Experimental Analysis of Diesel and Bio-diesel Spray in High Pressure Spray Chamber

[1*]P. Karthik Selvan,
[1]Assistant Professor,
Department of Automobile Engineering,
K.L.N. College of Engineering
Pottapalyam- 630612, Sivagangai, Tamil Nadu, India

[2*] P. Yuva Rajan
[2]U.G. Scholar
Department of Automobile Engineering,
K.L.N. College of Engineering
Pottapalyam- 630612, Sivagangai, Tamil Nadu, India

***Abstract* - The environmental concerns due to increased oil consumption, comes a solution for the development of CI engines which are used as alternative fuels. However, there is need of a fundamental study of mixture and spray formation for a fuel under various conditions. The spray characteristics of the fuel greatly influence emissions from diesel engines. Spray development plays a vital role in controlling the combustion and emission characteristics of engine because it directly affects the air fuel mixture. The spray characteristic of fuel mainly depends on fuel injection pressure, fuel density, fuel viscosity, ambient pressure and temperature. The present work is to examine spray formation in high pressure chamber through optical access. The material used to fabricate the high pressure spray chamber is Cast Iron (CI) and two optical glass fitted perpendicular to each other to capture the spray image inside chamber by using high speed camera. The analysis focused on spray characteristic on spray pattern and spray area. The viscosity effect and chamber pressure leads to change in formation of spray parameters. Spray tip penetration length decrease when increase in chamber pressure. Some other parameters like width, cone angle and area increase when there is an increase in chamber pressure. The spray cone angle increased as the chamber pressure increases for diesel and palm oil methyl ester (POME).**

Keywords: High pressure chamber, Injector, POME, High speed camera, Spray parameters, SMD.

1. INTRODUCTION

The macroscopic spray characteristics such as spray fuel penetration, spray cone angle and droplet size distribution are critical parameters that influence the in-cylinder air/fuel mixture and combustion process of the internal combustion engine. The spray performance is influenced by a large number of parameters including the fuel pressure, fuel temperature, ambient pressure, ambient temperature, fuel properties and nozzle geometry. For a direct injection diesel engine, the atomization performance of its fuel is very important because of its close relationship with the engine efficiency and pollutants emissions. In practical application, the combustion efficiency is strongly influenced by the fuel vaporization rate and the vaporization characteristics which are heavily dominated by the fuel spray atomization since the total surface area becomes large and interacts actively with ambient gas Montajir et al. [1]. The effect of varying fuel injection pressures and injection timings on particulate size number distribution and spray characteristics was investigated in a single cylinder, compression ignition engine fuelled with biodiesel blends with baseline mineral diesel. The investigation results of spray tip penetration and spray area of biodiesel blends and diesel showed that higher fuel injection pressure results in a longer spray tip penetration and larger spray area Saito et al. [2]. The experiment was conducted on "Spray characteristics of diesel in a high pressure constant volume spray chamber". The spray characteristics of the fuel greatly influence emissions from diesel engines. Spray development plays an important role in improving the combustion and emission characteristics of the fuel because it directly affects the air-fuel mixture formation. Spray characteristics of the fuel mainly depend on fuel injection pressure, fuel density, fuel viscosity, ambient pressure, chamber pressure and temperature. Among these, the effect of ambient pressure is very important parameters directly affecting spray pattern. This study investigates the effect of ambient pressure on spray characteristics such as spray tip penetration length, cone angle and spray area. Due to different in viscosity it leads to difference in spray formation Avinash Kumar Agarwal et al. [3].

The experiment conducted on Effects of injection pressure fluctuations on high pressure and evaporating spray behaviour, especially under the representative modern diesel engine injection conditions were carefully evaluated by using well validated two-stage modelling approach. The injection pressure fluctuations have strong potential to enhance fuel/gas mixing processes inside high-pressure and evaporating diesel spray Xiang Wanga et al. [4]. However, there is need for fundamental study of mixture formation and spray combustion process as fuel change. Macroscopic spray characteristics such as spray penetration, spray cone angle and droplet size distribution are critical parameters that influence the in-cylinder air/fuel mixture and combustion process of the internal combustion engine. The spray performance is influenced by a large number of parameters including the fuel pressure, fuel temperature, ambient pressure, ambient temperature, fuel properties and nozzle geometry. For a direct injection diesel engine, the atomization performance of its fuel is very important because of its close relationship with the engine efficiency and pollutants emissions. The transparent windows at the strategic locations on the cylinder to investigate the most significant events taking place inside the cylinder. Optical access for full length of stroke using annular transparent windows or entire cylinder made of transparent material.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

This approach has been mostly used in non-firing tests for flow studied G. Bracho et al. [5].

