EFFECT OF INJECTION PRESSURE ON THE PERFORMANCE AND EMISSIONS OF BIODIESEL FUELED CI ENGINE

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Abstract: The Biodiesel has been identified as an alternative relatively green fuel for CI engine to tackle the problems of ever increasing energy demand in transport sector and strict emission norms. The injection pressure influences the performance and emission characteristics of compression ignition engines. In this paper, an attempt has been made to review the current status of compression ignition engine fueled with biodiesel at different injection pressure. Some results from the literature have also been presented as case studies. From this study, it has been observed that the higher injection pressure improves the engine performances when fueled with biodiesel. In case of emission, the HC, CO and smoke level are found to be less whereas the emissions of NO_x and CO_2 increase.

Keywords: Biodiesel, Brake thermal efficiency, BSFC, Emission, Injection pressure.

Introduction: Depletion of fossil fuel resources and their contribution to environmental pollution from internal combustion engines and others are the major issues that lead to increasing demand for efficient and eco-friendly energy management schemes for power generation. Over the years, several alternative fuels and their blends with conventional fuels have come up which attracted researchers worldwide to study their performance and emission characteristics. Several factors like the shape of the combustion chamber, the location and angle of the nozzle, the injection rate, injection timing and injection pressure affect the performance and emissions from a CI engines. It is well known that the efficiency of combustion relies heavily on the quality of the air/fuel mixture, which is dependent on the fuel injection into the combustion chamber. Ideally, all of the injected fuel should be in contact with the maximum amount of available oxygen, to ensure that the combustion of the hydrocarbons can be as complete as possible. In general, penetration of fuel will be deeper when the fuel with higher density is sprayed by the injector [1]. When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period will also increase. This situation leads to increase the in cylinder pressure resulting more NO_x and CO emissions [2].

An increase of injection pressure has a significant effect on engine performance and emission characteristics. The increase of injection pressure decreases fuel particle diameter which leads to a better mixing of fuel and air during the ignition delay period, thus the emissions of HC and smoke are reduced as reported in references [3, 4]. It was also found that, a very high injection pressure adversely affects the fuel air mixture as the fuel droplets were very fine, which results an improper mixing [5]. Keeping this in mind, the authors have attempted to present the recent works on this aspect in summarized form.

Performance Characteristics of Biodiesel: Major performance parameters like specific fuel consumption and thermal efficiency as evaluated by different researchers under different operating conditions from their experimental studies are reported in this section.

Effect on brake thermal efficiency: Higher injection pressure causes a better spray formation and atomization which leads to a better combustion [3, 5, 7, 8]. As a result, the brake thermal efficiency increases with the rise of pressure over the manufacturer specification. Also the excess oxygen content of biodiesel enhances the combustion as stated by Gumus *et al.* [9]. As a case study, experimental results from the research works of Puhan *et al.* [8] have been presented here in graphical form in figure 1.

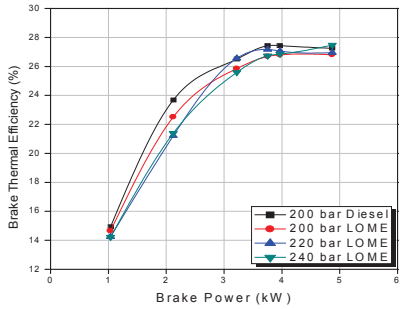

Fig. 1. Variation of brake thermal efficiency for different injection pressure

It can be clearly seen from figure 1 that, brake thermal efficiency at full load is closer to diesel fuel because of improved atomization and better mixing of the charge at higher injection pressure, it is also evident from the figure that at 240 bar injection pressure the efficiency with linseed oil methyl ester is higher compared to diesel at full load condition.

