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COMPARATIVE EXPERIMENTAL INVESTIGATION OF COMBUSTION CHARACTERISTICS AT DIFFERENT TEMPERATURES AND CYLINDER PRESSURESFOR PURE DIESEL OIL AND DIESEL FUEL BLENDS

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Abstract — For the recent development and advancement of internal combustion (IC) engine, ignition delay plays a vital role in the engine performance, exhaust emissions & knocking characteristics of a diesel engine. The Ignition delay is the time interval between the start of injection of fuel and the initiation of combustion process. A cylindrical combustion chamber is fabricated for the measurement of ignition delay characteristics for pure diesel oil (B0) and coconut oil-diesel fuel blends (B50). The combustion chamber consist of air heating coils, a hot surface plate, a fuel injector, a pressure gauge, a temperature indicator, a temperature controller and a photo sensor. A compressor is used for charging the air in the combustion chamber. The ignition delay of fuel spray was measured by recording the time delay between the event of injection of fuel and the event of appearance of flame (by using Photo sensor) inside the combustion chamber with the help of Digital Storage Oscilloscope. The measurement of ignition delay for different hot surface temperatures (350°C, 400°C and 450°C), at different cylinder pressures (10-bar, 15-bar, 20-bar and 25-bar) and a constant injection pressure (100-bar) for both pure diesel oil (B0) and coconut oil-diesel fuel blends (B50) is accomplished.

The results show that the value of ignition delay is decreasing with increase in temperature at all cylinder pressures for both types of fuels. At low cylinder pressure (10-bar) and low hot surface temperature(350°C), ignition delay is high for pure diesel oil than the coconut oil - diesel fuel blends. This is because at high temperatures the fuel- air mixing is faster and more fuels are vaporized within a given time period and hence ignition delay time decrease.

Index Terms— Combustion chamber, Digital Storage Oscilloscope, fuel blends, Hot surface temperature, Ignition delay, Photo sensor

1 INTRODUCTION

Auto- ignition is the spontaneous combustion of a fuel air mixture in the absence of any ignition source. Fuel is injected inside the cylinder at the end of compression process with very high injection pressure. This injected fuels in liquid form start vaporization and mixed with high pressure and temperature compressed air and attained the combustible mixture. After some period of mixing between the fuel and oxidizer, ignition occurs. The ignition delay time can be defined as the period between the creation of a combustible mixture, as by injection of fuel into an oxidizing environment, and sustain and onset of the rapid reaction phase leading to the rise of temperature and pressure.

For liquid fuels, the time to form drops, the time for the drops to heat up and vaporize and finally mix with the oxidizer adds considerable physical time to the process. However, once the physical delay has occurred, the chemical delay time dominates and depends upon the kinetics[1].

For light fuels, the physical delay is small, while for heavy and viscous fuels, the physical delay may be the controlling factor. The physical delay is greatly reduced by using high injection pressures and high turbulence to facilitate breakup of jet. In most CI engine, the ignition delay is shorter than the duration of injection [2].

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Hardenberg and Hases predict the duration of the ignition delay period in DI engine, with increase the pressure of combustion chamber, ignition delay will decrease, due to highpressure better mixing and atomization is occur and in the way physical delay of combustion is reduce and ignition delay is reduce [3].

The physical factors that affect the development of the fuel spray and the air charge state (its pressure, temperature, and velocity) will influence the ignition delay. These quantities depend on the design of the fuel injection system and combustion chamber, and the engine operating conditions. Geyer et al compared the engine performance and emission characteristics on a certified diesel fuel, cottonseed oil, sunflower seed oil, methyl ester of cotton seed oil, and methyl ester of sunflower seed oil. They reported slight improvements in thermal efficiency and higher exhaust gas temperatures when operating on vegetable oils[4].

Bagby MO studied fuel injection characteristics of four vegetable oils soybean, sunflower, cottonseed, and peanut in inert nitrogen atmosphere at 480°C and 4.1 MPa. It was reported that injection and atomization characteristics of vegetable oils were markedly different from those of petroleum-derived diesel fuels. Heating the vegetable oils to lower their viscosities increased the spray-penetration rate, reduced spray-cone angles, and resulted in decrease ignition delay [5].

Wang et al evaluated the performance and gaseous emission characteristics of a diesel engine when fuelled with vegetable oil and its blends of 25%, 50%, and 75% of vegetable oil with ordinary diesel fuel separately. They reported that the basic engine performance, power output and fuel consumption are comparable to diesel when fuelled with vegetable oil and its blends [6].

Fig. 1.1 given below showed values of ignition delays for diesel fuels plotted against the reciprocal of charge temperature for different cylinder pressures at the time of injection. The intake air temperature and pressure will affect the delay via their effect on charge conditions during the delay period. Since air temperature and pressure during the delay period are such important variables and increasing in the compression ratio will decrease the ignition delay.

