PRODUCTION AND PERFORMANCE ANALYSIS OF BIO-DIESEL FROM USED COOKING OILWITH NANOFLUID ALUMINA (Al_2O_3)

[1]S.Kaviyarasu,[2]J.Ubaidullah,[3]K.Yuvaraj, [4]P.Shanmugasundaram,[5]T.Tamilarasu
[1]Assistant Professor, [2,3,4,5]UG Student
Department of Mechanical Engineering,
Gnanamani College of Technology, Namakkal,India

Abstract : *A comparative study has been undertaken to investigate the production of biodiesel from used cooking oil and performance, emission characteristics of diesel engine using alumina nanoparticles blended biodiesel fuels. The fuel combinations used for the study were pure diesel for base line data generation and alumina Nano particle blended biodiesel. The biodiesel was prepared from used cooking oil. The alumina nanoparticles were blended with the biodiesel fuel in the mass fractions of 30 ppm and 50 ppm with the aid of an Ultrasonicator. Subsequently, the stability characteristics of alumina blended biodiesel fuels were analyzed under static conditions. The investigation were carried out using an experimental set-up consisting of a single-cylinder four stroke diesel engine coupled with an eddy dynamometer loading device and the results revealed that a considerable higher enhancement in the brake thermal efficiency and substantial reduction in the harmful pollutants for the blend of alumina nanoparticle due to the incorporation of alumina nanoparticle gives more surface area for reactivity and having higher thermal conductivity were observed.*

Index Terms– Biodiesel, Used cooking oil, Trans esterification, Yield of FAME, Alumina nanoparticle, Ultrasonicator, Performance of fuel in engine, Emission.

I. INTRODUCTION

As a result of increase in scarcity of petroleum resources over the world, researchers are driven to search alternative fuels like biodiesel, hydrogen fuel cells, biogas, ethanol, battery etc., to meet out the fuel demands. A recent survey says that the amount of petroleum products in the world will exhaust within 50 to 60 years. So there is increase in research is going on for effective substitute for petroleum product(1).

And also a report says that India produces only 40% of total petroleum requirements for its consumption and remaining is imported from overseas countries, which may cost about Rs.10,00,000 million per year. It is sure that mixing of 20%biodiesel with conventional diesel can significantly save the prices for fuel (2).

Biodiesel came into effect in 1990's.The reason behind that there is increase in effect of global warming, greenhouse gas emissions from vehicle emissions which cause many problems and affect environment. As a relief biodiesel can reduce significant emissions, biodegradable, less toxic and ecofriendly.

Biodiesel is obtained from sources like fresh or used vegetable oils, animal fats etc. It is superior to conventional diesel in terms of cetane number, flash point, exhaust emissions and lubricity. In the existing conventional diesel engines it can be used when blended with normal diesel and it doesn't require any modifications in the engine (1, 3)

Biodiesel can be prepared from following methods.
1) Direct using or blending
2) Micro emulsions
3) Thermal cracking
4) Trans esterification

This paper aims to focus on the biodiesel produced from Trans esterification process. It is the most commonly used method in preparing biodiesel (5, 6). Usage of pure biodiesel in conventional diesel engine has some performance issues. So blended type (B_5,B_{10}, B_1 , B_{20}) can be normally used in conventional diesel engine without any engine modification.

2. FEEDSTOCK:

The crops which is chosen for production of biodiesel are sunflower, corn, olive, canola, , palm, soybean, rapeseed ,cotton seed and peanuts oils, and animal-based lipid (e.g. butter). Waste animal fat is also is identified to be a good feedstock for biodiesel. Economic feasibility of biodiesel depends on the availability of low-cost feed stocks. The key issue for large scale application of biodiesel as compared to petroleum diesel is the high cost of biodiesel which is mainly concerned with cost of feedstock oils as both the edible and non-edible oils are limited. Moreover, it has been reported that nearly 60-95 % of the total production cost is related to the cost of raw materials. It can be overcome by the use of ***Used Cooking Oil (UCO)*** as raw material which can effectively reduce the feedstock cost to 60-70%. Similarly, the cost of catalyst also affects the overall production cost.

Many researches have been made to use waste materials for low cost catalyst preparation to develop sustainable biodiesel production process[4,5]

3. USED COOKING OIL (UCO)

Used cooking oil refers to the used vegetable oil obtained from cooking food. Repeated frying edible vegetable oil no longer suitable for consumption due to high free fatty acid (FFA) content.

