Comparative Analysis of Performance Characteristics of Various Biodiesel-Diesel-Alcohol Blends

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Abstract- *Energy is the most important topics in the current century and to the future. The fossil fuel crisis and emission problems lead to the investigation on alternative fuels. In this situation, Biodiesel have to be the proven next alternative fuel as it is environmentally friendly and renewable. However due to higher density and viscosity of biodiesel, pure biodiesel is not widely used in diesel engine. Nowadays to achieve the diesel fuel consumption and to reduce particulate matter emissions alcohols blends used with diesel. Though biodiesel has advantages, its viscosity and density becomes a limitation when using at diesel engine operating conditions. To improve density and viscosity of biodiesel, generally alcohols blends with biodiesel as well as the limitation of alcohol such as low cetane number, low heating values can be improved. In this study comparatively investigated the effect of various alcohol addition with diesel and biodiesel blends such as Biodiesel-ethanol-diesel(BED), Biodiesel-methanol-diesel (BMD) and Biodiesel-butanol-diesel(BBD).Three types of biodiesel used are madhua indica oil, linseed oil and eucalyptus oil. Engine performance characteristics were evaluated on Diesel fuel (D75%) was mixed with biodiesel (BD25%) and alcohol (5%) by volume percentage tested in a single cylinder, four stroke variable compression ratio (VCR) research Engine. From the study of ternary blends, use of diesel fuel consumption can minimize by 25% and reduce emission.*

Keywords- Madhua indica, Linseed oil, Eucalyptus oil, Performance, biodiesel alcohol blends.

I. INTRODUCTION

The increasing demands of fuel in automobile sector and in power sectors combined with limited availability of conventional fuels and harmful ecological and environmental effects from their usage attracted many scientists and researchers towards developing different types of alternative fuels to replace the petroleum and diesel fuels. In the journey of finding new alternative fuels biodiesel has received good attention due to their complete CO2 lifecycle. Biodiesel is completely renewable fuels and reduces the harmful emissions from the engine such as CO, SOx and HC. For these reasons pure biodiesel is not widely used in diesel engines without any modification. But on the other side a major problems limits the use of biodiesel are higher viscosities, lower calorific values, increased brake specific fuel consumption, and poor cold flow properties such as cloud point, pour point and cold filter plugging point.[1] The harmful NOx emission also increases at higher blends of biodiesel. To address these difficulties alcohol as an additive was added in biodiesel/diesel blend and properties, performance and emission analysis done by many researchers and scientist in last one decade. The use of oxygen rich alcohols improves both premixed and diffusion combustion stages and also alcohol fuel blends improves exhaust emissions. Ethanol addition improves combustion and reduces exhaust emissions due to its oxygen content. The flash point of ethanol is less than that of diesel. While methanol shows good miscibility. Butanol has very similar properties to diesel fuels that high cetane number, higher miscibility, lower vapour pressure, less corrosivity and high energy contents. But the use of alcohol has limitations that low cetane number, low miscibility, phase separation and long ignition delay. For these reasons, Use of ternary blends [biodiesel-diesel-alcohol] in diesel engines as a solution to reduce above drawbacks of a biodiesel and alcohol blends. Qi et al [2] investigated the performance, combustion and emission characteristics of a turbocharged common rail direct injection (CRDI) diesel engine using the Tung oil-diesel-ethanol micro emulsion fuels. The results indicated that the micro emulsion fuels showed higher the brake specific fuel consumption (BSFC), lower smoke emissions at high engine loads. However, the CO and HC emissions at low engine loads were higher as compared to a diesel fuel. S Imtenan et al [3] investigated the influence of n-butanol-diesel blend on the performance and emissions of a heavy duty diesel engine. They reported that the soot and CO emissions can be improved by the addition of n-butanol on cotton seed biodiesel-diesel blends. Nadir Yilmaz [4] reported that comparative analysis of biodiesel with ethanol and methanol blend as an additive. In that methanol blends are more effective than ethanol blends for reducing CO and HC emissions while NO reduction is achieved by ethanol blends. Qi et al [1] investigated the performance and combustion characteristics of biodiesel-methanol-diesel blends in compression ignited engines with methanol as an additive volume percent of 5% and 10% added to the baseline fuel and biodiesel. Results that BDM5 and BDM10 show a significant decrease of smoke emissions, while CO emissions are slightly lower. S.Madiwale et al [5] investigated the performance of a diesel engine fuelled with jatropha, soybean, palm and cottonseed biodiesel using ethanol as an additive. Results that improved BP, increased BSFC and increased BTE for various loads on engine of various biodiesel. S.Imtenan et al [6] analysed the impact of oxygenated additives to palm and jatropha biodiesel blends in the context of performance and emissions characteristics of light duty diesel engine. Use of ethanol, butanol and diethyl ether additive improved BP and BTE. The ethanol additive reduces CO emission up to 40% while use of ethyl ether reduces NO_x emissions up to 13%.

