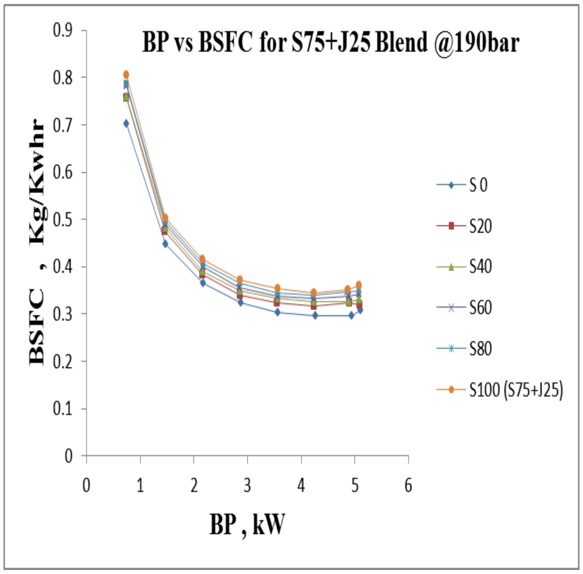

Fig 1.1.1 shows the effect of brake power on BSFC (brake specific fuel consumption) for diesel and biodiesel (S75+J25) blends at 190bar.

The effect of brake power on brake specific fuel consumption at 190bar injection pressure for diesel and biodiesel (S75+J25) blends is shown in fig 1.1.1. From the fig it is seen that the brake specific fuel consumption increases as the concentration (%) of biodiesel (S75+J25) in the blend increases. This is due to the lesser heating value (CV) of the biodiesel (S75+J25) blends, and also the BSFC of diesel is least, whereas for 100% biodiesel blends (S75+J25) is the highest. For other blends the BSFC lies between the specific fuel consumption of biodiesel blends (S75+J25) and neat diesel. The percentage increase in brake specific fuel consumption for different biodiesel (S75+J25) blends compared to diesel are B20, B40, B60, B80 and B100 presented here namely 3.69%, 7.66%, 11.39%, 13.52% and 17.27% respectively. The reason for increased brake specific fuel consumption (BSFC) because of the lesser calorific value (CV) of biodiesel (S75+J25), due to this region more amount of fuel oil has been supplied for getting the similar power out put as similar to neat diesel.

1.1.2. (BTE) Brake thermal efficiency for (S75+J25) blend at 190bar IP:

The effect of brake power on brake thermal efficiency (BTE) at 190bar injection pressure for diesel and biodiesel (S75+J25) blends are shown in fig 1.1.2. BTE is the indication of conversion of the chemical energy fuel into heat energy. Brake thermal efficiency increases as brake power (BP) increases, this is the being the properties of diesel engines. The diesel has got the higher BTE which is 27.54%. The BTE for 100% biodiesel blends (S75+J25) is the least. The lower brake thermal efficiency of biodiesel (S75+J25) may be because of lesser heating value (CV) biodiesel in context to the diesel. It may also because of incomplete combustion of biodiesel (S75+J25) and diesel blends, due to higher viscosity of the biodiesel fuel. Amongst all the blends B20 shows the higher BTE which is very much closer to neat diesel. For other blends the BTE lies between the brake thermal efficiency of biodiesel blends (S75+J25) and neat diesel. The percentage decrease of brake thermal efficiency for different biodiesel (S75+J25) blends with diesel are as presented here, for (B100, B80, B60, B40 and B20) is reduced by 7.49%, 6.78%, 6.62%, 6.17% and 4.87% respectively.

