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Exhaust Emissions and Combustion Performance Analysis Using Diesel-Biodiesel In A Diesel Engine

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Abstract - Alternative biodiesel for diesel engines due to better combustion generate as compared to petroleum fuels. In the present study, numerical simulation tried to improve combustion on a single cylinder, four stroke, direct injection naturally aspirated diesel engine performance and emission parameters by using pure diesel, jatropha methyl ester, microalgae spirulina, tire pyrolysis oil, waste cooking oil during suction stroke. The result shows that increasing fuel consumption and slightly decreasing thermal efficiency, but significant reduction in smoke, particulate matter emissions (PM). The brake thermal efficiency was found to be 2.68% lower microalgae spirulina biodiesel (B100) at full load and specific fuel consumption by maximum higher 12.4% for jatropha methyl ester biodiesel (B100). Smoke emission reduces by 49.1% for jatropha methyl ester, PM emission by 50% for jatropha methyl ester at full load condition.

Index Terms **-** Compression engine; performance; combustion; emission.

1. INTRODUCTION

Diesel engine most of the used in transportation and agricultural sector due to higher efficiency, power, torque and less fuel consumption than the gasoline engines. The diesel engine operating higher compression ratio leaner fuel mixing rate and lower losses occurred [1]. Nowadays great challenges in the world, reducing injurious exhaust gas emission from diesel engine such as carbon monoxide, hydrocarbon, particulate matter, oxides of nitrogen, etc. [2]. In this regards, many previous studies have been carried out of less destructive alternative energy sources in compression ignition engine.

One of the alternative energy source of graphic nanoplatelet addition to jatropha biodiesel investigated effects on diesel engine characteristics. The result shows that GNPs at 50-75 mg/L of JB20 increase of thermal efficiency and a reduction in brake specific fuel consumption as compared to JB20. The increasing of cylinder peak pressure by 6%, maximum rise of pressure rise by 5% and maximum heat release rate by 5%. The engine exhaust gas emissions reduction in NOX by 40%, CO by 60%, and UHC by 50%, at a GNP dosage of 25-50 mg/L [3]. Investigated effects of injection timing (20, 21.5, 24.5 and 26 ºCA b TDC) on engine combustion performance and emission characteristics using 80% jatropha methyl ester and 20% tyre pyrolysis oil. The result shows that better combustion performance and lower emission at injection timing (24.5º b TDC) as compared to other test injection timing. Higher cylinder peak pressure (2.7 bar) and ignition delay period and reduction in brake specific energy consumption by 7.1%, CO by 14.2%, HC by 13.26% and particulate emissions by 9.3% [4].

Studied effects of emission characteristics using five (edible and non-edible vegetable oil, animal fats, waste oil and alcohol) different categories of alternative fuels in a compression ignition engine. Results show that most effected in NO_X emission by 94.56% for butanol, PM emission by 93.78%, for poultry fats, smoke emission by 93.8% for sunflower and summary of emissions by 43.37% of veal oil reduction [5]. Investigated effects of ethanol by 15% and methanol by 15% addition to biodiesel CI engine characteristics. The result shows that increasing thermal efficiency, ignition delay period, heat release rate and reduction in NO_X emission, but increase PM and smoke emission with the addition of alcohol.

In this study, numerical investigation on diesel engine combustion performance and emission characteristics fuelled with pure diesel, jatropha methyl ester, microalgae spirulina, tire pyrolysis oil, waste cooking oil have been performed. The present research on the combustion performance (fuel consumption, efficiency, exhaust gas temperature, etc.) and emissions (smoke, particulate matter emission) characteristics at constant injection timing, speed, compression ratio and full load condition.

2. MATERIAL AND METHODS

The pure diesel, jatropha methyl ester, microalgae spirulina, tire pyrolysis oil, waste cooking oil were used in the present study, with properties taken from previous published data in reference [3, 4, 5, 8 and 9] as shown in Table 1. The numerical simulation carried out of pure diesel, jatropha methyl ester, microalgae spirulina, tire pyrolysis oil, waste cooking and evaluated performance and emission parameters on a single cylinder direct injection diesel engine.

