Recycling Waste Automotive Engine Oil As Alternative Fuel

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Abstract - Increase in energy demand, stringent emission norms and depletion of oil resources have led the researchers to find alternative fuels for internal combustion engines. On the other hand, waste oil spose a very serious environment challenge because of their disposal problems all over the world. In this context, waste oils are currently receiving renewed interest. In recent years, diminishing of fossil fuel sources, growing of demand and cost of petroleum based fuels, and environmental hazards as a result of burning of them have encouraged researchers to investigate possibility of using alternative fuels instead of the fossil fuels. Therefore, the researchers have focused on finding alternative new energy resources and utilizing them. They have stated that it is necessary to reduce consumption of the petro fuels due to the negative effects on human life by producing alternative renewable fuels. As known fossil energy sources have been exhausted rapidly nowadays, it is predicted that fossil fuel sources will be depleted in the near future. According to some studies, many research works addressed the utilization of waste oils that are of lubricating oils originated from crude oil and biomass origin waste oils for the case of diesel engine applications as sources of energy. This paper gives a brief review about using waste oil as a fuel for diesel engines with various microwave pyrolysis applications in waste to energy engineering. It can also be established that the pyrolysis process offers an exciting way to recover both the energetic and chemical value of the waste materials by generating potentially useful pyrolysis products suitable for future reuse. Furthermore, this review has revealed good performance of the microwave pyrolysis process when compared to other more conventional methods of operation, indicating that it shows exceptional promise as a means for energy recovery from waste materials. The conversion process of each type of waste oil is presented. The results obtained from the experimental studies on a diesel engine are discussed.

I. INTRODUCTION

The production of waste automotive engine oil (WO) is estimated at 24 million tons each year throughout the world, posing a significant treatment and disposal problem for modern society. WO, containing a mixture of low and high molecular weight aliphatic and aromatic hydrocarbons, also represents a potential source of high-value fuel and chemical feedstock. The preferred disposal option in most countries is incineration and combustion for energy recovery, though vacuum distillation and hydro-treatment have been researched to recycle this waste [1]. However, these disposal routes are becoming increasingly impracticable as concerns over environmental pollution, and additional cost, sludge and wastewater disposal are recognized due to the undesirable contaminants present in WO.

As part of the growing interest in waste recycling, alternative treatments have beeninvestigated with the aim of recovering both the energetic and chemical value of the WO. Pyrolysis techniques have recently shown great promise as an economic and environmentally disposal method for WO.The waste material is thermally cracked and decomposed in an inert atmosphere, with the resulting pyrolysis oils and gases able to be used as a fuel or chemical feedstock, and the char produced used as a substitute for activated carbon, though the use of this technology is not widespread as yet. The pyrolysis-oil is of particular interest due to its easy storage and transportation as a liquid fuel or chemical feedstock. The oil can be treated and catalytically upgraded to transport-grade fuels, or added to petroleum refinery feedstocks for further processing and upgrading. While most WO pyrolysis studies have been focused on conventional electricresistance-heated and electric-arc-heated pyrolysis , there are very few studies about the pyrolysis oil generated during microwave-heated pyrolysis of WO. Microwave-heated pyrolysis has recently shown promise as a route for the treatment and recycling of the WO; the advantages of microwave-heated-pyrolysis have been elaborated in previous work and will not be duplicated here. In this process, WO is mixed with a highly microwave-absorbent material such as particulate carbon; as a result of microwave heating the oil is thermally cracked in the absence of oxygen into shorter hydrocarbon chains. The resulting gaseous products are subsequently re-condensed into pyrolysis oils of different composition depending on the characteristics of the input substances and reaction conditions.

II. WASTE ENGINE OIL

In recent years, recycling of the waste lubricant oils and utilizing of the products as fuels have become important topics for researchers. Most of the lubricant oils are generally obtained from petroleum resources. The used or waste oils can be refined and treated to produce fuels or lubricating oil base stock. On the other hand, the waste oils pose an environmental hazard due to both their metal content and other contaminants. The high-volume waste oils can be turned into valuable fuel products by refining and treating processes. Converting of the waste oils into diesel-like fuels to be used in engines without disposing is very important. Utilization of the diesel-like fuels produced from the waste lubricant oils, and blending of the produced fuels decrease consumption of petroleum based fuels, protecting environment from toxic and hazardous chemicals. It also saves of foreign exchange, reduces greenhouse gas emissions and enhances regional development especially in developing countries. Characteristics of any fuel are very important from the point of deciding whether the fuel can be used for desired application or not. Therefore, some characteristics of the produced diesel-like fuel is shown in Tables 1. The table shows that some of the parameters of density, boiling point, viscosity, flash point and lower heating value are in the standard values of the diesel oil or reasonably close to the standard values. But, sulfur amount is considerably higher than that value. It should be decreased below the value of 50 ppm.

