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Waste oil powered burner

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ABSTRACT

Due to continuous consumption, increasing energy demand and harmful exhaust gases of fossil fuels in transportation and power generation lead to guessing about alternative fuels. The chemical and physical properties of waste cooking oil were measured and Analysed according to ASTM standards. Their utilization as cooking fuel can bring numerous benefits not only for urban but also for rural communities. The paper focuses on characterizing VCOs (vegetable cooking oil) and UCOs (used cooking oil) as fuels for the household cooking application using a pressurized cooking stove. Physical properties such as auto-ignition point, auto-ignition time, flash point, density and viscosity of VCOs (vegetable cooking oil) play the role in combustion. Some properties of these oils were measured and characterized. Waste cooking oil was preheated to 90°C before oil nozzle. The oil was used directly used as a fuel in the pressurized cooking stove, it is possible to improve the combustion performance, thus by reducing the ignition time and incomplete combustion. The main target is to determine the quality and performances of the oils combustion. Crude VCO (vegetable cooking oil) gave the fastest auto-ignition time 30 s when compared with the other oils than other oils.

Keywords: *Kerosene, Waste cooking oil, Pressurized cooking stove.*

1. INTRODUCTION

Fuels of such as used cooking oils (UCOs) are a new alternative cooking fuel resource is a sustainable and independent cooking energy supply. These alternative fuels can be produced from renewable energy sources such as soybean oil, sunflower oil, groundnut oil, palm kernels oil etc. Used cooking oil (UCO) has a higher flash point. Such fuels can be used directly as fuel for the household cooking application. The using of UCO has many advantages as combustion simple and low-cost, the VCO can be processed on the farm itself, time and energy.

Physical properties such as ignition point play the vital role in the combustion. It would be very beneficial to study the various factors surrounding the ignition of UCO. The properties of the oil would determine the auto-ignition temperature of the UCO due to different chemical compositions. Therefore different types of UCO would have different auto-ignition temperatures, resulting in different ignition times. The energy consumption is inescapable for the human race on our planet. There are some reasons which encourage us for searching for alternative fuels that are technically suitable, environmentally acceptable, economically competitive, and readily available. The increase in demand for fossil fuels in all sectors of human life, transportation, and power generation led to intensive search about alternative fuels. Fossil fuel resources are non-renewable and they will be depleted in the near future. Environmental impact causing greenhouse gases effect, harmful emissions, and global warming. The price instability of fuels and taxation of energy products and all these led to a search for alternative fuels.

Used oils and animal fats are triglycerides attached to glycerol. Vegetable oil is biodegradable, carbon neutral, and does not produce hazardous toxic exhaust gases. Waste cooking oil has attracted a lot of concerns to all scientists and researchers because it represents some problems in its conversion and disposing it away from harming human or the environment.

The brevity of fossil fuel reserves and accelerating environmental pollution has spurred a continuous search for sustainable and eco-friendly alternative fuels. The increasing industrialization, the depletion of natural fossil fuel reserves and the motorization of the techno-savvy world have led to a steep rise in the demand for petroleum-based fuel. These fuels are obtained from the limited natural fossil fuel reserves. However, these finite reserves are concentrated in the certain region of the world, and would soon get exhausted. In view of the above problems, the search for alternative fuel has become extensively important. These alternative fuels should be renewable and eco-friendly. Such energy sources are clean sources of energy that have a much lower environmental impact than conventional energy sources. Wood is still the main energy source in rural areas of tropical and sub-tropical countries. An increase in the consumption of wood for cooking purposes results in the cutting of trees, creating severe ecological, economical and sociological problems. Usage of wood as a fuel leads to increased pollution of the atmosphere. In this context, plant oils are a promising alternative energy source that can be used with minimum ecological damage. An agricultural country like India can have a technology that fully utilizes plant oil, thus reducing the dependence on foreign exchange used for importing petroleum products. The present work uses 'used-vegetable' oil as a fuel in a modified stove. In all agriculture-based developing countries, biomass finds extensive use as fuel for cooking and other household activities. The stoves being used at present have very low efficiency in the order of only 5–9%.Also, they cause emission of greenhouse gases like CO, NO_x, etc. Constant exposure to such pollutants frequently causes severe health problems such as respiratory disorders, lung disease, tuberculosis, lung cancer, and so on. Women and children are in particular affected by these gases. In most developing countries the exposure is 20 times more than the guideline values given for these gases. Because of the above, it is necessary to replace biomass with a suitable fuel and with a stove having better combustion efficiency.

