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STUDY ON PERFORMANCE ANALYSIS OF DIFFERENT USED COOKING OIL (UCO) WITH SOLVENT BLENDS AS FUEL SOURCE IN DIESEL ENGINE

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Abstract

Biodiesel is a fuel with numerous benefits over conventional fuel. Used cooking oil hasbeen chosen as primary oil source, hexane and ethanol were chosen as solvents. There has been no published work done particularly in this area. The Blended UCO fuel is tested for Viscosity, Density & calorific value tests as per ASTM standards. Also, the blended UCO fuel is subjected for performance analysis in CI engines.

1. INTRODUCTION

Biodiesel is derivedfrom renewable resources; it has less emission to the environment and has very limited toxicity.Above all its production can be decentralized which has huge potential in helping rural economies. It can be observedthat transesterification is a tedious process requiring sophisticated equipment's and high steady temperature maintenance equipment's, Micro-Emulsion is very sensitive towards atmosphericconditions and require immense floor area. Thermal Cracking involves interference with dangerously high temperature levels to produce a good quality biodiesel or merging oftransesterification with thermal cracking at slightly lower temperatures (450°C to 750°C). Butthermal cracking temperature is highly volatile with different types of oils (feed stocks). However, there are also some worth mentioning challenges associated with productionof biodiesel. Among them repeatedly mentioned are the cost of feedstock and the choice of convenient technologyfor efficient production of the fuel from diverse feedstock types. The day by day increase in consumption of fuel due to rapid modernization and industrialization has led to increase in demand andcost of conventional fuels. Since convention fuels offer ideal characteristics namely good heat value, ideal viscosity and low density which has worked in its favour as an ideal fuel for IC engine. Due to scarcity of conventional fuel, theuse of alternative fuels is encouraged. Cooking oil discarded after cooking can be processed and converted to fuel through it cannot be used in its pure form due to its viscous nature and lower calorific value, but can be used by blending it with conventional diesel.

2. LITERATURE SURVEY

Rubi et al. have examined the classification of lipidic feedstocks and catalysts for biodiesel production, highlighting the potential of waste cooking oil (WCO) as a sustainable option despite its high free fatty acid (FFA) content.The study addresses challenges related to both homogeneous and heterogeneous catalysts and explores the use of bifunctional catalysts to address these limitations. It also provides flow diagrams and insights into the mechanisms of enzymatic, homogeneous, and heterogeneous processes, emphasizing the need for improved catalysts to facilitate biodiesel production from low-grade raw materials.

Nagy et al. have improved fuel properties which is a relative process that depends on the method used, with considerations such as environmental impact, energy savingsand costs being crucial. The blending of waste cooking oil-derived biodiesel with mazout proves more favorable than the heating method, particularly in terms of cost-effective production. The addition of 10% of the prepared biodiesel results in a notable12% reduction in viscosity and a 1.5% decrease in heating value of mazout, leading todecreased energy requirements for pumping and heating. Additionally, the blending method contributes to a significant reduction of harmful compounds like sulfur and water content by 8.5% and 8%, respectively, thereby mitigating health, environmental,and maintenance concerns.

Martha et al. have studied that global surge in oil prices and the diminishing petroleum reserves, the quest for alternative energy sources like biodiesel has gained traction in Indonesia, with used cooking oil identified as a potential raw material for its production. Employing the transesterification method with KOH catalyst, the study details the process of converting used cooking oil and methanol into biodiesel, meeting the SNI 7182-2015 standards. The resulting biodiesel showcases favorable characteristics suchas a density of 0.886 g/mL, viscosity of 5.89 CSt, FFA content of 0.11%, acid value of 0.256mg KOH/g and flash point of 170.52°C.

