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Performance Evaluation on Direct Injection Diesel Engine with Tangential Grooves on Piston Crown

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Abstract: The motive of the experimentation is to improve the combustion of the direct injection diesel engine powered with biodiesel blend. Initial experimentation was made with the diesel in a conventional unmodified diesel engine. By careful literature survey and technical reviews 20% blend of Pongamia biodiesel with 80% of diesel (B20) has been taken as a test fuel. The swirl motion inside combustion chamber is increased by means of providing the tangential grooves over the piston crown with constant depth 2 mm and variable width of 5.5mm, 6.5mm and 7.5mm, maintaining the compression ratio of the engine. Among the various configurations, the tangential grooves of depth 2mm and width 6.5 mm showed the increase in brake thermal efficiency up to 11 % and decreasing trends in hydrocarbon, carbon monoxide, and smoke emissions. Thus the findings of the present work showed the increase in performance and reduction in the emission of the direct injection diesel engine fuelled with Pongamia biodiesel blend.

Key Words: Performance, Tangential Grooves, Pongamia Biodiesel

1. Introduction:

The number of internal combustion engines usage increased drastically after the middle of 20th century. This also increased the overall consumption of fuel for utilization in the internal combustion engine[1].The year wise rise reports on rise of pollution also needed the attention over eco friendly alternate source of fuel[2] Diesel engines are used in transportation power plants. Biodiesel is a clean burning organic fuel derived from the vegetable oils or animal fats. It is reported that the blending of biodiesel with diesel can be made at any proportions.

1.1 Source of Biodiesel:

Biodiesel selection depends on the availability of the crop on the region; it depends on the climatic condition and soil fertility. Again in country like India, the care has to be taken while selecting the biodiesel. This is because if the edible vegetable oil is selected for fuel source, it increases the demand of edible oil for food supply. Countries like United States uses Soya bean as biodiesel source, whereas Europe and other tropical countries canola and palm crop seeds as biodiesel source[3].Pongamia pinnata oil is one of the promising sources of biofuel with yearly production of 200 metric ton. Since India is a rural based country, Pongamia is abundantly available[4].Pongamia oil is a non edible oil obtained from seeds of *Pongamia pinnata* (L) Pierre, family Fabaceae commonly known as 'Karach', 'Karanja' in Assam. In Tamilnadu it is called as "Pungai". It is a hardy tree of 12-15 meter height, branches spread into hemispherical crown of dense green leaves and native to the Asian sub-continent. It is available all over India from the coast line to the hilly slopes. The tree propagates through branch cuttings and root suckers. Commercial productions of seeds start from 10th years onwards of plantation and a full-grown tree may yield up to100 kg[5].From the beginning of diesel engines. The various possibilities of using Pongamia oil as a fuel has been investigated. Pongamia oil is popular due to its low cost and ready availability[6, 7, 8] The viscosity of the vegetable oil is very high, comparing to diesel and hence the viscosity of the vegetable oil has to be reduced. For eradicating the problems arising due to the higher viscosity of the fuel in diesel engine, various methods like Pyrolysis, dilution, microemulsion, Transesterification. Use of additive, Preheating of vegetable oils have–been carried out[9,10,11,1213]. In this study methyl ester of Pongamia biodiesel (MEPO) is prepared by transesterification process. The blend used for experimental investigation was B20 (20% of MEPO and 80% diesel)

1.2 Transesterification process

For bringing out the vegetable oil suitable for using in the diesel engine transesterification had been carried out. The procedure is as follows- a vegetable oil of 1000ml has been taken in a three way flask, a 200 ml of methanol with 12-15 grams of potassium hydroxide (KOH) has been mixed in a beaker to form a solution. Now this solution has been added to three way flask with careful stirring by maintaining the temperature at 65 degree Celsius. At the end of 60 minutes, by maintaining the same temperature and constant stirring the solution has been poured down to the separation beaker and allowed to settle down for 4 to 6 hours. Now the methyl esters can be easily collected from the top of the beaker and heated separately up to 1000 degree Celsius for removing the untreated methanol .Now the impurities like sodium hydroxide can be removed by washing it with 350 ml of water. Again the ester is boiled to remove the water content in it. Thus the pure methyl ester of Pongamia oil (MEPO) has been obtained.

1.3 Swirl Groove:

The effect of swirl in combustion of diesel engine has been studied by many authors. The rotational flow of charge around the cylinder axis is widely named as swirl. Generation of swirl has been usually done by two general methods. One method is to provide a directed port or the deflector wall port and the second method is to provide flow discharged tangentially towards the cylinder centre[14].The swirl motion improves the air fuel mixing thus it promotes the combustion process. Changing the piston crown geometry is one of the easiest way to enhance the swirl motion [15]. In the previous work done by C.V. Subba Reddy et al it has been found that the tangential groove provided in the piston crown increased the brake thermal efficiency and reduced carbon monoxide and hydro carbon emissions from the direct injection diesel engine fuelled with cotton seed oil. In this present work the three configurations of the swirling grooves as similar to the previous work has be designed[16], but the calculations has been made using commercial software for normalizing the compression ratio similar to the conventional diesel engine compression ratio. Thus in this work, the comparison of three swirling grooved piston performance have been evaluated using single cylinder diesel engine fuelled with Pongamia biodiesel(MEPO).

