Investigation of Spray Characteristics of Biodiesel

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Abstract- *The depletion in fossil fuel and its increasing demand, along with the hazardous emission are some important issues which are leading scientist to research for alternative fuel to replace this fossil fuel. This alternative in case of C.I engines can be biodiesel. Biodiesel is basically a vegetable oil-or animal fat based diesel fuel consisting of long chain alkyl (methyl, ethyl, or propyl) esters. This paper aims to study and discuss the spray characteristics of biodiesel fuel in controlled environment also to identify a fuel in order to successfully replace the classical fuel for compression ignition engines without engine alteration. Spray process being an important part of C.I engine combustion process is one of the major research areas while performing these studies. In general, it was found that the biodiesel sprays penetrate faster and have narrow spray angle along with large droplet size compared to diesel.*

Keywords- Spray Characteristics, Biofuel, Injection Pressure, Performance

I. INTRODUCTION

There are two constant problems related to using petroleum diesel as a fuel in automobiles, they are,

1. Depletion in fossil fuel and its increasing demand
2. The hazardous emission on combustion of the fuel.

These reasons are serious enough to force scientist all over the world to research for an alternate fuel for automotive use. Once of the substitutes that is being considered is Biodiesel. Biodiesel is basically a vegetable oil-or animal fat based diesel fuel consisting of long chain alkyl (methyl, ethyl, or propyl) esters. The reasons for considering biodiesel as fuel are majorly,

- Biodiesel fuel is a renewable energy source unlike petroleum based diesel.
- One of the main biodiesel advantages is that it is less polluting than petroleum diesel; this may be because of the lack of sulphur in 100% biodiesel.
- Another of the advantages of biodiesel fuel is that it can also be blended with other energy resources and oil.
- The lubricating property of the biodiesel may lengthen the lifetime of engines.

Spray atomization of fuel is one of the major part of combustion process in engines. So, if the biodiesel used instead of usual petroleum fuel performs similar to the diesel in terms of atomization, then its engine performance may also be similar.

This paper is dedicated to study of spray characteristics of Cotton Seed Oil when compared to pure diesel in C.I.engine. Also, it will discuss which type of nozzle in terms of number of holes is better when it comes to performance of engine.

II. METHODOLOGY

This study needed two setups;

A. For study of spray and,
B. For performance analysis.

Three fuels with following compositions are used:-

1. Diesel100 [1000 ml diesel]
2. Diesel75 Biodiesel25 [750 ml diesel and 250 ml cotton seed oil]
3. Diesel50 Biodiesel25 Kerosene25 [500 ml diesel+250 ml cotton seed oil + 250 ml kerosene].

A. Setup and method for spray study

Figure 1. Experimental Set-Up

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. As the image below shows, we have modified the basic setup a little and added a transparent chamber with nozzle holder arrangement along with an electric motor (7.5HP).

1 - It shows the transparent box along with the nozzle
2- It shows the small pulley with which the engine output shaft is connected to the motor
3- It shows the bigger pulley connected to motor

The engine is run by rotating its output shat with the electric motor, via a pulley and belt mechanism. This keeps the engine running and the spray of fuel and air mixture from the carburetor doesn't stop. The nozzle connected with the hose pipe is removed from its slot in engine and attached to the chamber.

Due to the motor, the engine won't stop and since engine is running we get a proper fuel and air mixture spray through the nozzle. Since this nozzle is kept in the chamber, the spray can be visualized through the transparent acrylic sheets that make the side faces of the chamber.

This spray pattern was captured with a camera set at 50 frames per second, which allowed to compare the spray of pure diesel with that of blended biodiesel and to check whether these sprays are similar or not.

B. Setup and method for performance analysis

The setup is the same setup as shown above but without any modification. The engine runs properly on fuel and the performance of engine is studied by changing the fuels. The practical observations are taken from the Engine Panel Box. It is fitted with Fuel pipe (Glass), Manometer, Fuel DP transmitter, Air transmitter, Orifice for air metering, Transmitter panel (fitted with Power supply and five Temperature transmitters), NI-6210 USB interface with cable for computer. Below is the image showing the panel box.

