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# EVALUATION ON INFLUENCE OF FUEL INJECTION PRESSURE ON EMISSION CHARACTERISTICS OF CIDI ENGINE USING JATROPHA OIL METHYL ESTER

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## ABSTRACT
Ever-growing energy demands, diminishing conventional fossil fuel reserves and global inconsistent climatic changes due to emission of dangerous gases, has led to focus on environmental friendly, alternative renewable energy sources. Recently, biodiesels have emerged as the potential alternate to diesel fuel in renewable energy sources. The present work aims to evaluate the effect of fuel injection pressure on the emission characteristics of DI diesel engine when fuelled with Jatropha Curcas Oil Methyl Ester (JCOME). The experimental evaluation was carried out using a four-stroke, single cylinder, water cooled diesel engine fuelled with different blends (B20J, B40J, B60J and B100J) of JCOME at different fuel injection pressures varies from 210 to 240 bar. The test results revealed that B100 blend has lowest particulate matter (PM), CO emission, and higher NOx emission at all injection pressures and optimum emission values were observed at 220 bar for all tested biodiesel blends. The PM and CO emission was decreased with the increase of JCOME percentage in diesel blend. The PM, CO emission from diesel engine was low at 220 bar of injection pressure for all blend percentage of JCOME. The emission characteristics are optimal at fuel injection pressure of 220 bar and it can be treated as optimum injection pressure with reference to emisson parameters. Fuel injection pressure of 220 bar can be considered as rated injection pressure for the tested engine at full load condition in order to reduce the exhaust emissions .

**KEYWORDS**: Biodiesel, Jatropha Curcas Oil Methyl Ester, Fuel Injection Pressure, Emission Characteristics

## I. INTRODUCTION
In these modern days, the economic growth, the global raise in population and the improved living standards of human lives have caused for increased global energy consumption and the rate of energy consumption has became the indicator for measurement of human living standards. So, the global energy demand is ever increasing but not the production due to a range of social and economical factors. In 2014, the global energy consumption was increased by 0.9% and the energy production rate was considerably below the 10-year average. The emerging economies such as south-east Asian countries accounted for recent growth in energy consumption [1]. There is a huge disparity in production and consumption of fossil fuels and the worldwide fuel consumption has increasing more rapidly than its production rise which is causing the price increase of crude oil and raising the concern of need of alternative fuel(s).

The previous research was principally focused on evaluation of engine characteristics without any changes in the engine parameters to identify the suitable alternative fuel. Recent studies on diesel engines shows that engine operational and design parameters such as biodiesel blend percentage, engine load, compression ratio, injection pressure and timings has considerable effect individually or groups of parameters on the engine performance and emission properties. Kenneth et al were conducted engine performance, emission tests on six-cylinder turbocharged compression ignition engine using soybean oil as fuel and noticed considerable power loss with reduced combustion efficiency with the fixed fuel system using pure soybean oil. The drop in thermal efficiency was due to high viscosity and the lower calorific value of vegetable oil. It was suggested that alteration to the combustion chamber of the diesel engine can allow the use of diesel fuel and 100% vegetable oil inter changeability. Long-term endurance tests were also suggested to qualify specific fuels and engines [2]. Avinash et al. were conducted experiments using Karanja oil blends (K10, K20, K50 and K100) with mineral diesel in unheated conditions in a diesel engine at different loads and constant engine speed of 1500 rpm. HC, CO and smoke emissions were found to decrease for 20-50% (v/v) Karanja oil content in the fuel blends [3]. Chollacoop

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et al., have been investigated the effects of high quality biodiesel, namely, partially Hydrogenated Fatty Acid Methyl Ester or H-FAME, on 50,000km on-road durability test of unmodified common-rail vehicle. They concluded based on the assessment on the use of B10 from Jatropha H-FAME in unmodified common-rail vehicle over 50,000km shown no substantial difference from the normal diesel criteria. Maximum torque and power were within 3% variation from rated values throughout 50,000km. Euro III emission regulation was clear for NOx and HC+NOx while CO and PM can beneficially clear Euro IV emission regulation [4]. Several researchers experimented the use of vegetable oils as fuel on conventional engines (CE) and reported that the performance was poor, citing the problems of high viscosity, low volatility and their polyunsaturated character. It caused the problems of piston ring sticking, injector and combustion chamber deposits, fuel system deposits, reduced power, reduced fuel economy and increased exhaust emissions[5–8].

