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Experimental Investigation of Energy and Exergy of Diesel Engine using Hybrid Biodiesel

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Abstract

Hybrid biodiesel is prepared from by mixing the three non-edible oils viz. castor oil, cotton seed oil and Neem oil in optimum proportion. After transesterification reaction, the mixture of this oil is converted into hybrid biodiesel. This hybrid biodiesel and its two blends B5 and B15 is used in the single cylinder 4 stroke diesel engine. The performance of the engine is noted and compared it with mineral diesel and it is found the BSFC of the engine is good for hybrid biodiesel as compared to diesel. Energy and exergy analysis is also done in this study for the two blends and Hybrid diesel and mineral diesel. Exhaust gas analysis is also done in this study.

Keywords: non-edible oils, hybrid biodiesel, transesterification, energy and exergy analysis, exhaust emission.

1. Introduction

The biodiesel can be used in diesel engine by reducing the viscosity of the fuel and it is reduced by mixing it with diesel or preheating the biodiesel [1]. The idea to produce the biodiesel from mixture of three oil is based on the idea of the hybrid biofuel. Hybrid biofuel is produced by mixing the oil with butanol and ethanol in optimum proportion, five different biofuels are prepared by five non-edible oil [2]. Generally, biodiesels are prepared from transesterification method. Also, by methanolysis biodiesel are also made after optimizing the process of methanolysis high purity biodiesel can be obtained.[4]. From microalgae biodiesel are also made and compare with non-edible oils.[8]. By mixing the oils to produce the biodiesel decreases the temperature of the reaction needed for conversion it is also reduces the cost of production [9]. Lower percentage of biodiesel blends reduces the harmful emission and Neem oil biodiesel can be used in diesel engine without any modification [10]. Due to sulphur in the diesel reduces the phase transition temperature [11]. Biodiesels are also prepared by micro emulsion techniques, stability of the emulsion depends upon concentration of water.[13]. With the help of micro emulsion techniques the viscosity of the biodiesel can be reduced.[14] Butanol is used as a surfactant in micro emulsion preparation [15]. Mixing of two oils for making the biodiesel shows intermediate properties [20]. The biodiesels are prepared from non-edible oils are done by transesterification, micro emulsion, addition of surfactants. The biodiesels are used as fuel in an engine by many researchers to improve the performance of an engine. Increase in butanol percentage in the biodiesel increases the BSFC and but some investigators reported that BTE increases and some reported BTE is decreases [7&15]. Addition of alcohol in the diesel improves the perform of the engine [26]. By improving the content of biodiesel energy efficiency also increases [31]. As the biodiesel is made from non-edible oil by transesterification method, same strategy is used in this study. Three oil i.e. castor oil, cotton seed oil and Neem oil are used for preparation of hybrid biodiesel and this hybrid biodiesel and its blends are used in diesel engine as a fuel. Energy and exergy analysis of the engine is done and exhaust analysis is also done in this study.

2. Materials and method

2.1 Reagents and oil sample

KOH, methanol (99.5% pure) is purchase from Jalgaon, the three oils i.e. castor oil, cotton seed oil and Neem oil is purchased from local supplier. These three oils are mixed together at room temperature at magnetic stirrer 500 rpm up to 20 mins for proper mixing. Before, mixing these three oils are filtered to remove impurities. The samples of the hybrid biodiesel are prepared in the lab.

2.2 Transesterification reaction

After mixing the three oils, the mixture is heated up to 70-80^{o}C and stirrer at 600 rpm. After reaching the desired temperature the mixture is allowed to cool down at room temperature. KOH [8-10 g (1%wt)] is dissolved into 40 ml methanol, KOH work as catalyst in the reaction. This mixture is added to the mixture of an oils and it is then heated to 100^{o}C and the vapours of methanol is cool down by using reflux condenser. After, completion of reaction the glycerine and methyl ester are separated in separator. After preparation of biodiesel it is washed using warm water to remove impurity, glycerine amount of soap and non-reacted base [12]. This process of water washing is repeated 3-4 times to obtain the pure biodiesel.

3. Experiment

The engine used in this study was Kirloskar single cylinder four stroke Diesel engine. This engine is coupled with eddy current dynamometer for measurement of brake power. The test set up is as shown in fig.1 below

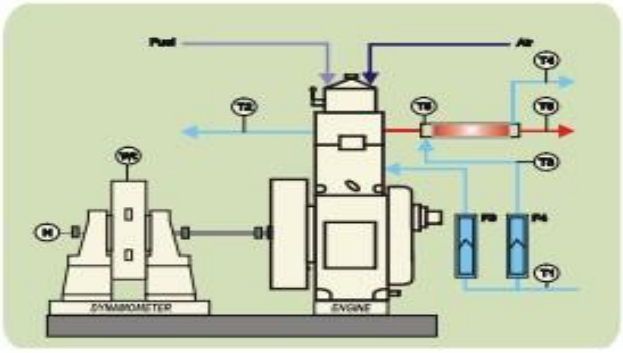

Fig.1. Kirloskar Diesel engine

The specification of the engine is tabulated below as shown in table 1.1. Also, three gas analyser is used in this study.

