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THE EFFECT OF INJECTION PRESSURE ON CIDI ENGINE PERFORMANCE FUELED WITH MADHUCA INDICA OIL METHYL ESTER AND ITS BLENDS

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ABSTRACT

An increased usage of diesel in compression ignition engines, deteriorating fossil fuel reserves and mainly the hazardous environmental pollution due to exhaust emissions from automotives have instigate to search for a alternative renewable fuel that can be used in compression ignition direct injection (CIDI) engines. Recently the vegetable/animal fat based biodiesel turn out to be potential alternative renewable fuel source to replace fossil diesel fuel. It was noticed from many experimental analysis that biodiesel has showing less thermal efficiency and higher brake specific fuel and energy consumption when compared with diesel in unmodified diesel engine. The present research work aimed to evaluate the effect of change in fuel injection pressure on engine performance when fueled with madhuca indica oil methyl ester (MIOME) as fuel and identify the injection pressure at which the engine delivers higher brake thermal efficiency (BTE) and lower brake specific fuel consumption (BSFC), and brake specific energy consumption (BSEC). The experimental analysis was carried-out using a single cylinder, four-stroke, water cooled direct injection (DI) diesel engine and the results indicated that injection pressure has considerable effect on engine performance. It also noticed that the test engine delivered higher performance (higher BTE, lower BSFC and BSEC) with 220 bar of fuel injection pressure at full load condition when fueled with B20M biodiesel blend and B100M blend of MIOME has the lowest engine performance.

KEYWORDS: Biodiesel, Transesterification, Madhuca Indica Oil, Methyl Ester, Engine Performance.

I. INTRODUCTION

The global industrialization, rapid growth in population, and dwindling reserves of fossil fuels instigated to research for alternative renewable fuels alternative to fossil fuel. Recently, the methyl esters of vegetable oil or animal fat known as biodiesel considered as alternative to petro-diesel, and gaining ground as a biodegradable, ecological friendly, effortlessly and sustainably available bio-fuel [1-3]. The crude vegetable oil or biodiesel or biodiesel blended with diesel fuel can be directly used in the existing unmodified diesel engine [4,5]. The Biodiesel produced from edible oils has raised the concern on raise of food/food related products, especially in densely populated developing countries such as China and India. The research and production of biodiesel is then encouraged towards preparion of biodiesel using non- edible oils such as Jatropha oil, Pongamia, Cotton seeds oil, Mustard oil, Neem etc. as feed-stock for biodiesel. Moreover the biodiesel production using non-edible oils promotes the rural economy, reduces the dependency on fuel imports and reduces the environmental pollution [6,7]. Moreover, non-edible vegetable oil plants grown in unfertile, barren lands with very less water and fertilizers. Thus, in this research work, non-edible madhuca indica oil was selected to evaluate the performance characteristics of direct injection diesel engine varying the fuel injection pressure of the engine to identify the best injection pressure where the engine delivers higher performance.

Usage of vegetable oils as fuel in diesel engines is not new as Rudolf Diesel first demonstrated his new diesel engine at the 1900 World Exhibition in Paris by using peanut oil. Some reviews have shown that the diesel engine delivers slightly lower brake thermal efficiency with less exhaust emissions when jatropha oil methyl ester was used as biodiesel in single cylinder DI engine [10, 11]. Lei Zhu et al. were carried-out investigations in a 4-cylinder DI diesel engine using biodiesel, and ethanol–biodiesel blends to evaluate the characteristics of the engine. From their experiments, slight improvement in performance with 5% ethanol in biodiesel and better brake thermal efficiency (BTE) was observed when compared to Euro V petro-diesel. They also noticed

