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INVESTIGATION OF EXHAUST VALVE DEPOSITION IN COMPRESSION IGNITION DIRECT INJECTION ENGINE

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Abstract
Experiments on short-term engine operation have shown that waste cooking oil is a desirable replacement for compression ignition engines. Using blends of waste cooking oil, the research was conducted over an extended endurance test. to understand the long-term effects of burning used cooking oil. The results of the study showed that the operating surface of the engine head had very little wear and tear. Nevertheless, the durability test using blends of waste cooking oil and diesel was carried out. Because it has the highest fuel oxygen content, the lowest cetane number, DF80WCO10Pn10, has the longest explosion delay and the shortest burning time. Deposits from engine exhaust valves were measured and contrasted with emulsion fuels. At the same locations, a qualitative investigation was carried out using scanning electron microscopy techniques. Visual inspection revealed some deposits on the engine exhaust valve when it was running on all fuels, according to the investigation's conclusions. According to the study, DF90WCO10 left more carbon deposits on the engine exhaust valve than DF80WCO10Pn10 and DF when SEM and EDS were used.

INTRODUCTION
Internal combustion engines that run on reduced crude oil exhibit wear on their mechanical parts as a result of friction, fuel quality, accumulated operating hours, the abrasive action of soot particles, the formation of acids from the fuel's sulfur content, high pressures, and temperatures [1]. The usage of fossil fuels is also linked to several environmental problems. It is thought that the diesel exhaust of fossil fuel-powered cars contains carcinogens unique to lung cancer. Greenhouse gas (GHG) emissions from the usage of petroleum diesel are substantial and are directly linked to both global warming and climate change [2]. It's commonly known that deposits accumulating around the injector can alter the combustion chamber's fuel flow rate and injection pattern, which lowers system performance overall. Fuel impurities, soot, volatile lubricating oil, and reactive combustion products are the main elements driving deposit development [3]. There is a greater need for energy due to the world's population rise and rapid urbanization. The social and economic growth, welfare, and health of people are all impacted by this rise in energy needs. The unrestricted use of fossil fuels has resulted in health risks and environmental

deterioration worldwide [4]. Due to the increased demand and usage of diesel for engine fuel, its reserves have decreased, cost volatility has increased, and environmental impact and public health issues have increased [5,6]. According to a study, there is a significant global production of waste cooking oil (WCO) from frying or cooking [7]. According to this research (Food and Agricultural Organization of the United Nations), India's food processing sector produces around 23 million tons of waste vegetable oil [8]. Waste cooking oil (WCO) disposal has also raised environmental problems, which necessitate consumption or reprocessing in conjunction with a financial incentive [9,10]. It was determined from the results that WCO was transesterified to produce biodiesel, and engine performance was then examined [11,12]. The amount of material pertaining to the use of unaltered WCO as blend fuel with diesel for the categorization of effluents and performance analysis when employed in a CI engine has been found to be limited. In 1893, Rudolf Diesel evaluated peanut oil as an engine fuel, which sparked the initial quest for alternative fuel sources for internal combustion engines [10]. When engine power was provided by vegetable oil from various food sources between 1930 and 1940, the necessity to look into this matter was recognized and research into alternating fuel oil was started at several locations [11]. According to research conducted in Japan, between 0.4 and 0.6 million tons of WCO are generated annually. But only 0.25 to 0.26 million tons are gathered for industrial use; the remainder is drained through household sinks, adding unnecessary strain on sewage systems and harming the drainage system. WCO has impacted aquatic ecosystem and reached it [12]. Negative environmental and health effects are associated with improper treatment and disposal of this fluid waste (WCO). Vegetable oil can cause excessive engine scratching, lubricating oil clotting, carbon buildup in machine parts, fuel strainer obstruction, and injector choking, among other problems, when used directly in compression ignition engines [13]. In compression ignition (CI) engines, WCO's high viscosity can lead to issues like excessive fuel consumption at startup, poor atomization during injection, carbon settling in the burning cylinder, and filter blockage [14]. WCO shows a high viscosity and low volatility in terms of deprived atomization. Because leftover cooking oil doesn't contain any particles, it can be used as fuel for internal combustion engines, like diesel engines. Used cooking oil can be used as fuel to generate more power. As a result, handling WCO carefully is necessary when using it as an uncommon fuel for CI engines. Techniques such as trans-esterifying WCO to biodiesel or preheating WCO are common [15].