Product	Engine test setup 1 cylinder, 4 strokes, Diesel		
Engine	Make Kirloskar, Model TV1, Type Single cylinder, 4 stroke Diesel, water cooled, power 5.2 kW (7 BHP) at 1500 rpm, stroke 110 mm, bore 87.5 mm. compression ratio 17.5:1, capacity 661 cc.		
Dynamometer	Type eddy current, with loading unit	Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel tank	Capacity 15 lit with glass fuel metering column	Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Calorimeter	Type Pipe in pipe	Speed indicator	Digital with non-contact type speed sensor
Temperature sensor	Thermocouple, Type K	Rotameter	Engine cooling 40-400 LPH; Calorimeter 10-100 LPH
Temperature indicator	Digital, multi-channel with selector switch	Overall dimensions	W 2000 x D 2500 x H 1500 mm

Table 1.1 Specifications of the engine

In this study the engine is operated on mineral Diesel, hybrid biodiesel and its two blends viz. B5 and B15. B5 and B15 is referred as blends of biodiesel (for B5 blend 5% of hybrid biodiesel and 95% diesel) and (for B15 blend 15% of hybrid biodiesel and 85% of diesel) respectively. Also, mineral Diesel and pure hybrid biodiesel is referred as D100 and B100 respectively. The engine was operated on all the above-mentioned fuel and performance of the engine was noted. The energy and exergy analysis were also carried out for all the fuel. R.p.m. of the engine was kept constant for all the fuel and readings were taken at 5 loads viz. 0, 25%,50%,75% and 100%. The following Results were obtained from the engine.

4. Results and discussion

Brake thermal efficiency of the engine operated on Diesel was found more as compared to B100, B5 and B15. As Shown in (fig. 3) as the load increases on the engine the BTE is also increases and for pure hybrid biodiesel (B100) BTE is low at all loads. The result obtained from Energy and exergy analysis is shown in following fig 4 & fig. 5 respectively for all fuels and at all loads. As shown in fig.4 almost all the hybrid biodiesel and its blends show similar energy content and there was most unaccounted heat in biodiesel were observed due to less brake power compared to diesel. The reason of more unaccounted heat is that there was radiation loss from the engine as the hybrid biodiesel oxygen content is more and this increases the exhaust temperature so there will be more loss of energy.

