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Research Article

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Bio diesel production by transesterification in presence of two different catalysts and engine performance of the biodiesels

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ABSTRACT

Most research on biodiesel has paying attention on using plant based oils as feed stocks. The aim of the research is utilize the used vegetable oil methyl ester (UVOME), as a substitute for diesel in compression ignition engine. Used vegetable oil methyl ester is derived through transesterification process by using used vegetable oil (UVO) and methanol in the presence of either Sodium hydroxide (NaOH) or Potassium hydroxide (KOH) catalyst. The UVO, methanol and NaOH catalyst are mixed with various proportions in the reactor and heated up to 60^{o}C at constant speed stirring for 4 hours and cool it for 12 hours to retrieve the UVOME. To get the better yield of Bio-diesel, the various proportions of UVO, methanol and NaOH are taken for producing the Bio-diesel. Then this yield is compared with the same proportions of UVO and methanol in presence of the catalyst KOH. The yield of produced Bio-diesels of BN (Bio-diesel in presence of NaOH), BK (Bio-diesel in presence of KOH) were analyzed. The maximum yield 87% of UVOME (BK) is derived through transesterification in the presence of KOH catalyst by using bio-diesel processor is higher than the yield of UVOME (BN) which is derived by using NaOH catalyst. If the methanol and catalyst concentration are increased in transesterification process, the yield of BK and BN are also increased. The experiments were carried out to investigate the engine performance of used vegetable oil methyl esters and their blends with diesel in varying proportions.

Keywords: Transesterification, catalysts, Bio diesel, biodiesel blends, engine performance.

INTRODUCTION

The increase in demand of energy resources and the environment leads to increase the interest in the study of alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines. Most research on biodiesel has focused on using plant based oils as feed stocks. One potential source of oil is Used Vegetable Oil (UVO). It has been retrieved from waste oil after cooking [1]. From this UVO, [3] the bio diesel can be produced through transesterification process. [2], [3].

To reduce the cost of biodiesel production, to use waste oil as feedstock, such as waste cooking oil, stale non-edible oils, and so on [4]. Anitha A et al (2010) analyzed the properties of raw vegetable oil and waste cooking oil [5]. Ramadhas A.S. et al, (2004) have insisted, the mixing is very important factor in transesterification reaction [6]. Transesterification is also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis [7] [8].

Venkateswara Rao et al (2008) revealed that the transesterification is an equilibrium reaction in which a large excess of alcohol is required for the reaction to the right. The aim of the study is to investigate the Used Vegetable Oil Methyl Ester (UVOME) as a substitute for diesel in compression ignition engine. Used vegetable oil was converted into their methyl ester using transesterification process. The properties of the fuels were determined using standard methods [9]. Lakshmi Narayana Rao G et al (2008) investigated the combustion and emission characteristics of diesel engine which is fuelled with rice bran oil methyl ester and its diesel blends. Rice bran oil methyl ester (RBME) was derived through the transesterification process [10].

Lakshmi Narayana Rao G. et al (2008) studied the combustion and emission characteristics of a diesel engine fueled with used cooking oil methyl ester (UCME) and its blends. In this study used cooking oil was dehydrated and then transesterified using an alkaline catalyst. Experiments were conducted on a single cylinder naturally aspirated direct injection, air cooled stationary diesel engine. It was observed that, compared to diesel delay of ignition of UCME and its blends were found to be lesser [11].

A.Karthikeyan et al (2009) analyzed the engine performance for Jatropa (JME), Fish oil (FME), Pungamia methyl esters (PME) and their blends in single cylinder, 4 stroke CI engine. The volumetric efficiency values of B20 and B40 blends of all the methyl esters are approximately equal to the volumetric efficiency values of diesel at all loads. For B60, the volumetric efficiency values of FME were higher than all other fuels. The air fuel ratio values of B20 blends for JME, RME, and FME are nearer to the air fuel ratio values of diesel. For B40, B60 and B100 air fuel ratios of JME, RME and FME are less than the air fuel ratio of diesel. The exhaust gas temperature is increased with percentage of methyl esters were increased in the test fuel at all load conditions. The exhaust gas temperature of FME and its blends were lesser than other two methyl esters such as RME, JME and their blends [12].