Phuong et al. have investigated the production of biodiesel from waste cooking oil using co-solvent technology, particularly employing acetone. Whileoffering multiple advantages, this method necessitates the removal of solvents from theresulting Dept. of Mechanical Engineering. Optimal transesterification conditions, including a 1 wt.% potassium hydroxide catalyst, 20 wt.% acetone, a 5:1 methanol to oil molar ratio, a reaction temperature of 40°C, and a 30-minute reaction time, result in a 98% purity of fatty acid methyl esters (FAMEs). Analysis of the final product indicates a water content of 104 ppm, methanol content of95 ppm, and acetone concentration of 247 ppm.

3. OBJECTIVES AND METHODOLOGY

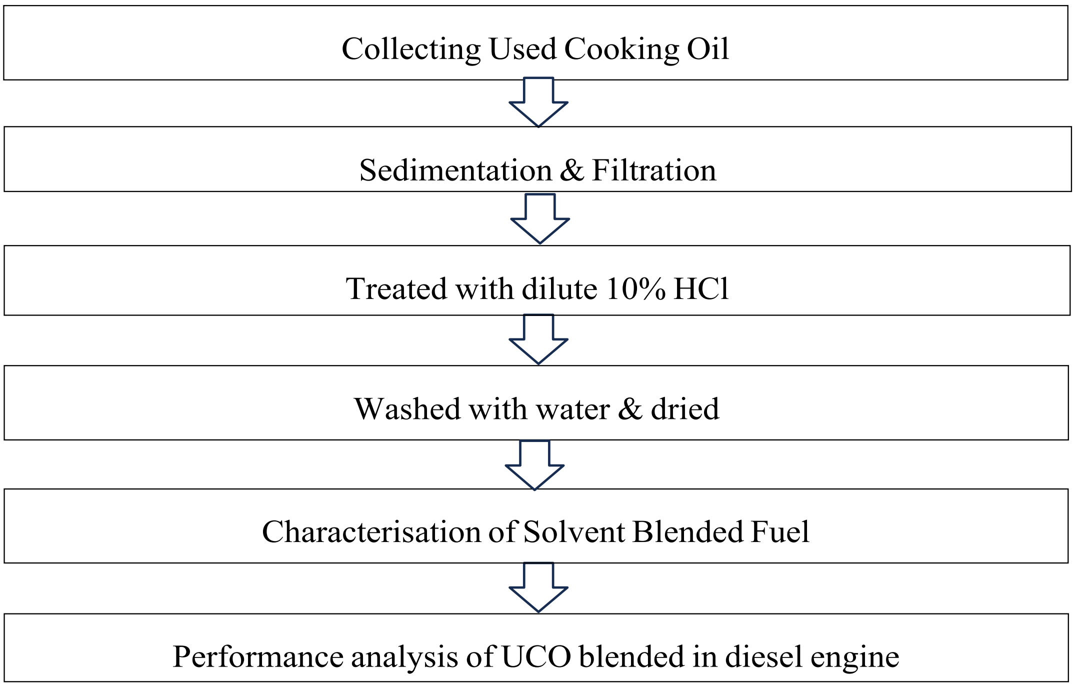
3.1 OBJECTIVES

a. Studying the characteristics of used cooking oil (UCO) blended with different solvents.

b. Analyzing Properties of UCO blended with different solvents as per ASTM standards.

c. To do the performance test of selected ratio UCO blended with solvents in IC engines.

3.2 METHODOLOGY



a. **UCO** - Used cooking oils are typically obtained from domestic and commercial kitchens, including restaurants, fast-food establishments, and food processing facilities. They are generated when frying foods like French fries, chicken, and donuts or cooking with vegetableoils.

b. **Sedimentation & Filtration** - Sedimentation and filtration are two common processes usedin various industries and applications to separate solid particles from liquids. These processesare vital in water treatment, wastewater treatment, food and beverage production,pharmaceuticals, and many other fields.

c. **Treated with dilute 10% HCl** - In the extraction of biodiesel, treating with 10% HCl (hydrochloric acid) is often used to remove impurities and contaminants from the biodiesel. This acid treatment helps neutralize any residual catalysts and can also remove soap and otherimpurities. After the acid treatment, the biodiesel is typically washed and separated from the acid and impurities to yield a purer product.