Physical and thermal properties of the fuel

Kerosene is commonly used as a liquid fuel where VCOs can be used as substitutes. Kerosene composed of hydrocarbon molecules. The kerosene fraction belongs to the group of hydrocarbon called paraffin, which has lower specific gravity than aromatic hydrocarbon of the same boiling point. The main components of kerosene are paraffin, cycloalkanes (naphtha) and aromatic compounds, where paraffin is the highest composition. UCO is tri-glycerol of fatty acids, with distinct chemical and physical properties, and different combustion characteristics than those of kerosene. VCO has a chemical composition that corresponds in most cases to a mixture of 95% triglycerides and 5% free fatty acids, sterols, waxes and various impurities. The viscosity of UCO can be up to about 30 to 50 times higher than that of kerosene. The flash point of UCOs ranges from 180 to 300ºC, compared to 80ºC for kerosene. This means the operating risks of kerosene are much higher due to its easy inflammation. All properties of UCO are close to kerosene except the viscosity. The high-value viscosity of the UCOs is considered to be the major constraint as combustion fuel, such as causing incomplete combustion and the formation of deposits on the burner nozzle.

High ignition points of UCO in connection with extremely high viscosity require special adaptation mechanism of the cooking stove. Many techniques have been developed to reduce the density and viscosity of UCO. Preheating of VCO reduce the viscosity which resulted in improved atomization property. Therefore these must be treated prior to the use of UCOs in the cooking stove. By adequately heating the UCO in the horizontal spiral coil before burning on burner spoiler, its physically parameters can reach values very close to that of kerosene. Consequently, by properly adjusting the temperature of UCO used as fuel, it is possible to improve their combustion performance thus reducing ignition time and incomplete combustion.

Pressurized cooking stove

The cooking stove, in general, is classified into two main categories; vapor jet burner (pressurized) and wick burners. The thermal efficiency of kerosene stove is between 20–40 % depending on stove and cooking equipment design. Since the viscosity of UCOs is higher than the viscosity of kerosene, directly usage of Kerosene wick-type stoves is not suitable for the use of UCOs. Due to its high viscosity, UOC has difficulty to be used as direct fuel for cooking. Also, the presence of other component forming coke and higher ignition temperature of UCOs compared to kerosene make it difficult to ignite the fuel. Therefore, the straight use of UCO as fuel in pressurized cooking stove entails adjusting several physical properties of density and viscosity. Designs of stoves using were based on the methods to vaporize and spray under pressure into a specially designed stove. In this experiment, UCO was used directly as a fuel using in a design of modified pressurized cooking stove equipped with the spiral coil as a preheater. Heating the UCO before injecting them into the combustion stove is one of the methods to reduce the viscosity number and reducing the ignition time. UCO was auto preheated before being burned to decrease its viscosity near to kerosene. Due to different chemical compositions, therefore different types of UCOs would have different auto-ignition temperatures, resulting in different ignition times. The results could give insight into safer VCOs to use that have higher auto-ignition temperatures. In this work, auto-ignition temperatures of these UCOs were measured and characterized according to ASTM standards. The main objective of present study was to analyze the UCOs and UCO as fuel and to reduce the viscosity of oils by auto preheating in a modified pressurized stove.

