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Effect of varying fuel injection pressure of Selective Vegetable oil biodiesel on C.I engine performance and pollutants

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Abstract: The aim of this work is to enhance diesel engine performance by varying fuel injection pressure of J20 (Jatropha biodiesel) from 180bar to 240bar through experimental investigation with respect to brake power, fuel economy and smoke emissions in a single cylinder. The result shows that the maximum BTE at 75% load for J20 at 240bar is 3.04% more than standard fuel injection pressure of 200bar, 3.5% Lowered SEC noticed at maximum load at 240bar, HC emissions lowered by 21.4% at 240bar, CO emissions lowered by 0.03% along with the increased NO_X emissions and exhaust gas temperature. The Smoke opacity is 5.2HSU higher for J20 at 240bar,the cylinderpeak pressure is found to be 2.8% higher, the HRR is found to be 4.3% lower when equated to diesel at 75% load against 200bar for standard diesel. From this study, it is clear that J20 biodiesel at 240bar fuel injection pressure will give optimum engine performance.
Keywords: Diesel,Jatropha Oil, Biodiesel, Performance, Emissions.

1. Introduction

Finding alternate fuel sources for diesel engines are significant owing to thinning petroleum assets and the ecological significances of pollutants from diesel engines. The enactment of vegetable oil and it esters were encouraging substitute fuel for diesel engine when the vegetable oil fuels and their methyl esters on CI engines. The researchersevidencedthatvegetableoilblendswerepossiblydecentstandby fuels for diesel engine (1-3). The usage of biodiesel can prolong the lifespan of diesel engines since it is added lubricating than diesel fuel. Biodiesel manufactured from renewable vegetable oils/animal fats progresses the energy safety and economy freedom.

Many researchers (4-10) were experimentally explored the influence of injection pressure on engine performance and pollutants on CI engines. BTE, SEC, Emissions, Cylinder Pressure and HRR were measured for both full load and part load by varying the injection pressure from standard to various reduced and increased fuel injection pressure ranging from100 to 250bar and at 50%, 75% and 100% load. The outcomes showed that the SEC and emissions were lesser except NOX, and BTE and NO_X were high for optimum fuel injection pressure ranging from 220 to 240bar.

Biodiesel is much cleaner than fossil-fuel diesel. It can be utilized in diesel engine without any alterations. Biodiesel is better for the environment because it is made from renewable resources and has lower emissions compared to petroleum diesel (10-12).

2. Vegetable Oil Biodiesel

The prospect of utilizing vegetable oilin diesel engines has been acknowledged ever since the launch of CI engines. Vegetable oil has high viscosity when equated to diesel. There are dissimilar methods to lessen the vegetable oil viscosity. Dilution, Transesterification, Emulsification and Pyrolysis are the four practices to resolve the difficulties met by the higher viscosity. The best collective method utilized to shrink oil viscosityis termed as transesterification. Organic alteration of oil to its identical oily ester is named as transesterification (13).

The transesterification ensues fine in the firm of certain identical substances such as potassium hydroxide, sodium hydroxide and sulphuric acid. Sodium hydroxide is well recognized and extensively utilized, because of its lower cost and higher yield (14). Transesterification is the exercise of switching the alkoxy cluster of an ester combined by added alcohol. These reactions are repeatedly catalyzed by the tallying an acid and base. Bases could catalyze the response by eradicating a proton in the alcohol, thus creating it added responsive; whereas acids can catalyze the response by contributing a proton towards carbonyl group, therefore building it further responsive (15). The schematic of the biodiesel production method as revealed in Figure 1:

