Experimental Study of Used Lubricant Oil Combustion as an Alternative Energy Source

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Abstract. Liquid waste such as used lubricating oil (ULO) is a very dangerous environmental polluting material. However, this waste can be used as an alternative energy source by burning directly because the basic material of this material is hydrocarbons such as petroleum in general. This article reports a study of the direct combustion of used oil using a simple stove. ULO was fed into the stove which has an internal air distributor. The air combustion needed was given through a blower and controlled using an airflow meter. A handheld thermometer was used to measure the temperature of the fire. The data were plotted in a graph and can be understood easily. The results showed that a higher combustion temperature of 900^{o}C can be produced during combustion. The observations show that the pollution produced is still within the limit of government regulations. This study's results showed that ULO can be an alternative energy source.

Keywords: Hazardous waste, Used lubricant oil, Combustion, Stove, Air distributor, Thermal energy

1 Introduction

Hazardous waste includes oil lubricant waste is defined as a residue or its combination that may be a potential hazard to humans or the environment. They are classified as hazardous because they exhibit one or more properties of ignitability, corrosivity, reactivity, or toxicity. Lubricating oil is widely used in applications in the petrochemical industry, machine manufacturing, and aerospace engineering [1]. After use, this lubricant becomes useless and is often disposed of as garbage, also known as used lubricating oil or ULO [2]. This material needs to be handled, stored, transported, treated, or disposed of carefully. ULO can be used as a fuel substitute in some industrial processes, such as burners, boilers, and furnaces. The use of ULO as a fuel substitute offers some benefits, including cost savings, resource conservation, waste reduction, and energy recovery. ULO has energy content that can be recovered and utilized through combustion. Another way is to store energy from ULO using a simple energy storage system with water as the working fluid [3] or can be integrated into the small-scale electricity generation plant design [4].

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Destruction of ULO by thermochemical is one of the best ways of hazardous disposal due to its high heating value [5]. Pyrolysis has been tried for the disposal of hazardous wastes that cannot be reused or recycled and cannot be disposed of safely in a landfill because of excessive toxicity or risk of infectious transmission [6]. This technique allows for significant volume reduction and varying magnitudes of toxicity reduction in the hazardous waste being treated. However, some challenges and potential drawbacks exist to using used oil as a fuel substitute. These include quality issues emissions concerns, and regulatory compliance. Overall, the use of ULO as a fuel substitute can offer some benefits in certain industrial applications, but it is important to carefully evaluate the quality, emissions, and regulatory considerations before implementing this practice. An appliance that can be used to get energy from ULO is combustion using a simple stove.

Stove technology refers to the use of specialized stoves or furnaces to safely and efficiently combust waste materials. The number of stoves that have been tested related to their function intended to collect and collate information about performances and their output in the form of energy and emission parameters [7], [8]. This technology aims to minimize the environmental and health risks associated with especially hazardous waste energy recovery. Some stove technologies, such as combustion and gasification systems, can produce a usable fuel, reducing the need for fossil fuels and offering potential cost savings. However, some challenges are associated with stove technology for burning ULO, including the high capital costs of the equipment, the need for specialized training and operation, and the potential for emissions of ash pollutants, and carcinogens [9]. It is important to carefully evaluate the risks and benefits of stove technology for ULO before implementing this technology.

The problem is how to make the mixture of vapor and air perfectly. Some challenges associated with this process include the need for precise control of fuel and air supply [10]. There are several initiatives taken by many researchers to promote energy-efficient cookstoves to improve fuel efficiency [11]. Staged air supply has also been tried to improve combustion performance on stoves [12]. However, studies of internal air supply for combustion are still very rare. Internal airflow supply refers to the air supplied from the center of the main combustion chamber. Some of the effects of internal airflow include improved mixing of the air and vapor more effectively, increased turbulence flow that can help to break up fuel droplets and promote more efficient mixing of the reactants, increased residence time that provides more time for fuel to react with oxygen, which can improve combustion efficiency, and reduced emissions.