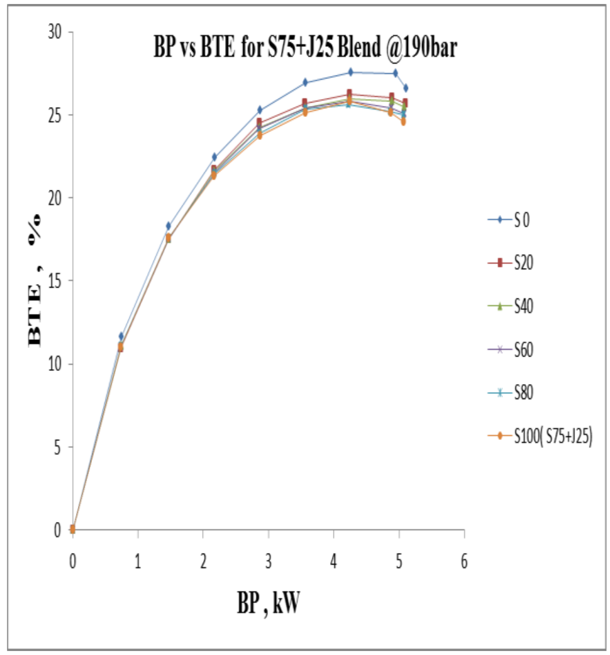

Fig 1.1.2 shows the effect of brake power (BP) on brake thermal efficiency (BTE) for diesel and biodiesel (S75+J25) blends at 190bar.

1.1.3. (EGT) Exhaust gas temperature for (S75+J25) blend at 190bar:

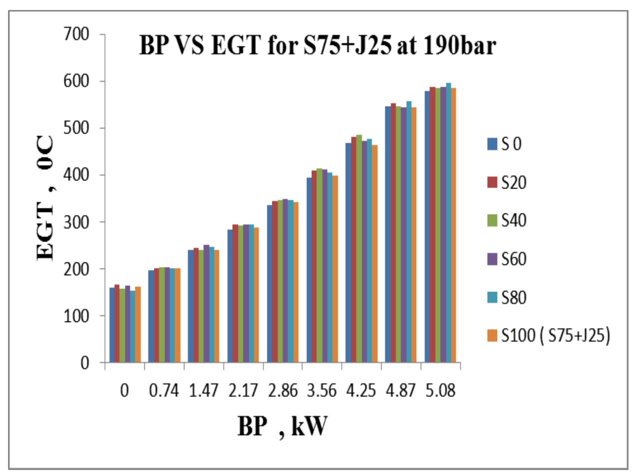

Fig 1.1.3 shows the effect of brake power on exhaust gas temperature for diesel and biodiesel (S75+J25) blends at 190bar.

The effect of brake power on exhaust gas temperature at 190bar injection pressure for diesel and biodiesel (S75+J25) blends are shown in fig 1.1.3. EGT for all the diesel and biodiesel (S75+J25) blends are more in comparison with diesel. The more EGT may because of delayed combustion of biodiesel (S75+J25) and diesel blends due higher viscosity of biodiesel (S75+J25) blends, that forms larger droplet size, take more time to evaporate and burn due this region the EGT is more i.e., higher for biodiesel (S75+J25) blends which is differ from diesel. Higher EGT shows that the indication of converting heat energy into mechanical energy is less. More of the heat is going waste in the form of exhaust. The increase of exhaust temperature for diesel and pure biodiesel is observed, Compared to B0, the EGT increases for B20 by 1.36% and reduces for B100 and B40 by 1.19% and 0.92% respectively.

1.2. b. Emission Characteristics for blend (S75+J25) at 190bar:

1.2.1 Carbon monoxide (CO) for blend (S75+J25) at 190bar:

The effect of brake power on carbon monoxide at 190bar injection pressure for diesel and biodiesel (S75+J25) blends are shown in fig 1.2.1. It mainly depends upon the availability of oxygen (O_2), mixture strength and oil viscosity. Carbon monoxide emissions initially decrease at lowers loads and increases sharply after 4.2 kW of power for all test fuels. Emissions of CO is lower for biodiesel (S75+J25) and diesel blends in comparison with diesel, this may be due to availability of oxygen in the biodiesel that converts CO to CO_2. Higher viscosity of biodiesel and lower injection pressure causes the larger droplets size during injection. Amongst all the blends, the blend B60 shown highest CO in comparison with some other blends, due to incomplete combustion @ higher loads which results in higher CO emissions. It may be noted that with increase in concentration (%) of biodiesel in the blends, the carbon monoxide emission decreases. By keen observations of graph, the 100% biodiesel (S75+J25) blend has lowest CO before 4.2kw power due to complete combustion. At 4.2 kW power on words there is an increase in CO emissions due to incomplete combustion and it burns more biodiesel blends for the production of similar power o/p as same to neat diesel.