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reduction in NOx, particulate emissions with all biodiesel blends, but reduced CO and HC emissions with 5% ethanol blend [12]. Jinlin Xue has conducted experiments in a diesel engine using waste edible oils (WEO) and noticed slight reduction in thermal efficiency, power performance with increased fuel consumption for pure WEO biodiesel. However, less CO2, PAH and higher NOx emissions were observed [13]. Fasogbon & Asere have investigated the effect of soybean methyl ester on performance characteristics of cummins-6V-92TA DDEC diesel engine and reported that biodiesel has satisfactory performance as diesel [14]. Gopinath & Suresh were conducted experiments using corn oil Methyl Ester (COME) and its diesel blends in a single cylinder diesel engine. They have observed less CO2, NOx and UBHC emissions with all blends of biodiesel when compared with diesel fuel [15]. Huzayin et al. have conducted experimental studies to evaluate the emission and performance characteristics using Blends of jojoba oil with gas oil and their experimental results shown that slightly reduced engine power, trivial raise in brake specific fuel consumption (BSFC), reduction in NOx and soot emission using blends of jojoba oil with gas oil as compared to gas oil [16]. Reheman et al. evaluated the engine performance and emission characteristics of a single cylinder DI compression ignition engine fuelled with karanja oil methyl ester and its diesel blends and notified that the biodiesel blend up to 40% shown satisfactory performance without power loss with reduced exhaust emissions such as smoke, carbon monoxide and NOx when compared with petro-diesel fuel [17]. Hüseyin Aydin et al. have conducted experimental studies to evaluate the performance and emission characteristics of CI engine using cotton seed methyl ester (CSOME) and its diesel blends of B5,B20,B50,B75, and B100. They have identified slight increase in engine torque for lower blends with reduced exhaust emissions. The lower blends of CSOME can partly be replaced for petro-diesel fuel unmodified engine [18]. Bhojraj N. Kale and S.V. Prayagi investigated the influence of cottonseed oil methyl ester (CSOME) and its blends with diesel on the engine performance of diesel engine and compared with diesel and jatropha biodiesel. They have observed slightly higher BTE and indicated thermal efficiency with CSOME when compared other tested fuels [19].

II. MATERIALS AND METHODS

Biodiesel Preparation

The raw mahua oil was collected from local vendor, filtered and kept some time to get settled impurities. Then the biodiesel was prepared by using transesterfication method to improve the properties and make it compatible for combustion without any further problems. Because, the crude Mahua oil has higher viscosity and density that causing operational problems in diesel engine. The figure 1 below shows the transesterification reaction used in production of biodiesel which is called methyl ester of madhuca indica oil (MIOME). The reaction between the fat or oil and the alcohol takes place and forms methyl esters and heavy glycerine which will be separated later to prepare biodiesel. This neat MIOME biodiesel was then filtered and further purified prior to use in diesel engine as fuel in the place of petro-diesel fuel.

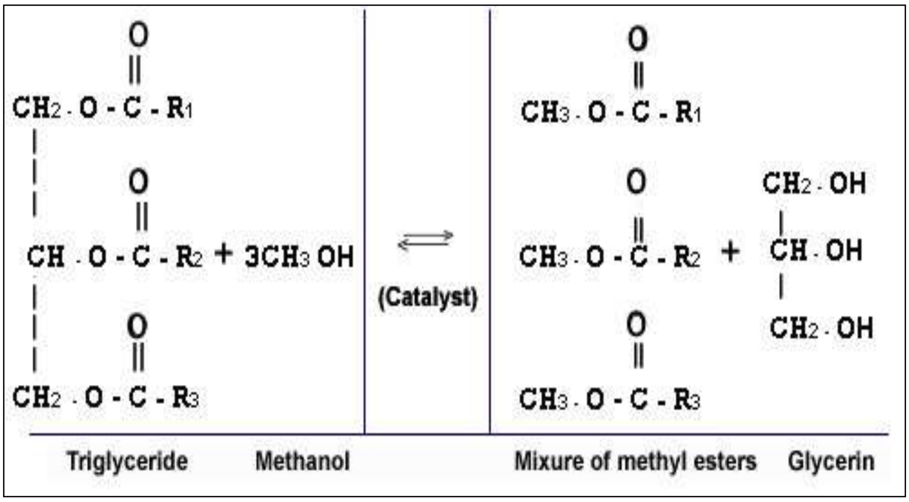

Figure 1: Transesterification Process

Fuel Properties of Diesel and MIOME Biodiesel

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To carry-out the present research study, madhuca indica (mahua) oil methyl ester wasd blended with diesel fuel and prepared 20:80 (B20M), 40:60 (B40M), 60:40 (B60M) and 100:0 (B100M) blends on volume basis. The chemical properties of diesel fuel and madhuca indica oil methyl ester (MIOME) were assessed and are presented in Table 1.

Table 1. Fuel Properties of Diesel and Biodiesel

Property	Diesel	MIOME
Kinematic Viscosity at 40^0 C (Cst)	3.58	4.8
Density at 15^0 C (Kg/m^3)	830	862
Flash Point (^{0}C)	51	127
Cetane Number	50	65
Calorific Value (KJ/kg)	42000	38200
Total Sulphur (% by mass)	0.01	Nil

Experimental Setup

The experimental evaluation was carried-out using a single cylinder, 4-stroke, water-cooled, direct injection (DI) diesel engine fueled with diesel and blends of MIOME biodiesel. The engine is coupled with an eddy-current dynamometer.. The dynamometer was used for loading the engine at pre-specified load conditions. Before conducting the experiments, the dynamometer was calibrated for its efficiency at different loads. The detailed specifications of the test engine are presented in Table 2. The test engine was firstly started with diesel fuel and then continued with methyl esters of mahua oil and its blends at various fuel injection pressures varying from 200 to 240 bar. After engine has reached the stabilized working condition at constant speed of 1500 rpm, time for 10ml of fuel consumption was recorded for each applied load for diesel and each biodiesel blend in order to calculate the performance characteristics of compression ignition direct injection engine. The test setup is presented in Figure 2 as a schematic diagram and photographic view in Figure 3.