A.Karthikeyan et al (2009) analyzed the engine performance for fish oil methyl esters in single cylinder engine. The thermal efficiency of B20 blends is less than diesel by 3%, the thermal efficiency of B40 blends FME is less than diesel by 4% and less than diesel by 4% [13]. Gui M.M et al, (2008) reviewed, the demand of fossil fuel increases day to day in the near future, the need to find a renewable energy sources becomes more important all over the world. Bio-diesel is produced from vegetable oils has characteristics similar to petroleum-derived diesel oil and has received considerable attention and used as a substitute fuel for diesel engines [14].

EXPERIMENTAL SECTION

Tranesterification

Used vegetable oil (UVO) is considered as feedstock for the biodiesel production. The method of biodiesel production is transesterification. The general equation for transesterification reaction is given in equation (1).

RCOOR' + R'' OH ↔ RCOOR'' + R' OH ---------------- (1)

Transesterification is an effective way to reduce the viscosity of the vegetable oils. During the process of transesterification, used vegetable oil (Used Sunflower oil) reacts with methanol in the presence of catalyst NaOH and form glycerol and vegetable oil methyl ester.

A specified quantity of vegetable oil and methanol were taken in the reactor. A few grams of NaOH were also added to reactor. The proportions were heated up to 60^oC that is below the boiling point of methanol and the contents need to mix vigorously fast for 2-3 hours till the ester was formed so that the chemical reaction should take place with effect. The mixture was cooled to room temperature and few drops of hydrochloric acid were added to neutralize it. Then the contents were washed with hot distilled water and allowed to settle overnight in a separator vessel. But the result can be far better if the mixture in mixing tank is kept for 1 day. Two layers were formed, top layer was the methyl ester and the bottom was glycerol. The glycerol was settled down at the bottom of the reactor because bio-diesel is lighter than glycerin. The glycerin was drained off using the separator valve fitted at the bottom of the reactor.

To retrieve the better yield of UVOME, the experiments were conducted for different proportions of Used vegetable oil, Methanol in presence of NaOH and the results were recorded. The same proportions of UVO, methanol in presence of KOH were also recorded. From the experiments results the better yield of UVOME in presence of NaOH which is called as BN and UVOME in presence of KOH that is BK were compared. The properties of the diesel, BN and BK are given in Table.1.

Table 1. The properties of the diesel, BN and BK

Properties	Diesel	BN	BK
Density (kgm^{-3})	830	889	878
Kinematic Viscosity @ 40^oC	3.2	6.5	6.2
Heating Value ($MJkg^{-1}$)	42.9	37.8	36.7
Flash point (^{o} C)	50	172	178
Auto ignition temperature (^{o} C)	260	455	463
Oxygen (%)	0	10-12	10-13

Experimental engine setup

The performance tests were carried on a single cylinder, four stroke, and water-cooled kirloskar computerized diesel engine setup. Diesel engine was directly coupled to an eddy current dynamometer. The engine and dynamometer were interfaced to a control panel, which was connected to a computer. This computerized test rig was used for reading the test parameters such as fuel flow rate, temperature, air flow rate, and load for calculating the engine such as power, brake specific fuel consumption, brake thermal efficiency, etc. The experimental engine setup is as shown in fig.1. Experiments were conducted when the engine was fuelled with UVOME and their blends with proportions of 20:80, 100% (by volume), which are generally called as B20, B100 respectively. The experiments are conducted for diesel, Bio diesel blends of B20N, B100N, B20K, and B100K.

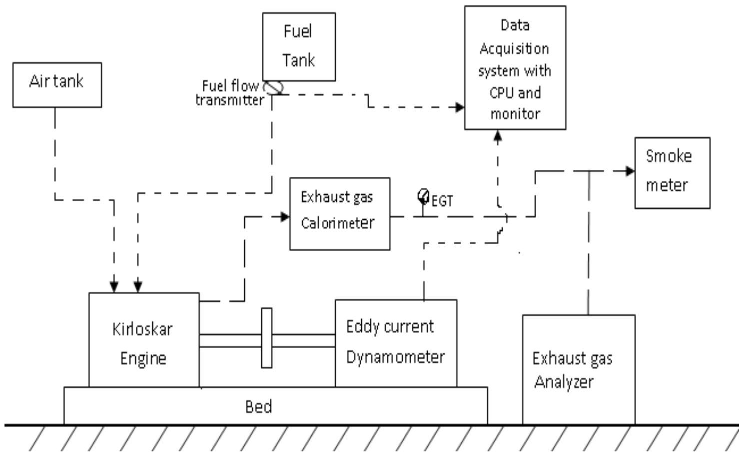

Fig1. Experimental engine setup

RESULTS AND DISCUSSION

Results of the yield of Used Vegetable oil Methyl ester (UVOME)