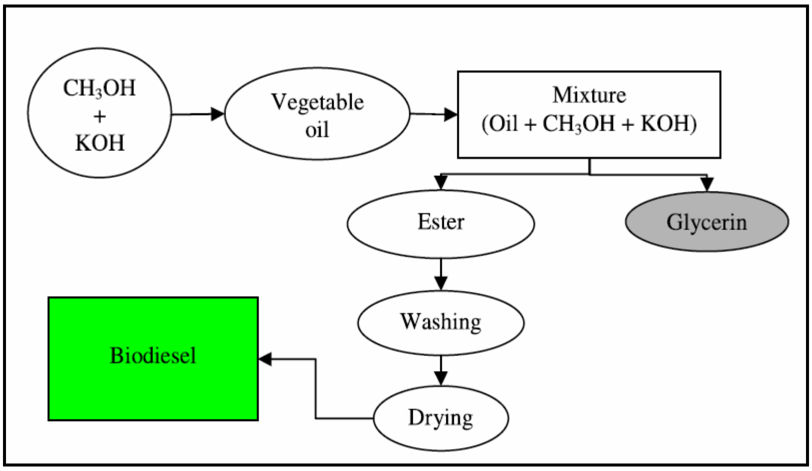

Fig. 1 Schematic of the biodiesel production method

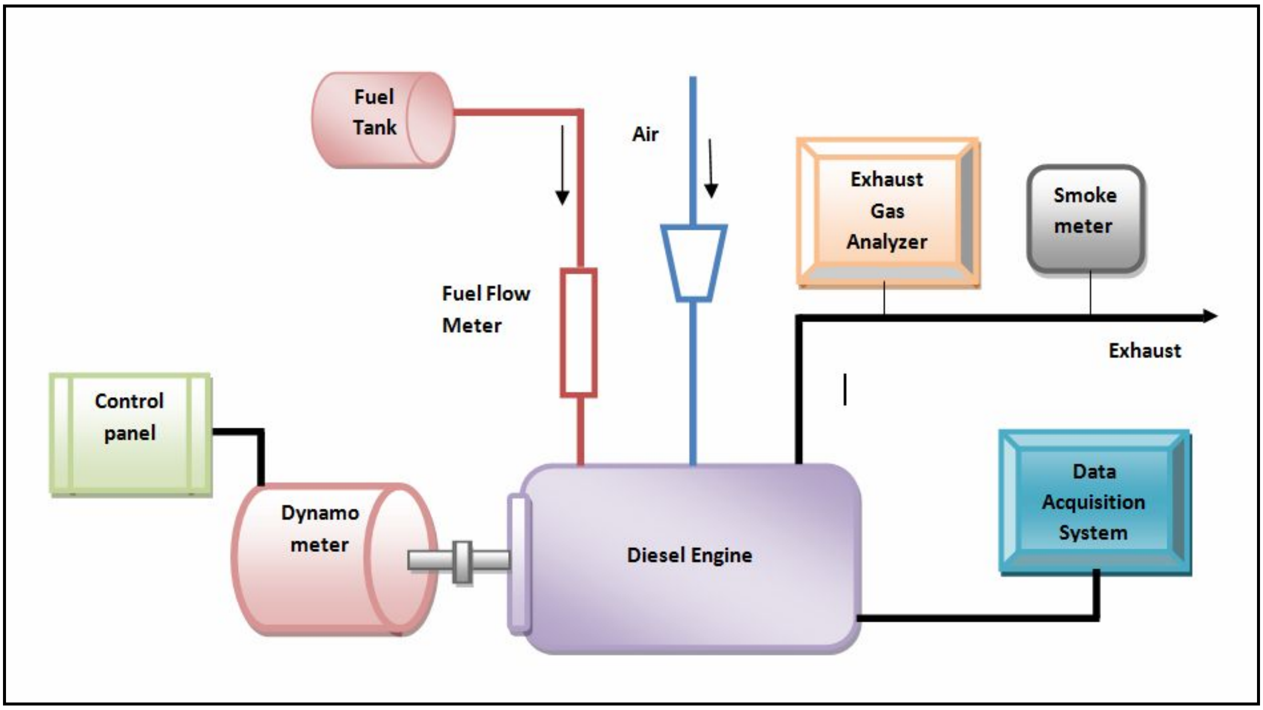

Fig.2 Experimental Setup Line Diagram

3. Experimental Setup

Experimentation were conceded on a water cooled single cylinder diesel engine and the performance and pollutant features of the engine with biodiesel blends were gauged and equated using the outcomes of diesel. The exhaust emissions were quantified by a Crypton290 series Exhaust Gas Analyzer and AVL make Smoke meter was utilized to size the smoke concentration. The engine was started and run to achieve the stable condition and the engine load was increased gradually to maxi-mum recommended value. The applications of loads were 0%, 25%, 50%, 75%, and 100% respectively. The engine speed was constant at 1800 rpm. Fig. 2 demonstrates the experimental organization. For every load stages, the quantity of fuel consumption, exhaust gas temperature, fuel injection timing, crank angle, hydrocarbon (HC) emission, carbon monoxide (CO) emission, nitrogen oxides (NO_X) emission, smoke emission, combustion chamber pressure and HRR were conceded and recorded the data for several loads. The diesel and biodiesel blends were tried at standard engine specification at normal injection timing 27^0 BTDC, injection pressure of 200bar with compression ratio of 17.5.