Table 2. Specifications of Test Engine

Engine Make	Kirloskar AV1, India
Engine Details	Single Cylinder, Four stroke, Water cooled
Injection Type	Direct Injection
Bore & Stroke	80 × 110 mm
Rated Power	3.7 KW (5 HP) at 1500 rpm
Speed	1500 rpm
Injection Pressure	200 bar
Compression Ratio	16.5:1
Dynamometer	Eddy Current

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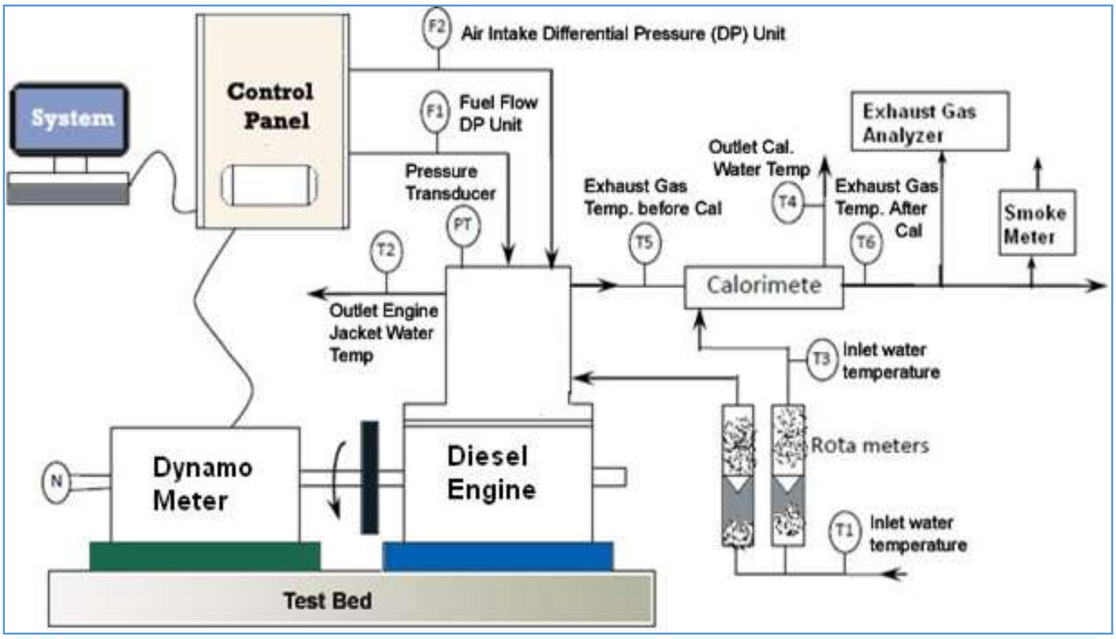

Figure 2: Schematic Diagram of Test Setup

Figure 3: Photographic View of Experimental Setup

III. RESULTS AND DISCUSSION

The effect of fuel injection pressure on engine performance in terms of brake thermal energy (BTE), BSFC and

BSEC was performed using single cylinder, DI diesel engine fueled with mahua oil biodiesel and its diesel blend and presented below.

Brake Thermal Efficiency (BTE)

The variation of brake thermal efficiency (BTE) with fuel injection pressure when engine operated at full load condition with constant engine speed of 1500 rpm is shown in Figure 4. It was observed that the BTE values raised from 200 to 220 bar of injection pressure and then declined at 230 bar and 240 bar for all tested biodiesel blends. The highest BTE value observed at 220 bar of injection pressure for all tested blends. The decrease in BTE with the increase of biodiesel percentage in the blend also noticed at full load condition. The highest BTE was noticed with B20M blend of mahua oil methyl ester and the lowest BTE with B100M blend of MIOME biodiesel. Hence the experimental results confirming that B20M blend of biodiesel delivers highest BTEat 220 bar of injection pressure of unmodified diesel engine at full load condition.