Table 1FUEL PROPERTIES

Properties/ biodiesel	Density (kg/m^3)	Viscosity (mm^2/s) at 40 °C	Calorific value (MJ/kg)	Flash point (°C)
Waste cooking oil	871	4.6	37.5	453
Jatropha	881-883	5.26-5.6	40.63	156
waste tire pyrolysis	907	4.98	40.125	>100
Microalgae *Spirulina*	860	5.6	41.36	130
Diesel	830	2.8	42.5	75

3. EXPERIMENTAL SETUP

The diesel engine was constant speed of 1500 rpm and injection timing was fixed. To investigation were carried out at 100% engine load. Experimental setup consists of piezoelectric pressure sensor, K-type temperature sensors, and eddy current dynamometer, air box connected opposite site of an eddy current dynamometer, computer system, and data acquisition system parameters were recorded for off-line analysis. All input parameter were summarized in Table 2 and setup as shown in Fig.1.

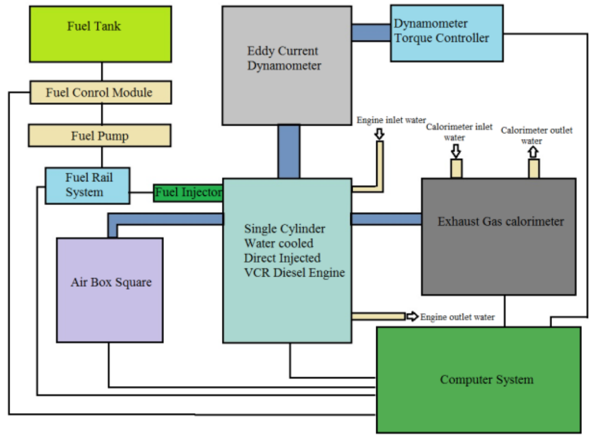

Fig. 1.Experimental Setup

Table 2
BOUNDARY CONDITION AND EXPERIMENTAL ENGINE SPECIFICATION

Parameter	Value
Initial pressure	1.0 bar
Cylinder and type	Single and four stroke
Initial temperature	300 K
Piston temperature	530 K
Liner temperature	420 K
Head temperature	500 K
Compression ratio	17.5
Fuel injection timing	23.5˚ CA b TDC
Fuel spray angle	70˚
Higher fuel injection pressure	220 bar
Piston	bowl shape
Cooling system	Water
Fuel	Diesel, biodiesel

4. RESULTS AND DISCUSSION

4.1 *Performance characteristics*

Specific Fuel Consumption

The specific fuel consumption is a measure of fuel, efficiency of the engine and hence it plays an important role in selecting a specific fuel [6]. The variations of specific fuel consumption versus biodiesel and diesel fuel as shown in Fig 2 at full load condition. The higher amount of injected specific fuel consumption (SFC) higher for biodiesel as compared to regular diesel fuel due to higher density and viscosity [7]. The SFC (g/kWh) was found to be 256.9 for diesel, 293.52 for jatropha, 276.2 for microalgae spirulina, 262.1 for tire pyrolysis oil and 298.5 for waste cooking oil. From all tested biodiesel maximum higher 12.4% of jatropha methyl ester biodiesel (B100) according base fuel of diesel.

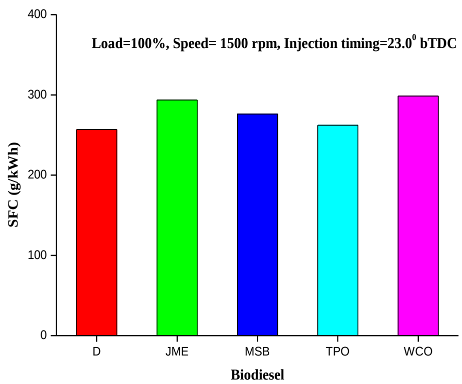

Fig.2. Specific Fuel Consumption

Brake Thermal Efficiency

The brake thermal efficiency (BTE) depends on an engine speed, biodiesel percentage, engine load [8]. The BTE reduction with poor atomization of fuel due to higher viscosity and density as compared to regular diesel fuel and also affected the heat release rate of combustion [1]. The BTE (%) was found to be 33.09 for diesel, 31.05 for jatropha, 32.2 for microalgae spirulina, 32.1 for tire pyrolysis oil and 31.1 for waste cooking oil. From all tested biodiesel 2.68% lesser for microalgae spirulina biodiesel (B100) according base fuel of diesel as shown in Fig.3.