Table.I. Engine Specifications

Manufacturer	**KIRLOSKAR Oil Engines Ltd**
Engine Type	Single cylinder Diesel engine
Speed	1800 rpm
Rating at 1500 rpm	5.9 kw
Compression Ratio	17.5:1
Fuel Injection Timing	27˚ BTDC
Method of Cooling	Water Cooling
Injection Pressure	200 bar

4. Results and Discussion

4.1 Brake thermal efficiency (BTE)

Figure.3displays the assessment of BTE with brakepower for dissimilar injection pressures for J20 blend. The investigational outcomes display that the BTE declines when injection pressure is retarded and rises once injection pressure is advanced. The higher BTE for dissimilar injection pressures for J20 blend is witnessed at 75% of load. The BTE at75% of load rises by 1.5% for J20 blend at 220 bar and 3.1% for J20blend at 240bar, when equated to J20 blend at 200 bar at 75% of load (standard injection pressure). This is because at this injection pressure, the fuel sprayed entirely diffuses with air in the combustion chamber which progresses the whole burning prospect. For J20 blend at 180bar, at 75% of load the BTE declines by 3.99% when equated to J20 blend at 200 bar at 75% of load. This might be owing to the deprived atomization and mixture creation throughout combustion, which consequences in imperfect burning.

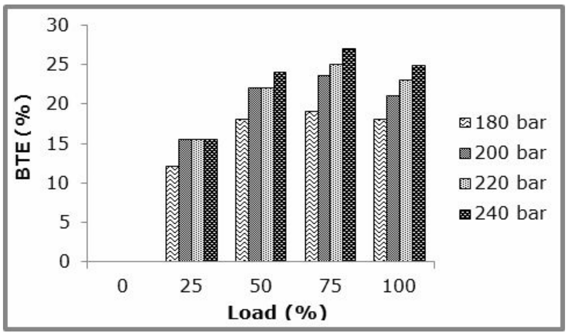

Fig.3 BTE vs. Load

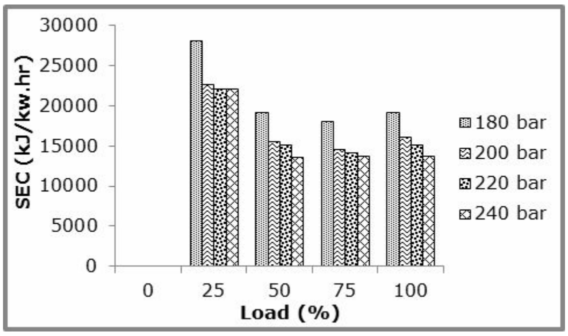

Fig.4 SEC vs. Load

4.2 Specific energy consumption (SEC)

The fig.4 shows that the SEC rate against the various load for all the different injection pressures, noticed SEC at 100% load decreases by 3.15% for J20 blend at 220 bar and 12.36% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at 100% load the SEC is establish to be 3.5% lower when equated to diesel at maximum load. This may be due to the fact that fuel is optimally injected such that proper diffusion of the biodiesel takes place, which results in better combustion. For J20 blend at180 bar, at maximum load the specific energy consumption at increases by 16.5% when compared to J20 blend at 200 bar at maximum load. This may be due to the large cone angle, the intensity of the spray is not optimum which causes more amount of fuel to produce power.

4.3 Hydrocarbon emission (HC)

From fig.5, it is observed that the HC emission at maximum load decreases by 1.3% for J20 blend at 220 bar and 14.5% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load (standard injection pressure). For J20 blend at 240 bar at maximum load the HC emission is establish to be 21.4% lower when equated to diesel at maximum load. This is because of proper diffusion takes place at this injection pressure, due to this it is clear that more amount of HC are burnt and hence the HC content reduces. For J20 blend at 180 bar, at maximum load the HC emission increases by 6.5% compared to J20 blend at 200 bar at maximum load.