Collecting Used Cooking Oil Sedimentation & Filtration Treated with dilute 10% HCl Washed with water & dried Characterisation of SolventBlended Fuel Performance analysis of UCO blended in diesel engine Emission Test Dept. of Mechanical Engineering.

d. Washed with water & dried - the biodiesel is washed multiple times with water to removeimpurities, soap, and glycerine. Typically, a separation step is used to allow the water and impurities to settle at the bottom, while the biodiesel floats on top. After washing, the biodieselmay still contain some water. Drying methods, such as heating or using drying agents, are usedto remove the remaining water content.

e. Characterisation of Solvent Blended Fuel - Adding a solvent in biodiesel extraction helpsto selectively dissolve and separate specific components, making it easier to achieve the desiredphysical properties of the final product.

f. Performance analysis of UCO blended in diesel engine - Performance analysis of used cooking oil blended with diesel in a diesel engine involves evaluating factors like fuel efficiency, power output, emissions, engine wear, and combustion characteristics to ensure engine performance and environmental standards are met.

4. RESULTS AND DISCUSSION

Below table 4.1 shows data regarding Blending percentage of the Used Cooking Oil (UCO), Hexane,Ethanol and Diesel.

Table 4.1 - Blending percentage

SL. NO.	UCO	HEXANE	ETHONAL	DIESEL
B1	12.50%	2.50%	2.50%	82.50%
B2	15%	5.00%	5.00%	75%
B3	20%	7.50%	7.50%	65%
B4	30%	10%	10%	50%
B5	40%	12.50%	12.50%	35%
B6	45%	15%	15%	25%

4.1 PHYSICAL PROPERTIES

4.2 ENGINE PERFORMANCE

Below table 4.2 shows data regarding Kinematic Viscosity, Density and Calorific valueof the fuel samples prepared.

Table 4.2 - Physical properties

SAMPLE	KINAMATIC VISCOSITY-CSt	DENSITY-g/cc	CALORIFIC VALUE-KJ/Kg
B1	3.8839	0.84708	43,492
B2	3.761	0.85048	41,985
B3	3.6787	0.8296	42,158
B4	3.756	0.83326	41,162
B5	4.022	0.83354	38,782
B6	3.575	0.83368	37,904

The below figures fig. 4.1 and fig. 4.2 shows the Viscosity and Density variations of different sample of fuel.