2 Materials and Methodology

2.1 Used lubricant oil (ULO)

Used lubricant oil refers to any petroleum-based or synthetic oil that has been used for its original purpose and has subsequently become contaminated with impurities and is used in this study. It usually has a dark color and a slightly viscous. It is a type of hazardous waste material that requires special handling and disposal procedures to prevent harm to human health and the environment. Used motor oil is generated by vehicles during routine oil changes. This material is taken from the motorcycle repair workshop for free. This material contains a variety of impurities, including heavy metals, organic compounds, and other contaminants. These impurities can make the oil hazardous to human health and the environment if not properly handled and disposed of. The appearance of ULO is depicted in **Figure 1.**

Fig. 1. The appearance of ULO

2.2 Experimental rig description

Figure 2 shows the schematic diagram of the ULO combustion experiment as an alternative fuel. Several units are used such as an air blower, air regulator, air distributor, oil tanks, thermocouples, combustion chambers, and chimneys. A certain volume of ULO is inserted into the combustion chamber by opening the oil controller valve according to the allowable level. For initial ignition, tissue paper is used, and after the fire starts, the blower is turned on and the combustion air valve is slowly opened. As a result of heating, the ULO begins to evaporate and easily burn. The distributed air by the distributor pipe makes the ULO steam mix with the combustion air which makes combustion better and the combustion temperature increases quickly. The higher the temperature of the combustion chamber, the more ULO evaporates and the larger the flame generated.

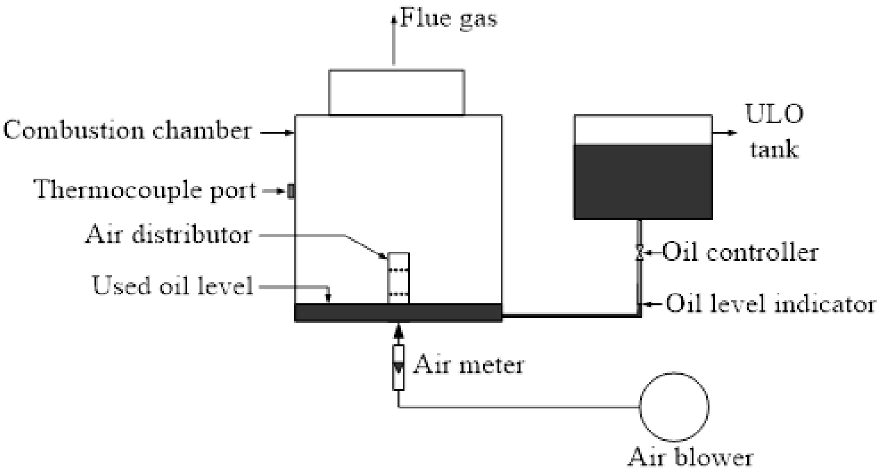

Fig. 2. Experimental rig diagram combustion of ULO

3 Results and Discussion

3.1 Effect of air flow rate on temperature

A complete combustion produces high temperatures. A mixture of fuel with the appropriate combustion air makes the combustion better. The quality of the air-fuel mixture is greatly influenced by the air distributor used. Turbulent air condition in the combustion chamber will cause the air-fuel mixture to be more homogeneous and combustion is more complete or stoichiometric. To get optimal combustion airflow, this experiment tested air flow rates ranging from 10 m^3/hour to 60 m^3/hour. From the graph in **Figure 3**, it can be seen that the optimum air flow rate is about 40 m^3/hour. At that time, the temperature in the combustion chamber and exhaust gas respectively about 900 ^oC and 605 ^oC respectively. Unlike ULO combustion without using an air distributor, where the combustion chamber temperature can only reach 495^{o}C. This finding is in line with research conducted by Simanjuntak et al. [9], where they used internal distributors with larger orifice holes. This shows that the air distributor has a good effect on the combustion process.