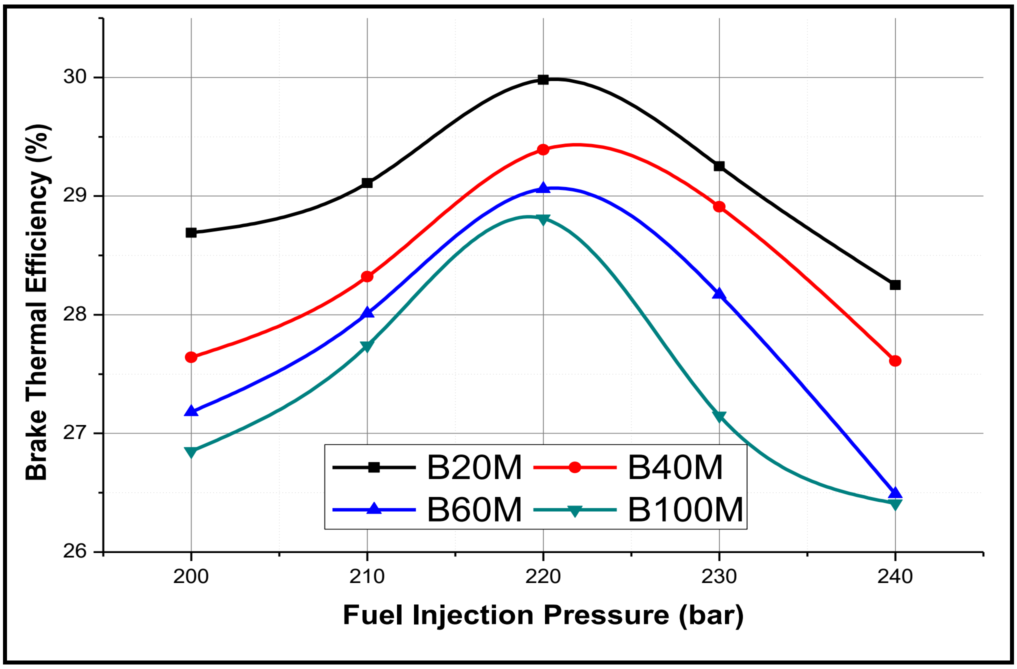

Figure 4: Variation of BTE with fuel injection pressure for different test fuels

Brake Specific Fuel Consumption (BSFC)

Figure 5 shows variation of BSFC with fuel injection pressure of a single cylinder diesel engine at full load condition when MIOME biodiesel and its blends used as fuel. The highest brake specific fuel consumption (BSFC) noticed at fuel injection pressure of 200 bar and after that progressively decreased from 200 bar to 220 bar and then raised slowly from 220 bar to 240 bar of fuel injection pressure. The graph evidently shown that the BSFC was influenced by the biodiesel percentage in the blend. As percentage of biodiesel increases in the blend, the increase in brake specific fuel consumption was observed. The low BSFC was noticed at 220 bar of injection pressure. As the biodiesel content percentage increases in the blend, the BSFC also increased. The lower brake specific fuel consumption was noticed with B20M blend of MIOME biodiesel at around 220 bar of fuel injection pressure.

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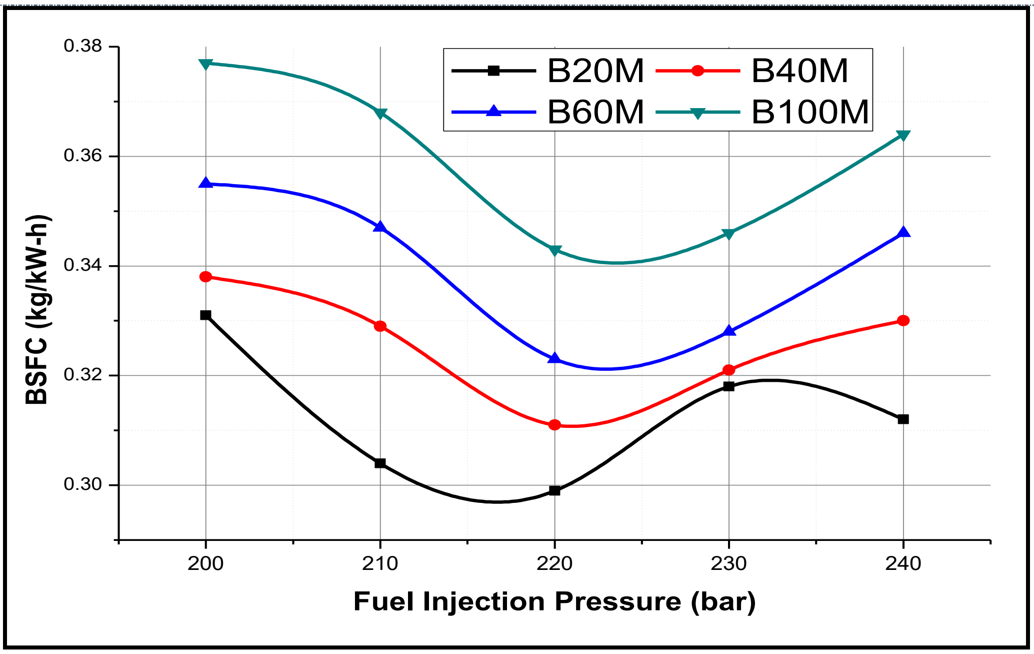