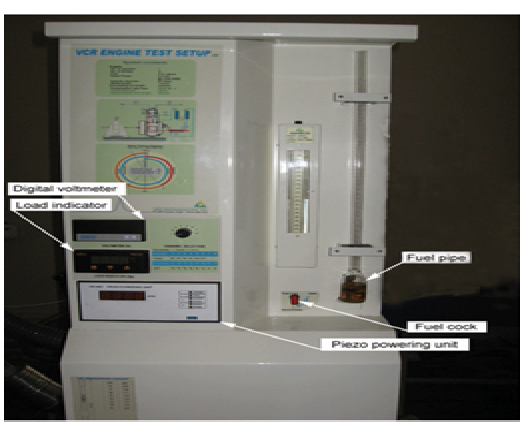

Figure 2 Reading Panel (Fluid Flow, RPM, Load, Manometer, Rotameter & Loading)

Fuels taken for experimentation are as follow,

Table 1.Fuels taken for experimentation

S.No.	Fuel	Density (Kg/M^3)	Calorific Value (kJ/Kg)
1.	Diesel(100%)	830	42000
2.	Diesel(75%)+Cottonseed Oil(25%)	850	39500
3.	Diesel(50%)+Cottonseed Oil(25%)+Kerosene(25%)	833	38500

Images obtained from fuel spray are as follow;

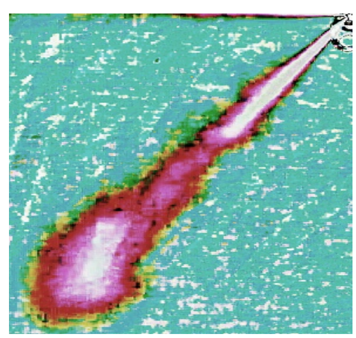
Figure 3. D50B25K25 3-hole

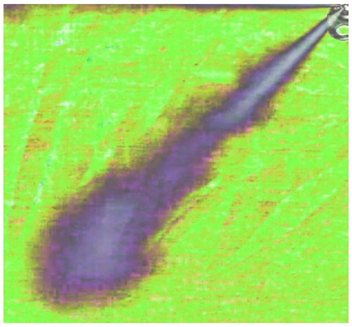

Figure 4. D50B25K25 4-hole

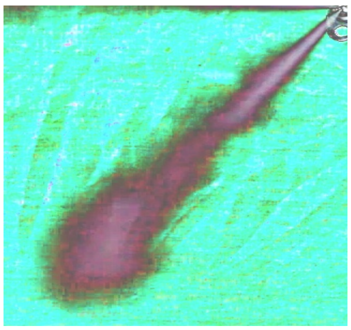

Figure 5. D50B25K25 5-hole

Graphs obtained from the observations made for performance analysis are as follow,

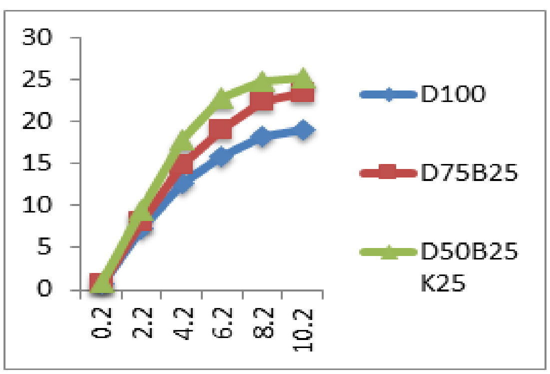

Figure 6. Graph No.01:-Break Thermal Eff. vs Load (3 HOLE)

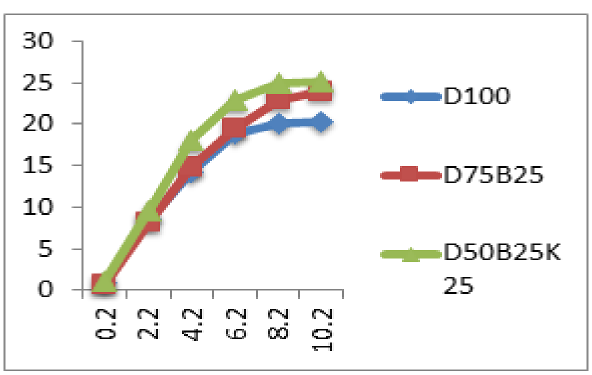

Figure 7. Graph No.02:--Break Thermal Eff. vs Load (4 HOLE)

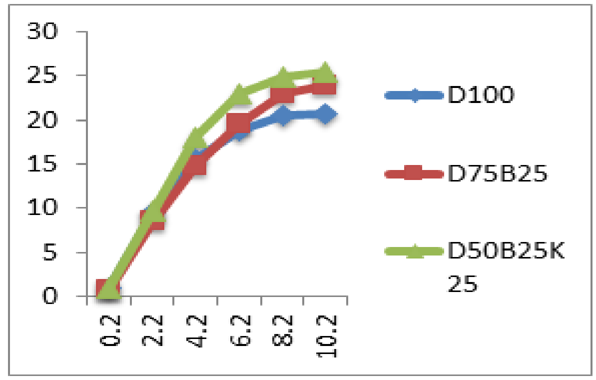

Figure 8. Graph No.03:--Break Thermal Eff. vs Load (5 HOLE)