## II. MATERIALS AND METHODS

### 2.1 Transesterification Process

Biodiesel can be prepared using transesterification, pyrolysis, micro-emulsion technique or can be used by direct blending with diesel fuel [9]. The transesterification process is one of the preeminent processes to reduce the viscosity of jatropha curcasoil and the same process was used in the present research study [10]. The transesterification chemical reaction was presented in figure 1.

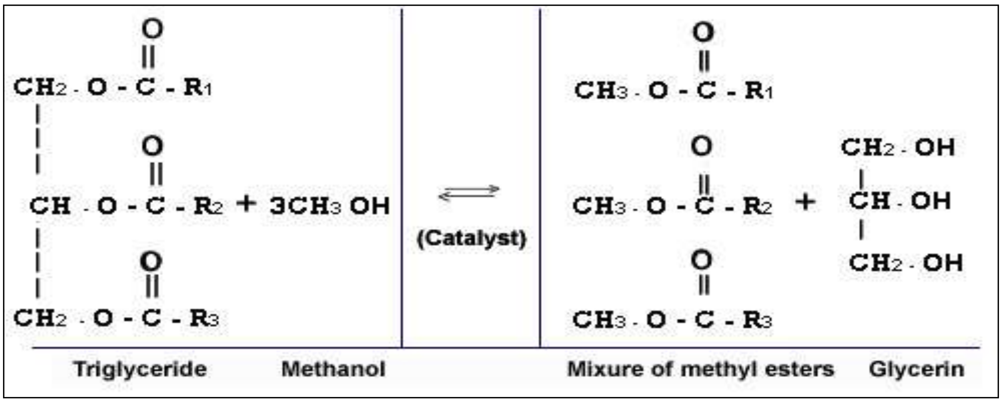


*Figure 1: Transesterification Process*

These esterified plant based oils after chemical reactions with either ethyl/methyl alcohol will produce diesel engine friendly bio-fuel. Generally, biodiesels are produced through the reaction of vegetable oils with methanol in the presence of catalyst to yield glycerine and methyl esters. Methanol in the presence of NaOH as a catalyst was used for transesterification of vegetable oils. The parameter involved in the above processing includes the amount of catalyst, reaction temperature, molar ratio of alcohol to vegetable oil, and reaction time. For the present study, rice bran oil that is available in commercial market, Sodium Hydroxide (NaOH), Methanol and distilled water as used as raw material for transesterification process. The fuel properties of JCOME are shown in table 1.

***Table 1: Fuel Properties***

| Fuel Property | Unit | ASTM Standard | JCOME |
|---|---|---|---|
| Kinematic Viscosity @ $40^0$C | Cst | D445 | 5.4 |
| Flash Point | $^0$C | D93 | 169 |
| Density @ $15^0$C | Kg/m$^3$ | D1298 | 872 |
| Calorific Value | KJ/Kg | - | 38500 |
| Cetane Number | - | D613 | 53 |

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## III. EXPERIMENTAL SECTION

For the present experimental study, a single cylinder, four-stroke, water cooled compression ignition direct injection (CIDI) engine was used. The experiment setup was depicted as a schematic diagram in figure 2. It consists of 3.7 KW (5HP) Kirloskar diesel engine, eddy current dynamometer, smoke meter and exhaust gas analyzer.

