International Engineering Research Journal

Experimental Investigations on Biodiesel-Alcohol-Diesel Low Proportion Blends with a Single Cylinder Diesel Engine

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Abstract

The use of fossil diesel in transportation is through CI engine increases. In this investigation additives are used to improve the performance, combustion and emission characteristics of Caster biodiesel (B) and Diesel (D) blends. Methanol (M) and Ethanol (E) used as additives in existing CI engine. The effective additives improve performance in diesel engine is methanol. The reduction of NOx, CO, CO_2, HC emission in diesel engine and also increase performance in addition of 10% to 15% methanol. From this conclude the result methanol is alternative to improve efficiency of diesel engine by using the blended biodiesel.

Keywords: Castor-Biodiesel, ethanol, methanol, performance, combustion, emission.

1. Introduction

The rapid industrialization has increase the demand of fossil fuels. But depletion fossil fuel day by day the major issues. From world energy scenario the fossil fuel available only to complete demand up to 2035. The need of alternative fuel is developed and the fulfillment of that Biodiesel is best option. The many research is done on biodiesel as a fuel in diesel engine at various load and compression ratio but the major issues is lower performance, incomplete combustion and increase rate of emission. The additives are added in the blend of Diesel and Biodiesel is effective to increase performance, complete combustion and reduce emission. Additives used alcohol first two order Methyl alcohol called as Methanol and Ethyl alcohol called as Ethanol due to more oxygen content.