2. EXPERIMENTAL SETUP

A schematic diagram of experimental setup shown in Fig. 1 The setup consists of high pressure chamber, fuel injection system, high speed camber, pressure gauge, optical window, electric motor (0.25hp) and drain cock. In the experiment diesel and biodiesel spray parameters were observed from a high pressure spary chamber at variable chamber pressure and constant injection pressure (200bar). Testing fuel is supplied to the high pressure chamber by fuel injector from fuel tank. Muti holze nozzle is used to spray the testing fuels. Two optical glasses are fitted in a chamber which is perpendicular to each other to make the inside observable. A halogen lamp is used to illumine for clear and visible images. Pressure inside the chamber was varied by sending compressed gas to the chamber and to measure the pressure inside the chamber using pressure gauge. To exceed the pressure to set value is maintained by relief valve and injected fuel is drained through drain cock. A high speed camera, Fastec motion is used to capture the image under various chamber pressure condtion and it will be further processed and analysed by using Proanalyst software.

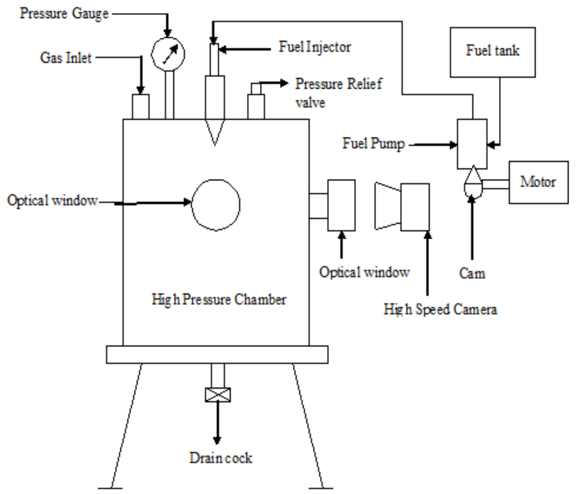

Fig. 1 Schematic Diagram of High Pressure spray chamber

3. RESULT AND DISCUSSION

The objective of this work is to study the spray characteristics like spray tip penetration , cone angle, SMD, width, area and injection velocity for the testing fuel diesel and biodiesel (POME) in a high pressure spray chamber under various chamber pressure conditions.