The comparison of the yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying methanol is shown in Fig.2. Fig 3.shows the comparison of the yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying UVO. The yield of UVOME (%) is compared by using two different catalysts (NaOH and KOH) by varying catalyst concentration as shown in fig 4.The fig 2 to fig.4 clearly show that, the yield of UVOME (BK) is derived through transesterification by KOH catalyst is higher than the yield of UVOME (BN) which is derived by using NaOH catalyst. It is observed that when the methanol concentration is increased in transesterification process, the yield of BK and BN are also increased. The yield is higher, when the catalyst concentration is increased; however it is lower when the UVO concentration is increased. Compared to the yield of BN, BK has the maximum yield of 87% which is increased by 2.4 % than BN. If the UVO is increased, the yield of BK and BN are reduced. BN is reduced by 2% in the yield of BN than the yield of BK. When the concentration of catalyst is increased in the transesterification process, the yield of BN and BK are also increased. The yield of BK is increased by 8% than the yield of BN. From these results it is observed that this emulsification can be alleviated reducing shaking intensity during washing and separation of biodiesel from glycerol. In spite of better yield, using NaOH causes more emulsion than KOH and makes difficult to separate biodiesel from glycerin. Due to this reason, KOH has been concluded as a better catalyst than NaOH to retrieve the maximum yield.

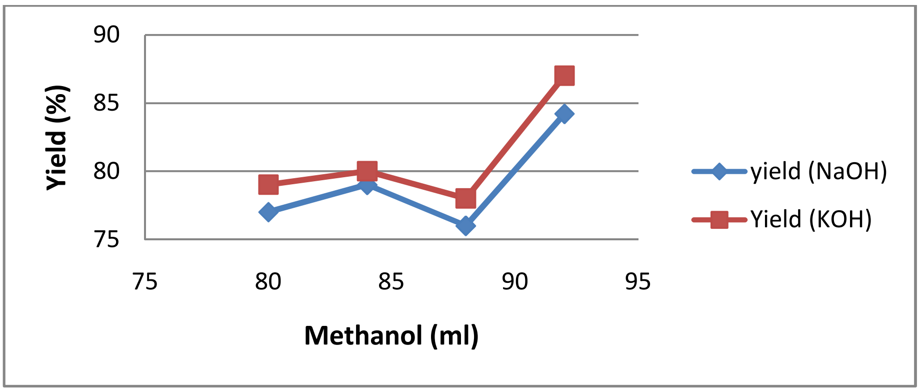

Fig.2. Yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying methanol

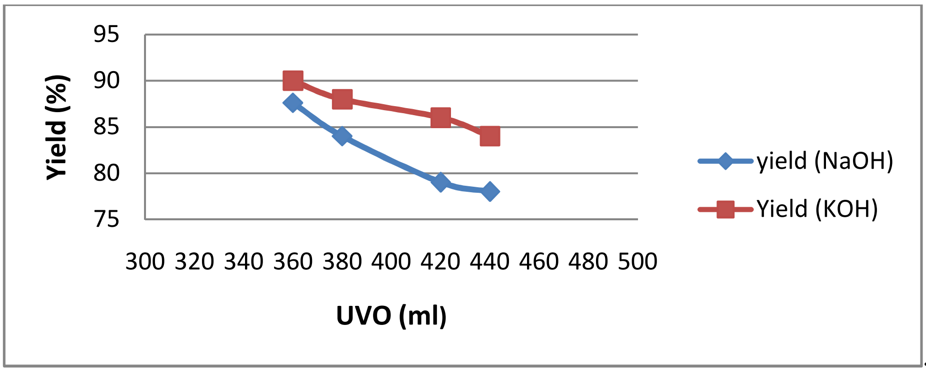

Fig 3. Yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying UVO

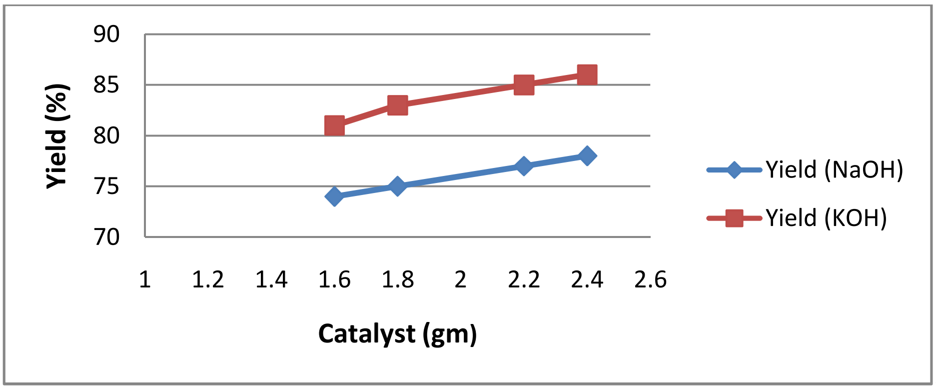

Fig 4.Yield of UVOME (%) by using two different catalysts (NaOH and KOH) by varying catalyst concentration