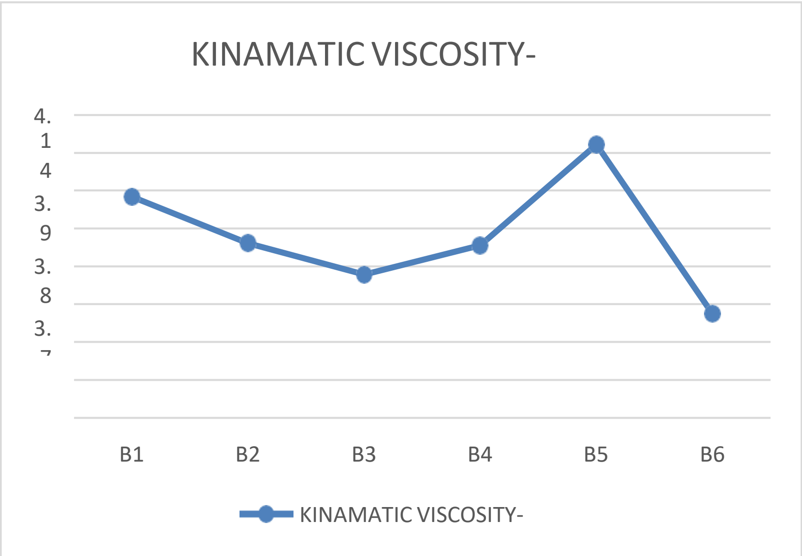


Fig. 4.1 Kinematic viscosity

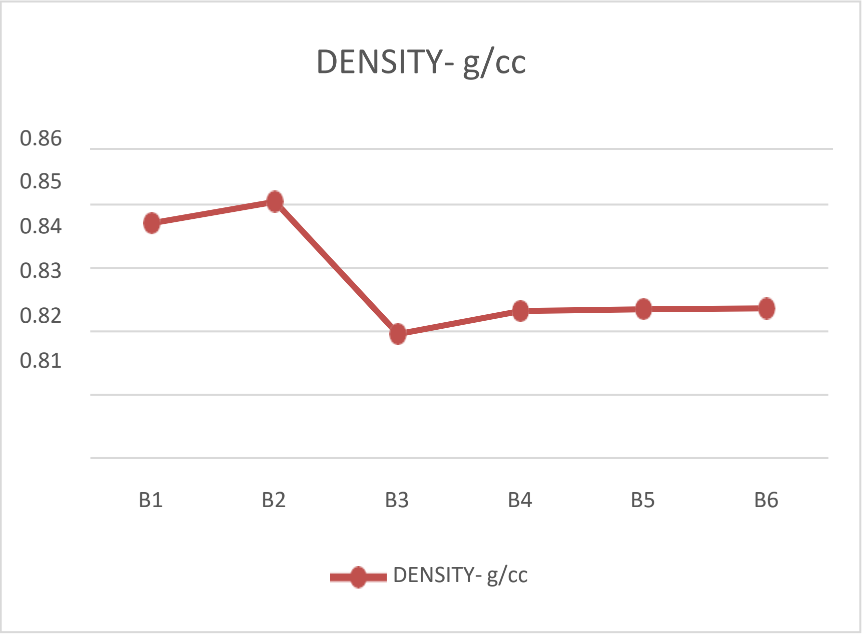


Fig. 4.2 Kinematic viscosity

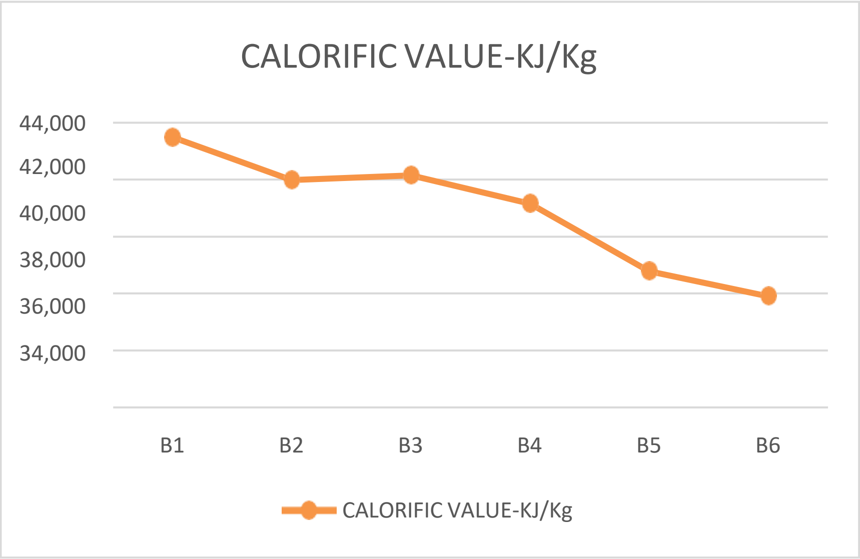


Fig. 4.3 Calorific value

The above figure 4.3 shows that as the percentage of solvent increases, the calorific value of fuel blend decreases, showing that Calorific value is inversely proportional to solvent percentage. Also, calorific value varies inversely with oil percentage i.e.,Calorific decreases from B1 to B6 samples. But there is no significant difference in calorific value with ethanol to hexane blended fuels.