Effect on BSFC: The brake specific fuel consumption (BSFC) value is increased in both increased and decreased injection pressure. While decreasing the

pressure, the coarse fuel particle causes a higher ignition delay period which increases the value of specific fuel consumption. With the increasing pressure, BSFC values also increases because of the shorter ignition delay which causes an improper mixing of air-fuel mixture and causes an increase in BSFC. It was reported that with the higher percentage of biodiesel, BSFC value decreases with the increased injection pressure because of better atomization. It was also reported by Sayin & Gumus [5], that an increase in injection pressure decreases the BSFC value. With higher injection pressure, better atomization occur and with the higher needle lift pressure, lesser fuel is admitted into the cylinder as reported by Jindal *et al.* [7] and Puhan *et al.* [8]. Gumus *et al.* [9] observed that, with the increase in injection pressure, the SFC value increases due to lower heating value and higher density. The experimental results from the work of Puhan *et al.* [8] have been presented in figure 2.

The figure shows that fuel consumption with linseed oil methyl ester is higher than diesel. It is due to higher density and lower calorific value of linseed oil methyl ester.

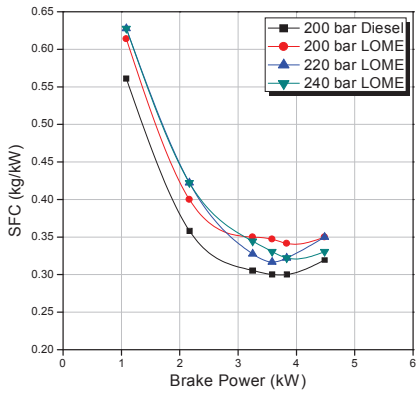

Fig. 2. Variation of specific fuel consumption for different injection pressure

Emission Characteristics of Biodiesel: Major exhaust emissions like HC, NO_x, CO and CO_2 are reported in this section.

Effect on HC emission: HC emission decreases with the increase in injection pressure due to the better combustion. Spray formation improves with the increase in injection pressure which leads to a lower ignition delay results a better combustion [3]. It is observed by Jindal *et al.* [7] and Puhan *et al.* [8] that at lower injection pressure the atomization of fuel is poor, large droplets are formed, which leads to condensed HC at the exhaust. Gumus *et al.* [9] reported that, high velocity of fuel may hit the wall of combustion chamber which can be a cause of higher HC emission at higher injection pressure. The HC emission at higher injection pressure with biodiesel is still lower than that of diesel at design pressure. Raheman & Ghadge [4] experienced that with the decrease in injection pressure, HC emission increased because at lower injection pressure the droplets are coarse, the atomization is poor which results more HC at exhaust. As a case study, experimental results from the works of Puhan *et al.* [9] have been presented here in graphical form in figure 3. It can be clearly seen from figure that, HC emissions at 240 bar injection pressure are higher than 200 and 220 bar injection pressure but still lesser than diesel fuel. The increase in injection pressure may increase the fuel droplet velocity and that may hit the wall of the combustion chamber, which may lead to higher unburnt hydrocarbon emissions.

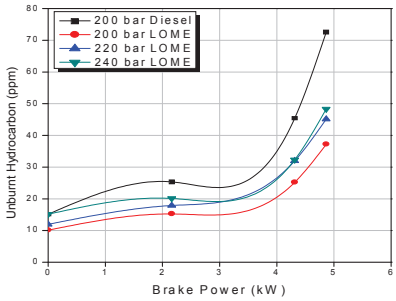

Fig. 3. Variation of hydrocarbon emission for different injection pressure

Effect on NO_x emission: Reddy and Ramesh [5] observed that NO_x emission increases with the increase in injection pressure due to faster combustion and high temperature rise. Higher injection pressure reduces the particle diameter, resulting faster fuel spray vaporization. For that, the combustion rate grows faster initially which causes a high temperature into the cylinder and leads to a higher emission of NO_x. The ignition delay also causes more NO_x with biodiesel [4, 7]. Gumus *et al.* [9] observed that with the increase in injection pressure the ignition delay reduced and the emission of NO_x is slightly lower than diesel at original pressure. Sayin & Gumus [5] observed during their experimental study that, at lower injection pressure NO_x emission is lower. Puhan *et al.* [8] reported that at lower injection pressure, due to availability of fuel inside the cylinder, the peak temperature and pressure raises which causes higher NO_x emission. As a ready reference, experimental results from the research works of Puhan *et al.* [8] have been presented here in graphical form in figure 4. Higher ignition delay produces higher amount of NO_x with linseed oil methyl ester, but with the increase in injection pressure, the physical delay period is less which results a shorter delay and less amount of NO_x produced as shown in figure.