III. CONVERSION OF WASTE ENGINE OIL

The high-volume waste oils can be turned into valuable fuel products by refining and treating processes. Converting of the waste oils into diesel and gasoline-like fuels to be used in engines without disposing is very important. Utilization of the diesel and gasoline-like fuels produced from the waste lubricant oils, and blending of the produced fuels with gasoline or turpentine decrease consumption of petroleum based fuels, protecting environment from toxic and hazardous chemicals. It also saves of foreign exchange, reduces greenhouse gas emissions and enhances regional development especially in developing countries.

In the study of the authors used a recycling system for the waste lubricant oil. A recycling system was designed and manufactured in industry to purify waste oil from dust, small carbon soot and metal particulates, and reutilize the waste oil. Schematic representations and picture of the system are shown in Figure 1. In the recycling system, two fuels to be used in engines were produced by applying pyrolitic distillation.The fuels named as gasoline-like fuel (GLF) and diesel-like fuel (DLF) were obtained from waste lubrication engine oil. The oil was collected from gasoline and diesel engines. The recycling system was consisted of waste oil and produced fuel storage tank, pump, filter, a reactor, heaters, mixer, condenser and control unit. The waste lubricant engine oil was collected and stored in the storage tank. The oil pump was used to transfer waste oil in the storage tank to metallic filter. The waste oil was taken by the pump from the storage tank, and it was filtered using a quality filter with 20 mm mesh size to purify it from heavy metal particles, carbon soot, gumtype materials and other impurities. After removing the purified oil from the filter, it was flowed into the reactor.

The reactor is the most important part of the recycling system, since pyrolitic distillation or thermal treatment of the waste oil is performed in the reactor. It has a cylindrical shape with dimensions of 30 cm in diameter and 40 cm in height. It has a capacity that will be able to produce 20 L of fuel. This volume is enough to do all tests, which include characteristics of the fuel, performance and emissions. The reactor was isolated with glass wool with a thickness of 5 cm to minimize heat loss from the reactor. It includes a mixer and electrical heaters. The mixer was used to blend the oil and additive to obtain uniform blend and temperature in the oil. The heaters were used to heat the mixture of the purified oil and additive in order to make thermal destruction more easily. The heaters with a total heating capacity of 5 kW were placed around the reactor container. They can be capable of heating the mixture up to 600°C. They were controlled by a controlling unit adjusting heating rate. Then, the reactor was used as a heater of a distillation unit, and fuel sample produced from the waste lubricant oil in the reactor was distilled. The distillation unit was named as condenser, which is shown on Figure 1. After being condensed of the fuel sample was collected in the fuel storage tank. In the recycling system, 80 wt. % of the total, waste lubrication oil was converted into useful fuel in the pyrolysis process. Remaining parts such as impurities smaller than 20 mm, sludge and solid additives in the reactor were named as residue. It was about 20 wt. %, and was rejected from the reactor. It is necessary to purify the waste oil to produce a valuable fuel. Therefore, it was taken from the tank by the oil pump, and was flowed through the filters having 20 µm mesh sizes. It was separated from dust, carbon soot, metal and other particles, and then charged to the reactor. The oil was heated up to 330°C in the reactor, in which the pyrolysis process occurred, and it was treated for 1 h at this temperature. During the process, the mixer in the reactor mixed the oil-additive mixture. Heating process wascontinued by increasing the reactor temperature with electronic control unit in order to pass to the distillation process after the pyrolysis process. The vaporized fuel due to heating process was condensed through condenser in which water was used as cooling fluid. After the fuel become liquid, it was stored in fuel storage tank. Properties and distillation of the produced fuel should be tested to determine whether it can be used in a diesel engine or not, and they should also be compared with the diesel fuel commonly used in diesel engines. The produced fuel was segregated into light and heavy fuels according to characteristics and distillation test results, since some amount of the produced fuel was lighter than diesel fuel. That is why it was necessary to segregate the light fuel from the heavy fuel to eliminate detrimental effects of these fuels on an engine.