This work emphasizes the importance of the need to understand the vegetable cooking oil fires, especially the ignition characteristics of common UOCs. These experiments were researched to give insight into the temperatures ranges at which cooking oil will auto-ignite. The purpose of this research is to experimentally determine the combustion characteristics of three vegetable oils, namely VOC, UCO, crude VOC. To determine its usefulness as an alternative fuel, the combustion characteristics of vegetable oils are compared with kerosene. The physical properties of VCOs and UCO were tested according to ASTM methods. An experiment was designed and several tests were conducted to determine the density, viscosity, auto ignition temperatures, ignition time and smoke point of vegetable oils. To determine auto-ignition temperature, a small amount (5 ml) of cooking oil was heated in a small pan on a hot plate until the oil auto-ignited. The temperature of the oil in the pan was measured by using digital thermocouple Krisbow-KW06-283. The temperature of a smoke point was observed if enough volatile compounds emerge when a bluish smoke becomes clearly visible from the oil. The auto-ignition temperature and ignition time were measured when the minimum temperature at which an oil will start to burn without additional application of external heat.

Three fairly common household cooking oils of UCO, crude UCO, fresh VCO and the peanut cooking oil were tested. The density measurements were performed gravimetrically at 30°C using volumetric glassware. Three test runs were taken to ensure the repeatability and accuracy of the data according to ASTM D1298 methods. The viscosity of household cooking oils was measured by using a Cannon-Fenske capillary viscometer immersed in a thermostatic bath. The measurements of viscosity were carried out at temperatures of 30°C, for a total of 3 measurements, each of which was obtained by averaging the values of three repetitions. The Cannon-Fenske type 200 viscometer with the viscosity range of 20-100 mm2/sec. (centi-Stokes or CST) was utilized to measure the viscosity of the oil using method suggested by ASTM D445. They allowed measuring the viscosity of all VCOs with flow times within the recommended range set by the standard ISO 3105:1994.

2. COMPOSITION OF WASTE COOKING OIL

Fatty acids may be saturated such as politic acid and static acid or unsaturated, with one double bond such as oleic acid in which case they are called polyunsaturated fatty acids such as linoleum and linolenic acids. Chain length and number of double bonds for fatty acids determine the physical properties of both fatty acids and triglycerides. Fatty acids in waste cooking oil were oleic, linoleic, palmitic, palmitoleic, pentadecanoic, myristic, linolenic, heptadecanoic and stearic fatty acids. The fatty acid composition of the oil is

3. METHODOLOGY

If the future program is to achieve their intended societal objectives and satisfy consumer requirements, research on designing improved stoves with lower emissions is critical. The integrated research will also be required on other related aspects, such as measurements of emissions from various stove bio-fuel combinations, and on developing improved procedures, evaluation, and dissemination. The multiple benefits that can accrue from these programmers make continuing and increased investment of efforts worthwhile. Although on a global basis biomass accounts for about one-seventh of energy consumed, it is dose to being the only source of energy for over two billion of the world's poorest people. The increase in oil prices, however, made more remote the hope of a transition to these fuels for a substantial portion of the world's population and in fact, in places, there has been a return to traditional fuels. In densely populated areas, past unsustainable use of firewood has created a scarcity that forces people to turn to even poorer biomass materials: twigs, leaves, agricultural residues and animal dung. Because modem fuels can be burnt more completely and at higher efficiencies than traditional, solid biomass fuels, using modem fuels could possibly reduce the emissions of CO_2 in the short term, depending on the extent to which the source of biomass was being regenerated. In the longer term from a greenhouse perspective, clean, efficient and entirely sustainable use of bio-fuels (upgraded! would be preferable to the increased use of fossil fuels.