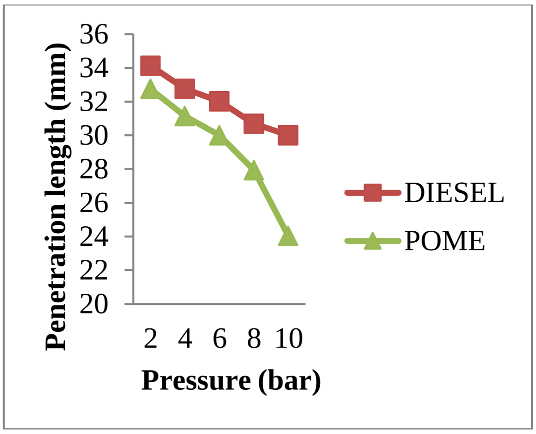

Fig. 2 Effect of chamber pressure on spray Penetration length

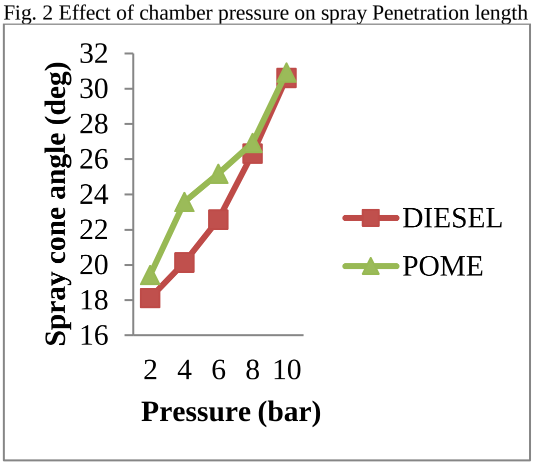

Fig. 3 Effect of chamber pressure on cone angle

Fig 2 shows that spray penetration length for diesel and POME. Spray tip penetration length is total distance covered by the spray in the desired volume. The penetration length is the distance from the nozzle to the end spray. Due to change in viscosity, the liquid kinetic energy is transferred progressively to the working fluid. Increase in fuel viscosity and increase in chamber pressure leads to reduce in spray tip penetration length. By increasing chamber pressure to create a opposing force or upwards force against injector tip will lead to reduce in spray tip penetration length. This is the reason for reducing spray tip penetration length. POME has more viscosity range than compare to diesel so that POME has less penetration range than compare to diesel fuel.

Fig. 3 shows that spray cone angle for diesel and POME fuel in the high pressure chamber at constant injection pressure 200 bars and various chamber pressures 1 to 10 bars are used in evaluating spray formation. The spray cone angle is used to define the angle of the spray penetration**.** It is defined as the quasi steady angle, which is reached after the passing of the spray head. It is the angle formed by two straight lines drawn from the tip of the injector to the outer periphery of injector and is obtained by drawing appreciate lines in the captured images using graphical tool. Due to higher viscosity range pressure acting on the fuel droplets will cause major deflection in cone angle. Spray cone angle has higher fuel density compared to

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

blends and biodiesel, therefore the spray cone angle fuel droplets movement in radical direction is lower compared to its blends.

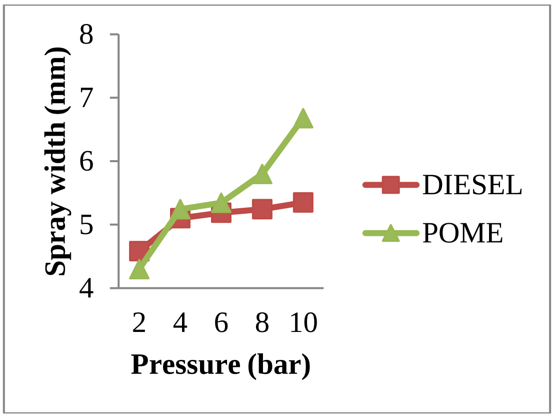

Fig. 4 Effect of chamber pressure on spray width

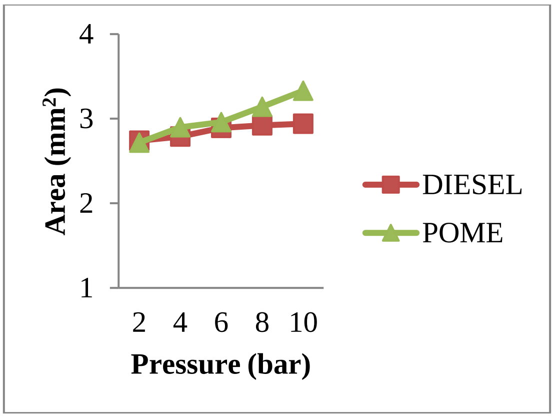

Fig. 5 Effect of chamber pressure spray area

Fig. 4 shows that formation spray width for diesel and POME fuel is in the high pressure chamber at constant injection pressure 200 bars and various chamber pressures 1 to 10 bars are used in evaluating spray formation. The spray width is used to define the size of the spray. It is defined as spray width is measured from a standard distance from the nozzle tip. The spray width of a fuel generally increases for an increase in temperature and chamber pressure. Due to increase in chamber pressure, it restricts spray tip penetration length because of opposing force created inside the chamber against injector tip. This is the main reason for increase in spray width. As compared to diesel fuel, POME has higher viscosity so that it also plays a vital role for increase in width formation.

Fig. 5 shows that total area formation for diesel and POME fuel in the high pressure chamber at constant injection pressure 200 bars and various chamber pressures 1 to 10 bars are used in evaluating spray formation. Overall formation of spray in a chamber during injection process is defined as a spray area. Due to higher friction effect, liquid kinetic energy is transferred progressively to the working fluid. The energy will decrease continuously until the movement of the droplets depends solely on the movement of the working fluid inside the control volume. With increase in chamber pressure and viscosity the friction effect increase thus the formation of spray area will increase with increase in chamber pressure. As the chamber pressure increases from 1 to 10 bar, fuel droplets start concentrating near the centre of spray because of increasingly denser chamber air, which offers stiffer resistance to the fuel droplets. And force them to spread in radial direction thus increasing the cone angle and spray area.