2. Experimental Work:

In the present work piston of 87.5 mm diameter has been designed in an commercial software. Later on the swirling grooves of constant depth 2mm and variable width of 5.5mm, 6.5mm and 7.5mm have been created. After this the volume of the combustion chamber has been obtained using the inbuilt tool of the software. And then the excel sheet has been created to match the new cubic capacity with old conventional cubic capacity. The main cubic capacity volume has been adjusted by means of varying the sphere radius of the piston bowl.

Fig-1 Swirling grooved piston
(width 5.5mm depth 2 mm)

Fig-2 Swirling grooved piston
(w idth 6.5mm depth 2 mm)

3. Experimental Setup :

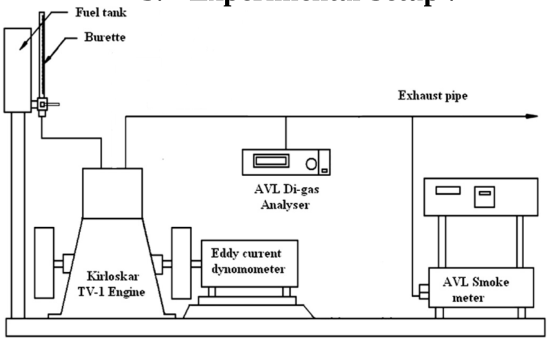

Fig-3 Experimental Setup

The engine used for the investigation is kirloskar SV1, single cylinder, four stroke, constant speed, vertical, water cooled, high speed compression ignition diesel engine. The kirloskar Engine is mounted on the ground. The test engine was directly coupled to an eddy current dynamometer with suitable switching and control facility for loading the engine. The liquid fuel flow rate was measured on the volumetric basis using a burette and a stopwatch. AVL smoke meter was used to measure the smoke emissions and crypton five gas analyzer is used to measure CO and HC emissions from the engine exhaust.

4. Test Method:

The engine performance and emission characteristicshave been taken with neat diesel and 20% blend of MEPO is used as base fuel. Then the engine performance and emission characteristics were taken for following configurations.

1. BR-1: Base performance and emission characteristics of engine with neat diesel fuel (100% Diesel)
2. BR-2: Base performance and emission characteristics of engine with B20 (20%MEPO + 80% Diesel)
3. BR-3: Base performance and emission characteristics of engine with B20 fuel and with swirling grooved piston of width 5.5 mm and depth 2 mm [SGP-1]
4. BR-4: Base performance and emission characteristics of engine with B20 fuel and with swirling grooved piston of width 6.5 mm and depth 2 mm [SGP-2]
5. BR-5: Base performance and emission characteristics of engine with B20 fuel and with swirling grooved piston of width 7.5 mm and depth 2 mm [SGP-3]

5. Results and Discussion:

5.1 Performance Characteristics:

5.1.1 Brake Thermal Efficiency:

The variation of brake thermal efficiency with respect to brake power is plotted in the figure 4 .From the figure it is clearly seen that the brake thermal efficiency of the B20 of methyl ester Pongamia oil is lower than diesel. But the modifications on the piston crown improved the combustion efficiency by means of better mixing of air and fuel. The brake thermal efficiency of the engine is found to be maximum with swirling grooved piston 2 of width 6.5mm and depth 2mm this is an eventual cause of optimized turbulence inside the combustion chamber.