This study examines the carbon deposition occurs on engine exhaust valve by using three fuel samples vis. DF, DF90WCO10 and DF80WCO10Pn10 in single cylinder diesel engine.

METHODOLOGY

The engine under study is currently in operation at QUEST University Nawabshah's thermodynamics lab, which is part of the Mechanical Engineering Department. The required fuel properties are listed in Table 1. The actual fuel sample and the experimental setup are shown in Figures 1 and 2, respectively. A four-stroke, one-cylinder diesel engine is selected and set up on a test bed. Two fuel tanks, one for mix fuels and the other for DF, provided the test engine's fuel. A dynamometer that uses eddy current is connected to the engine. In order to establish baseline values, the engine was initially fueled with DF and subsequently with mix fuels. Every test was run three times in order to get mean values.

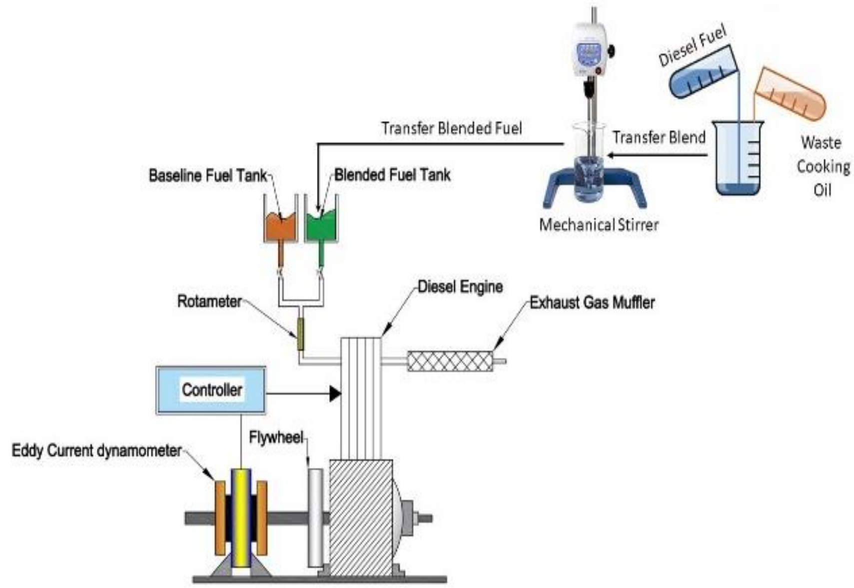

Figure.1 Experimental Test Bed Setup

Figure 2. Physical postures of test fuels (a) Diesel (b) DF90WCO10 (c) DF80WCO10Pn10

Table 1. Properties of tested fuel samples

Properties	Diesel Fuel	WCO	N-pentanol
Viscosity 40 °C Cst	2.28	52	2.89
Right Density g/mL	835	900	814.4
Flash point °C	78	271	49
Oxygen (wt %)	0	20	8.47
Calorific valve MJ/Kg	42.5	37.68	34.75
Cetane number	50	54	20

RESULTS AND ANALYSIS

Endurance test

An endurance test was conducted in a compression ignition engine to evaluate deposition on engine parts, particularly the exhaust valve. The studies used n-pentanol (DF80WCO10Pn10), diesel (D100), and waste cooking oil (DF90WCO10). Following 200 hours of operation, each sample's engine piston was swapped out for a deposition analysis. Prior to running on alternative fuels, the engine was warmed up with diesel petroleum for ten minutes. To maintain consistency throughout the test, the engine was run at a steady load and speed after the warm-up phase was finished. Determining the amount of elemental deposition on the engine exhaust valve for each of the three fuels under evaluation was the primary objective of this study. Elemental deposition was observed on the surface of three distinct engine heads after 200 hours of testing. A deposition study was carried out using microscopic and visual inspection tests at various engine head locations to determine the element's deposition on the valve surface. The test also measured the loss of film viscosity to determine the effect on engine performance. The examination showed that for all three fuels, the endurance test caused aromatic chemicals to collect on the engine exhaust valve. The engine exhaust valve had elemental deposition of different compounds, as demonstrated by the energy-dispersed X-ray method's microscopic test. It was discovered that the sample with the DF90WCO10 mix had a larger residue than the blended fuel with DF and DF80WCO10Pn10. The deposit was also found to be unevenly distributed across the exhaust valve surface, with more deposition in some areas than others, when examined under a microscope. The unequal distribution of fuel in the engine cylinder was found to be the cause of the unequal deposition, resulting in localized combustion and increased deposition in certain areas.