If Waste oil is disposed it has many problems like water and soil pollution, human health concern and disturbance to the aquatic ecosystem. In spite of disposing it and harming the environment, it can be used as an effective and cost efficient feedstock for Biodiesel production as it is readily available and easily process able. If using fat of animal lipids it has many concerns in refining and processing and has certain technical problems also. UCO collected can also be used to prepare soaps and additive for lubricating oil got by by product of biodiesel as glycerine. Several researches assured that production of biodiesel from cooking oil is successful. Vegetable oil contains saturated hydrocarbons (triglycerides) which consist of glycerol and esters of fatty acids . In some places, UCO from restaurants were re-used by street sellers to fry their food, this waste oil is termed as second –used cooking oil can also be utilized by converting to biodiesel.

Infact, using waste vegetable oil reduces the need for biodiesel-producing crops and the competition with food. UCOs have different properties from those of refined and crude vegetable oils .The chemical and physical properties of UCO are different from those of fresh oil since some changes due to chemical reactions - such as hydrolysis, oxidation, acidity content polymerization, and material transfer between food and vegetable oil occur during the frying process.

4. ACID NUMBER

Acid value (or "neutralization number" or "acid number" or "acidity") is the mass of potassium hydroxide (KOH) in milligrams that is required to neutralize one gram of chemical substance. The acid number is a measure of the amount of carboxylic acid groups in a chemical compound, such as a fatty acid, or in a mixture of compounds. In a typical procedure, a known amount of sample dissolved in organic solvent (often isopropanol), is titrated with a solution of potassium hydroxide (KOH) with known concentration and with phenolphthalein as a color indicator.

The acid number is used to quantify the amount of acid present, for example in a sample of biodiesel. It is the quantity of base, expressed in milligrams of potassium hydroxide, that is required to neutralize the acidic constituents in 1 g of sample.

In this research obtained Acid value is 4.38.

5. CATALYST

Catalyst which is used for this process is KOH or NAOH. Catalyst does not alter the reaction but only speed up the reaction. Excess of catalyst results in more soapy formation and less result in not formation of biodiesel.

6. METHODOLOGY

I. Filtration:

Initially the Used Cooking oil is filtered in a filter to remove slag and impurities in a separate container.

II. Preheating:

The Used cooking oil (UCO) is heated up to 60°C for 30 to 60 minutes in a magnetic stirrer shown in fig.1 to avoid impurities and moisture content.

Fig.1 Magnetic stirrer

III. Methoxy solution:

Before Tran esterification process Potassium hydroxide (KOH) was first mixed with methanol together in one container to form meth-oxy solution before adding to the Used Cooking oil. After adding the methanol / Potassium hydroxide and Used Cooking oil the agitator speed were used to mix the solvents until they became murky. This was then heated to about 60° C for 30 minutes.

IV. Trans esterification:

Trans esterification process and any methanol evaporation the resultant biodiesels were left to lie for at least 8 hours. Separations were used to separate the top (methyl ester) and bottom (glycerol) layers of the biodiesel. The top layer was mainly composed of free fatty acid methyl esters. The bottom deposit was mostly made up of glycerol, salts, soap, other impurities and excess methanol as it is a very polar compound i.e. it partitions more with polar glycerol as opposed to the non-polar methyl esters.

Fig.2 Biodiesel and glycerine formation by Trans esterification process

V. Washing

The top methyl ester layer was separated and removed from every production sample. The water washing process was then used on some of the biodiesel batches. Once separated from the glycerine the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. In some processes this step is unnecessary. This is normally the end of the production process resulting in a clear amber-yellow liquid with a viscosity similar to petro diesel. In some systems the biodiesel is distilled in an additional step to remove small amounts of colour bodies to produce a colourless biodiesel.

7. BLENDING OF ALUMINA NANOPARTICLE

The aluminaNano particles will be weighed by using electronic balance. Then nanoparticles are weighed separately for quantities 30mg and 50mg accurately. The nanoparticles blended used cooking oil biodiesel fuel is prepared by mixing the Used cooking oil biodiesel and alumina nanoparticles with the aid of an Ultrasonicator displayed in Fig.3

Fig.3 Ultrasonicator

The Ultrasonicator technique is the best method to disperse the alumina nanoparticles in a fluid, as it facilitates possible agglomerate nanoparticles back to nanometre range. The nanoparticles are weighed to a predefined mass fraction say 30ppm and 50ppm dispersed in the biodiesel fuel the blend that prepared is called $UCOB_{100}ALUMINA_{30}$*(Used Cooking oil biodiesel + 30ppm Alumina) and* $UCOB_{100}ALUMINA_{50}$*(Used Cooking oil biodiesel + 50ppm Alumina)*. Those twoare taken as samples (B&C) and sample without blending alumina nanoparticle $UCOB_{100}$is taken as sample (A) as shown in Fig.4

Fig.4 Samples

In this samples A and C are taken for performance analysis in Single cylinder four stroke diesel engine with electrical dynamometer as displayed in Fig.5

The Table 4.1 below shows the properties of alumina nanoparticles for this present work.