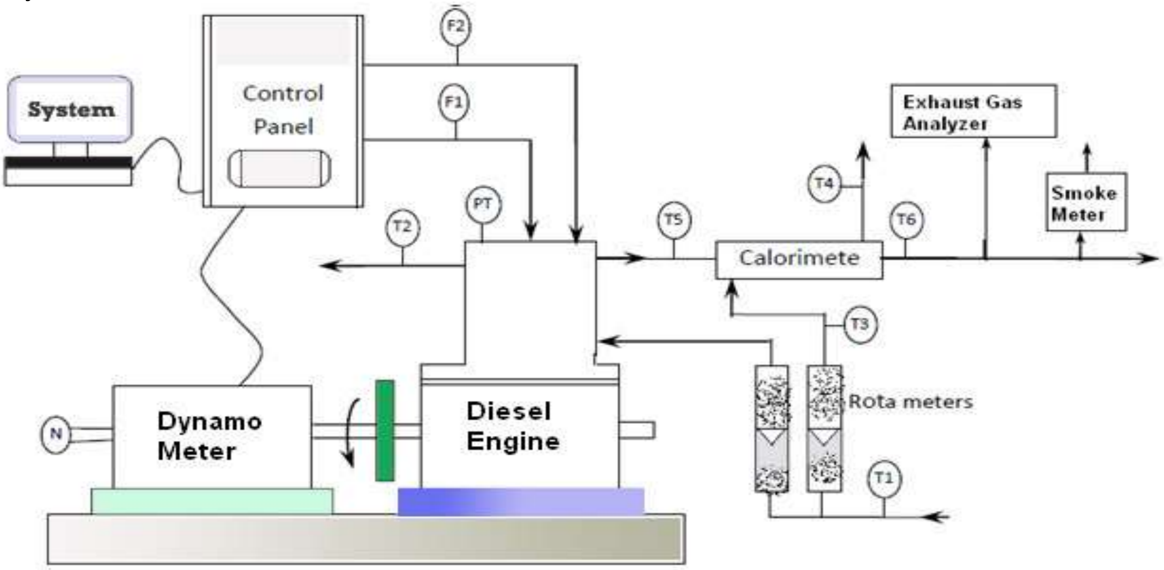


*Figure 2: Schematic Diagram of Experimental Setup*

| | | | | |
|---|---|---|---|---|
| T1 | Inlet water temparature | | PT | Pressure transducer |
| T2 | Outlet engine jacket water temp | | F1 | Air intake differential pressure unit |
| T3 | Inlet water temparatue | | F2 | FuelFlow differential pressure unit |
| T4 | Outletcal.water temparature | | T6 | Exhaust gas temparatue after Cal |
| T5 | Exhaust gas temparatue before Cal | | | |

The engine specifications are given in Table 2.

*Table 2: Engine Specification*

| | |
|---|---|
| Type | Kirloskar Engine |
| Details | Single cylinder, Direct injection, 4-Stroke, Water cooled engine |
| Bore & Stroke | 80 × 110 mm |
| Rated Power | 3.7 KW (5 HP) |
| Speed | 1500 rpm |
| Dynamometer | Eddy Current |

Initially, the engine was operated with diesel fuel for few minutes and after engine warmup, a series of tests for emission analysis were conducted at full load condition with 20% blend of JCOME (B20J) while recording the readings at diffrent injection pressures ranging from 210 bar to 240 bar. Consequently, the same was repeated using different blends of jatropha curcas oil methyl esters and the readings of each blend at full load condition were loged. For each operation, speed of the engine was verified and maintained almost constant rated speed of 1500 rpm. Each experiment was repeated with similar operating condition and each reading was recorded as arithmetic mean of three readings for accuracy. The experimental test data was then analyzed using graphs and are given in the subsequent paragraphs. In this study, Particulate Matter (PM), Carbon Monoxide, and Oxides of Nitrogen (NOx) were considered as emission characteristics of CIDI engine.

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## IV. RESULTS AND DISCUSSION

The experimental analysis was carried-out in order to evaluate the effect of fuel injection pressure on emission characteristics of a single cylinder DI diesel engine and the test results are discussed in below sections.

### 4.1 Particulate Matter (PM)

The investigation on variation of particulate matter (PM) with injection pressure for different blends of jatropha biodiesel is shown in Figure 3. The graph reveals that particulate matter (PM) has the lowest value at 220 bar of fuel injection pressure for all tested blends of jatropha biodiesels at full engine load condition. It was also noticed decrease in PM emission for all tested blends when biodiesel percentage in the blend increased. The particulate matter has increased with increase of fuel injection pressure except at 220 bar due to poor combustion. The highest PM was observed with B20 blend of methyl ester of jatropha curcas oil at 210 bar and lowest with B100 blend of jatropha curcas biodiesel at 220 bar of injection pressure.