Figure 5: Variation of BSFC with fuel injection pressure for different test fuels

Brake Specific Energy Consumption (BSEC)

Figure 6 illustrates the variation of BSEC with injection pressure for different blends of madhuca indica oil methyl ester (MIOME) biodiesel. All blends shows the highest BSEC at rated FIP and lowest at 220 bar of injection pressure. The B20M blend of MIOME has the lowest BSEC at 220 bar of injection pressure and B100M blend of MIOME has the highest BSEC among all tested biodiesel blends at full load condition. As shown in graph, the BSEC increased with the increase of biodiesel percentage in blend.

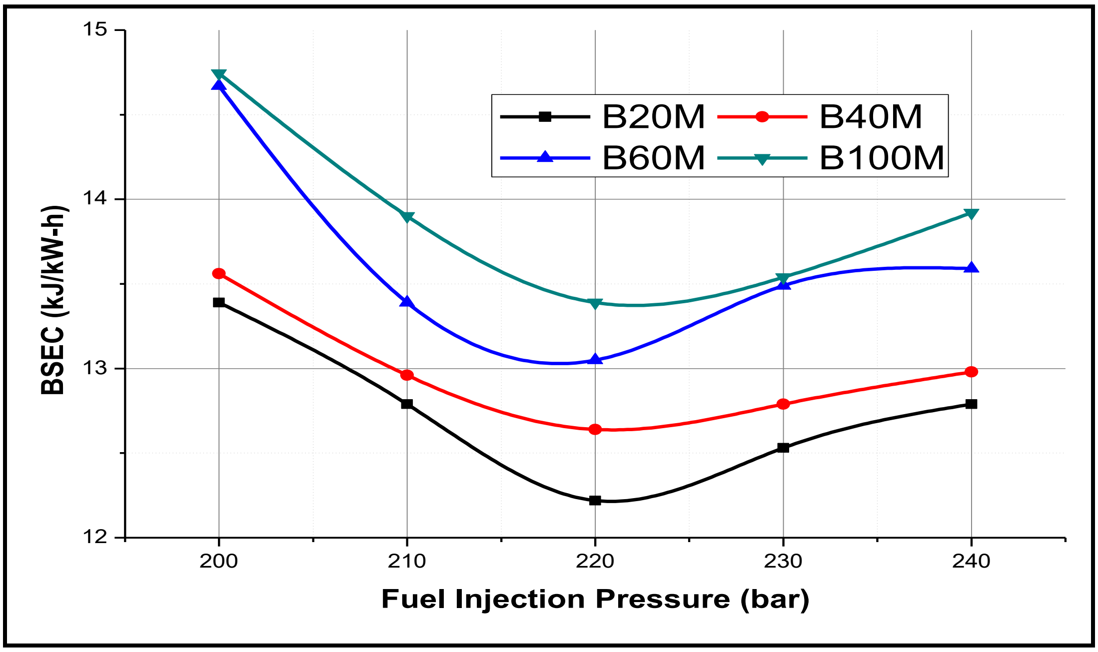

Figure 6: Variation of BSEC with fuel injection pressure for different test fuels

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IV. CONCLUSION

The experimental results of the present research work in a single cylinder, four stroke, water cooled diesel engine fuelled with different blends (B20M, B40M, B60M and B100M) of madhuca indica oil methyl ester (biodiesel) at fuel injection pressures of 200 bar, 210 bar, 220 bar, 230 bar and 240 bar at full load condition revealed that B20M blend has highest brake thermal efficiency (BTE), lowest BSFC, BSEC and EGT when compared with all blends of biodiesel. The optimum engine performance characteristics were found at 220 bar of injection pressures. The results have also shown that the BTE has decreased and the BSFC, and BSEC increased with the increase of biodiesel percentage in the blend. The test results recommended that it is better to operate diesel engine at 220 bar of injection pressure to obtain higher performance than at rated injection pressure.

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