Table 4.1: Specification of alumina nanoparticle

Item	Specification
Manufacturer	M/s. Sigma Aldrich, USA
Chemical Name	Alumina (Al_2O_3)
CAS No	1344-28-1
Molecular weight	101.96 g/mol
Average particle size diameter	50 nm
Specific surface area	32 m^2/g
Appearance	White

8. EXPERIMENTAL SETUP

After this the samples A& C are taken and it is converted to B_{20} Biodiesel (200ml Used cooking oil Biodiesel with alumina nanoparticle + 800ml petro diesel). The both samples are tested in Single cylinder four stroke diesel engine with electrical dynamometer as displayed in Fig.5 and their performance and their properties are displayed in Table 8.2

Fig.5 Single cylinder four stroke diesel engine with electrical dynamometer

The Table 8.1 displays the technical specifications of experimental engine.

Table 8.1: Technical Specification of experimental engine.

Manufacturer	KIRLOSKAR
Engine type	Single cylinder diesel engine
No. of strokes per cycle	4
Rated speed	1500 rpm
Stroke	110mm
Bore	80mm
Orifice diameter	20 mm
Loading type	Electrical dynamometer
Rated power	5HP

9. RESULTS AND DISCUSSION

9.1Fuel properties

The results obtained are compared in order to study the effect of nanoparticle and its dosing level of fuel properties.

From this analysis it is observed that there is no significant differences are observed in the density and kinematic viscosity due to the addition of alumina nanoparticles as a blend. But in other side there is an improvement in flash point temperatures and calorific value of $UCOB_{20}ALUMINA_{50}$*(200ml Used Cooking oil biodiesel + 50ppm Alumina+800 ml petro diesel)* when compared to unblended $UCOB_{20}$*(800ml petro diesel +200 ml Used cooking oil biodiesel)* and D_{100} *(1000ml petro diesel)*.The higher flashpoint temperatures are desirable for safe handling of fuels(6). The calorific value is desirable for better thermal efficiency and lower fuel consumption(7).

The Table 9.1 shows the properties of test fuels. The test fuels are D_{100} *(1000ml petro diesel)*, $UCOB_{20}$*(800ml petro diesel +200 ml Used cooking oil biodiesel)*&$UCOB_{20}ALUMINA_{50}$ *(200ml Used Cooking oil biodiesel + 50ppm Alumina +800 ml petro diesel).*

Table 9.1: Properties of test fuels

Properties	D_{100}	$UCOB_{20}$	$UCOB_{20}ALUMINA_{50}$
Density at 20°C, kg/cm^3	0.832	0.84	0.84
Kinematic viscosity at 40°C, mm^2/s	2.98	2.96	2.97
Flash point °C	50	53	56
Fire point °C	54	57	60
Calorific value , KJ/kg	42570	46952	44676

9.2 Brake Thermal efficiency

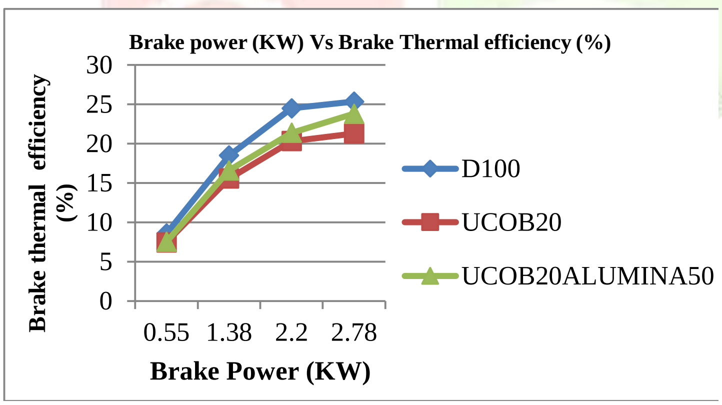

Fig.6 Brake power (KW) Vs Brake Thermal efficiency (%)

The variation of the BTE with respect to the Brake power is shown in the Fig.6. The BTE of the Used cooking oil biodiesel ($UCOB_{20}$) was lower than the diesel(D_{100}) due to the lower calorific value . However, a small improvement in BTE was found when addition nano particles to the base fuel. From the above graphs it is observed that $UCOB_{20}ALUMINA_{50}$ has increase in the Brake Thermal Efficiency.