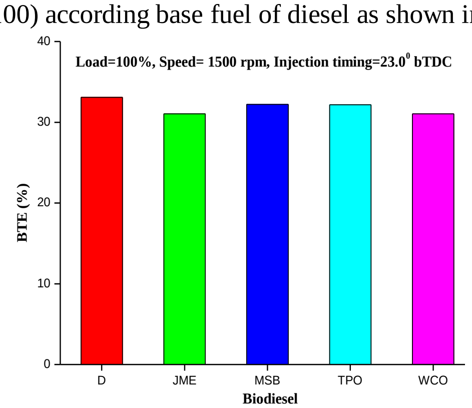

Fig. 3. Brake Thermal Efficiency

4.2 ***Emission Characteristics***

Smoke Emission

Formation of smoke emission in compression ignition engine depends on engine speed, engine load and engine maintained, higher content of oxygen within the fuel, and complete combustion lead to lesser smoke emission [7, 8 and 10]. The smoke (BSN) was found to be 0.91 for diesel, 0.464 for jatropha, 0.663 for microalgae spirulina, 0.569 for tire pyrolysis oil and 0.51 for waste cooking oil. From all tested biodiesel found to be lower smoke emission as compared to diesel fuel and 49.1% lower for jatropha methyl ester biodiesel (B100) according base fuel of diesel as shown in Fig.4.

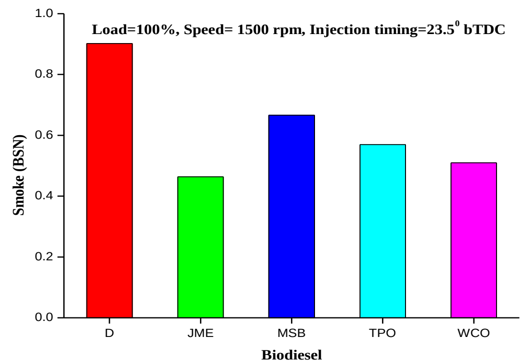

Fig. 4. Smoke Emissionwith Biodiesel

Particulate Matter Emission

The most injurious pollutants to human fitness and the atmosphere of compression ignition engine are NO_X and PM [2]. The reduction in particulate matter (PM) emission for biodiesel respect to diesel fuel which may be due to a higher percentage of oxygen content and better oxidation of air and fuel. The main factor of PM emission is an improper fuel burning within the combustion of the fuel-rich sections and completely fuel burn and decrease PM emission [5]. The PM (g/kWh) was found to be 0.146 for diesel, 0.073 for jatropha, 0.124 for microalgae spirulina, 0.084 for tire pyrolysis oil and 0.083 for waste cooking oil. From all tested biodiesel 50% lesser for jatropha methyl ester biodiesel (B100) according base fuel of diesel.

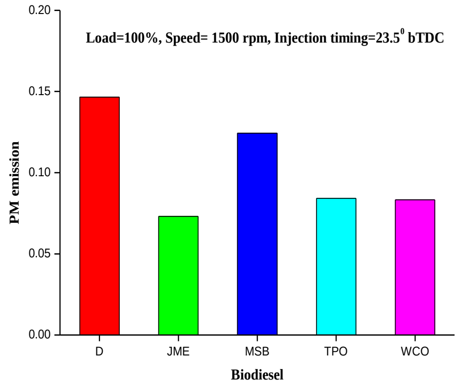

Fig. 5. PM Emission Vs Biodiesel

5. CONCLUSION

According the numerical investigation results, the following conclusions were drawn:

- The SFC (g/kWh) was found to be 256.9 for diesel, 293.52 for jatropha, 276.2 for microalgae spirulina, 262.1 for tire pyrolysis oil and 298.5 for waste cooking oil. From all tested biodiesel maximum higher 12.4% of jatropha methyl ester biodiesel (B100) according base fuel of diesel.
- The brake thermal efficiency was decreased by 2.68% for microalgae spirulina biodiesel (B100) base fuel of diesel.
- Smoke emission was found to be lower by 49.1% of jatropha methyl ester biodiesel (B100) as compared to diesel (D100).
- PM emission significant reduction by 50% of jatropha methyl ester biodiesel (B100) as compared to diesel (D100).

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