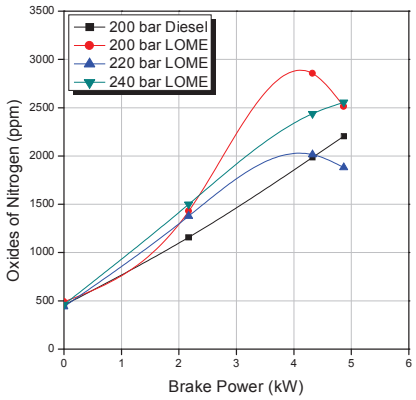

Fig. 4. Variation of oxides of nitrogen emission for different injection pressure

Effect on CO emission: With the increase of injection pressure the emission of CO decreases because the air-fuel mixing is much easier and better which leads to a complete combustion of the mixture, thus the emissions of CO is reduced [5, 9]. Jindal *et al.* [7] and Puhan *et al.* [8] observed that, with the increase in injection pressure CO emission increases because higher injection pressure causes poorer diffusion flame combustion, which results more CO at tailpipe. As a case study, experimental results from the works of Puhan *et al.* [8] have been presented in figure 5. It can be clearly seen from figure 5 that for all injection pressure, CO emissions for linseed oil methyl ester is lower than diesel; it is due to better combustion with linseed oil methyl ester compared to diesel.

Effect on CO_2 emission: Higher injection pressure increases the CO_2 emission [7-9]. With the higher injection pressure, in cylinder temperature increases and the oxidation process of oxygen and carbon molecules also increases which results in higher CO_2 at tailpipe. As a ready reference, experimental results from the works of Puhan *et al.* [8] have been presented here in graphical form in figure 6. It can be clearly seen from figure 6 that for all injection pressure CO_2 emissions for linseed oil methyl ester is higher than diesel.

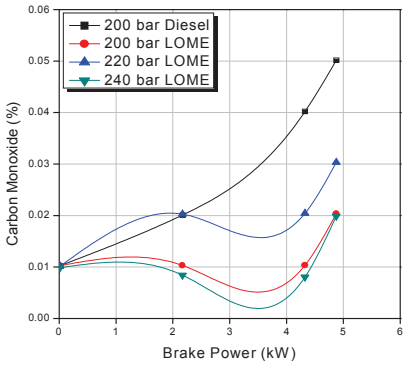

Fig. 5. Variation of carbon monoxide emission for different injection pressure

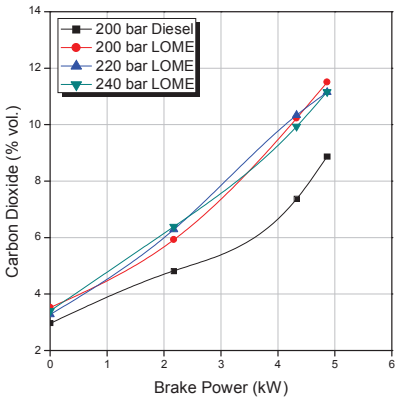

Fig. 6. Variation of carbon dioxide emission for different injection pressure

Conclusions: From the above study it is concluded that, biodiesel can be a suitable alternative to that of diesel. It doesn't require any major engine modification. This makes it very popular among the alternative fuels. Engine operating parameters like injection opening pressure has an effect on engine performance and emissions. The study reveals that the higher injection pressure improves the engine performances when fueled with biodiesel because of better mixture formation leading to a better combustion. It is observed that, in case of emission, the HC and CO are less at tailpipe. On the other hand NO_x is increased because of higher in-cylinder pressure and CO_2 increases because of complete combustion.

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