Effect of Injection Pressure on Emission of CO, Smoke Opacity of Diesel Engine Using Jatropha Curcas Oil Methyl Ester as Biodiesel

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Abstract - ***Global energy crisis, depletion of petroleum reserves, volatile fossil fuel prices and hazardous emissions have led to an imperative need of alternative fuels to replace the conventional fossil fuel with renewable energy sources. Vegetable oil based biodiesel considered as an alternative for petro-diesel due to their comparable chemical properties as petro-diesel fuel. The performance and emission characteristics of engine depend on many factors such as compression ratio, type of fuel, combustion rate, and fuel injection pressure. Fuel opening injection pressure plays a major role for complete combustion of fuel that reduces exhaust emissions. The main objective of the present research work is to evaluate the effect of injection pressure on emission characteristics of a single cylinder, four stroke and water cooled diesel engine. Non-edible vegetable oil based jatropha curcas oil methyl ester and its diesel blends were used as biofuel at different injection pressures. A series of experiments were conducted at a constant engine speed of 1500 rpm with varied injection pressures of 210, 220, 230 and 240 bar on the test engine using the biodiesel and its blends. The effect of injection pressure on CO and smoke opacity of direct injection diesel engine was observed. The test results showed that jatropha biodiesel blends were less CO emission and smoke opacity at 220 bar injection pressure when compared to the remaining injection pressures.***

Key Words: *Biodiesel, Direct injection diesel engine, Emission characteristics, Injection pressure, Jatropha curcas oil.*

1. INTRODUCTION

In recent times, biodiesel shows the best alternative fuel to diesel to meet the present global demand, reduce the dependency on imports and to reduce the environmental pollution. Vegetable oils in neat form can also be used in diesel engine without engine modifications. The past research reviews revealed that edible oils such as soybean oil [1] , soya oil, canola oil [2], Rapeseed Oil [3], sunflower oil [4], palm oil [5], olive oil [6] can be directly or in the form transesterified mode used in diesel engines as biofuel. Vegetable oil as biodiesel fuel usage in diesel engines is as old as Rudolf diesel first demonstrated his new diesel engine at the 1900 world exhibition in Paris by using peanut oil. During that period, availability of cheap fossil fuel, it became a fuel for diesel engine and at World War-II, vegetable oils were again used as fuel in emergency situations when crude oil fuel availability became scarce. Recently depletion of petro-diesel reserves and price hikes re-focussed many nations on usage of vegetable oils as biofuel. It is observed that edible oils in persistent commercial production of biodiesel caused negative impact on diminution of food supply leading to economic imbalance [7,8] especially in thickly populated countries such as India. The research and development in the production of biodiesel is then moved towards using non- edible oils such as linseed oil, mustard oil, cotton seeds oil, castor oil, pongamia, jatropha oil, neem [9] etc., in the production of biodiesel.

Biodiesel is a mono alkyl esters of long chain fatty acids derived from edible and non-edible oils and animal fats. Non-edible oil plants such as jatropha curcas will grow in marginal, waste lands with no possibility of land use and low rainfall. Jatropha oil content varies depending on the types of species and climatic conditions, but mainly on the altitude where it is grown [10]. Moreover, biodiesel is free from sulphur and aromatics, produces lower exhaust emissions than fossil fuel. They are bio-degradable, non-toxic and emit very less exhaust gases when compared with petro-diesel. It is observed that there is decrease in power, reduction in thermal efficiency, increase in BSFC, and lower emissions [11, 12]. So as to prevail these problems few modifications in the engine operating parameters such as oil preheating, varying injection timings, injection pressure, compression ratio, use of multiple injections, and so forth are suggested. As injection pressure increases, the diameters of fuel particle will become small. Fuel injection pressure is one of major factors that influence that fuel injection system in a direct injection diesel engine. For the present work, jatropha curcas oil which is non-edible oil is selected for the study of effect of injection pressure on emission characteristics.

2. MATERIALS AND METHODS

Jatropha curcas seeds are the primary source from which the oil is extracted. Climatic conditions and soil type generally affect the yield of the oil. Jatropha curcas oil was extracted from seeds using mechanical oil expeller and then filtered to remove the impurities. The extraction process was depicted in figure 1.