2. Literature Survey

2.1 Summery

The use methanol and ethanol are very practical in the biodiesel blends due to its miscibility with the pure biodiesel [1]. Alcohol additives are very helpful to reduce the viscosity and density of the biodiesel which is higher compared to standard mineral diesel. The alcohol additives improve the combustion efficiency and produce lower exhaust emission when fuelled the diesel engines. Ethanol and methanol has approximately 35% and 30% higher oxygen in basis as compared to mineral diesel that help diesel engine to achieve higher complete combustion [2]. More oxygen in fuels means more complete combustion to be achieved. Qi et al [3] conducted the study on biodiesel-methanol-diesel blends with the volume ratios of 5% and 10% of methanol as an additive in the compression ignition engine. The investigated survey results showed that B20D55M25 and B20D50M30 produced a significant decrease of smoke emission and CO emissions. As for combustion results, B20D55M25 and B20D50M30 have a combustion delay compared to B50D50 at low engine load. However at the high engine load, the engine start for B20D60M20 and B20D65M15 were comparable to B40D60. Najafi and Yusaf[4]investigated the performance of methanol-diesel blends on a diesel engine. Methanol was added to diesel as additives with volume concentrations of 10%, 20% and 30% (methanol (10%)-diesel (90%), methanol (20%)-diesel (80%) and methanol (30%)–diesel (70%). The lowest exhaust temperature produced for the mixing ratio fuels was methanol (15%)-diesel (85%). While mineral diesel produced the highest exhaust temperature as compared to methanol-diesel blends. The comparison of brake specific fuel consumption (bsfc), the diesel produced lower bsfc as compared to other methanol-diesel blends while the bsfc for methanol (30%)-diesel (70%) was the highest. Anand et al. [5] the concude influence of the methanol as an additive on the combustion, performance and exhaust emission when blended with neat jathropa biodiesel in a single-cylinder direct injection. The test fuel was blended according to the volume ratio (90% biodiesel and 10% methanol). The combustion results indicated that the peak cylinder pressure and peak energy release rate decreases for biodiesel diesel methanol blend. However, the unburned hydrocarbon and emissions of CO were slightly higher for the methanol blend compared to neat biodiesel at low load conditions [6]. The experimental study, biodiesel-methanol-diesel blends were tested in the same diesel engine under the same operating conditions. Those finding results were compared to B20 and mineral diesel as for the baseline. Biodiesel-methanol-diesel blends were prepared with 20:15:65 and 20:20:60 ratios (B20 M15 and B20 M20). Brake specific fuel consumption (bsfc), exhaust temperatures, CO and NO emissions were compared based on the fuel type and mixing ratio. Biodiesel is mainly methyl ester of triglycerides prepared from animal fat and virgin or used vegetable oils. It can be used in diesel engines as a single fuel or as a diesel–biodiesel blend. These require little or no engine modifications [5,6]. Ethanol is also an attractive renewable fuel. But it cannot be used as a single fuel in diesel engines thus it is blended with diesel which results in an oxygenated fuel. This blend of ethanol and diesel is also known as diesohol diesel. Diesohol has a number of advantages [7,8]. It is already known that adding ethanol to the fossil diesel fuel increases the ignition delay, increases the rate of premixed combustion, increases the thermal efficiency and reduces the smoke exhaust. The solubility of ethanol in the diesel fuel is mainly affected by hydrocarbon composition of diesel, temperature and water content of the blend [9]. However, there are some technical barriers in the direct use of diesel–ethanol blends in the CI engine. Many researchers have tested these blends with different additives (emulsifiers) but all of the blends contained small quantity of ethanol as the additives can only improve the solubility but other properties of the blend are not affected [10]. The low flash point of this blend without biodiesel, is another critical problem, which hinders the application of this blend in the CI engine and studies have shown no effect of emulsifiers on this property [11]. This blend is stable well below under sub-zero temperature and have equal or superior properties to fossil diesel fuel [12]. Studies haves that the diesel–biodiesel–ethanol blend has improved physicochemical properties compare to diesel–biodiesel or diesel–ethanol blends separately. This blend has better water tolerance and stability than the diesel–ethanol blend. Some researchers have studied this blend with hydrous ethanol [13] while some of the used anhydrous ethanol [14]. From previous studies it is obvious that for better physic chemical properties, anhydrous ethanol must be used in ternary blends [8] but the quantity of ethanol in ternary blend to demonstrate best performance needs to be determined. while some of them used maximum 80% biodiesel in a single ternary blend with 10% ethanol and 10% diesel [16]. Their results showed very good performance of this ternary blend. Although many researchers have reported good performance of this blend there are also many of them who reported very high BSFC and emissions from this blend. So there is need to evaluate research works done on this blend to conclude about its performance. The present study reviews the literature one valuating power, torque, fuel consumption, efficiency and emissions (soot, smoke, NOx, CO, CO2, HC, PM, unregulated emission, sulfur dioxide and exhaust gas temperature) of this ternary blend found by many researchers around the globe. In this review the data from research studies conducted for evaluating diesel–biodiesel–ethanol blends are collected, summarized and compared to high light potential of this blend as an alternative to diesel fuel. Performance, Power and torque Diesel–biodiesel–ethanol blends reduces engine power and torque output as the portion of oxygenated compounds (biodiesel and ethanol) in the blends increases [17]. This is due to the low cetane number and calorific value and higher ignition delay of the blends, compared to diesel fuel. This found approximately 4.4–8.7% reduction in maximum power output by using diesel–biodiesel–ethanol blends compared to fossil diesel fuel [18].

2.2 Remark on literature

Overall review we conclude that mixing of Biodiesel 20% in diesel is giving optimum result of Performance, combustion and emission. Availability of Caster oil in India in large amount and result for above proportion is good, so we use Caster Biodiesel as fuel in Blends.

3. Experimental setup and Methodology

3.1 Experimental setup

Experiments were carried out using a single cylinder, four stroke, direct injected, water cooled kirloskar TV1 VCR engine. Table 1 shows the technical specification of the test engine. Engine performance characteristics were determined using eddy current dynamometer with loading unit. The performance characteristics measure using sensors inserted at various location in combustion chamber. And the emission characteristics measure by exhaust gas analyzer in which non dispersive infrared sensor for CO, CO_2, HC and electromechanical sensor for O_2, NO. The data acquisition technique connected computer and by using engine performance and combustion software result are calculated. Figure 1 shows the block diagram of all engine setup.