From the table 4.2, the B4 sample matches the diesel property. Hence B4 sample was considered for engine performance.

The below table 4.3 shows the properties of diesel and B4 fuel.

Table 4.3 Properties of diesel and B4 fuel.

Property	**Diesel**	**B4**
Kinematic viscosity - CSt	4.74	3.756
Density – g/cc	0.82	0.83326
Calorific value- KJ/Kg	45000	41,162

Below table 4.4 shows data regarding performance test conducted for B3 Sample in (CI)Diesel Engine.

- Engine speed = 1500 rpm

Table 4.4 – Engine performance result

Sample	Density - Kg/l	Fuel Flow Time for 10ml ,'t' in Sec	SpringLoad -Kg	TFC - Kg/hr	BP - KW	SFC - Kg/KW - hr	HI - KW	BTE - %	Mechanical Efficiency - %	ITF - %
B4	0.833	72	0	0.4165	0	-	4.7622	0	0	0
B4	0.833	50.06	4.3	0.599	0.994	0.6026	6.848	14.51	28.86	50.29
B4	0.833	40.06	8.1	0.7485	1.872	0.3998	8.5582	21.87	43.31	50.5
B4	0.833	32	12	0.937	2.77	0.338	10.71	25.86	53.06	48.74
B4	0.833	26.25	16.2	1.1424	3.7445	0.305	13.06	28.67	60.44	47.43
B4	0.833	22.22	19.8	1.35	4.576	0.295	15.4357	29.64	65.19	45.51

The above table 4.3 shows that there is no significant difference in performance with variation in percentage. The specific fuel consumption increases with increase in oil percentage in blendat low and high loading conditions, but specific fuel consumption remainssame at half load condition.The specific fuel consumption of each blended fuel decreases withincrease in loading conditions and similarly break thermal efficiency increases with loading conditions. The same is interpreted in below figures fig 4.4, fig. 4.5 and fig. 4.6.