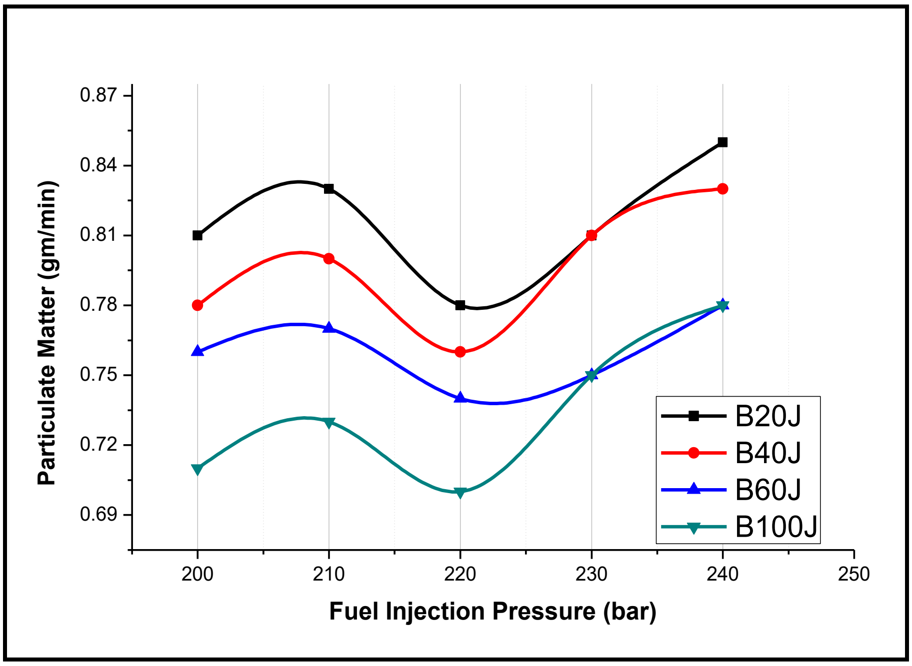


*Fig: 3 Variation of PM with Injection Pressure for Different JCOME Biodiesel Blends*

### 4.2 Carbon Monoxide (CO)

The variation of carbon monoxide (CO) emissions for JCOME blends when used in a single cylinder CIDI engine as fuel at different injection pressure is presented in Figure 4.The influence of fuel injection pressure on CO emission is almost similar to particulate matter (PM) for the jatropha biodiesel blends. Similar to PM emission, the increase in biodiesel percentage in the blend has decreased the CO emission for all tested blends.

The graph revealed that the CO emission with B100J biodiesel blend has the lowest at 220 bar injection pressure and highest by B20J blend of methyl ester of jatropha curcas oil at 210 bar of injection pressure among all the tested blends. It was noticed that the emission of carbon monoxide (CO) was increased with increase in jatropha oil content percentage in blend at all tested injection pressures. It was also observed that the increase of fuel injection pressure resulted in increase of CO emission as compared to rated injection pressure at full engine load condition. The carbon monoxide emission was constantly increased except at 220 bar when fuel injection pressure increased.

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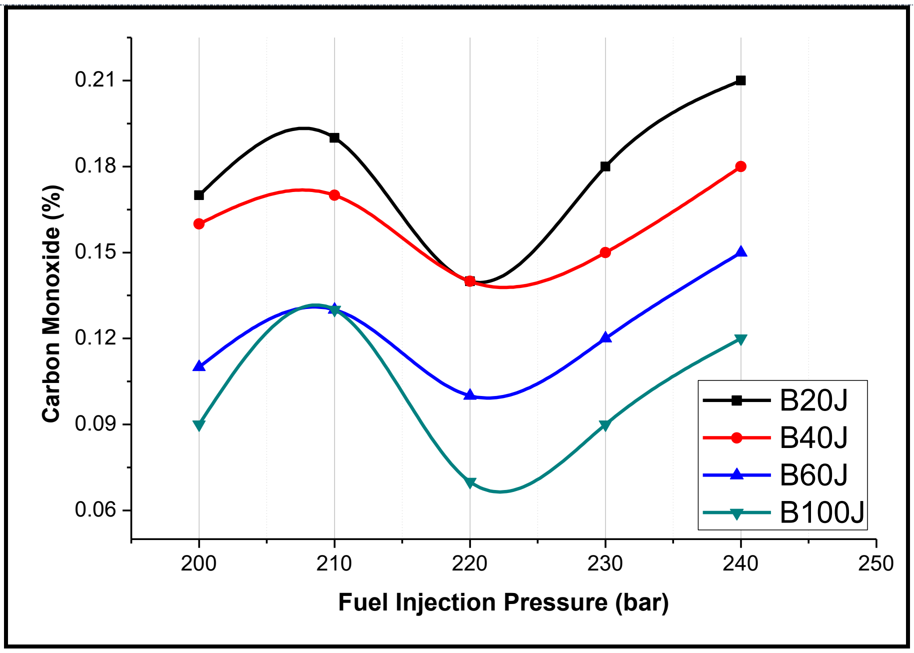