Fig -1: Extraction of Jatropha curcas oil

Generally vegetable oils have high viscosity and low volatility that creates problems in the test engine. To avoid the engine problems, biodiesel will be prepared using transesterification process.

2.1 Transesterification Process

The triglycerides are converted into alkyl esters, which is the chemical name of biodiesel. Transesterification is the process of using methanol in the presence of catalyst such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), which chemically breaks the molecule of the jatropha oil into glycerol and methyl esters which reduces the viscosity of the selected jatropha oil. Transesterification is the change of the trivalent glycerin molecules against three molecules of mono-valent alcohol methanol. If methanol is used in the chemical reaction, methyl esters are formed, but if ethanol is used, then ethyl esters are formed. Both these compounds are biodiesel fuels with different chemical combinations. In the chemical reaction alcohol replaces glycerin.

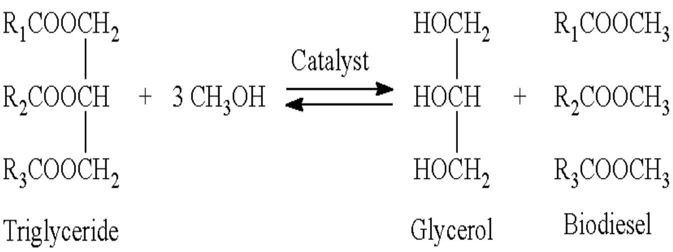

Fig -2: Transesterification reaction

3. EXPERIMETNAL SETUP

Experimental work was carried-out to evaluate the impact of emission of CO and smoke opacity of jatropha biodiesel. Jatropha methyl ester blends (B20J, B40J, B60J, and B100J) and pure Diesel were used in single cylinder, 4-stroke, water-cooled 5 HP diesel engine at 1500 rpm at injection pressures of 210, 220, 230 and 240 bar. The engine emissions from the test engine were studied at full engine load condition. After the engine reached the stabilized working condition, emissions of CO and smoke opacity were measured using a smoke-meter and an exhaust gas analyzer. The experimental set-up is as shown in Figure 3.

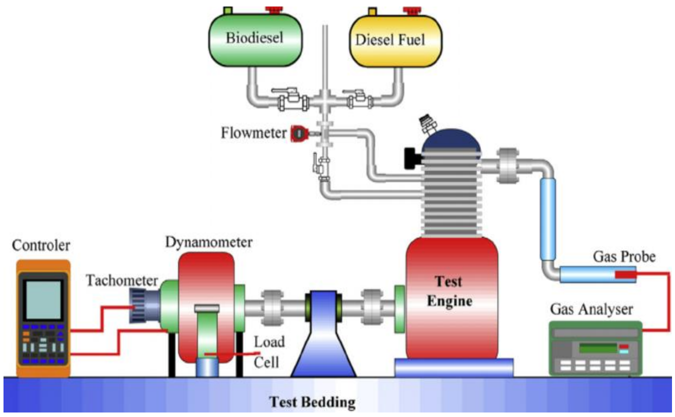

Fig -3: Test engine diagram

The specification of test engine is given in table 1.

Table -1: Engine Specification

Type	Kirloskar
Details	Single cylinder, Four stroke, DI, Water cooled
Bore & Stroke	80 × 110 mm
Rated Power	3.7 KW (5 HP)
Speed	1500 rpm
Dynamometer	Eddy Current

4. EXPERIMETNAL RESULTS AND DISCUSSION

The experimental data obtained from series of experiments were analyzed and the impact analysis was presented below.

4.1 CO Emission

Figure 4 shows variation of carbon monoxide emission at different injection pressures. As shown in figure, neat biodiesel has lowest CO emission and B20J has highest among in all blends of jatropha biodiesel. It is also observed highest CO emission at 240 bar of injection pressure of all blends and the optimum value is found at 220 bar. However the increase of injection pressure from 220 to 240 bar resulted in increase of CO emission as compared to 200 bar of rated injection pressure at full load of the engine. The figure also indicating that after slight increase (10 bar) of rated injection pressure (200 bar), there was a slender increase in CO emission.