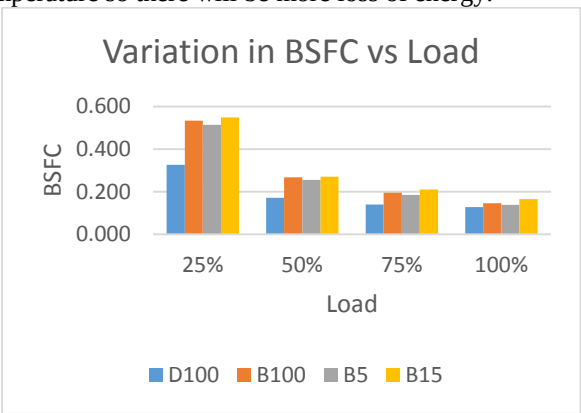

Fig. 2 Variation in BSFC vs load for all fuels

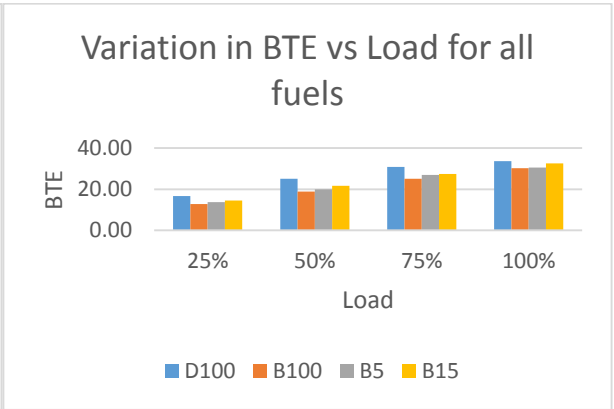

Fig. 3 Variation in BTE vs load for all fuels

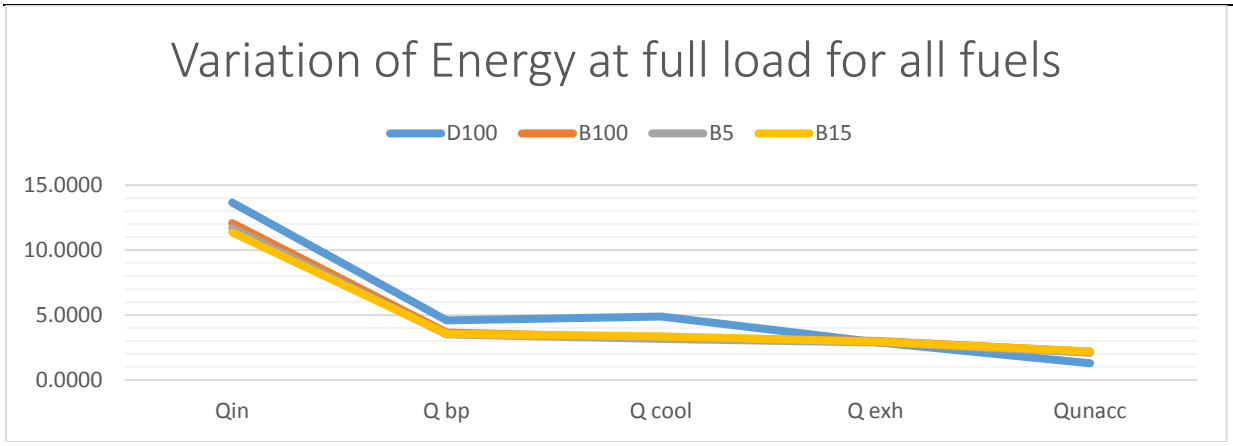

Fig 4 Variation of energy at full load for all the fuels.

The exergy analysis is shown in fig 5. B15 blend show more destruction as compared to other fuels because the temperature of the engine surface is higher and irreversibility created due to heat transfer. The efficiency availability variation shown in fig. 6. From fig. 6 we observe that at 75% load efficiency availability for Diesel is more as compared to others.
But, at full load B5 blend shows more availability efficiency than Diesel.