In the present experimental investigation, alcohol is added to different feedstock of biodiesel such as Madhua Indica, Linseed and eucalyptus biodiesel with diesel as an additive by 5% volume. All properties such as viscosity, density, calorific value, flash point and fire point of blends of biodiesel/diesel with various alcohol(ethanol, methanol and butanol) are investigated as per IS 1448 standards. Investigation reported that addition of alcohol as an additive reduces the kinematic viscosity, cloud point and pour point of blends of biodiesel. The test fuels BD20E5D75 (20% biodiesel + 75% diesel + 5% ethanol), BD20M5D75 (20% biodiesel + 75% diesel + 5% methanol), and BD20B5D75 (20% biodiesel + 75% diesel + 5% butanol), of Madhua indica, linseed, and eucalyptus biodiesel are tested on single cylinder, four stroke, VCR (Variable Compression Ratio) electric start diesel engine connected to eddy current dynamometer for various load conditions to evaluate performance analysis of the engine.

II. METHODS AND MATERIAL

The mahua indica oil, linseed oil and eucalyptus oil were purchased from Annamalai University Chidambaram, Tamilnadu and the alcohols were collected from chemical laboratory, Coimbatore. The oil has higher viscosity and density which raising problems in the diesel engine and therefore transesterification process was used to improve the properties and make it compatible for combustion without any further problems. In this process, the carbonyl carbon of the starting ester carryout nucleophilic attack by the arriving alkoxide(R20-) to give a tetrahedral intermediate, which either reverts to the starting material or proceeds to the transesterified product (RCOOR2).

A.FUEL CHARACTERISTICS

For this comparative research study, three types of biodiesel used namely madhuca indica oil, linseed oil, and eucalyptus oil and three types of alcohol used namely ethanol, methanol and butanol. Diesel fuel referred as base line fuel. Biodiesel blends with diesel by volume 20%percentage.Alcohol blended with biodiesel diesel blend by volume 5% percentage. Fuel blends were prepared based on volume percentage ratio at magnetic stirrer at constant 1000 rpm for 20minutes on steady conditions. Prepared fuel blends were tested for properties. Most researchers have focused their attention to density, kinematic viscosity, flash point and calorific value to define fuel quality. Among these properties, density and viscosity are the most important fuel parameters because fuel flows through various pipelines, nozzles and orifices. Density and viscosity also greatly influences fuel atomization, which influences combustion quality and the performance and emission characteristics. The density and viscosity of biodiesel are higher than that of diesel. The use of ethanol, methanol and butanol, as additives helped to decrease both density and viscosity. The additives have lower calorific values than biodiesel, which means that the blends have lower calorific values

Table 1. Properties of alcohol

Property	Ethanol	Methanol	Butanol
Kinematic viscosity at 40□c (Cst)	1.1	0.59	2.63
Density 15□c (kg/m^3)	790	792	808
Flash point(□c)	13	11	35
Calorific value(KJ/kg)	28600	19800	33100

Table 2.fuel properties of diesel and biodiesel

Property	Madhua Indica methyl ester	Linseed methyl ester	Eucalyptus methyl ester	diesel
Kinematic viscosity at 40□c (Cst)	4.86	3.52	1.85	3.43
Density at 15□c(kg/m^3)	867	880	908	836
Flash point(□c)	108	196	32	50
Calorific value(KJ/kg)	38513	37251	42500	42700

B.EXPERIMENTAL SET UP

For the present experimental research study performance characteristics, used ICEngine variable compression ratio (VCR) research engine setup having power 3.50 kW at 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder

Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 17.50, Swept volume 661.45 (cc).The engine was coupled to an eddy current dynamometer which can be operated at a maximum power of 20kW.The engine was first operated with diesel to warm-up and to define baseline fuel parameters. The measured engine performance parameters are brake power, indicated power, frictional power, brake thermal efficiency (BTE), brake specific fuel consumption, brake mean effective pressure, indicated thermal efficiency, mechanical efficiency, volumetric efficiency, A/F ratio and heat balance.. Tests were carried out at 0%, 25%, 50%, 75% and 100% load conditions. For data acquisition, ICEngine control system was used, which was monitored with help of ICEngine software 9.0.

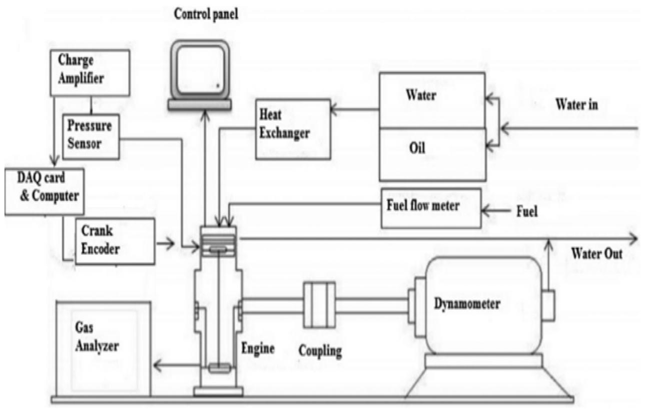

Figure 1.Schemmatic diagram of experimental set up.