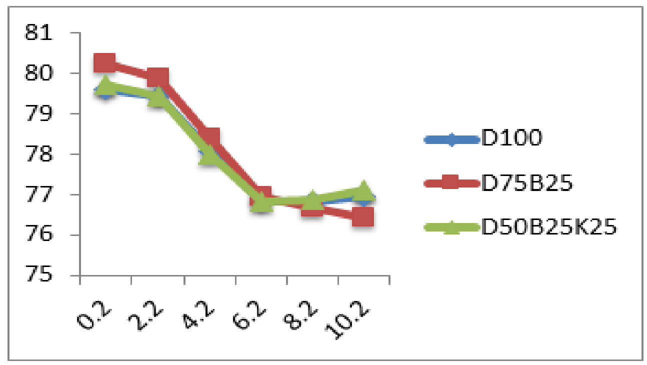

Figure 9. Graph No.04-Volumetric Eff. vs Load (3 Hole)

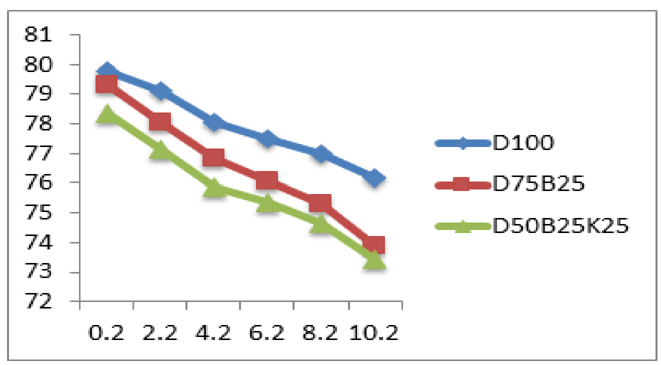

Figure 10. Graph No.05-Volumetric Eff. vs Load (4 Hole)

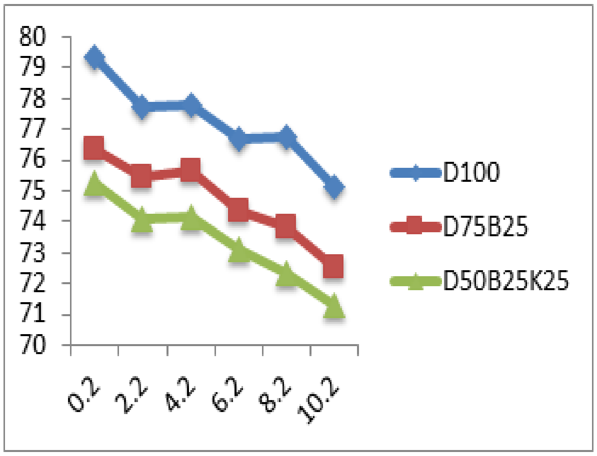

Figure 11. Graph No.06-Volumetric Eff. vs Load (5 Hole)

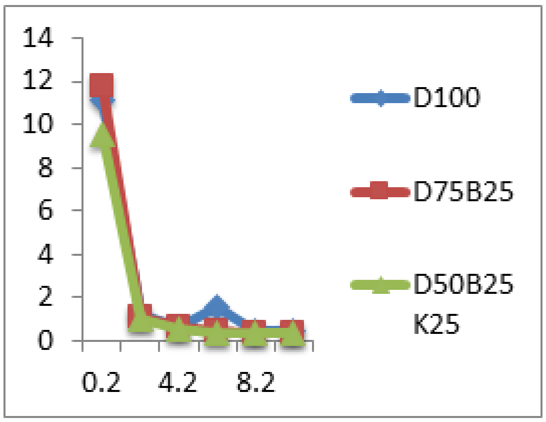

Figure 12. Graph No.07-Brake Specific Consumption vs Load (3 Hole)

