Kashf Journal of Multidisciplinary Research
Vol: 02 - Issue 3 (2025)
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

EFFICIENT USE OF USED COOKING OIL IN A DIESEL ENGINE BY ADDING 1-BUTANOL TO REMOVE DEBRIS

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DOI : https://doi.org/10.71146/kjmr325

Article Info

Abstract

This experiment uses a single-cylinder, water-cooled diesel engine to investigate deposit accumulations on engine heads. The tested fuels chosen for this investigation are DF, DF95UCO5, and DF65UCO20Bu10. The lowest cetane number, DF65UCO20Bu10, has the shortest burning time and the longest explosion delay due to its highest fuel oxygen percentage. Engine heads were measured and contrasted with emulsion fuels. Scanning electron microscopy was also used for a qualitative examination at the same sites. Visual inspection, which revealed some deposits on engine heads when using all fuels, corroborated the investigation's findings. Using SEM and EDS, the study discovered that DF95UCO5 produced more carbon deposits on the engine head than DF65UCO20Bu10 and DF.

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Keywords:
Used cooking oil,1-butanol, Deposition

Introduction

Energy needs have grown due to the world's population growth and rapid urbanization. [1]. The characteristics of the oil, which are very comparable to those of diesel, have attracted attention [2–3]. WCO oil should not be used immediately as it may cause problems such as blocked injectors, carbon accumulation in the combustion chamber, stuck piston rings, and uneven fuel burning [4-5]. Because industrialization and modernization are accelerating, the world's energy consumption is growing quickly. To address their growing energy needs, the majority of rising nations buy crude oil [6]. Both the pollution from exhaust emissions and the worldwide depletion of fossil fuel reserves are currently on the rise. Encourage the gradual replacement of diesel fuel with biofuels and other renewable energy sources [7]. According to a study, waste cooking oil (WCO) is produced in significant amounts worldwide during the cooking or frying process [8]. According to research by the Food and Agricultural Organization [9], India's food processing industry generates over 23 million tonnes of wasted cooking oil annually. Waste cooking oil (WCO) disposal has also sparked environmental concerns, leading to proposals for its consumption or reuse along with financial incentives [10].The primary cause of these issues is SVO's higher viscosity and lower volatility when compared to traditional petroleum diesel [11–12]. To restore its properties, plant oil's viscosity is decreased through the use of heat or chemical processes. These chemical processes include pyrolysis, dilution, microemulsion, and transesterification. Warming the fuel reduces viscosity in the thermal process [13–14]. Transesterification is currently the most widely used process for converting vegetable oil into biodiesel. Regretfully, this method of purifying biodiesel has significant energy and processing time requirements. Ultimately, glycerol is an additional byproduct. For every 10 kg of biodiesel, about 1 kg of glycerol is produced. Crude glycerol is typically disposed of because of the costly purification process, especially in small- or medium-sized biodiesel businesses [15]. On the other hand, improper glycerol disposal could damage the environment [16]. The viscosity of the vegetable oil (palm oil) has been attempted to be decreased by heat treatment. Heating vegetable oil before use lowers its viscosity to a level comparable to petroleum diesel [17]. Stricter rules on engine emissions and the depletion of fossil fuels have been imposed on searchers, engine manufacturers, and regulators due to the need for alternative fuel sources [18]. Exhaust gas recirculation (EGR) and thermodynamic cycle-based waste heat recovery systems are two examples of energy-saving techniques that could be created to lessen environmental pollution [19–20]. The increasing demand for fuels and strategies to reduce greenhouse gas emissions can be met by a variety of fuel options, including LPG, CNG, biodiesel, bioethanol, and others [21]. It is believed that high surface tension, kinematic viscosity, and high density are the primary causes of low volatility, poor atomization, and deposit development on the injectors, piston grooves, and other combustion chamber components [22]. Consequently, it is thought that to use vegetable oils directly in compression ignition engines, the three properties of high density, high surface tension, and kinematic viscosity must be reduced [23]. Heating is thought to be the simplest way to overcome the aforementioned drawbacks of vegetable oils, even though other strategies, like combining with petroleum diesel oil or adding chemicals, are also used [24]. One of the main causes of deposit accumulations is inefficient combustion of the air-fuel mixture and saturated bonds [27–28]. Deposits begin on the combustion chamber nose, which is the coldest part of the injector and spread to the cylinder head, chamber wall, and piston rings [29–30]. D'Alessandro et al. [31] tested the fuel injectors of a 33-kW diesel engine powered by diesel fuel and a range of straight vegetable oils. This study used DF, DF95UCO5, and DF65UCO20Bu10 to assess deposit formation on the engine head.