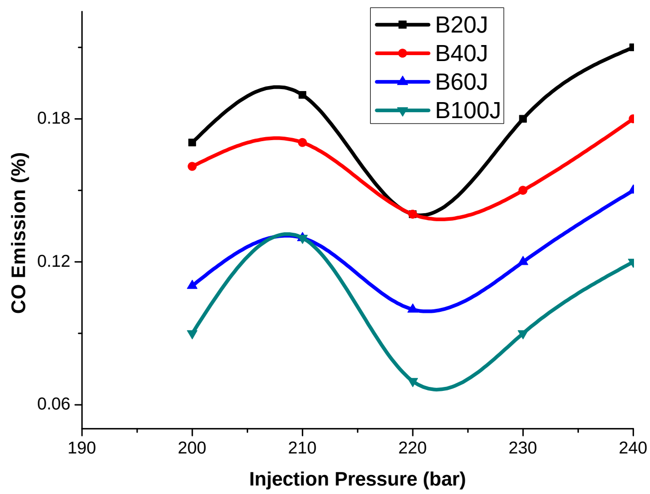

Fig -4: Fuel injection pressure vs. CO emission

The CO emission is found to be decreased with increase in percentage of methyl ester of jatropha curcas oil in biodiesel blend.

4.2 Smoke Opacity

Figure 5 shows the variation of fuel injection pressure with smoke opacity at constant engine speed of 1500 rpm at full load condition.

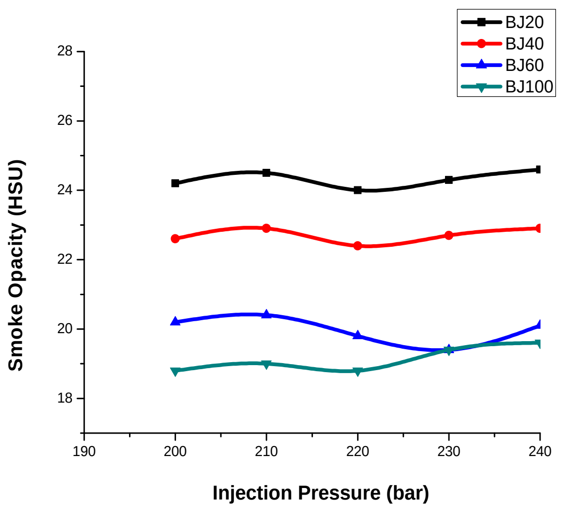

Fig -5: Fuel injection pressure vs. smoke opacity

As shown in graph, reduction of smoke opacity observed with increase of blend percentage of JCOME irrespective of injection pressure. There was increase of smoke opacity of biodiesel at 210 bar, 230 bar and 240 bar of injection pressure when compared with rated injection pressure of 200 bar and less value was identified which can be considered as optimum fuel injection pressure at 220 bar.

5. CONCLUSIONS

Fuel injection pressure is one of the important engine parameters that influences on emission characteristics of diesel engine when fueled with biodiesel. Higher injection pressures generate faster combustion rates, resulting in high cylinder gas temperatures and fuel atomization characteristics improve with higher injection pressure so that higher surface area is exposed to the surrounding air. Experimental evaluation of single cylinder, 4-stroke, water cooled diesel engine fuelled with different blends (B20J, B40J, B60J and B100J) of JCOME at injection pressures of 200 bar, 210 bar, 220 bar, 230 bar and 240 bar at full load condition revealed that B100J has lower carbon monoxide and lower smoke opacity emission at all injection pressures and optimum emission values were observed at 220 bar. The results have also revealed the following:

- CO emission from diesel engine was low at 220 bar of injection pressure for all blend percentage of JCOME. The lowest CO emission at 220 bar of injection pressure is lower than the CO emission at rated injection pressure. Neat biodiesel has lowest carbon monoxide emission in among all blends of JCOME

- smoke opacity has decreased with the increase of blend percentage of JCOME. Neat biodiesel has lowest smoke opacity when compared with all blends of JCOME and at 220 bar is the lowest injection pressure which is considered as optimum fuel injection pressure

The diesel engine with different blends of JCOME exhibits very good emission characteristics at injection pressure of 220 bar at full load condition. This can be considered as rated injection pressure to reduce the emission when fueled with biodiesel in a single cylinder, 4 –stroke water cooled direct injection compression ignition engine at full load condition.

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BIOGRAPHY

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