9.3 Brake Specific fuel consumption

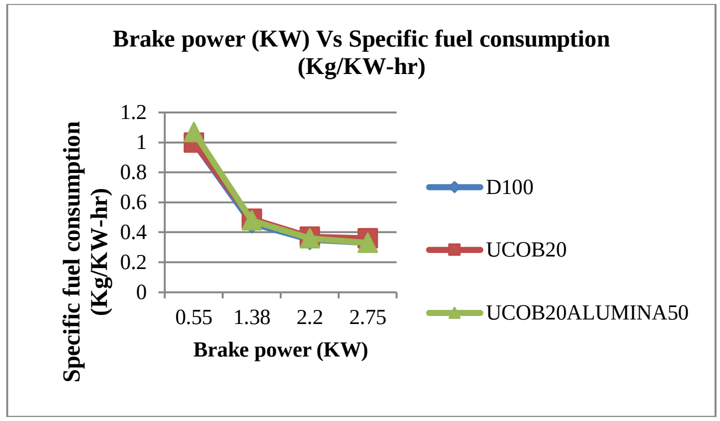

Fig.7 Brake power (KW) Vs Specific fuel consumption (Kg/KW-hr)

The variation of the specific fuel consumption with Brake power are shown in Fig.7. The specific fuel consumption decreases with an increase in the engine loads. . Lower SFC is observed for c this occurs due to the enhanced surface area to volume ratio by the catalytic effect during the combustion inside the engine cylinder and also for $UCOB_{20}$ blends there is a slight increase in specific fuel consumption due to the increase in the calorific value. From the above graphs it is concluded that $UCOB_{20}ALUMINA_{50}$ shows lesser specific fuel consumption than $UCOB_{20}$ and D_{100} due to Nano addition and catalytic effect.

9.4 Emission characteristics

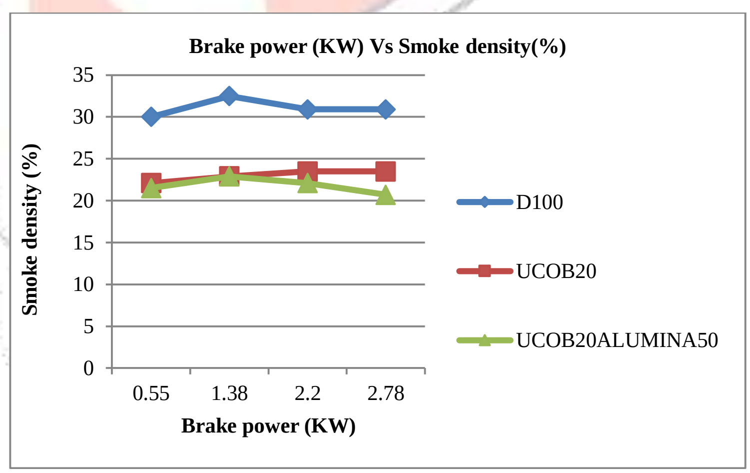

Fig.8 Brake power (KW) Vs Smoke density(%)

The variations of Smoke density with respect to the Brake power are shown in the Fig.8. From the graph it is observed that addition of Nano-fuel additives resulted in an effective reduction in smoke density. This is due to that Nanoparticles oxidizes and supports combustion process. From the graph it is concluded that $UCOB_{20}ALUMINA_{50}$ shows low smoke density than the $UCOB_{20}$ and D_{100}. It is considered to be more eco-friendly than petro-diesel.

10. CONCLUSION

Based on the study let we conclude that there exists a variety of feedstock in India that could be utilized to produce biodiesel. It can significantly reduce the demand of fuels and reduce the price of fuels. And also by utilizing the alumina Nano particle blended biodiesel can significantly has the following benefits:

a) The calorific value decreases with addition of Al_2O_3 blends and flash point increases with addition of Al_2O_3 blends.

b) The decrease in level of calorific value results in better thermal efficiency and lower fuel consumption and increase in flashpoint results in safe handling of fuels.

c) Considerable improvement is obtained in case of brake thermal efficiency is observed with Al_2O_3added Used cooking oil biodiesel than the unblended used cooking oil biodiesel at full operating condition.

d) Compared with D_{100} *(1000ml petro diesel)* and $UCOB_{20}$ *(800ml petro diesel +200 ml Used cooking oil biodiesel),* the specific fuel consumption is reduced in case of $UCOB_{20}ALUMINA_{50}$ *(200ml Used Cooking oil biodiesel + 50ppm Alumina +800 ml petro diesel).*

e) Compared with D_{100} *(1000ml petro diesel)* and $UCOB_{20}$ *(800ml petro diesel +200 ml Used cooking oil biodiesel),* the smoke density is reduced in case of $UCOB_{20}ALUMINA_{50}$*(200ml Used Cooking oil biodiesel + 50ppm Alumina +800 ml petro diesel)* i.e., alumina nanoparticle blended biodiesel.