MATERIALS AND METHODS

It was suggested to use compression ignition in a direct-injection diesel engine. The engine configurations are displayed in Table 1. Three test fuels—DF, DF95UCO5, and DF65UCO20Pn15—were used for the reliability test. They were run for 200 hours at 1300 rpm and 1 N m load, respectively. The engine test rig's schematic diagram is displayed in Figure 1.

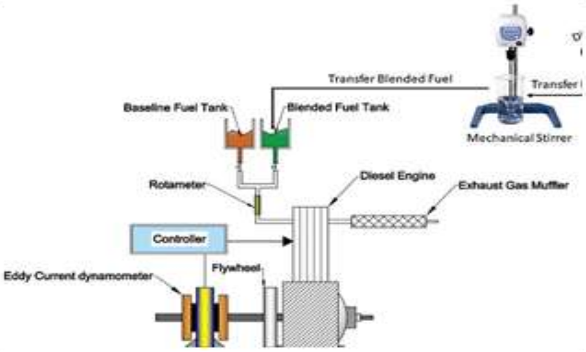


Fig. 1. Investigational setup of engine test.

The nearby restaurant offered to pick up the used cooking oil. The usual temperature range for frying chips in oil is 130 to 180 degrees Celsius. Before mixing, the UCO was heated and filtered to get rid of any food particles or water particles. Since diesel is water-repellent and the presence of water could cause phase separation, this procedure was used to increase blend stability. Table 2 displays the characteristics of n-pentanol, diesel, and used cooking oil.

Table 1: Engine specification

Model	**Single-Cylinder CIDI Engine**
Bore	75mm
Compression ratio	21-23
Displacement	0.353L
Output (12 hours rating)	4.4kW/2600r/min
Injection pressure	14.2 + 0.5 MPa (145+5kg/cm^2)
Valves clearance	Inlet valve 0.15-0.25mm
Governor type	Mechanical. All speed and centrifugal-type
Stroke	80mm
Injection Pressure	14.2 + 0.5 MPa

A 200-hour endurance test was conducted using all of the fuel samples. After the engine was disassembled, the engine head was removed. The other test fuels were then subjected to this procedure. Every engine head sample that was gathered in this manner was examined using SEM and EDS. SEMs are used to examine deposits of all sizes. It can use EDS to assess small deposits for elements. Every fuel sample's engine head was photographed at 0 hours (for the Fresh test) and 200 hours (for the Endurance test).

Table 2. Fuel characterization.

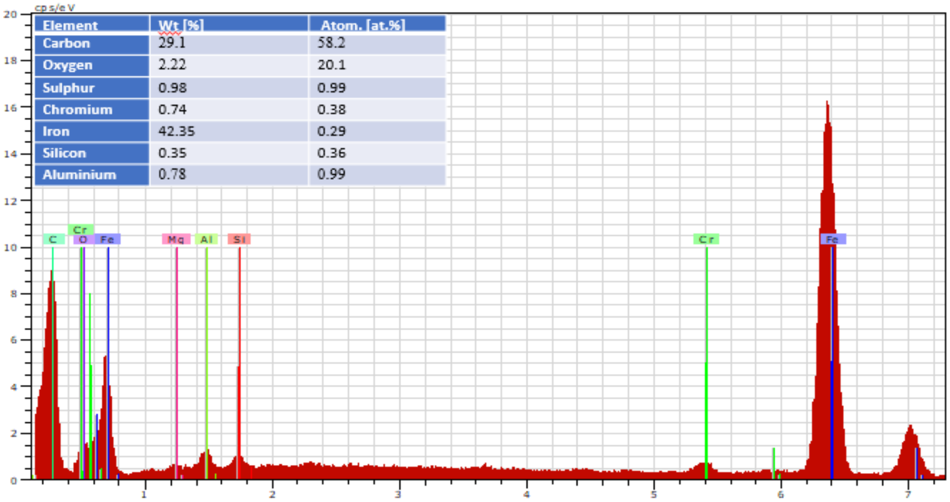
Properties	**Diesel fuel**	**Used cooking oil**	**!-bentanol**
Viscosity Cst at 40 ^oC	2.28	52	2.28
Density g/m^3	835	900	810
Flash Point ^oC	78	279	49
Calorific Valve MJ/Kg	42.5	37.68	33.09
Cetane Number	50	54	17