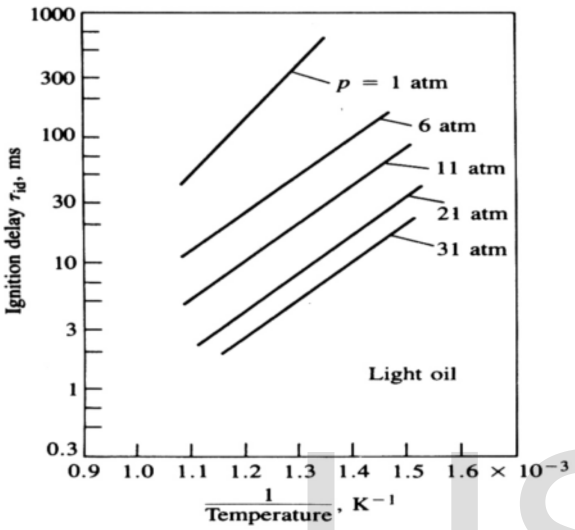

Fig. 1.1: Ignition Delay as a Function of Reciprocal Air Temperature for Light Oil Spray Injected into Constant Volume Bombs. Injection Pressure is 9.8 MPa.[7]

2 Experimental Setup and Test Procedure

The main objective of this experiment to fabricates a constant volume combustion chamber for measuring ignition delay at a different temperatures and pressures. The different pressures are maintaining by using pressure gauge and different temperatures are controlled by using temperature controller. After maintaining required temperature and pressure and fuel is injected at a very high injection pressure for both pure diesel oils (B0) and diesel fuel blends (B50).

The Pictorial view of Experimental setup is shown in Fig 2.1

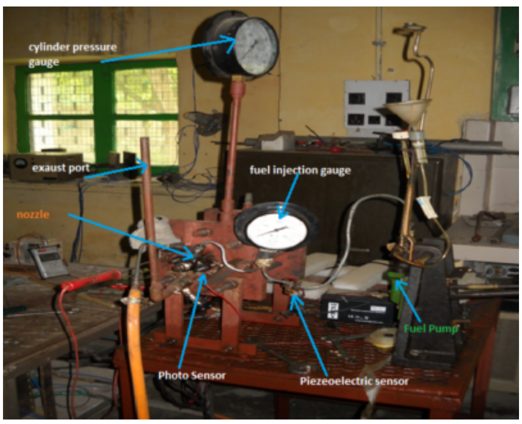

Fig.2.1. Pictorial view of the Experimental Setup

2.1 Components of Experimental Setup

2.1.1 Combustion chamber: A stainless steel cylindrical tank having a constant volume combustion chamber is fabricated for maintaining high pressures and temperatures. High pressure compressed air is supplied from the two stage high pressure reciprocating air compressor. A Single hole nozzle is fitted on the head of the combustion chamber and air heating coils is fitted inside the combustion chamber between two stainless steel plates for increasing the temperature of surface. A photo sensor and a fuel injector are also placed at the other end of the cylinder. The Pictorial view of Combustion Chamber is shown in Fig.2.2.

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Fig.2.2.Pictorial view of Combustion Chamber for Maximum Pressure of 500 bar at Maximum Temperature of 800^{0}C

2.1.2 Air Compressor: During the experiment compressed air is supplied inside the cylinder by using two stage high pressure reciprocating air compressor. Cylinder pressures are maintaining at 10 bar, 15 bar, 20 bar and 25 bar with the help of pressure gauge before injecting fuels in a combustion chamber. The Pictorial view of two stage high pressure reciprocating air compressor is shown in Fig 2.3

Fig.2.3. Pictorial view Air Compressor System

2.1.3 Photo Sensor: The photo sensor is attached to the chamber to detect the event of start of ignition, on the storage oscilloscope (channel 2). For this purpose, we are using a b o-rosil glass window (30 mm thick). Pictorial view of Photo Sensor is shown in Fig .2.4

Fig.2.4. Pictorial view of Photo Sensor.

2.1.4 Temperature Indicator:

The temperature of heated compressed air inside the co m-bustion chamber is display by digital temperature indicator before injection of fuels.

2.2 Test Procedure:

First of all, a sufficient amount of fuel is filled in the fuel metering system and supply a high pressure compressed air in the combustion chamber. The pressure (10 bar) is maintaining by using pressure gauge and heating coil is placed in between the plates to maintain the hot surface temperature (350 ^{0}C) for igniting the fuels. When pressure and temperature are mai n-tained a high pressure fuel injector (200 bar) is used to inject the fuel and time of injector is recorded by using piezomertic sensor. After this fuels start ingiting inside the combustion chamber which is recorded by using photo sensor. Time interval between the start of injection and start of combustion is display at Digital Storage Oscilloscope. Same process is r e-peated for both pure diesel (B0) coconut oil-diesel blends (B50) fuels.If there is no fuels combustion inside the combustion chamber, there is no light intensity on the photo sensor so the output of the Digital Storage Oscilloscope is zero.

