International Journal of Advanced Scientific Research
ISSN: 2456-0421
www.newresearchjournal.com/scientific
Volume 1; Issue 1; April 2016; Page No. 01-04

A review: Waste lubricating oil as an alternative fuel blended with diesel

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Abstract

This paper discusses about waste lubrication oil as a fuel for diesel engines with various microwave pyrolysis applications in waste to energy engineering from various researchers. Conversion of waste lubrication oil into useful fuel that is diesel like fuel (DLF) in the pyrolysis process.

The objective of this paper is to study on prepare Diesel like fuel from waste lubrication oil and also involve the study of analysis of the performance and emission characteristics of the diesel like fuel and comparing with petroleum diesel from various researchers.

Keywords: Review, Waste Lubricating Oil, Alternative Fuel, Diesel

1. Introduction

1.1 Diesel like Fuel (Recycling Of Waste Lubrication Oil)

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 and gasoline-like fuels to be used in engines without disposing is very important.

1.2 Waste engine oil

Waste lubricant oils and bio fuels are two important alternative fuel sources proved to be the best substitutes for existing petro fuels, since waste generated oils represent more than 60% of used lubricant oils. Therefore, waste oils are one of the most abundant pollutant residues that are generated nowadays, reaching the value of 24 million metric tonnes per year. 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. Petroleum-derived base oils currently account for about 97% of the total lubricant production. However, these oils become waste oils harmful for environment after a certain time period. Recycling of the waste lubricant oils by purifying and converting them into fuels is very important in terms of protection of the environment. After waste lubricant oils are converted into fuels, they can be used as fuels in internal combustion engines. In recycling process, waste lubricant oils are exposed to various processes, and then used as fuel or they are converted into various chemicals in order to minimize the harmful effects of these wastes. Millions of tons of used oils are disposed through dumping on the ground or in water, land filling, or nonenergy-recovery. 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. 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 and gasoline-like fuel are shown in Tables 1 and 2, respectively, together with standard values of a diesel and gasoline fuel. 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 50ppm.

Table 1: Comparison of diesel-like fuel obtained from waste lubrication oil and diesel fuel

S. No	Properties	Diesel fuel	Diesel like fuel
1	Density at 15°C (kg/m^3)	820-845	818
2	Viscosity at 40°C (mm^2/s)	2-4.5	3.49
3	Flash point(°C)	>55	59
4	Fire point(°C)	>50	53
5	Low heating value(kJ/kg)	42.700	42.500

Management of waste oils is a growing concern particularly in industrial and urban areas. Generation of waste oils is closely linked with increase in population of automobiles and industries. When additives and foreign substances, such as metal powder, chips and other particles, are mixed with lubricating oil, aging, degrading and failure will likely occur, leading to mechanical fault and degraded performance. In such cases, the oil is replaced to improve the performance. The used, spent or waste oils should be collected and recycled not only to prevent the environment pollution but also to preserve natural resources. The management of waste oils is particularly important because of the large quantities generated globally through transport and Industrial activities. These Waste Oils may have detrimental effect on the environment if not properly handled, treated or disposed. In recent decades a number of innovative treatment technologies have been developed that promise to solve technical, economic and environmental problems associated with used oil recycling for further motivates that 1liter of waste-oil reprocessed as fuel contains about 8000 kJ of energy, which is enough to light a 100 W bulb for 24 hours. The efficient recycling of waste lubricant could help reduce both the environmental pollution and gas emission from greenhouses, thus creating an environmental and economic benefit.

1.3 characterization of waste lubrication oil

The main constituents of waste lubricating oils are the base oil, degraded additives, metallic debris, oxidation products and carbon soot. A large number of additives are used to impart performance characteristics to the lubricants. The main additives are antioxidants, detergents, anti-wear elements, metal deactivators, corrosion inhibitors, rust inhibitors, friction modifiers, extreme pressure withstanding elements, antifoaming agents, viscosity index improvers, demulsifying or emulsifying agents and stickiness improver. During their use, these additives lose their characteristics rendering the lube oil non usable for lubricating purpose. In addition, during their use, the lubricating oils and the metal processing oils pick up fractions of various metals as a result of wearing out of components. The concentration of these impurities depends purely on the application to which the particular oil is put to. Some contaminants, such as chlorinated solvents, water, unburned fuel, carbon and dust are also picked upbythe waste oil during use or during storage.