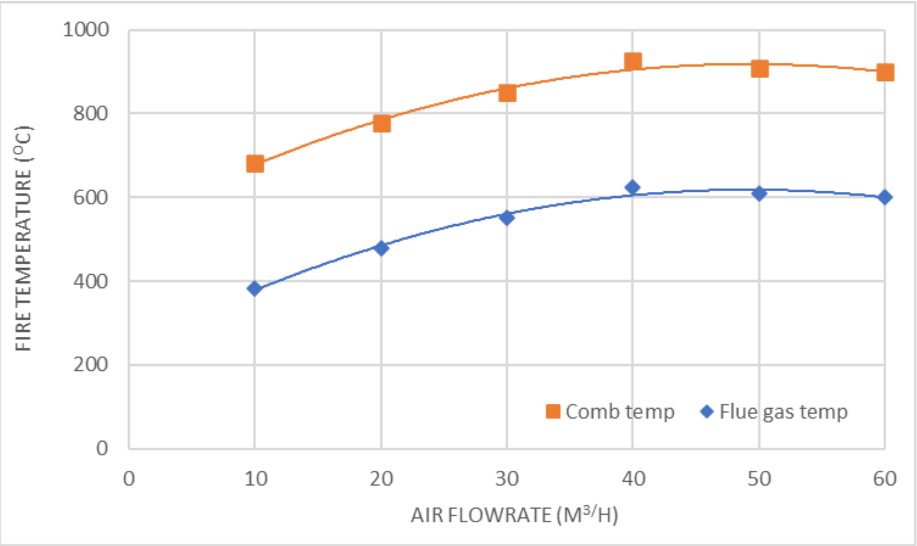

Fig. 3. Effect of air flow rate on temperature

3.2 Effect of ULO flow rate on combustion temperature

The air-fuel ratio is the main key to fuel combustion. To achieve complete combustion, the fuel flow rate must also be controlled. From the graph in **Figure 4** it can be seen that the fuel flow rate greatly affects the temperature of the combustion exhaust gas. The higher the fuel flow rate, the higher the temperature of the exhaust gas produced. However, it is limited to the required combustion air. To achieve the optimum temperature, the airflow rate is in control in the combustion chamber.

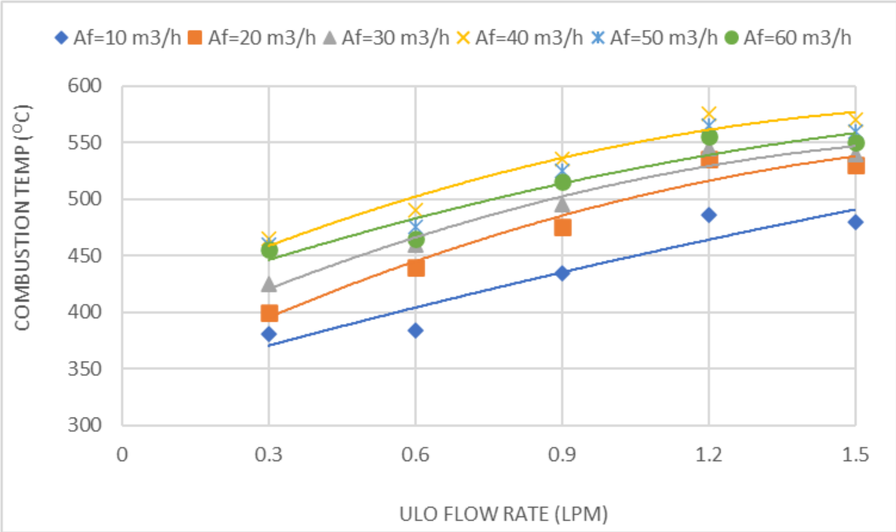

Fig. 4. Effect of ULO flowrate on temperature

4 Conclusion

Direct combustion of used lubrication oil (ULO) in domestic stoves can be used for supplying daily residential energy in households. The self-vaporization and complete combustion of ULO can be achieved by auto-preheating utilizing the heat during combustion. The contribution of this paper is to provide academic data for researchers to do further work on recycling ULO oil and guide for government to replace low-quality fuels in rural households with cleaner and cheaper waste oil. Burning used oil by paying attention to the air-fuel ratio can produce high thermal energy and low exhaust gas pollution. A simple stove with an internal air supply can be used to burn waste lubricant oil with high performance.

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