Brake Specific Fuel Consumption (BSFC)

Comparison of the Brake Specific Fuel Consumption **(**BSFC) for diesel, B20N and B20K with varying Brake Power (BP) is shown in fig.5. The lower value of BSFC is obtained when the B20N fuel is tested than B20K.The value is increased by 1.875% in B20K which is almost closer to diesel. Fig. 6 shows the comparison of BSFC for diesel, B100N and B100K with varying Brake Power. The value of BSFC is increased when the B100N fuel is tested. The value of BSFC is reduced by 4.75% than that of B100N. The result for the variation in the brake specific fuel consumption (BSFC) is represented in the fig.5 and fig.6 are clearly explained that, all the fuels, the BSFC falls with increasing load and Brake Power and the differences of BSFC are very small when varying the fuels. The lowest BSFC value is 0.2852 kg/kW-h for diesel than other BN and its blends, BK and its blends because UVOME has lower calorific value than that of diesel. Hence the specific fuel consumption is slightly higher than that of diesel for UVOME and its blends. The higher BSFC value in the case of B100N in higher brake power is due to their low energy content, high specific gravity and low calorific value, compared to diesel.

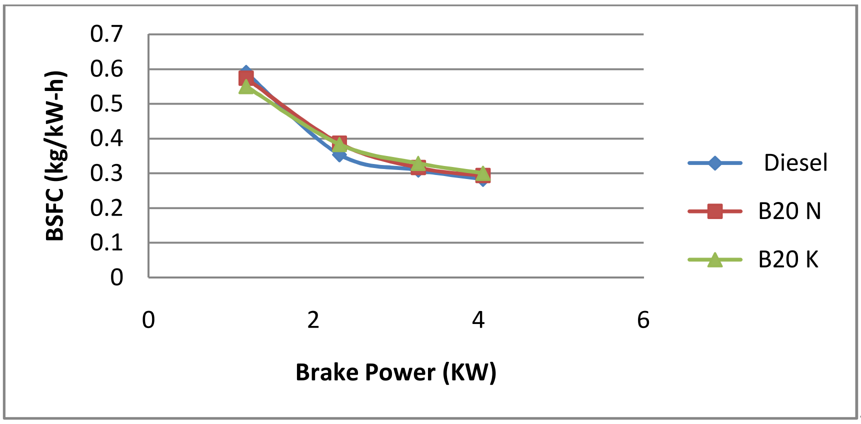

Fig 5. Comparison of BSFC for Diesel, B20N and B20K with varying Brake Power

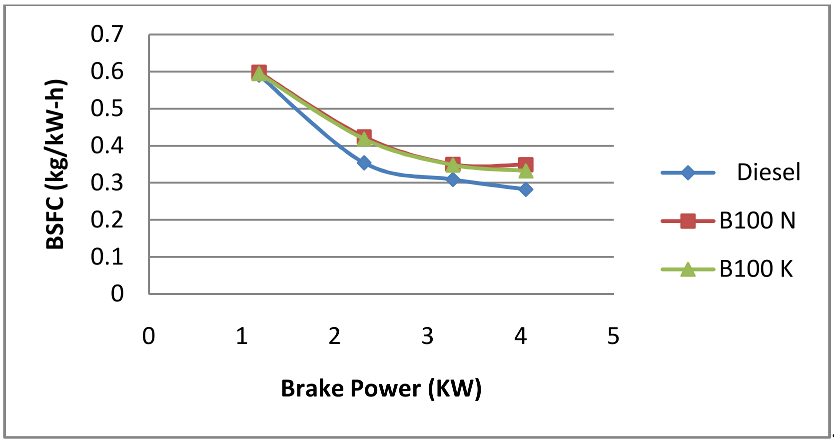

Fig 6. Comparison of BSFC for Diesel, B100N and B100K with varying Brake Power

Brake Thermal Efficiency (BTE)