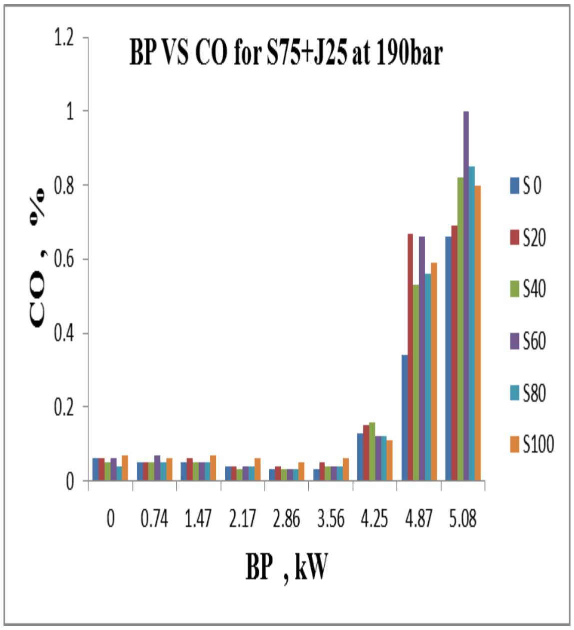

Fig 1.2.1 shows the effect of brake power on carbon monoxide with for diesel and biodiesel (S75+J25) blends at 190bar.

1.2.2 Hydro carbons (HC) for (S75+J25) blend for 190bar:

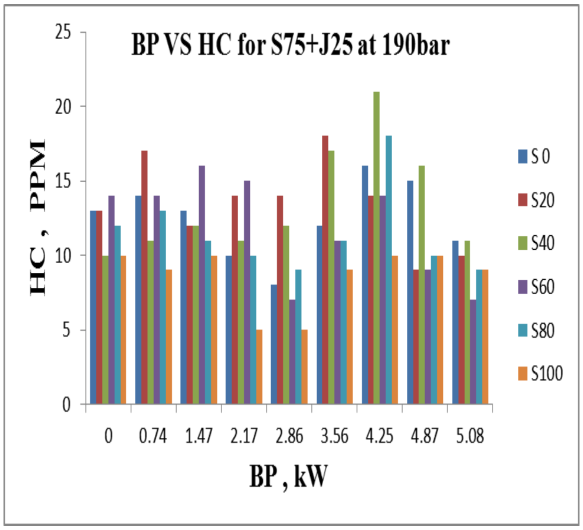

Fig 1.2.2 shows the effect of brake power on hydro carbon (HC) emission for diesel and biodiesel (S75+J25) blends at 190bar.

The effect of brake power on hydro carbons at 190bar injection pressure for diesel and biodiesel (S75+J25) blends is shown in fig 1.2.2. By observing towards the fig, at lower loads emission of HC is higher; this may be due to incomplete combustion.

The incomplete combustion may be due lesser amount of fuel is injected at the lower loads. The quantity fuel which is injected may not find the oxygen for combustion. That may be region for the incomplete combustion that increases the HC emissions at lower loads. As the load increases emission of unburned hydro carbon (HC) decreases this may because of complete combustion of air fuel mixture. By increasing load, there is an increase in fuel quantity injected increases for carrying this increased load. It might be region for complete combustion. If the load increased nearer to the rated load then the emission of unburned hydrocarbon increases again, this may be due to incomplete combustion. By observing the graph, the biodiesel blends namely B40 and B20 exhibits emission of HC similar to diesel and B100 has the least emission of HC in comparison to other blends which has higher O_2 Content which causes the clear and complete combustion of fuel.