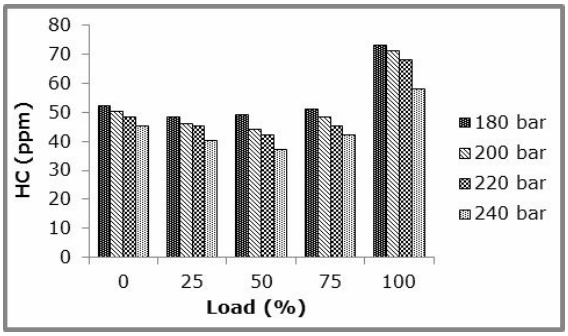

Fig.5 HC vs. Load

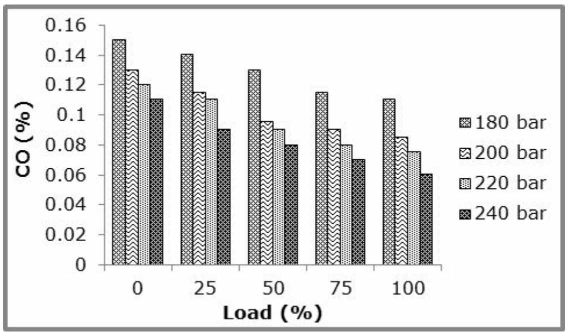

Fig.6 CO vs. Load

4.4 Carbon monoxide emission (CO)

Fig.6 shows that the CO emission at maximum load decreases by 0.006% for J20 blend at 220 bar and 0.017% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at maximum load the CO emission is establish to be 0.03% lower when equated to diesel at maximum load. This may be due to the proper burning, which converts the carbon molecules to CO2 molecules. For J20 blend at 180 bar, at maximum load the CO emission increases by 0.025% equated to J20 blend at 200 bar at maximum load due to the greater droplet size of the fuel, which results in incomplete combustion.

4.5 Oxides of nitrogen emission (NOX)

Fig.7 shows that the NO_X emission at maximum load increases by 5.3% for J20 blend at 220 bar and 19.8% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at maximum load the NOX emission is establish to be 34.8% higher when equated to diesel at maximum load. This may be due to the good atomization and spray characteristics, which results in higher adiabatic flame temperature. For J20 blend at 180 bar, at maximum load the NOX emission decreases by 11.0% equated to J20 blend at 200 bar at maximum load due to the poor atomization and reduced spray penetration which results in poor combustion.

4.6 Smoke opacity

Fig.8 shows that the Smoke opacity at maximum load decreases by 3.1 HSU for J20 blend at 220 bar and 16.1 HSU for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at maximum load Smoke opacity is establish to be 5.2 HSU higher when compared to diesel at maximum load. This may be owed to the improved mixture development, resulting in lower smoke emission. For J20 blend at 180 bar, at maximum load the CO emission increases by 8.5 HSU compared to J20 blend at 200 bar at maximum load due to the heavier molecules in structure, which leads to poor atomization of fuel, thereby increasing smoke emission.