Brake thermal efficiency (BTE) of BN and its blends, BK and its blends is lower compared to that of diesel. Fig.7 shows the comparison of BTE for diesel, B20N and B20K with varying Bake power. Compared to diesel and B20N, B20K has the lower value of BTE. BTE value for B20K is decreased by 0.96% when compared with B20N. The comparision of BTE for diesel, B100N and B100K with varying brake power is shown in fig.8. The BTE of B100K is lower than that of diesel and B100N. The value of B100N is increased by 0.8% than B100K. At higher brake power, the BTE of BK, BK blends, BN and its blends is lower than that of diesel by 0.12-2.26%. Since the engine is operated under constant injection and BN, BN blends, BK and BK blends have a smaller ignition delay; combustion is initiated much before TDC is reached. This improved the compression work and more heat loss and thus reduces the brake thermal efficiency of the engine. This can also be explained by the fact that maximum efficiency is obtained when most of the heat is released close to TDC. The start of heat release much before TDC for UVOME and its blends results in larger deviation from the ideal cycle and hence lower thermal efficiency is recorded. Also it is noticed that, the decrease in BTE is not proportional to the increase in % UVOME in the fuel. This variation is due to better lubricating properties of UVOME and higher density as compared to diesel.

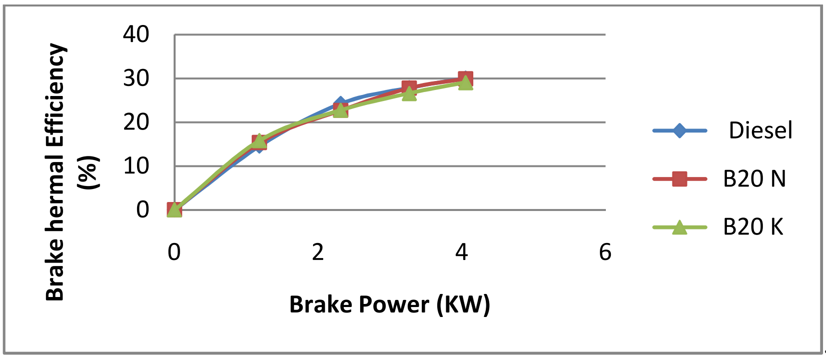

Fig 7. Comparison of BTE for diesel, B20N and B20K with varying Brake Power

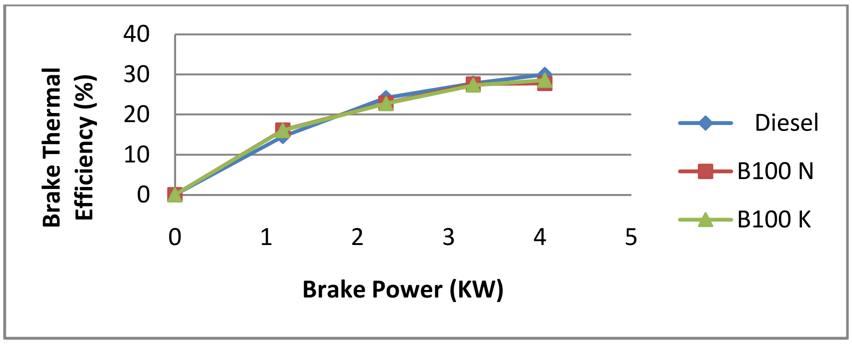

Fig 8. Comparison of BTE for diesel, B100N and B100K with varying Brake Power

CONCLUSION

The bio-diesel can be produced from used vegetable oil. The maximum yield of 87% is obtained for UVOME (BK) which is derived through transesterification in the presence of KOH catalyst by transesterification is higher than the yield of UVOME (BN) which is derived by using NaOH catalyst. If the methanol and catalyst concentration are increased in transesterification process, the yields of BK and BN are also increased. The density of BN and BK are higher than that of diesel. Brake thermal efficiency (BTE) of UVOME and its blends are lower compared to that of diesel. At rated load condition, the BTE of UVOME (BN) is lower than that of diesel by 2.54%. The BTE of B100K is lower than B100N.The value of B100N is increased by 0.8% than B100K at higher brake power. Hence the BTE of BK, BK blends, BN and its blends are lower than that of diesel. Brake specific fuel consumption (BSFC) is decreased with increasing load and brake power. The lowest BSFC value is 0.2852kg/kW-h for diesel than other BN and its blends, BK and its blends because of their lower calorific value than that of diesel. The highest BSFC value is obtained when B100N fuel is tested in rated load condition with higher brake power, when compared to all other BK blends and BN blends.

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