TABLE 1 Technical specification of engine [19]

Specification	Values
Bore x stroke	87.5 x 110 mm
Cubic capacity	0.661 liter
Compression ratio	18:1 (vary 12 to 18)
Peak cylinder pressure	77.5 kg/cm^2
Maximum speed	2000 rpm
Sump capacity	2.70 liter
Connecting rod length	234 mm
Overall dimension	617 x 504 x 877
Weight	160 kg

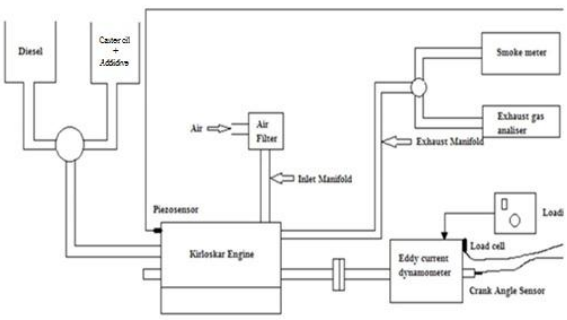

Fig 1 Block Diagram of Experimental setup

3.2 Methodology

The various blends are tested as per volume basis proportion listed in table II and the properties of diesel, biodiesel, Methanol and Ethanol are tabulated in table III. The engine load varies as in kilogram are 0, 4, 8, 12 and 16. The compression ratio of engine is constant 18:1.

Compare the result on engine performance, combustion and emission of pure Diesel, Diesel Biodiesel and Diesel Alcohol biodiesel.

TABLE 2 Percentage of Blend to Tested

Blends	Diesel	Biodiesel	Methanol	Ethanol
Diesel	100%	-	-	-
Blend I	80%	20%	-	-
Blend II	75%	20%	5%	-
Blend III	70%	20%	10%	-
Blend IV	65%	20%	15%	-
Blend V	75%	20%	-	5%
Blend VI	70%	20%	-	10%
Blend VII	65%	20%	-	15%

TABLE 3 Properties of Diesel, biodiesel, ethanol and methanol [20]

Properties	diesel	biodiesel	ethanol	Methanol
Viscosity (cSt)	18.75	21.91	15.25	12.24
Flash point (°C)	126	155	13	10
Calorific value (Kcal/kg)	10867.49	10440.34	3057.23	5493.45
Heating value (Kcal/kg)	10091.25	10439.34	6830.99	5421.80
Cetane number	52	52.87	6	5
Density (g/cm^3)	0.835	0.935	0.789	0.792
Moisture (g/100g)	0.07	0.09	-	-

4. Result and Discussion

4.1 *Performance parameter*

4.1.1 Brake power

Figure 2 shows that there is little variation in result of brake power at various loading condition. At low loading condition only variation in result of B20M15D65 blend as compare to other blends. But as compare to diesel brake power increases by adding additives.

4.1.2 Brake mean effective pressure

Figure 3 shows the variation of brake mean effective pressure at various loading condition. At low load the brake mean effective pressure increases and at high load the result are not vary by blend B20M15D65 as compare to other blends. The effect additives at low proportion nothing so much variation as compare to diesel and biodiesel.

4.1.3 Indicated mean effective pressure

Figure 4 shows the IMEP increases as increases a loading condition. The variation of result shows that the IMEP of diesel is low as compare to other blends. At low load IMEP of B20M5D75 blend is small value and increases maximum at high load.