1.2.3 Nitrogen oxides (NOx) for (S75+J25) blend at 190bar:

The effect of brake power on nitrogen oxides at 190bar injection pressure for diesel and biodiesel (S75+J25) blends is shown in fig 1.2.3. From fig, nitrogen oxides emissions for all of the biodiesel (S75+J25) and diesel blends emission of oxides of nitrogen are lesser in comparison with neat diesel. It might be mainly due to (IP) injection pressure which forms the larger atoms of biodiesel and diesel blends. The larger atoms of fuel particles injected because of higher density (Viscosity) of biofuel blends. This makes the combustion to be at the slower rate this may cause the lower combustion temperature and hence reduces the emission of NOx. The lesser emission of nitrogen oxides may be also due to the absence of aromatics in biodiesel fuel. Aromatics are the constituents of the forms the nitrogen oxides. Because of absence of aromatics the NOx formation may be lower for biodiesel and diesel blends. With increase in power o/p of engine, the emission of nitrogen oxides increases. With the larger amount of fuel oil supply to engine, there is a gradual increase in combustion temperature is seen and hence there will be higher and longer nitrogen oxides emissions. Increase of NOx in comparison to diesel and for blends B20 and B40 by is increased by 6.30% and 4.30%.

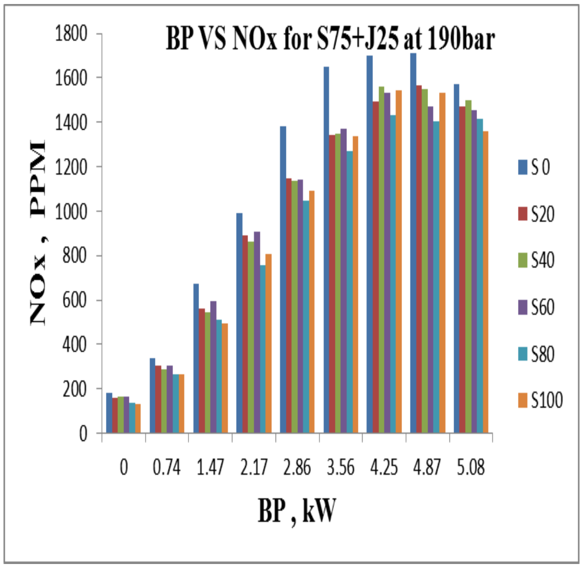

Fig 1.2.3 shows the effect of brake power on nitrogen oxides for diesel and biodiesel (S75+J25) blends at 190bar.

1.2.4 Smoke opacity for (S75+J25) blend at 190bar:

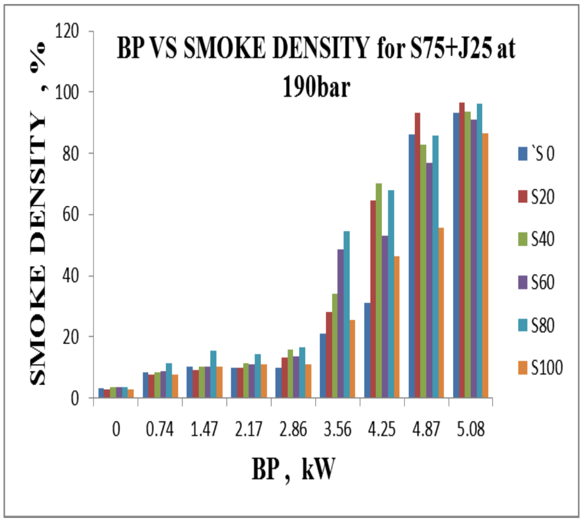

Fig 1.2.4 shows the effect of brake power on smoke opacity for diesel and biodiesel (S75+J25) blends at 190bar.