IV. EFFECT ON PERFORMANCES

Conducted an experimental study on diesel-like fuel (DLF) on engine performance and exhaust emission. It is observed from the test results that about 60 cc out of each 100 cc of the waste oil are converted into the DLF. It is observed that the produced DLF can be used in diesel engines without any problem in terms of engine performance. The DLF increases torque, brake mean effective pressure, brake thermal efficiency and decreases brake specific fuel consumption of the engine for full power of operation.

The author found that T, Bmep, thermal efficiency and Bsfc trends for the DLF and diesel fuel are similar in nature. It is known that T and Bmep are directly proportional but Bsfc is indirectly proportional with the engine brake power given. The T, Bmep, and thermal efficiency values obtained for the DLF are slightly higher than those obtained for diesel fuel, but Bsfc is lower in all revolutions. Average increases of the T and Bmep values are approximately 0.69% for the DLF. This was due to high distillation temperature of the DLF than diesel fuel.

In internal combustion engines, the T increases to a maximum point with the increase of engine speed. After that critical point, generally the torque decreases step by step. The maximum T and Bmep values obtained from the measured data for the DLF and diesel fuel in 2000 rpm are 33.86 and 33.71 Nm, 1048.21 and 1043.38 kPa, respectively. The corresponding thermal efficiency and Bsfc for the same fuels and the engine speed are 40.68 and 37.88%, 213.23 and 224.52 g/kWh respectively. After the maximum and minimum values of these parameters they decrease and increase with the engine speed gradually. It is expected that the Bsfc should decrease when the brake power increases up to engine speed of 2200 rpm. At high speeds, friction, heat loses and deteriorating combustion increase Bsfc performance parameters for the DGL are similar to those of diesel and are parallel to them in a regular way. Arpa found that the torque, Bmep, and thermal efficiency for the DLF ishigher than those of diesel while the Bsfc for the DLF is lower than that of diesel. This is an important criterion that makes the DLF advantageous. Characteristics and distilled temperatures of fuels are the other effects on the performance parameters. The characteristics give better mixing and combustion characteristics of the fuels, which cause reduction in heat loss. It was also emphasized that higher distilled temperature gives better performance. The distillation temperature makes it possible to explain these differences in performance parameters. Diesel fuel is lighter than the DLF. Distillation temperatures of the DLF are higher than those of the diesel fuel up to 80 cc of 100 cc volume. This indicates that DF is a more volatile fuel than the fuel obtained from waste engine oil. High volatility decreases volumetric efficiency and cause vapor lock on hot climate conditions. When low volatile fuels or fuels distilled at higher temperatures are burned in combustion chamber of engine gradually, temperature and pressure in the combustion chamber will increase, which improves performance parameters of the. As a result, ignition timing, air–fuel ratio, characteristics and higher distilled temperatures for the DLF give slightly better performance parameters than the diesel fuel. Therefore, T, Bmep and thermal efficiency increase and Bsfc decreases. Test results from the study have clearly shown that the DLF has a positive effect on the performance parameters of the engine, and it can be used as a fuel in the gasoline engine without any problems. found that the lowest torque values were obtained for WEO100, WEO75 and WEO50 fuels, respectively. The main reason of torque reduction is considered to be the slightly lower calorific alue of the WEO fuel. Therefore, the reduction in the torque values of the WEO blends were linear with the WEO amount contained in the blend. The average bsfc of the test fuels obtained were 322.91, 322.81, 325.46, 325.86, 329.76, 333.64, 343.25, 354.21 and 367.17 gr/ kWh for diesel fuel, WEO5, WEO10, WEO15, WEO25, WEO35, WEO35, WEO50, WEO75 and WEO100 fuels, respectively. Bsfc is directly affected by the fuel consumption, power value at corresponding engine speed and calorific value of the fuel. Since the calorific value of blend fuels of WEO and diesel fuel is lower than that of diesel fuel bsfc values of WEO blends were lower than that of diesel fuels. The exhaust gas temperature values ever increased with the increase of the engine speed, for all the test fuels. The lowest exhaust gas temperature values were odiesel fuels. Exhaust gas temperature is affected by the combustion temperature, in-complete and retarded combustion. Lower exhaust temperature of the engine operation with pure WEO and WEO blend fuels can be attributed to all the reasons given above. II.

V. CONCLUSION

Fuel obtained from waste engine oil can be used as fuel in diesel engines without any problems in terms of engine performance. The thermal and physical characteristics of the DLF are close to those values of a typical diesel sample. Moreover, its distillation temperature increases gradually, and its behavior is similar to that of diesel fuels used in engines. When the DLF was used, it was observed that torque, brake mean effective pressure and brake thermal efficiency were higher than those of the diesel sample while the brake specific fuel consumption was lower.

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