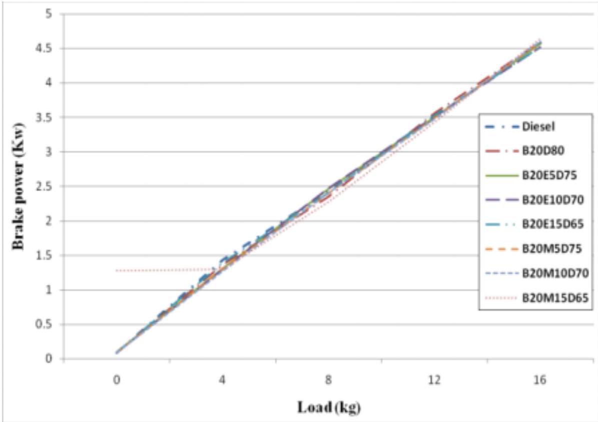

Fig 2 Variation of brake power at different load

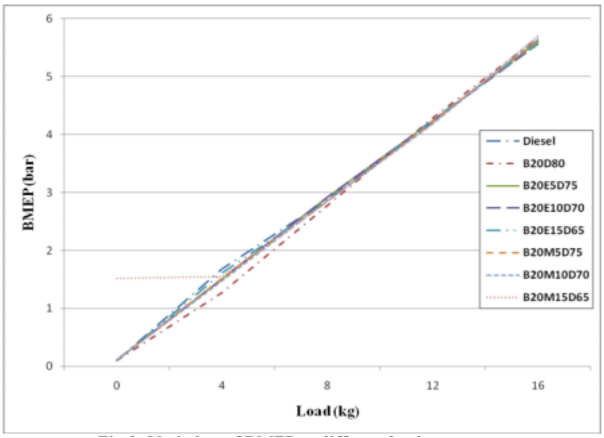

Fig 3 Variation of BMEP at different load

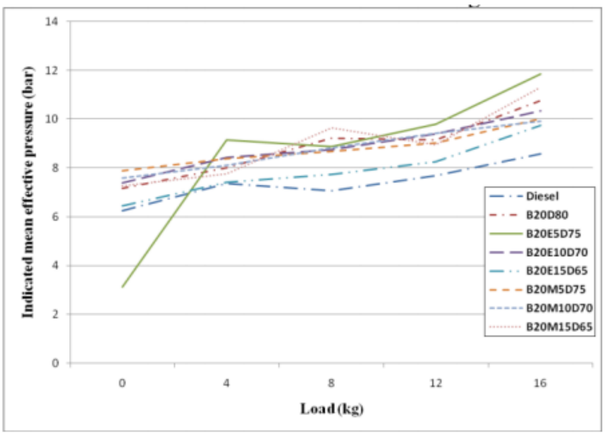

Fig 4 Variation of IMEP at different load

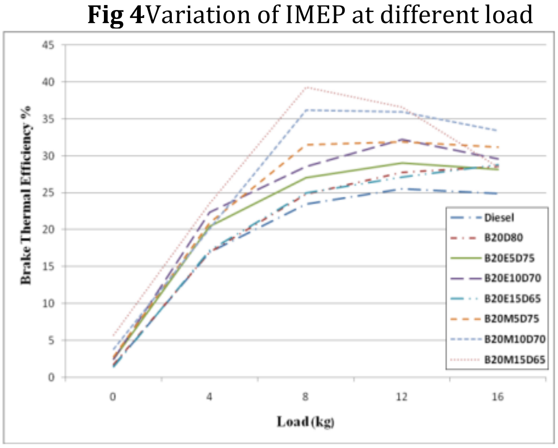

Fig 5 Variation of Brake thermal efficiency at different load

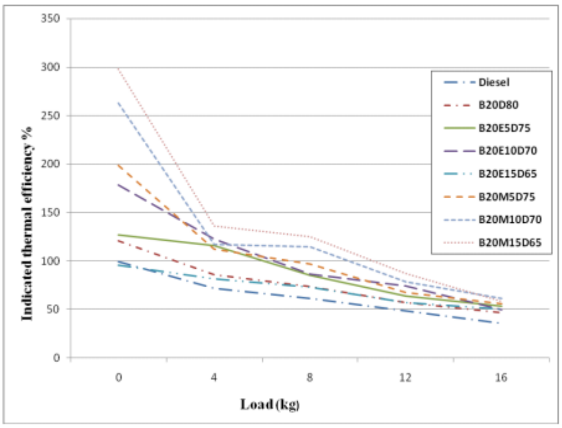

Fig 6 Variation of Indicated thermal efficiency at different load

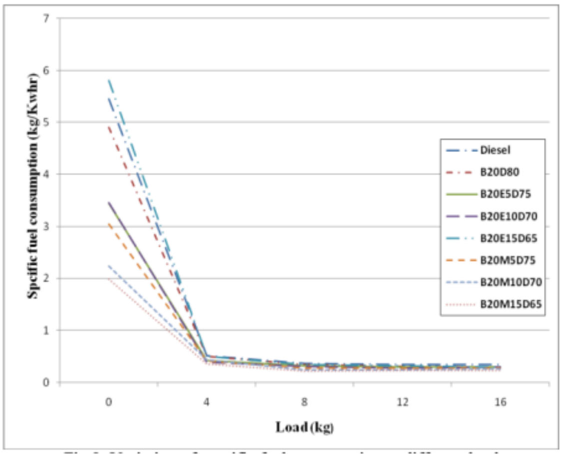

Fig 7 Variation of Specific fuel consumption at different load

4.1.4 Brake thermal efficiency

Brake thermal efficiency is the ratio of brake power to the input fuel energy. Figure 5 shows that the variation of brake thermal efficiency of various blends at various loading condition. The brake thermal efficiency of diesel is very low as compare to other blends. The maximum brake thermal efficiency at various loading condition is B20M15D65 blend below that B20M10D70, B20M5D75, B20E10D70, B20E5D75, B20D80, B20E15D65 and last pure biodiesel.

4.1.5 Indicated thermal efficiency

Figure 6 shows the variation in result of indicated thermal efficiency according to engine load. The indicated thermal efficiency decreases as increase in engine load.. The result shows that the as the concentration of additives of ethanol increases then increase in indicated thermal efficiency as compare to diesel. Also the methanol concentration increases the indicated thermal efficiency increases as compare to diesel as well as ethanol additives blends.

4.1.6 Specific fuel consumption

Figure 7 shows the variation of specific fuel consumption with respect to various loading condition. Specific fuel consumption is the ratio of fuel consumption per unit time to power consumption. The specific fuel consumption of diesel is higher than ethanol and methanol concentration blends. Methanol higher concentration blends less specific fuel consumption as compare to ethanol concentration blends. The B20D80 blend specific fuel consumption is less than diesel and B20E15D65 as compare to other blends.

4.2 Combustion parameter

4.2.1 Pressure verses crank angle

The variation of pressure verses crank angle as shown in figure 8. The variation of crank angle is 320° to 390°. The variation of pressure in diesel as a fuel is lower than the B20M15D65, B20M5D75, B20D80, B20M10D70, B20E10D70 respectively and higher than the B20E5D70, and B20E15D65 respectively.

4.3 Emission parameter

4.3.1 CO

Figure 9 shows the variation of carbon monoxide emission with respect to various loading condition. The CO emits diesel is maximum as compare to other blends. The ethanol concentration blends emits less CO as compare to diesel but high as compare to methanol concentration blends and B20D80.