The effect of brake power on smoke opacity at 190bar injection pressure for diesel and biodiesel (S75+J25) blends are shown in fig 1.2.4. Smoke density are lower at lower loads may be due lesser amount of fuel is supplied that may producing less smoke. there will be increase in smoke density, which might be because of partial or incomplete combustion biodiesel (S75+J25) blends. The incomplete combustion may be due to the fuel atoms injected may be of larger size. The larger atoms of fuel particles may be due to higher viscosity of fuel and lower injection pressure. Smoke formation might depend on the fuel quantity burned and use type fuel used in the engine. Biodiesel (S75+J25) and diesel blends has higher viscosity in comparison with diesel due to the larger (density) viscosity of biodiesel (S75+J25) the droplets formed during injection may be larger that takes more time to evaporate and burn and forms more smoke density in comparison with diesel.

2. Pressure variation with changeable crank angle:

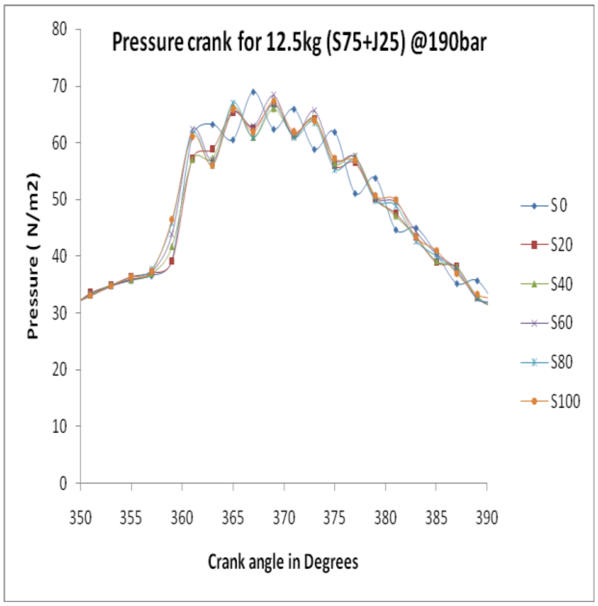

Fig 2. shows the effect of change in crank angle on pressure variations at 190bar injection pressure for blends (S75+J25) at 12.5kg load,

The variation of pressure with change in crank angle for different blends biodiesel (S75+J25) and diesel @190bar injection pressure is shown in fig.2. The variation of pressure with change in crank angle for blends B0, B20, B40, B60, B80 and B100 at 12.5kg load are presented. The maximum peak pressure for B0 recorded at 190bar injection pressure is 76.29bar where as for biodiesel B80 the maximum pressure 73.05 bars. The lower pressure for the biodiesel is due to the lower energy content of biodiesel. Maximum peak pressure for blends B20, B40, B60 and B80 are 75.75bar, 73.05bar, 73.89bar and 73.05bar respectively as shown in fig 2. From graph it will be noted that the biodiesels (S75+J25) has the more peak cylindrical pressure. It is observed from the figure that the delay period in case of pure biodiesel is lower compared to that of other blends and diesel. The reduced delay period for the pure biodiesel may be due to the higher cetane number of biodiesel. As the percentage of biodiesel in the blend increases the delay period for the blends of biodiesel (S75+J25) and diesel decreases.

VI. CONCLUSIONS

From the performance and emission characteristics of compression ignition engine for different blends of biodiesel and diesel the following conclusions were drawn.

- Pure simarouba and pure Jatropha oils have higher viscosity and density.
- Self-ignition temperature of biodiesel is higher.
- Biodiesel fuel properties are closer to diesel fuel.
- Brake specific consumption of biodiesel and diesel blends are more than that of diesel fuel for all the blends.
- Brake thermal efficiency of biodiesel and diesel blends is lower than those of diesel fuel for all the loads.
- Emission of CO, UBHC and NO_x are lower in case of biodiesel and diesel blends.
- Ignition delay in biodiesel and diesel blends are lower.
- Maximum pressure in case of biodiesel and diesel blends is lower.
- Maximum pressure is higher more number of degrees after TDC in case of biodiesel and diesel blends.

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