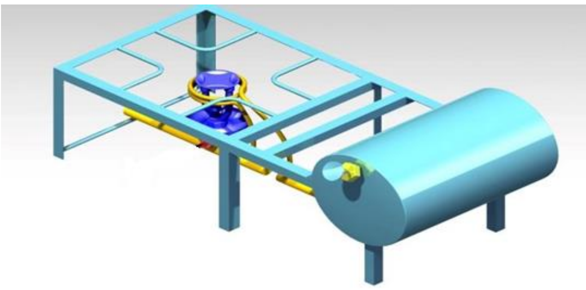

Fig 1: View of Modified Kerosene Stove

4. MODIFICATIONS IN STOVE

It is seen from the literature that the It is seen from the literature that the man universities have work on vegetable oil stove with independent tanks pressurized to around 2 bar pressure or by keeping the fuel tanks at a higher level for supplying the fuel. In our studies, the standard stove available in the market used with minor addition/ modification in the pipe line. i.e. "fuel tank placed 10cm above from the base and a capillary phenomenon is introduced before the fuel entering the nozzle". The capillary phenomenon is introduced for preheating the fuel before entering the nozzle.

Horizontal pressurized kerosene stove, consists of a fuel tank of capacity 2 liters at the side, along with the main fuel pipe attached to the burner assembly. The tank is pressurized by means of a small hand pump integrated into the tank. Shows the working burner assembly. Kerosene with the aid of air pressure forced from the fuel tank passes to the burner through main fuel supply pipe and raises through the rising tube (A) through the ascending pipe (B) to the pre- heated burner head (C), where the fuel is heated and vaporized.

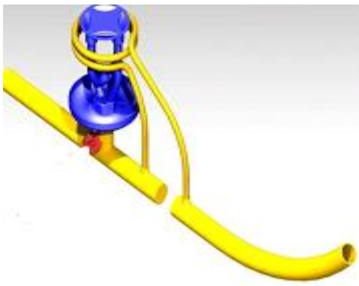

Fig 2: Pictorial View of Nozzle

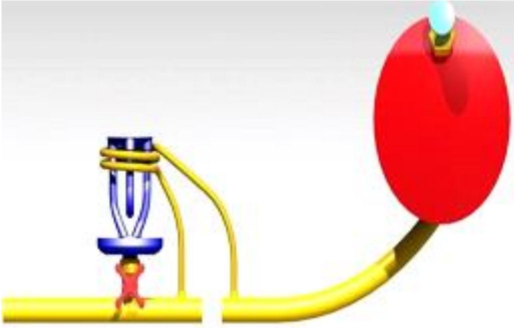

Fig 3: Pictorial View of Modified Fuel Supply

5. RESULT

To understand the performance of modified horizontal pressure stove, we have performed the various test with kerosene and cottonseed oil blended with kerosene. Also, a test of water boiling was performed.

We have taken various blends like;
80:20 (80% kerosene and 20% UCO)
70:30 (70% kerosene and 30% UCO)
60:40 (60% kerosene and 40% UCO)
50:50 (50% kerosene and 50% UCO)

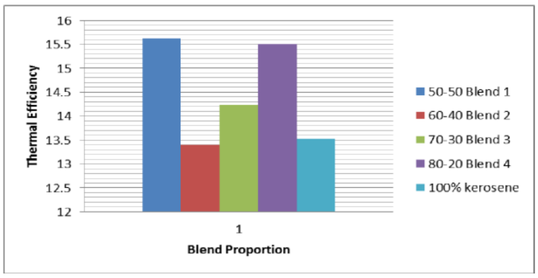

Fig 4: Blend Proportion Vs Thermal Efficiency

First of all the test using 100% kerosene were performed experimentally the thermal efficiency using 100% kerosene was13.59%. Also, the same test on UCO blends with kerosene was performed (80:20,70:30,60:40,50:50).Thermal efficiency for 80:20 blend got up to 15.59% which is 1.92% greater than thermal efficiency of 100% kerosene. The thermal efficiency for 70:30 blend got up to 14.24% which is 0.65% greater than thermal efficiency of 100% kerosene. Thermal efficiency for 60:40 blend got up to 13039% which is 0.2% greater than the thermal efficiency of 100% kerosene. Thermal efficiency for 50:50 blend got up to 15.62% which is 2.03% greater than the thermal efficiency of 100% kerosene. It clearly shows that UCO blends with kerosene having thermal efficiency more than thermal efficiency of 100% kerosene.