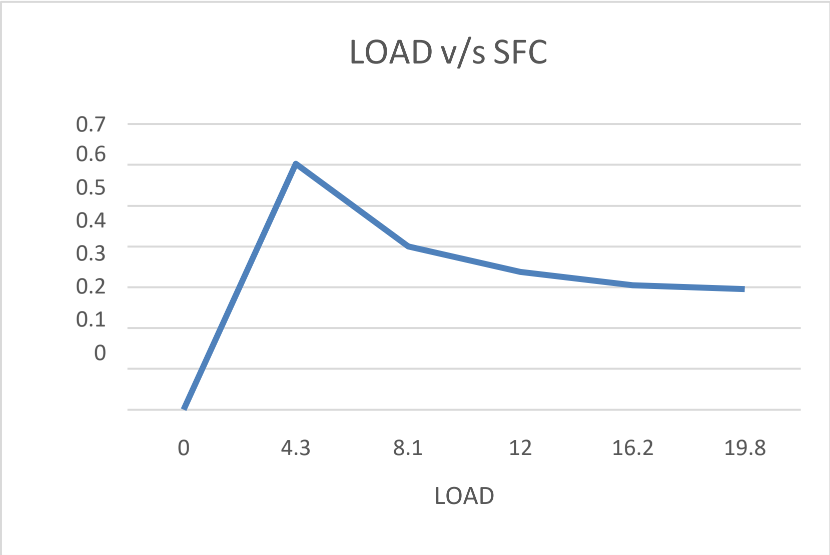


Fig. 4.4 Load v/s SFC

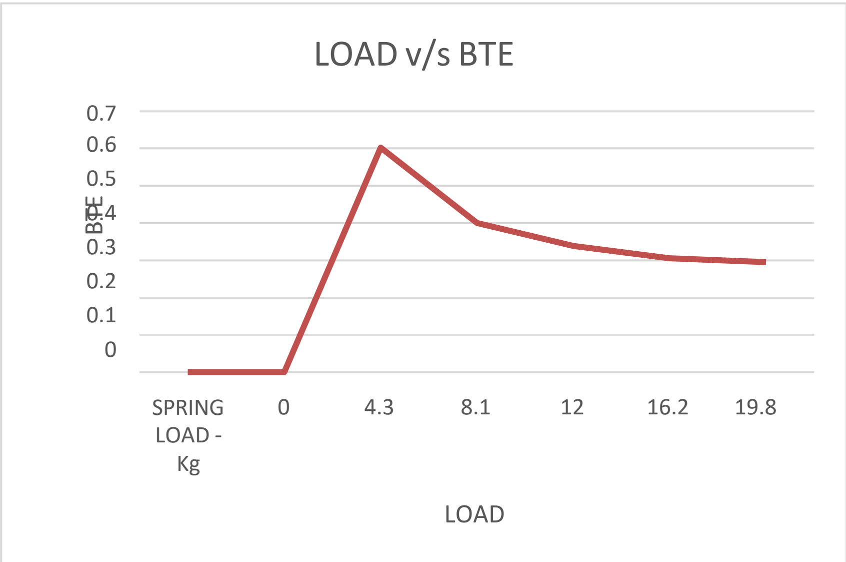


Fig. 4.5 Load v/s BTE

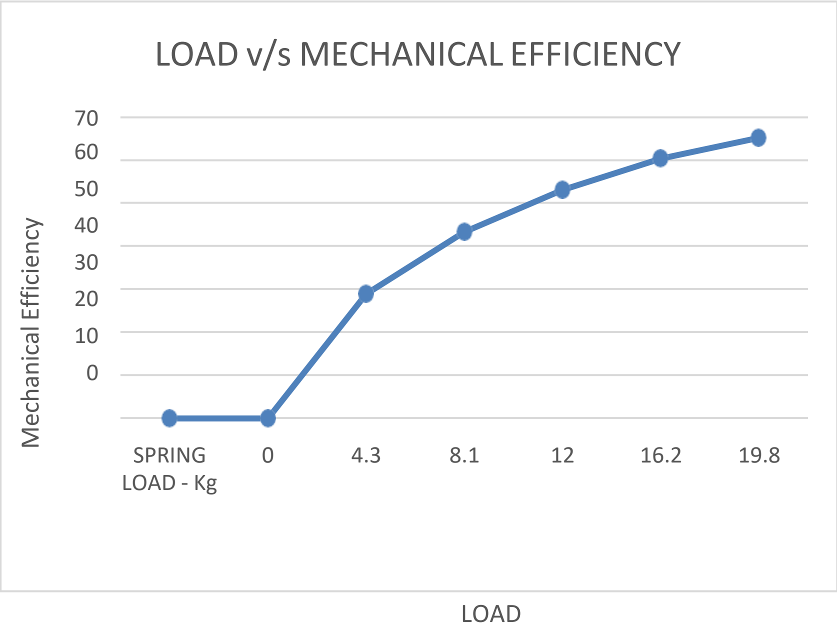


Fig. 4.6 Load v/s Mechanical Efficiency

5. CONCLUSION

1. Based on the results obtained from Viscosity tests, Density & calorific value, it was observed that there was no significant difference in fuel properties for different samples.

2. Based on results obtained from Calorific value tests, the B4 blend fuel with calorific value of 41.162 MJ/Kg is most near to that of diesel with a calorific value of 45.5 MJ/kg.

3. The base UCO need to be uniform to further analyze the engine performance with respect to different samples.

4. This method can be used for effective production of biodiesel with higher grade, and this is the simplest and easiest method to produce biodiesel even at remote locations without sophisticated equipment, which also allows for decentralization of fuel production.

6. REFERENCES

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