III. RESULTS AND DISCUSSION

ENGINE PERFORMANCE.

Engine performance was evaluated in terms of brake power, BSFC and BTE. The following sections will describe the results of these performance parameters.

A. Brake power:

Variation in brake power as a function of load for diesel(D100),BD1E5D75,BD1M5D7,BD1B5D75, BD2E5D75,BD2M5D75,BD2B5D75,BD3E5D75,BD3M5D75,BD3B5D75,BDD1D75,BD2D75 and BD3D75 blends are shown in Figure.2 respectively. Brake power increased for diesel blends at every increasing loads. A the part of oxygenated compounds of biodiesel and alcohol in the blend with diesel increases, the brake power of the biodiesel/diesel/alcohol blend and biodiesel/diesel blend reduces than the conventional diesel fuel for all the variable loads. Lower cetane number and lower calorific value of the biodiesel and alcohol are the important factors to reduce brake power of the blend. Investigation reported that ternary blends BD3B5D75, BD2B5D75 shows high brake power than other blends. But lower than diesel. In biodiesel/diesel blends BD3D75 shows high value compared to other biodiesel/diesel blends. In the consideration alcohol blends, eucalyptus biodiesel blends with butanol shows comparable value of BP increases .Slightly reduces 10% compare with diesel, brake power for the madhua indica biodiesel.

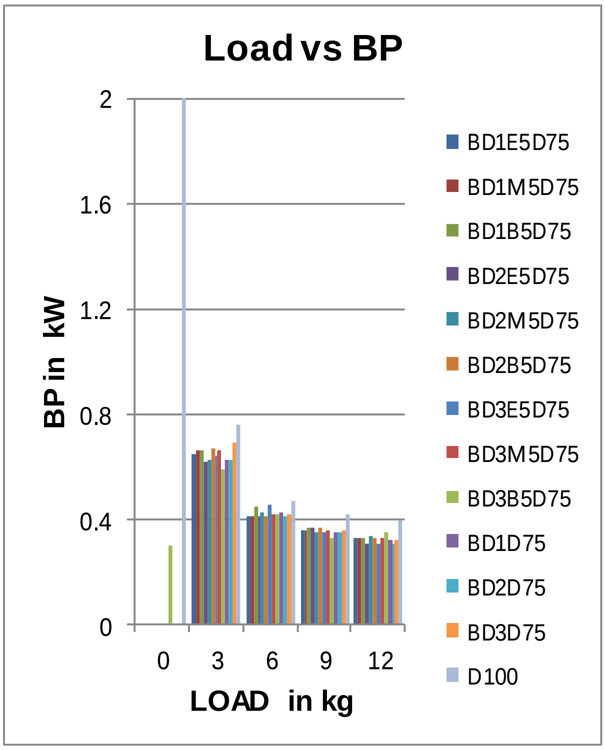

Figure 2. Variation of BP with respect to Load.

B. BRAKE THERMAL EFFICIENCY (BTE)

BTE is the efficiency of a heat engine measured by the ratio of the work performed by it to the heat supplied to it. Variation in BTE as a function of load for diesel(D100),BD1E5D75,BD1M5D7,BD1B5D75,BD2E5D75, BD2M5D75,BD2B5D75,BD3E5D75,BD3M5D75,BD3B5D75,BDD1D75,BD2D75 and BD3D75 blends are shown in Figure.3 respectively. Based on graph shown, the BTE for blended fuels increased gradually as loads increase. At higher loads of 25%, 50% 75%, 100%, all fuel blends shows higher BTE than diesel D100. Higher BTEs for the blends of BD3B5D75 and BD2D75 can be attributed to the increased availability of fuel-bound oxygen content in the fuels and finer atomization, which in turn increases brake power enhancing the combustion efficiency. Another significant reason for higher BTEs for BD3B5D75 is may be the lower heat losses due to lower temperature at the initial part of the combustion which also justifies little higher BTE. At 100% load BD2 linseed biodiesel blends shows higher BTE, it exerts more bound of oxygen and atomization.

C.BRAKE SPECIFIC FUEL CONSUMPTION

The brake specific fuel consumption was plotted in figure 4.The fuel flow rate per unit power is defined as BSFC which are important parameter to measure efficiency of supplied fuels.