*Fig: 4 Variation of CO Emission with Injection Pressure for Different JCOME Biodiesel Blends*

## 4.3 Oxides of Nitrogen (NOx)

The comparison of variation of NOx with injection pressure for different jatropha biodiesel blends is depicted in Figure 5. The 20% blend of tested biodiesels shown lowest NOx emission among all tested biodiesel blends. It has an order of B20, B40, B60 and B100 respectively. The NOx emissions from the engine has more when biodiesel content in blend increases and NOx emission increased with increase of fuel injection pressure except at 220 bar due to improved combustion. From the graph, the highest NOx emission was noticed with B100J blend of jatropha biodiesel at 240 bar and B20J blend of JCOME has the lowest NOx emission at 220 bar among all the blends.

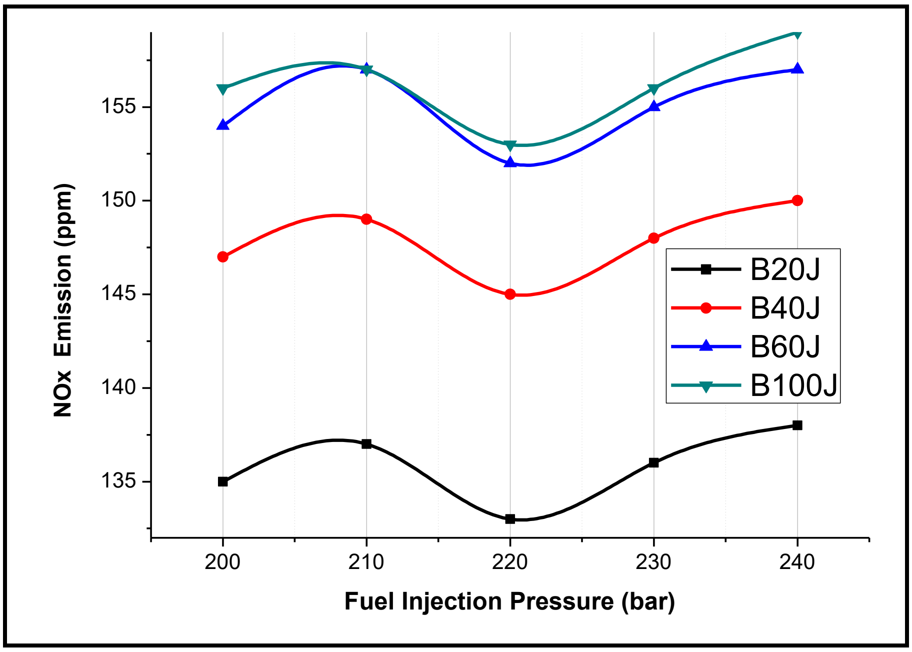


*Fig: 5 Variation of NOx Emission with Injection Pressure for Different JCOME Biodiesel Blends*

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## V. CONCLUSION

The fuel injection pressure is one of the imperative engine parameters that influences on emission characteristics of a diesel engine. The experimental results of a single cylinder, 4-stroke, water cooled diesel engine fuelled with different blends (B20J, B40J, B60J and B100J) of JCOME at injection pressures of 210 bar, 220 bar, 230 bar and 240 bar at full load condition revealed that B100 blend has lower particulate matter, lower CO emission, and moderately higher NOx emission at all injection pressures and optimum emission values were observed at 220 bar for all tested biodiesel blends. The PM emission was decreased with the increase of blend percentage of JCOME. The CO emission from diesel engine was low at 220 bar of injection pressure for all blend percentage of JCOME. The diesel engine with different blends of JCOME exhibits very good emission characteristics at injection pressure of 220 bar at full load condition. Fuel injection pressure of 220 bar can be considered as rated for the tested single cylinder, 4 –stroke water cooled direct injection compression ignition engine at full load condition.

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