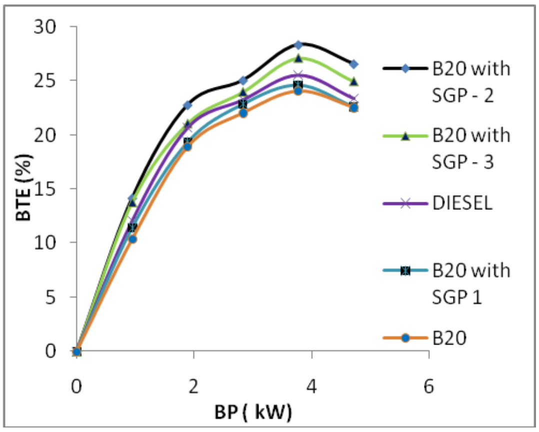

Fig-4 BTE Vs BP

5.1.2 Specific fuel consumption

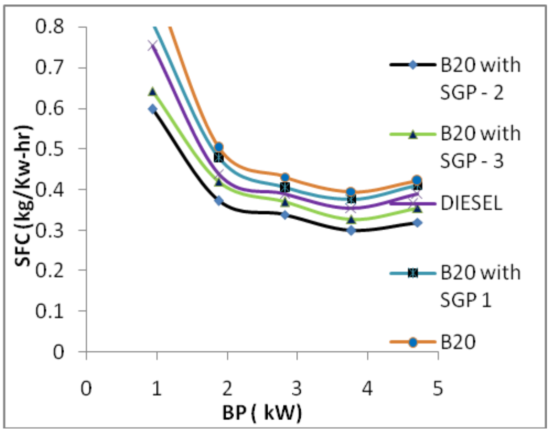

Fig-5 SFC Vs BP

Figure 5 shows the variation of specific fuel consumption with respect to brake power. Specific fuel consumption decreases sharply with increase in load for all configurations. The main reason for this may be that percent increase in fuel needed to run the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads. B20 of MEPO has the highest specific fuel consumption; this is mainly due to the lowest calorific value.

5.2 Emission Characteristics:

5.2.1Carbon monoxide:

Carbon monoxide is formed mainly due to the incomplete combustion and lesser oxygen available during combustion. In the case of SGP – 2 configurations, the carbon monoxide percentage is too low comparing to the other configuration. This is mainly due to the better air fuel mixing and higher turbulence made a way for oxidization of carbon monoxide to carbon dioxide.

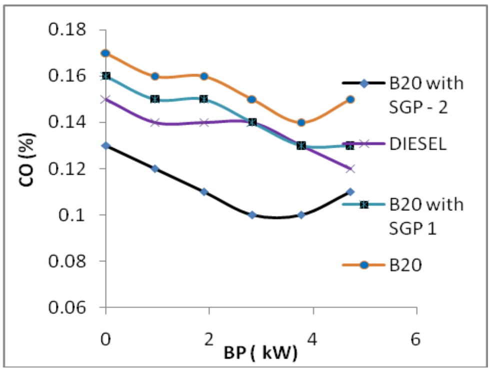

Fig-6 CO Vs BP

5.2.2 Hydro carbon emission

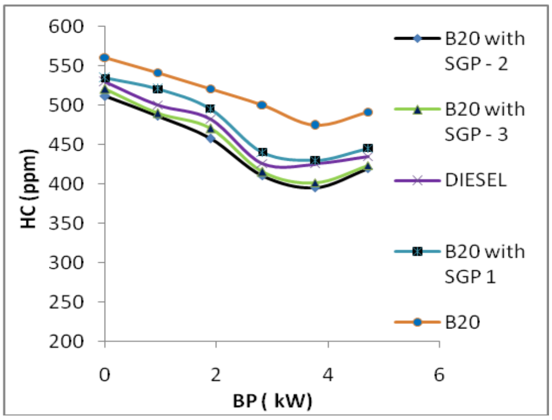

Fig-7 HC Vs BP

Hydro carbon emission from the engine is due to the incomplete combustion of fuel due to the lack of fuel air mixing, lesser combustion time, poor vaporization etc. In case of SGP – 2, the hydro carbon emission is low compared to the other configurations. This is due to the enhanced combustion of fuel.

5.2.3 Smoke

Smoke formation strongly depends on the air flow into the cylinder oxygen amount in the fuel and the composition and structure of hydrocarbon in the fuel. In case of SGP – 2 ,from the graph it is noticed that the smoke is lower due to the better combustion of fuel due to air entrainment due to swirl motion.

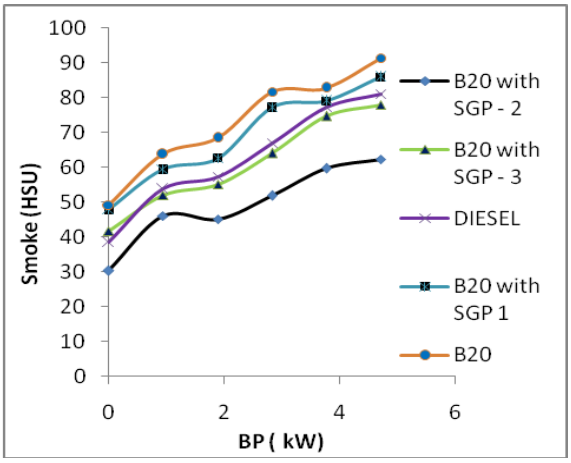

Fig-8 Smoke Vs BP

Conclusion

- The present work reveals that performance, emission characteristics of B20 of methyl ester Pongamia biodiesel can be improved by suitably designing the combustion chamber by providing the swirling grooved piston.
- By means of providing the swirling groove, the emission from the engine is reduced effectively.
- From the results it can be justified that the performance of biodiesel operating engine can be improved by modifying the combustion chamber.
- Thus at this level , it can be concluded that Kirloskar SV1 engine with compression ratio 17.5: 1, Cubic capacity 0.661 litres and injection pressure 200 bar gives better performance and emission characteristics with swirling grooved piston – 2 with constant depth 2mm and width 6.5 mm.

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