RESULTS AND DISCUSSION

Injector deposition

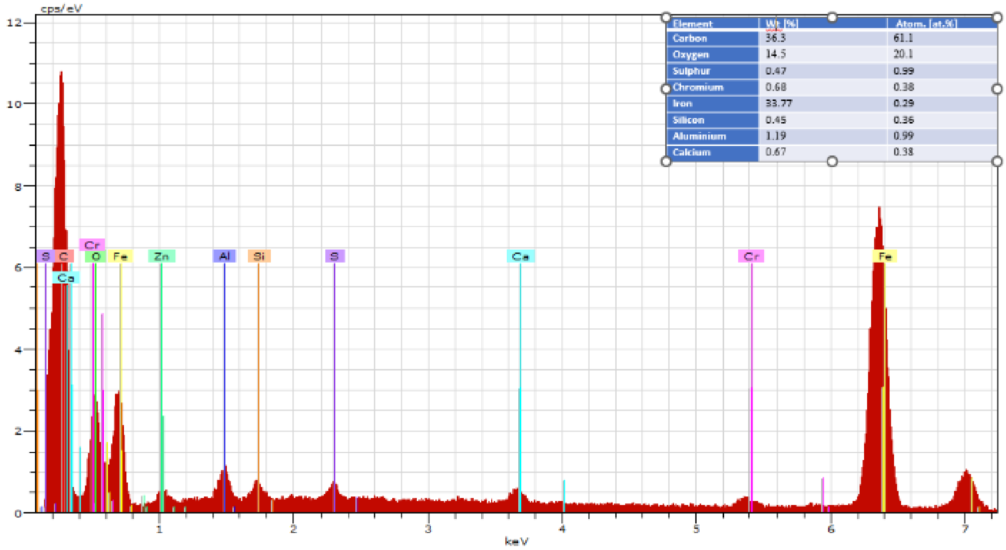
Diesel engines' major components are subjected to high temperatures and mechanical strains. Incomplete or pyrolysis combustion, oxidative and thermal lubricant deterioration, and lubricant degradation also cause deposits to form on these parts. These deposits impair engine operation, efficiency, and performance in addition to raising maintenance expenses. Engine failure could result from large deposits [32]. When fuel is burned, carbon is produced as a byproduct. Both incomplete fuel combustion and trace levels of lubricating oil pollutants contribute to carbon deposition. The engine's service life is shortened by the accumulation [33]. The carbon deposits on engine heads were photographed and evaluated for this investigation. Figures 4 and 5 demonstrate that a thick carbon deposit was discovered on the engine head of the DF95UCO5 when it was used with damp and dirty conditions in comparison to petroleum diesel. This could be caused by a combination of evaporation of lighter fraction fuel content and degradation. The carbon deposit is lower in the DF65UCO20Bu10-powered engine. Burning DF65UCO20Bu10 cleaner in the presence of higher oxygen concentrations may result in less deposition. Figure 2 shows the engine head in a slanted view during an endurance test, running at various engine operating hours and using various fuels. It was difficult to distinguish between engine heads using different fuels just by looking at them. Carbon deposits on important engine parts were examined visually. The engine maintained power output during the trials by operating at the same speed and load. To compare the carbon deposits, a DSLR was used to take images of the engine head before and after operations. Additionally, it was found that the exterior of the engine head was dirtier when using DF95UCO5 mixes than when using DF. The carbon deposits created when this leftover gasoline is polymerized and combined with oxygen by the engine head's residual heat are depicted in Figure 3. Figure 4 displays SEM images demonstrating that the carbon deposit was thicker than that of DF95UCO5 when it was applied to the gasoline engine head. This could be due to sticky components, unburned materials, or high-temperature failures. In the deposition, a thin layer covered the engine head. However, as illustrated in figure 5, DF65UCO20Pn15 yields some better results because of the oxygen content of the fuel.