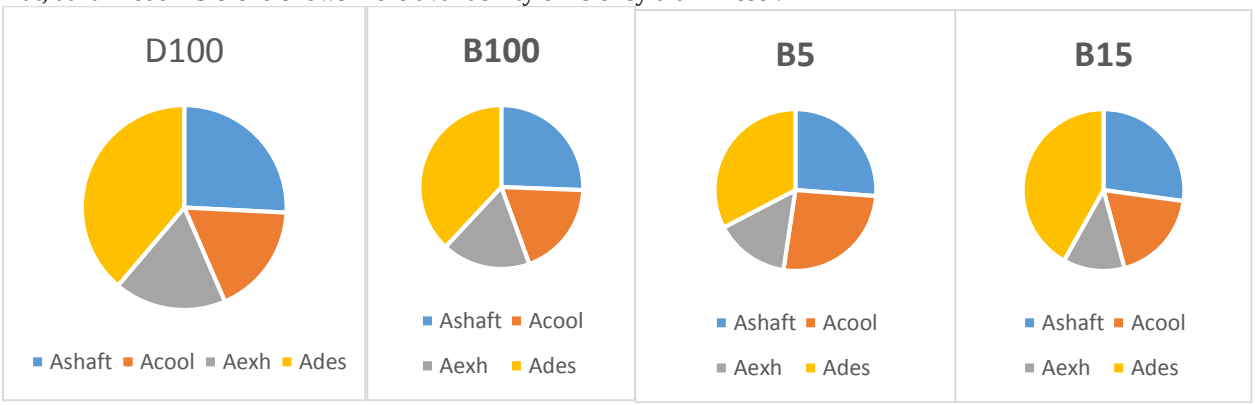

Fig 5 Exergy Variation at full load for all blends

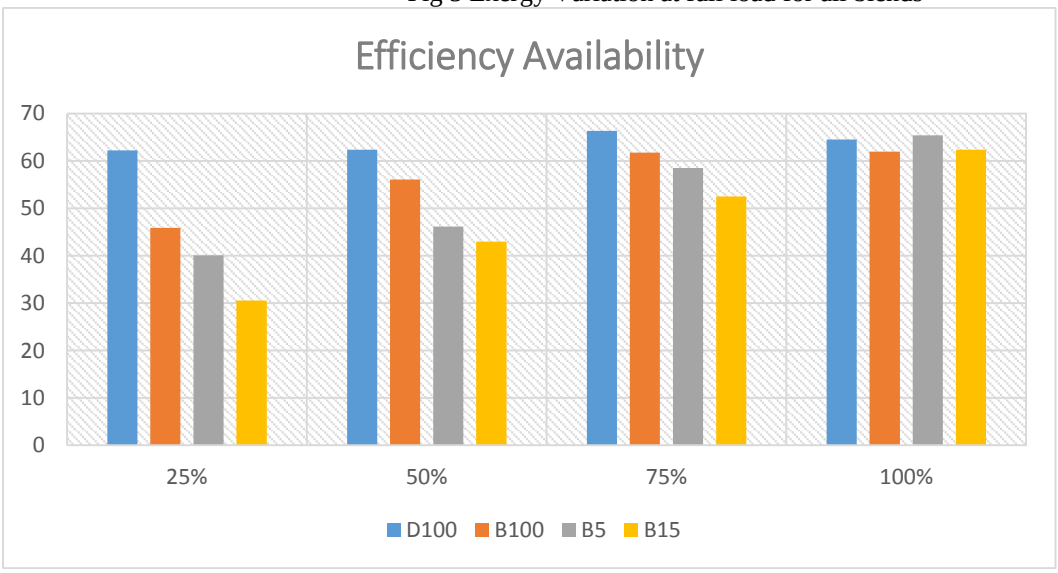

Fig. 6 variation in efficiency Availability

Exhaust emission

As the load on the engine increases CO emission also increases this is because rich air-fuel mixture . The CO emission for all the fuels are shown in the fig. 7

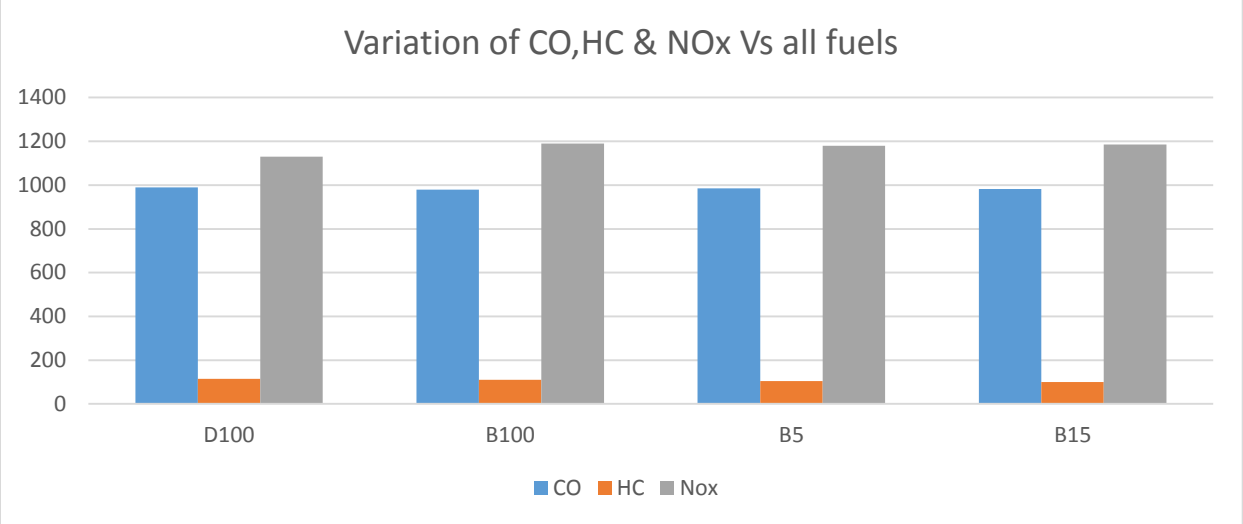

Fig.7 Variation of CO, HC & NOx Vs all fuels

As we can see in the fig. 7 NOx emission is increases in hybrid biodiesel as compared to Diesel but HC and CO emission decreases compared to Diesel fuel. When we operate engine on pure 100% hybrid biodiesel (B100) the NOx emission is more as compared to other fuels. As many researchers reported that using biodiesel HC and CO emissions are reduced compared to Diesel fuel same results were obtained but NOx emission found increased which can be reduced using microemulsion technique.

Conclusion

In this study, hybrid biodiesel is made from three oils by mixing with each other. This biodiesel and its blends were used in diesel engine and the performance of the engine is noted also energy and exergy analysis was done along with emission analysis was also done. From this, we can conclude that by using the hybrid biodiesel the BSFC of the fuel increases BTE reduces and the exhaust emission reduces except the NOx emission it increases for biodiesel compared to diesel fuel. The NOx is increases because the higher temperature inside the combustion chamber at this temperature nitrogen in the air react with air and NOx is formed. Hence, we can use hybrid biodiesel in diesel engine without any modification in the engine.

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