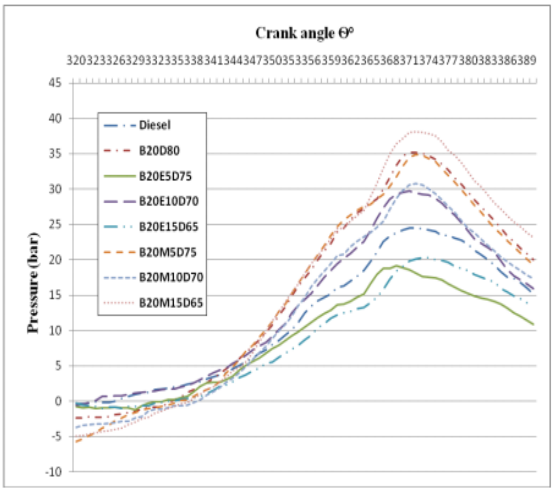

Fig 8 Variation of pressure verses crank angle

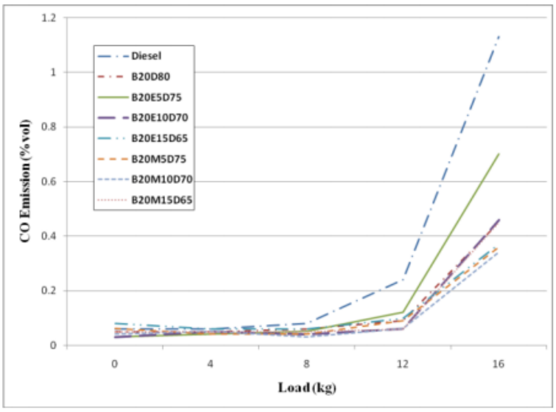

Fig 9 Variation of CO emission at different load

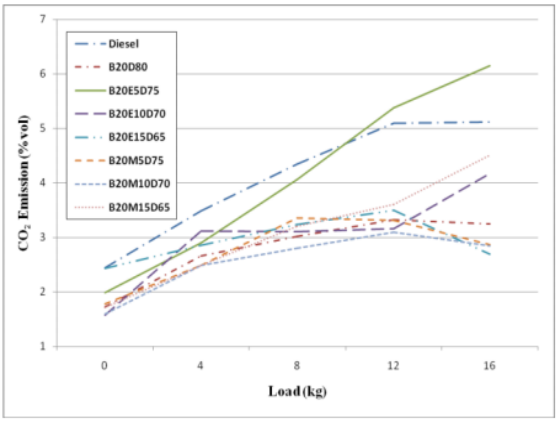

Fig 10 Variation of CO_2 emission at different load

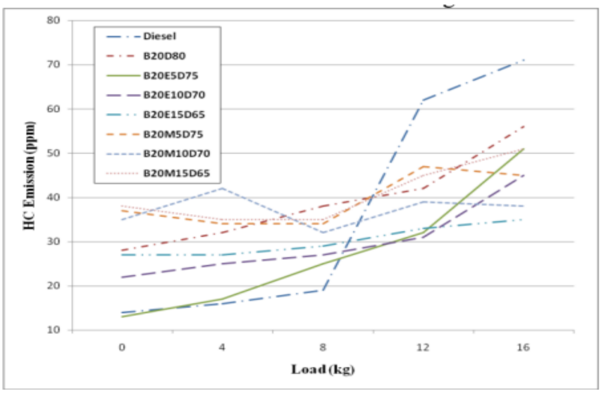

Fig 11 Variation of HC emission at different load

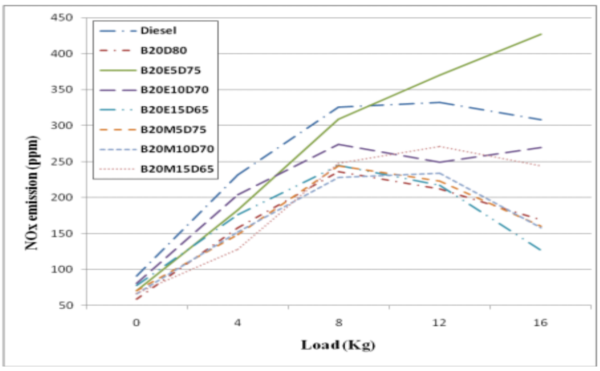

Fig 12 Variation of NOx emission at different load

4.3.2 CO_2

Figure 10 shows the variation of carbon dioxide emission with respect to various loading conditions. The diesel is emits maximum CO_2 at low load condition at higher loading emits less as compare to B20E5D75 blend. Other than B20E5D75 other are emits lesser CO_2 as compare diesel. The methanol concentration blends giving best result for CO_2 emission at all loading condition.

4.3.3 HC

Figure 11 shows the variation of hydrocarbon emission with respect to various loading condition. The HC emission at low load diesel is minimum as compare to other blends but as load increases the emission also increases. At higher loading ethanol concentration blends minimum emission of hydrocarbon. The methanol concentration blend B20M10D70 emits minimum amount of HC at high loading condition.

4.3.4 NOx

Figure 12 shows the variation of nitrous oxide emission with respect to various loading condition. The use of low concentration of ethanol in blends gives more NOx emission and methanol higher concentration blends obtained same result. At low loading condition methanol concentration giving optimum result but at high load B20M10D70 gives variation in result. The blend without additives also getting accurate result as compare to low concentration of ethanol and high concentration of methanol blends.

Conclusions

The experimental investigation concludes as given below

1) In performance the brake thermal efficiency is increase as compare to diesel. The maximum for the methanol additives blend.
2) The combustion of biodiesel is incomplete when used in diesel engine. The addition of additives gives the complete combustion of blends in methanol concentration as compare to ethanol concentration.
3) The emission of CO, CO_2, HC and NOx is reducing by addition of methanol in diesel and biodiesel.
4) The experimental investigation we conclude that comparisons of ethanol and methanol as additives in diesel- biodiesel blend methanol is best additives.

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