Engine Head deposit visual inspection

Exhaust valve images were captured upon completion a 200-hour endurance test on DF, DF90WCO10, and the DF80WCO10Pn10 mix, as shown in Figure 3. Visual inspection carried out after different operating hours revealed some deposits on the exhaust valve surfaces for all fuel types, as seen in Figure 3.

Figure. 3.Visual inspections of fresh, DF, DF90WCO10 and DF80WCO10Pn10.

Nevertheless, compared to the exhaust valve operating on DF, the engine exhaust valve operating on DF90WCO10 was dirtier. Waste cooking oil was found to cause more deposit development in the exhaust valve in a different investigation, according Birgel et al. [16]. Furthermore, it was noted that deposits on the exhaust valve running with DF were greasy and oily, whereas deposits on the exhaust valve running with the DF90WCO10 mix were dry. While utilizing mix fuel sample DF80WCO10Pn10, there is less deposit on the exhaust valve.

SEM (scanning electron microscopy)

The engine was partially dismantled and the deposit formation on each exhaust valve was examined after the 200-hour long endurance test on DF, DF90WCO10, and the DF80WCO10Pn10 mix was finished. Improved diesel injection systems are distinguished by elevated temperatures around the exhaust valve, which may cause very tenacious deposits in and around the exhaust valve [17]. Figure 4 shows SEM images of three fuel samples respectively.

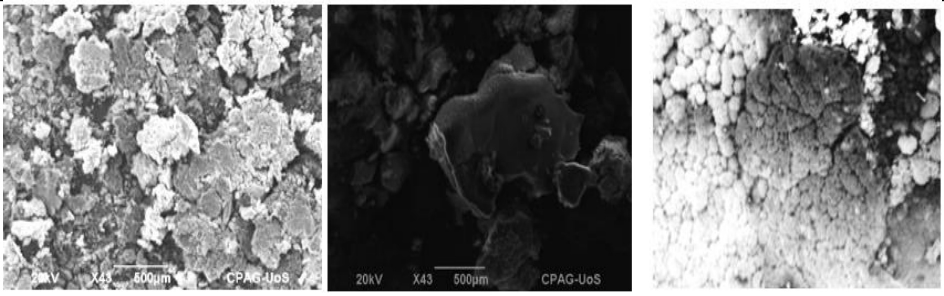

Figure. 4. SEM running 200h on diesel fuel DF100, DF90WCO10 and DF80WCO10Pn10

Figure 3 shows the SEM micrographs of deposits on the exhaust valve that were fuelled with DF and DF90WCO10, respectively, at various magnifications. Compared to deposits with the DF90WCO10 mix, deposits with DF are substantially lower. Figure 4 shows the SEM of deposits on an exhaust valve that is running on DF (diesel fuel), waste cooking oil (DF90WCO10), and n-pentanol (DF80WCO10Pn10).

CONCLUSIONS

This study examined and contrasted the exhaust valve deposition endurance test of blend fuels, such as DF100, DF90WCO10, and DF80WCO10Pn10, with diesel fuel:

Minor deposit deposition was seen in the engine head of both fuel-running engines (DF, DF90WCO10, and DF80WCO10Pn10) upon visual inspection. However, it was found that the engine head utilizing DF and DF80WCO10Pn10 was cleaner than the exhaust valve using DF90WCO10. After the endurance test, SEM and EDX analysis revealed that the engine running with DF and DF80WCO10Pn10 had far fewer deposits on the exhaust valve than the engine running with the DF90WCO10 mix. A uniformly thick layer of carbon was not deposited. Moreover, deposits on or around the exhaust valve did not significantly impair it.

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