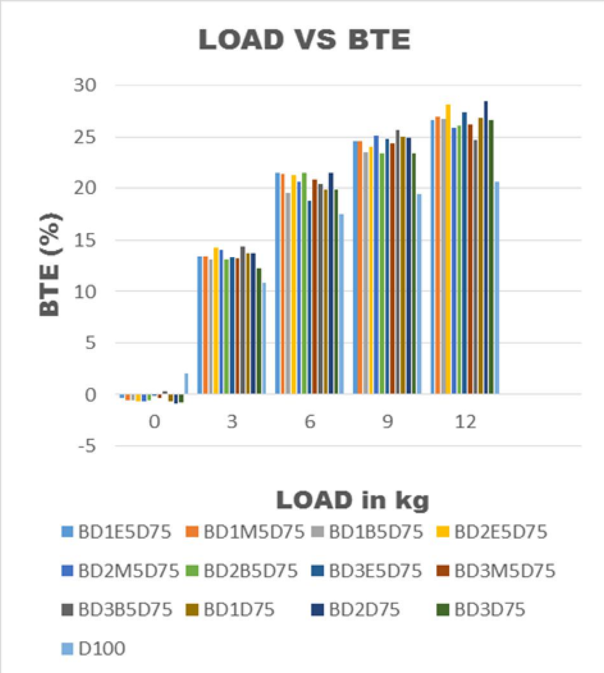

Figure3.Variation of BTE with respect to Load.

As seen in the figure, BSFC decreases with increasing of engine loads. It shows BSFC has decreased for all ternary blends and biodiesel/diesel blends compared with diesel at all increasing loads. Reason that at low engine loads, the in-cylinder gas temperature is relatively low leading to incomplete and low efficiency combustion, resulting in higher BSFC. While at higher engine load, the in-cylinder and gas temperature was higher, leading to more complete and efficient combustion which producing in lower BSFC for diesel.

All alcoholic ternary blends shows enormous decrease in BSFC, especially methanol blends with biodiesel due latent heat of vaporization. Diffusion rates of the fuel vapour inside the combustion chamber, thus promotes the mixtures preparation before ignition it cools in-cylinder and temperature decreases. Moreover, fuel blends have a shorter ignition delay due to higher cetane number, so it is expected that the blends lead to better combustion and lower BSFC.

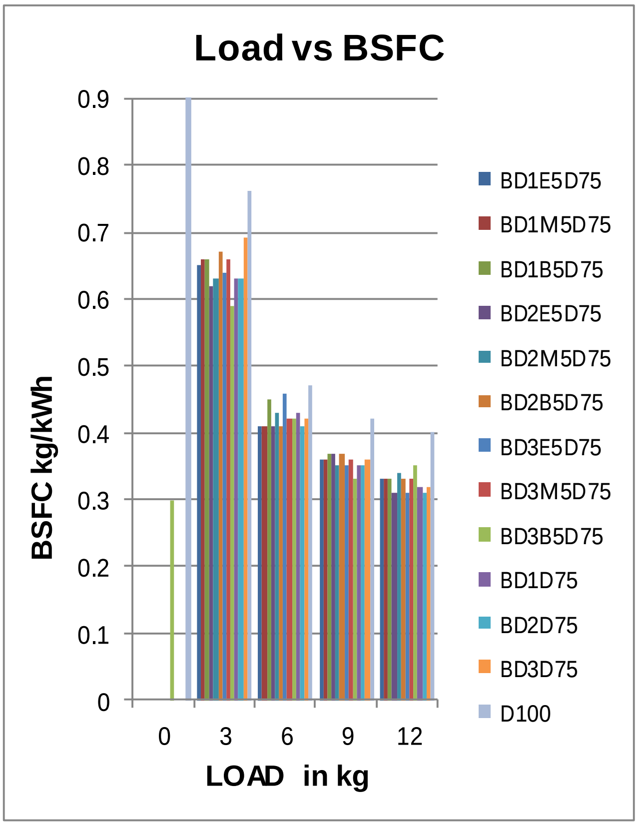

Figure 4. Variation of BSFC with respect to load.

IV. CONCLUSION

To prepare a blend of biodiesel-diesel fuel with alcohol as an additive, amount of alcohol should be kept as low as possible up to only 5% by volume in the total blend ratio. According to the experimental results addition of alcohol decreases the density of all biodiesel diesel ethanol blends also the heat content or calorific value of the blend decreases by addition of alcohol. But on the other side the kinematic viscosities decreases for all the blends of biodiesel/diesel with alcohol which improves the spray pattern of the fuel in the cylinder and enhanced the quality of combustion. This will increases the usability of biodiesel in cold conditions. The performance analysis of investigation shows that there is an improved BP (brake power), increased BSFC (brake specific fuel consumption) and increased BTE (brake thermal efficiency) for various loads on engine for linseed, madhuca indicia and eucalyptus oil blend with diesel and alcohol as an additive .

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