4. CONCLUSION

A number of techniques over the years have been used for combustion and flame visualization in IC engines. Spray characteristics are calculated in a high pressure spray chamber for various chamber pressure condition of 1 to 10 bar pressure value. So that due to viscosity effect and chamber pressure leads to change in formation of spray parameters. Spray tip penetration length decrease when increase in chamber pressure. Some other parameters like width, cone angle and area increase when there is an increase in chamber pressure. The spray cone angle increased as the chamber pressure increases for diesel and palm oil methyl ester. The spray tip penetration of the test fuels decreases as the chamber pressure increases. Initially at 1 bar chamber pressure, cone angle is higher for biodiesel blends is higher compared to biodiesel blends. The cone angle of POME was found to the highest for all chamber pressures condition followed diesel and POME. The spray area is also increased with increasing chamber pressure. The spray area of POME was highest for all chamber pressures followed by diesel. At higher chamber pressure, larger number of biodiesel droplets cluster together because of higher spray penetration length, which is significantly shows a different spray behaviour compared to normal diesel. Injection velocity and SMD values are higher for POME as compared to diesel due to friction effect of a working fluid.

REFERENCES

[1] Montajir, R. Tsunemoto, H. Ishitani, H. and Miami, T. (2000) "Fuel spray behavior in a small diesel engine", SAE paper, 2000-01-0946.
[2] Saito, T. Daisho (2012) "Spray characteristics of biodiesel blends in a high pressure constant volume spray chamber" Experimental thermal and fluid science vol.42, pp. 212-218.
[3] Avinash Kumar Agarwal, Atul Dhar (2014) "Effect of fuel injection pressure and injection timing on spray characteristics" Applied Energy 130 (2014) 212–221.
[4] Wang et al., (2010), "Experimentally and analytically the spray characteristics of biodiesels (from palm and cooked oil) and diesel under ultra-high pressures ", Applied Energy 130 (2014) 212–221.
[5] Hanzhengnan Yu, Xingyu Liang (2016) "Experimental investigation on spray-wall impingement characteristics of n-butanol/diesel blended fuels.
[6] Qiang Cheng, Min Xu "Investigation on the Spray Characteristics of Standard Gasoline, N-pentane, Isooctane and Ethanol " Applied Thermal Engineering ATE 8799
[7] Sangki Park, Seungchul Wooa (2016) "The characteristic of spray using diesel water emulsified fuel in a diesel engine " , Applied Energy 176 (2016) 209–220
[8] J.B. Heywood, (1988) "Internal combustion engine fundamentals", Mcgraw-Hill.
[9] Chandrashekharapura Ramachandraiah Rajashekhar, (2012), "Studies on effects of combustion chamber geometry and injection pressure on biodiesel combustion" CSME-99.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 03, March-2018

[10] Raul Payri, Tiemin Xuan "A study on diesel spray tip penetration and radial expansion under reacting condition", Applied Thermal engineering 90 (2015) 619-629 .
[11] Asif, F. Christopher, SW. Michael, PW. (1996) Air pollution from motor vehicles: Spherical chambers and technologies for controlling emissions. Washington D.C., The World Bank Publications.
[12] Ezoio mancaruso, Luigi sequin "First and second generation spray characteristics in a diesel engine "Fuel 90 (2011) 2870-2883.
[13] Ugural A.C., "Mechanical Design, an Integrated Approach", McGraw-Hill, 2003.
[14] Sundararajamoorthy. T.V, Shangumam. N, "Machine Design", Anuradha Publications, Chennai, 2003.
[15] Investigation', SAE Technical Paper Series, Volume 84 No. 422 ASKzn 2007, Stainless Steel Technical Data, Viewed April 11 2007, http://www.askzn.co.za/tech.
[16] Reddy **(**1994**) , "**Droplet size measurement and engine performance using non-edible oils", Industrial Crops and Products 74 (2015) 767–77
[17] Luo Maji. (2011) "Numerical simulation of the effects of combustion chamber pressure on spray formation in diesel engine", School of automotive eng.
[18] Saito, T. Daisho, Y. Uchida, N. Ikeya, N. (1986) "Effects of combustion chamber geometry on diesel combustion", SAE paper, 861186.

(This work is licensed under a Creative Commons Attribution 4.0 International License.)