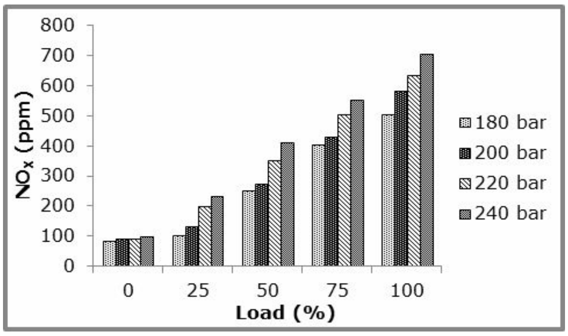

Fig.7 NOX vs. Load

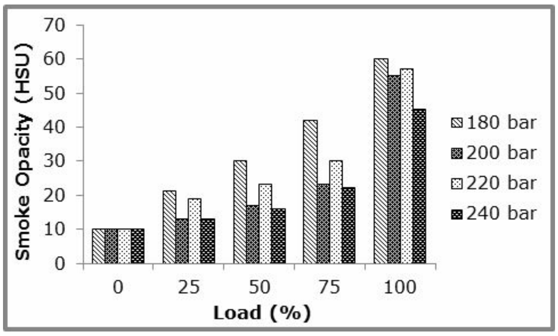

Fig.8 Smoke Opacity vs. Load

4.7 Cylinder pressure and crank angle

Fig.9 shows that the Peak pressure at 75% load increases by 5.03% for J20 blend at 220 bar and 16.77% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at three fourth of load the Peak pressure is found to be 2.7% higher when equated to diesel at 75% load. This may be due to the better utilization of the fuel is which results in increase in the pressure as a result of proper combustion. For J20 blend at 180 bar, at 75% load the Peak pressure decreases by 8.7% when equated to J20 blend at 200 bar at 75% load due to the comparatively poorer burning of fuel because of lower intensity, the combustion pressure is slightly lower.

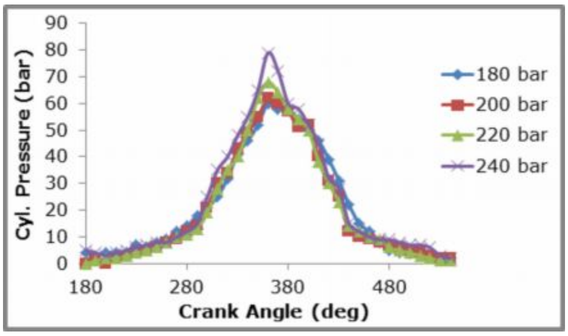

Fig.9 Cylinder Pressure vs. Load

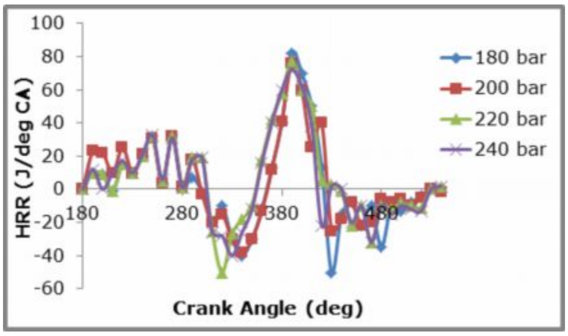

Fig.10 HRR vs. Load

4.8 Heat release rate (HRR)

Fig.10 shows that the HRR at 75% load decreases by 0.15% for J20 blend at 220 bar, 8.66% for J20 blend at 240 bar, when equaled to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at 75% load the HRR is establish to be 4.3% lower when equated to diesel at three fourth of load at standard engine specification. This may be due to the lower release of the heat to the exhaust, which reduces the heat release rate. For J20 blend at 180 bar, at three fourth of load the HRR increases by 7.7% when equated to J20 blend at 200 bar at three fourth of load due to the improper combustion.

5. Conclusion

The present work is to improvise the diesel engine performance by varying fuel injection pressure of J20 biodiesel from 180bar to 240bar through experimental investigation in a single cylinder CI engine. The result shows the following:

- The BTE at 75% of load rises by 1.5% for J20 blend at 220 bar and 3.1% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at 75% of load due to the fuel sprayed diffuses entirely with air in the combustion chamber and progresses the burning. The SEC at maximum load decreases by 3.15% for J20 blend at 220 bar and 12.36% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load.
- For J20 blend at 240 bar at maximum load the HC emission is establish to be 21.4% lower and CO emission is establish to be 0.03% lower when equated to diesel at maximum load due to the proper burning of fuel.
- For J20 blend at 240 bar, at maximum load the NOX emission is establish to be 34.8% higher when equated to diesel at maximum load due to the good atomization and spray characteristics.
- For J20 blend at 240 bar, at maximum load Smoke opacity is establish to be 5.2 HSU higher when equated to diesel at maximum load due to the better mixture formation, resulting in lower smoke emission.
- The Cylinder peak pressure at 75% load increases by 5.03% for J20 blend at 220 bar and 16.77% for J20 blend at 240 bar, when equated to J20 blend at 200 bar at maximum load. For J20 blend at 240 bar, at 75% load the HRR is establish to be 4.3% lower when equated to diesel at 75% load due to the lower release of the heat to the exhaust, which reduces the HRR.

Hence it is clear that J20 biodiesel blend at injection pressure of 240bar with a standard injection timing of 27º bTDC and with a standard compression ratio of 17.5:1 gives slightly improved performance and lesser emission when equated to diesel fuel.

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