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REFERENCES

[1] A Sunthitikawinsakul and N. Sangatith; Procedia Engineering 32 (2012) 219 – 224

[2] K. NanthaGopal ,Arindam Pal , Sumit Sharma , CharanSamanchi , K. Sathyanarayanan , T. Elango ; Alexandria Engineering Journal (2014) 53, 281–287.

[3] A Javidialesaadi and S. Raeissi; Biodiesel Production from High Free Fatty Acid-Content Oils:Experimental Investigation of the Pretreatment Step ;APCBEEProcedia 5 (2013) 474 – 478

[4] Muhammad Farooq ,AnitaRamli b, Abdul Naeemc; Renewable Energy 76 (2015) 362e368

[5] Honglei Zhang, Jincheng Ding, Zengdian Zhao; Bioresource Technology 123 (2012) 72–77.

[6] Sajith V, Sobhan C B & Peterson G P, AdvMechEng, 2(2012)205.

[7] Farkade H S &Pathare A .P, Int J Emerg Techno AdvEng, 2(2012)205.

[8] Osmano Souza Valente, VanyaMárcia Duarte Pasa ,Carlos Rodrigues Pereira Belchior ,José Ricardo Sodré ;Fuel 90 (2011) 1700–1702.

[9] AlemayehuGashaw, AbileTeshita(2014), Production of biodiesel from waste cooking oil and factors affecting its formation: A review, International Journal of Renewable and Sustainable Energy, 2014; 3(5): 92-98, ISSN: 2326-9715

[10] S.Gopalakrishnan, J.Ubaidullah, P.Shanmugasundaram, K.Yuvaraj and T.Tamilarasu. "Production of Biodiesel from used Cooking Oil." International Journal for Innovative Research in Science & Technology . (2017): 90-95.

[11] Balakrishnan, N, Mayilsamy, K &Nedunchezhian, N 2015, 'An investigation of the performance, combustion and emission characteristics of CI engine fueled with used vegetable oil methyl ester and producer gas', International Journal of Green Energy, vol.12, pp. 506-514. P-ISSN: 1543-5075, E-ISSN: 1543-5083 (Electronic).

[12] Balakrishnan, N, Mayilsamy, K &Nedunchezhian, N 2015, 'Experimental investigation of evaporation rate and emission studies of diesel engine fueled with blends of used vegetable oil biodiesel and producer gas' Thermal Science, vol. 19, No. 6, pp. 1967-1975, ISSN: 0354-9836.

[13] Idusuyi, N, Ajide. O.O., Abu, R.(2012) Biodiesel as an Alternative Energy Resource in Southwest Nigeria Volume 2 No.5, May 2012, International Journal of Science and Technology, ISSN 2224-3577

[14] Karthikeyan, R, Solaimuthu, C &Balakrishnan, N 2014, 'A study of performance and emissions of diesel engine fuelled with neat diesel and heat hydnocarpuspentandra biodiesel' IOSR Journal of Mechanical and Civil Engineering, vol. 10, issue.2, pp. 53-57, E-ISSN: 2278-1684, P-ISSN: 2320-334X.

[15] Prafulla D. Patil, VeeraGnaneswarGude, Harvind K. Reddy, TapaswyMuppaneni, Shuguang Deng(2012) , Biodiesel Production from Waste Cooking Oil Using Sulfuric Acid and Microwave Irradiation Processes, Journal of Environmental Protection, 2012, 3, 107-113

[16] Y.C.Wong and S. Devi(2014) ,Biodiesel Production from Used Cooking Oil, Oriental Journal Of Chemistry, ISSN: 0970-020 X

[17] Mohammed Abdul Raqeeb and Bhargavi R(2015), Biodiesel production from waste cooking oil, Journal of Chemical and Pharmaceutical Research, 2015, 7(12):670-681, ISSN : 0975-7384

[18] Nor Hazwani Abdullah, Sulaiman Haji Hasan, and NurrulRahmahMohdYusoff(2013), Biodiesel Production Based on Waste Cooking Oil (WCO), International Journal of Materials Science and Engineering Vol. 1, No. 2 December 2013