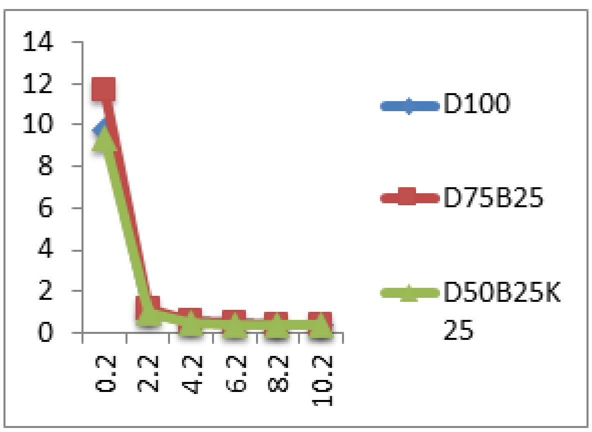

Figure 13. Graph No.08:Brake Specific Consumption vs Load (4 Hole)

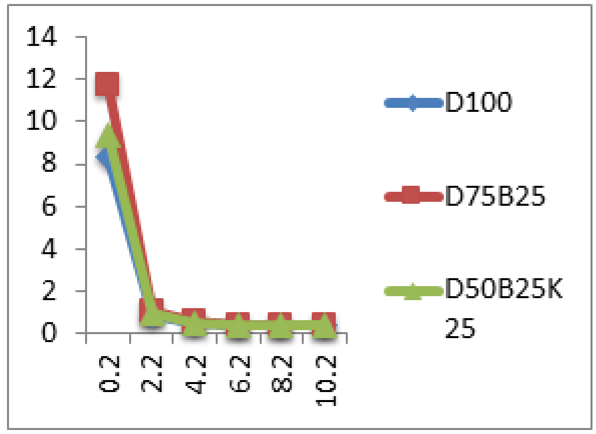

Figure 14. Graph No.09Brake Specific Consumption vs Load (5 Hole)

III. RESULTS

A] Results from spray image analysis,

Table 2.

S.No	Spray Characteristic	Fuel	Nozzle Type
1.	Spray Angle	D75B25 > D50B25K25 > D100	5 Hole > 4 Hole > 3 Hole
2.	Spray Length	D100 > D50B25K25 > D75B25	3 Hole > 4 Hole > 5 Hole
3.	Spray Break-up Length	D100 > D50B25K25 > D75B25	3 Hole > 4 Hole > 5 Hole

B] Results from engine performance analysis,

S.No	Analysis Factor	Fuel	Nozzle Type
1.	Break Thermal Efficiency	D50B25K25 > D75B25 > D100	5 Hole > 4 Hole > 3 Hole
2.	Volumetric Efficiency	D100 > D75B25 > D50B25K25	3 Hole > 4 Hole > 5 Hole

V. CONCLUSION

A. SPARY STUDY CONCLUSIONS

- The spray angle of D75B25 is the highest and this can be said due to the comparatively higher density.
- Both spray length and break up length are highest for D100 and it is also because of the fact that fuel with low density show highest penetrating behavior.
- It can also be concluded that as the number of holes increase the penetration of spray decreases and the spray and increases. So, 5 hole nozzle has highest spray angle and the lowest penetration.
- In terms of spray behavior, it can be clearly seen from the images that the blend D50B25K25 has more similar spray nature to that of pure diesel (i.e. D100).
- This similar spray nature of blend D50B25K25 to pure diesel can be because of the little difference in the densities of the two fuels.

So it can be concluded that the spray characteristics of fuel is highly depended on the density of fuel and hence a substitute fuel having density near to that of pure diesel will generate similar spray characteristics to it.

B. ENGINE PERFORMANCE ANALYSIS CONCLUSIONS

- Break thermal efficiency (BTE) of pure diesel is lower than other two fuels. And this is because BTE is inversely proportional to fuel flow and calorific value, and since D100 has lowest density, its fuel flow is higher and also it has the highest calorific value.
- When comparing g D50B25K25 and D75B25, since the calorific value of D75B25 is higher, it has lower BTE. But the difference in their values is minimal because of the fact that density of D50B25K25 is lower than the other, and hence causing the BTE to balance out the high difference in calorific values.
- The high volumetric efficiency of D100 shows that the better combustion of fuel takes place when pure diesel is used.
- And the lower value of volumetric efficiency for D50B25K25 clearly states that the combustion of fuel is comparatively of lower quality than the other two fuels.

Eventually it can be concluded that-

Cotton seed oil can be used as a substitute of pure diesel in C.I.Engine if its blend formed with diesel has a density closer to that of pure diesel. Also if better spray characteristics are need then an additive needs to be added to this blend in small quantity which is more volatile in nature similar to kerosene, but less polluting one.

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