The process is repeated for different parameters values for measuring the Ignition Delay for the experiment is shown in table 2.1.

TABLE 2.1

THE PARAMETERS VALUES USED FOR MEASURING THE IGNITION DELAY

Fuel used	Surface Temperature (^{o}C)	Air Pressures (bar)	Injection Pressure (bar)
Pure Diesel	350, 400 and 450	10, 15, 20 and 25	200
Blends (B50)	350, 400 and 450	10, 15, 20 and 25	200

3 RESULTS AND DISCUSSION

The experimentally observed ignition delay times for pure diesel oil (B0) and coconut oil-diesel fuel blends (B50) are shown in below figures.

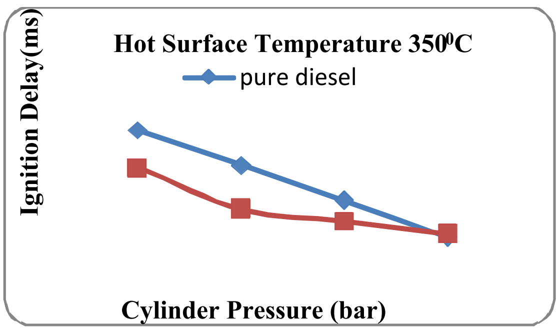
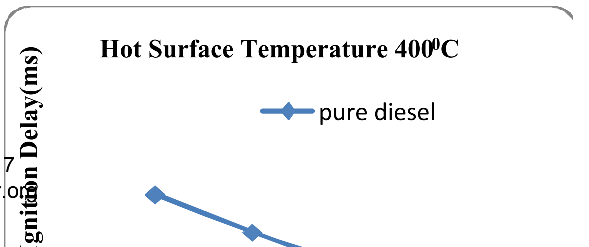


Fig.3.1. Injection Pressure(200 bar) and surface tempera-

80



From the above Fig 3.1, it is clear that Ignition Delay is higher for the Pure Diesel as compared to the Diesel with Vegetable Oil at any cylinder pressures. Ignition Delay value is decreasing if increasing the cylinder pressures for both the fuels because at high cylinder pressure physical delay decreases and hence over all ignition delay decreases. Similar trends are followed for hot surface temperature at 400⁰C which is shown in a Fig 3.2

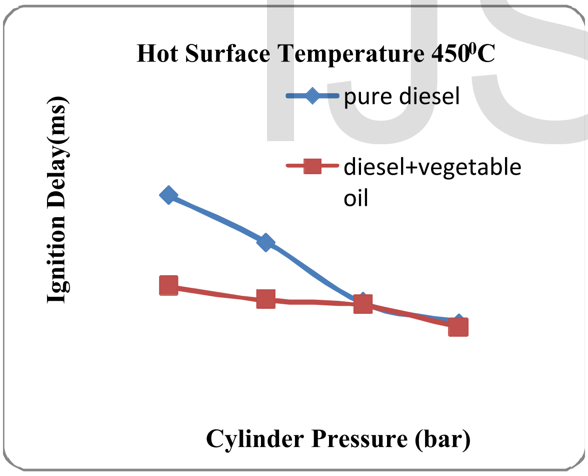


Fig. 3.3. Injection Pressure (200 bar) and surface temperature 450°C

From the fig 3.3, it is clear that Ignition Delay is almost equal at high temperature (450⁰C) and high cylinder pressure (above 20 bar) for both fuels. This is because at high temperature and high pressure the fuel - air mixing is faster and homogenous mixture of fuel and air prepares at faster rate and hence fuels vaporizes easily causing relatively short ignition delay.

4 CONCLUSION

The following conclusions drawn from the present study are given in the following points:

- Ignition delays of diesel fuels (B0) are larger than coconut oil blended diesel fuel (B50) at low pressures and at low hot surface temperatures.
- Ignition Delay for both fuels are decreasing for increasing the cylinder pressures (10 bar to 25 bar) at a fixed Injection Pressure (200 bar) and fixed hot surface temperature.
- At a Particular Injection Pressure, Ignition delay of Pure Diesel (B0) and Vegetable Oil with Diesel fuels blends (B50) are decreasing with increasing the Hot Surface Temperature at a fixed cylinder pressure
- At a high temperature and high cylinder pressure, no effects on Ignition delay if blended fuels are used and do not affect on the engine performance

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