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Spray Structure of Alternative Fuels - a Comparitive Analysis of Bio – Diesel and Diesel

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Abstract. The aim of the work was to fabricate a constant volume chamber to analyse the spray structure of different fuels. The constant volume chamber is a chamber made of glass, in the shape of a cube. The dimensions of a single cylinder engine are taken and are scaled down in a suitable ratio to give the dimensions of the chamber. The injector used in this process is a multi hole injector. The motor is a single phase AC motor and a diesel pump is used. The fuel is stored in a tank, from which it is pumped to the chamber by means of the pump, which is driven by the motor. The injector sprays the fuel and the image of the spray is captured with the help of a camera. The different images of the different sprays at different bars are analysed and so result is obtained. In this study the spray structure of bio – diesel, diesel and vegetable oil are investigated under ambient conditions by means of a constant volume chamber using a camera. The experimental results show that by adopting bio – diesel in a multi hole nozzle the spray developing patterns are not significantly changed.

Keywords: Spray structure, Bio – diesel, Nozzle

1. Introduction

1.1. Injector

An Injector is a pump like device that uses the pump effect of a converging – diverging nozzle to convert the pressure energy of a motive fluid to velocity energy, which creates a low pressure zone that draws in and entrains a suction fluid. After passing through the throat of the injector, the mixed fluid expands and the velocity is reduced which results in re-compressing the mixed fluids by converting velocity energy back into pressure energy. An Injector consists of a motive fluid inlet nozzle and a converging-diverging outlet nozzle. Water, air, steam, or any other fluid at high pressure provides the motive force at the inlet. Injectors are generally made of Carbon and Stainless Steel, Titanium, PTFE (Poly Tetra Fluoro Ethylene), Carbon and other materials. The image shown below is that of an injector.[1]

1.2. Pump and motor

A pump is a device used to move fluids such as liquids, gases and slurries. A pump displaces a volume by physical or mechanical action. The pump used for this experiment is a diesel pump, which is mainly used for pumping oils. The oil pump in an internal combustion engine is usually a gear type (gear pump), driven by the crankshaft or camshaft, or a rotor type (rotary pump). Gear Pumps are the main oil pumps used. They have two gears that mesh with each other. The two gears are spur gears. They are positive displacement pumps, which mean they pump a constant amount of fluid for each revolution.

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The motor used for this experiment is a single phase AC motor with a 0.25 KW rating. This motor is used to drive the pump, which passes on the fuel to the injector, which sprays it inside the chamber. An AC motor is an electric motor driven by an alternating current. It commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft that is given a torque by the rotating field. An AC Motor has two windings. They are: (i) a constant voltage AC main winding, a constant voltage AC winding in quadrature.[2][3]

2. Specifications of the Motor

The specifications for the motor used in the experiment are as follows:

2.1. Materials used

The material used for the chamber is Glass. The reason for using Glass is that it is transparent, so it enables the spray to be easily captured on camera. The chamber would be under high pressure, when the fuel is injected into it from the injector. Hence, it should be able to withstand high pressure. It is also likely to get heated up. So, it should withstand a certain amount of temperature too. The pipe used for pumping oil from the pump to the chamber is a metal pipe. It should also be able to withstand high pressure. (Considering all the above factors, the material used for chamber is Glass and the pipe is steel).

2.2. Drawbacks of the system

The main drawback of the system is the camera used. The camera used for the project is a medium resolution camera with approximately 30 frames per second (fps). But for the spray structure to be crystal clear, the camera should be a very high resolution camera with nearly 1000 fps in order to capture the spray structure clearly. Such a high resolution camera would cost in lakhs which would be well beyond the budget of the mini project. Hence a high resolution camera is the main drawback of this setup.

3. Design of the Components

3.1. Design of the chamber

The chamber used for the project is made from glass. Glass has been chosen as the material because it is transparent and it enables the structure to be caught on camera easily. Apart from that, glass can withstand certain amount of temperature. The chamber has iron beadings on all the four sides. The chamber used for the project is shown below:

3.2. Specifications of the single cylinder engine

The specifications of the single cylinder engine have been taken as reference for fabricating the chamber to create an engine like condition.

Table – 2:

Rated Power	3.7 KW
Rated Speed	1500 rpm
Bore Diameter	80 mm
Stroke Length	110 mm
Compression Ratio	16.5 : 1
Orifice Diameter	19 mm
Co-efficient of discharge	0.6
Type	4 stroke, single cylinder, Vertical water cooled diesel engine

3.3. Design calculations

The specifications of a single cylinder engine are taken as the base for fabricating the chamber.

The dimensions of the single cylinder engine are:

D : 80mm

L : 110mm

V1 : $\pi \times R^2 \times L$

: $= \pi \times (0.040)^2 \times 0.110$

: $= 0.0005531\ m^3$

Now this volume is equated to the volume of the cube.