Fig. 2. Before using DF and blend fuels.



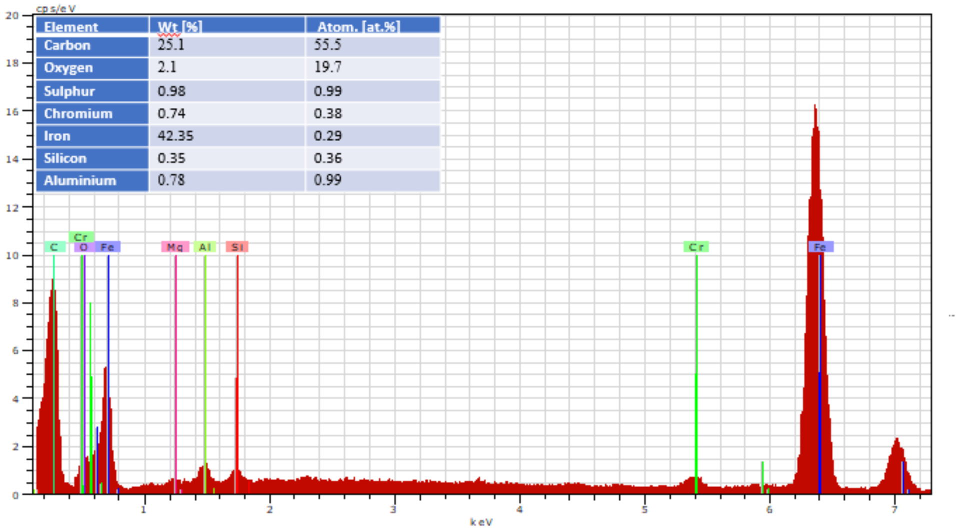
Element	Wt [%]	Atom. [at.%]
Carbon	29.1	58.2
Oxygen	2.22	20.1
Sulphur	0.98	0.99
Chromium	0.74	0.38
Iron	42.35	0.29
Silicon	0.35	0.36
Aluminium	0.78	0.99

Fig. 3. EDS analysis along with related peaks of DF100 fuel.



Element	Wt [%]	Atom. [at.%]
Carbon	36.3	61.1
Oxygen	14.5	20.1
Sulphur	0.47	0.99
Chromium	0.68	0.38
Iron	33.77	0.29
Silicon	0.45	0.36
Aluminium	1.19	0.99
Calcium	0.67	0.38

Fig. 4. EDS Analysis along with related peaks of DF95UCO5 blend.



Element	Wt [%]	Atom. [at.%]
Carbon	25.1	55.5
Oxygen	2.1	19.7
Sulphur	0.98	0.99
Chromium	0.74	0.38
Iron	42.35	0.29
Silicon	0.35	0.36
Aluminium	0.78	0.99

Fig. 5. EDS analysis along with related peaks DF65UCO20bu10 blend.

CONCLUSION

To investigate its effects, the current study project used petroleum diesel fuel as a reference fuel. The two remaining test fuels, DF95UCO5 and DF65UCO20Pn15, were used in the investigation. The development of deposits on engine heads for each fuel sample was investigated. The following likely results could be obtained from the experiment:

- DF, DF95UCO5, and DF65UCO20Pn15 were the test fuels that showed deposits on the engine head while it was running. DF65UCO20Pn15 was found to be better than both, while DF95UCO5 engine head was found to be dirtier than DF.
- SEM and EDS analysis after the 200-hour endurance test showed that DF65UCO20Pn15 had significantly fewer engine head deposits than DF95UCO5. Carbon deposits were found in patches. However, engines powered by DF95UCO5 have thick, overlapping deposits at the engine head outlet and a smaller engine head. Carbon concentrations increased throughout the entire deposited layer.

Acknowledgment

We are grateful to the QUEST Nawabshah Department of Mechanical Engineering for allowing us to conduct experiments in the Thermodynamics Laboratory. Conflict of Interest
There is no conflict of interest between all the authors

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