This clearly shows that the modification in stove such as a copper tube in fuel supply line to maintain the viscosity of blends by using capillary action has resulted in improvement in thermal efficiency using cottonseed oil blends with kerosene oil. Also, a modification like increasing the height of fuel tank from the ground has resulted in the proper supply of fuel because of gravity fuel comes into the nozzle at lower pressure also, which may reduce the effort of the operator.
In the present experiment, horizontal type kerosene stove was modified to burn a higher percentage of UCO blends with kerosene. In normal kerosene stove, the copper coil is incorporated to absorb the heat radiated through the burner and heat up the blend to reduce its viscosity. The heat which is utilized to heat up the blend is the waste heat. The results are highly encouraging the normal stove could burn with a maximum of 40% blend with kerosene (40% cottonseed oil and 60% kerosene)

However, in the modified kerosene stove 50% blend could be easily burnt and with a thermal efficiency of almost same as a kerosene operated stove. A comparison of the thermal efficiency of various tests blends for modified horizontal type kerosene stove is plotted on the graph. It can be observed that for all blends the modified stove was performing better when operated on blends of cottonseed oil than kerosene.

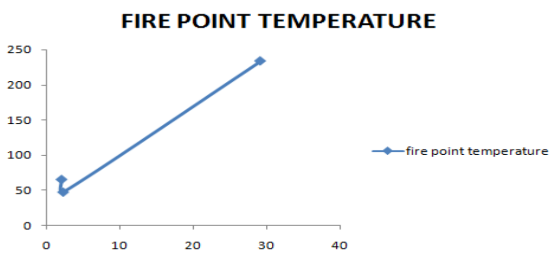

Fig 5: Fire point temperature

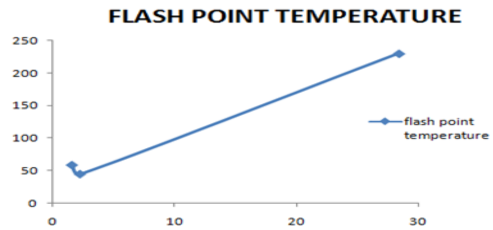

Fig 6: Flash point temperature

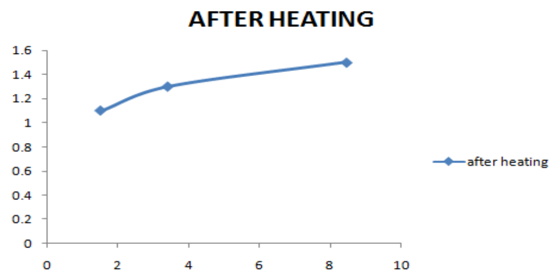

Fig 7: Viscosity of oil after heating

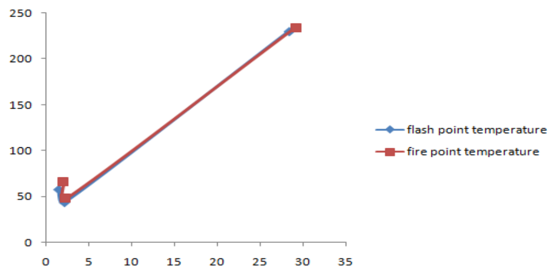

Fig 8: Comparison between flash and fire point temperature

Table 1: Flash and Fire Point Test

	Before heating (mins)	After heating (mins)
UCO	8.46	1.50
Kerosene	1.50	1.10
Mixed oil	3.25	2.20

Water Temperature=87^0C

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