Volume of the cylinder = Volume of the cube

V1 = V2

Hence, volume of the cube = $0.0005531\ m^3$

Volume of a cube : a^3

Therefore : $a^3 = 0.0005531$

: $a = (0.0005531)^{1/3}$

: $a = 0.0820$ m

$a = 8.20$ cm

This value is increased by the ratio 5 : 1

Hence the value of a is 5 x 8.20cm = 41cm

So, the value of a, which is equal to the side of the chamber is 41 cm.

a = 41cm

3.4. Terms used in design calculations

D – Diameter of the cylinder of the single cylinder engine

R – Radius of the cylinder of the single cylinder engine

L – Stroke length of the single cylinder engine

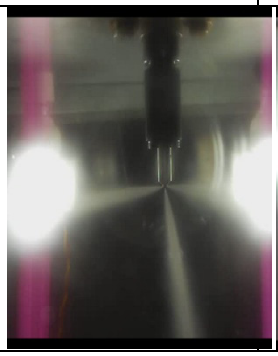
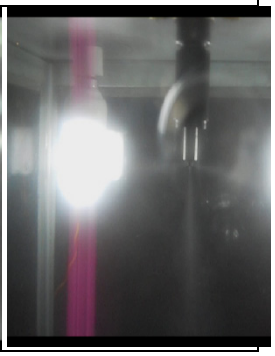
V1 – Volume of the cylinder of a single cylinder engine

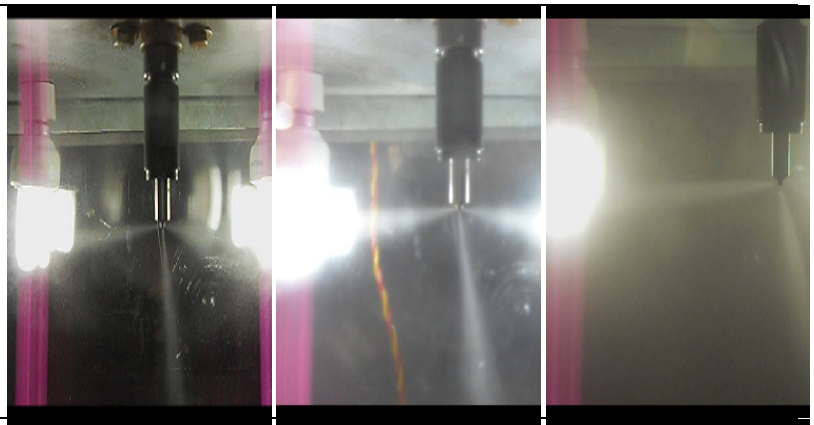
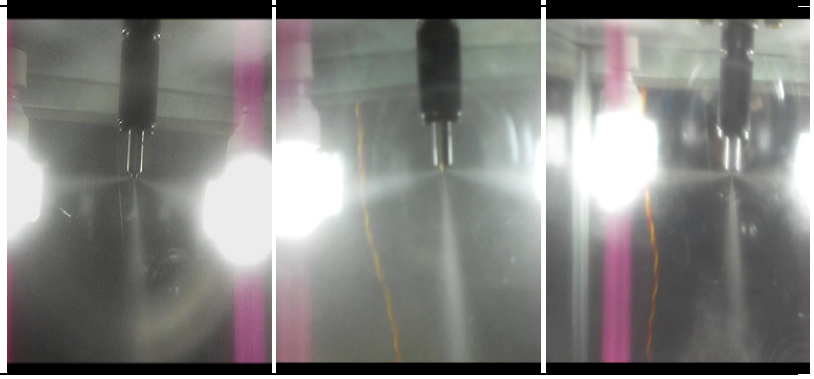
V2 – Volume of the cube

a – Side of the cube

4. Project Images

The images obtained during the project are tabulated as follows:

PRESSURE	180 BAR	200 BAR	240 BAR
DIESEL			

VEGETABLE OIL	
BIO DIESEL	

Various spray angles are given below

PRESSURE	**180 BAR**	**200 BAR**	**240 BAR**
DIESEL	4 degrees	5 degrees	3 degrees
VEGETABLE OIL	4 degrees	8 degrees	9 degrees
BIO DIESEL	4 degrees	4 degrees	4 degrees

5. Inference

From the above experiment it was inferred that the spray structure of diesel was found to be clearer than either the vegetable oil or the bio-diesel. Spray tip penetration decreases and spray angle increases with the addition of bio – diesel fraction. The spray structure of Bio-diesel was least clear among the three.

6. Scope for Further Implementation

This project can further be extended by doing it under evaporating condition. The project now carried out has been at non-evaporating condition. In order to do it at evaporating condition, a heating coil should be added to the chamber so that the fuel that is sprayed inside the chamber is evaporated and then the spray structure is captured. Also, a suction pump can be attached to the chamber by drilling a small hole in the chamber and vacuum is created inside the chamber using the pump and a spray structure at that condition can also be captured.

7. Result and Discussion

With the increase in pressure, say 240 bar, spray pattern decreases for diesel when compared to bio – diesel and vegetable oil. Lower the injection pressure, say 180 bar, bio – diesel gives the better spray structure compared to vegetable oil and diesel. Fuel spray, spray tip penetration and spray angle are usually used to characterize the overall spray structure. The spray angles were obtained by drawing a horizontal line at 20 mm downstream from the nozzle tip and measuring the angle between the edges of the spray and the horizontal lines and the nozzle tip.

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9. References

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