1.4 environmental pollution

The contaminants in waste oil have adverse environmental and health impacts. Reference states that the presence of degraded additives, contaminants, and by-products of degradation render waste oils more toxic and harmful to health and environment than virgin base oils. If put into storm water drains or sewers, they can affect waterways and coastal waters. When dumped in soil or sent to landfill, they can migrate into ground and surface waters though numerous land treatment processes. In addition, uncontrolled used oils are a threat to plant and animal life, which can further result in economic losses, for example, recreation and fishing industries. For example, used oil from internal combustion engines generally accumulates a variety of contaminants, which increase the oil's toxicity.

1.5 importance of used oil recycling

A large range of waste oils can be recycled and recovered in a variety of ways, either directly or after some form of separation and refinement. As per the waste management hierarchy, the first option is to conserve the original properties of the oil allowing for direct reuse. Other options could include recovering its heating value and/or using in other lower level applications. Certain types of waste oils, lubricants in particular, can be reprocessed allowing for their direct reuse. The use of waste oils, after treatment, can be either as a lube base stock comparable to refine virgin base oil or as clean burning fuel.

- Re-refining in lubricating oil recovery
- Re-refining in Dedicated grass-root unit
- Reprocessing in primary refinery
- Reprocessing to fuel
- Burning untreated
- Disposal

2. Literature review

RA Berg *et al*. (2010) [1] had studied on production of diesel fuel from used engine oil Due to scarcity of petroleum products, the used engine oils can be used in engine as engine oil after purifying it. Production of diesel fuel from used engine oil is involving chemical filtrations and blending process. It could solve some of the energy problem with increasing the blending percentage of pre-treated used engine oil (UEO) or by using pre-treated used engine oil as a diesel fuel. In the present study, samples of shipyard and light vehicles (bus and truck) pre-treated used engine oil and different percentage of blending of pre-treated used engine oil (including clay treatment, CT) into fresh diesel have been considered. Results show that pre-treated (including CT) used engine oil of shipyard (UEO) and 35% blending of pre-treated (including CT) used engine oil (UEO) into fresh diesel are suitable to use as a diesel fuel considering Caterpillar Specific Limit and comparing with the fresh diesel.

They concluded that from the experimental study, it is evident that pre-treated (including clay treatment, CT) used engine oil (UEO) and 35%blending of pre- pretreated (including, CT) used engine oil of shipyard (UEO) into fresh diesel are suitable to use as a diesel fuel considering Caterpillar Specific Limit and comparing with the fresh diesel. Though the samples have a little bit higher value of viscosity (kinematics), flash point fire point but these value are in tolerable range. Produced diesel is technically suitable, economically viable and less responsible to pollute environment.

K. Nalma *et al*. (2013) [2] had studied on this waste oils as alternative fuel for diesel engine.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 oils pose a very serious environment challenge because of their disposal problems all over the world. In this context, waste oils are currently receiving renewed interest. The properties of the oil derived from waste plastics, cooking and engines oils were analyzed and compared with the petroleum products and found that it has properties similar to that of diesel. This paper gives a brief review about using waste oil of these three types of oil as a fuel for diesel engines. The conversion process of each type of waste oil is presented. The results obtained from the experimental studies on a diesel engine are discussed.

They concluded this paper gives a brief review on the conversion process of the most waste oils available in now days in order to use them in Diesel Engine. From the results obtained from various studies we can summarize the following points:

i) Results from using waste cooking oil as fuel for diesel engines showed that the fuel obtained has a higher viscosity and lower calorific value; this will have a major bearing on spray formation and initial combustion. The ignition delay of UCO biodiesel decreases. The peak pressure of UCO biodiesel and its blends is higher than that of diesel fuel. WCO showed a higher exhaust gas temperature compared to diesel fuel. Increased oxygen content which improves combustion is a reason given for this. A relatively high disparity of results has been found regarding the emissions characteristics of used cooking oil biodiesel and/or its blends. Most of the reports recorded slight increases in NOx when compared to diesel at rated load. The reasons most frequently given include higher oxygen content of biodiesel and its blends and advanced injection process with biodiesel. CO and unburned HC emissions were found to significantly decrease with biodiesel and its blends due to a more complete combustion caused by higher oxygen content.

ii) Engine was able to run with 100% waste plastic oil. Ignition delay was longer by about 2.5°CA in the case of waste plastic oil compared to diesel. NOx is higher by about 25% for waste plastic oil operation than that of diesel operation. CO emission increased by 5% in waste plastic oil compared to diesel operation. Unburned hydrocarbon emission is higher by about 15%. Engine fueled with waste plastic oil exhibits higher thermal efficiency up to 75% of the rated power.

iii) 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.

Motshumi J. Diphare *et al*. (2013) [3] had studied on this a comparison of waste lubricating oil treatment techniques.Waste lubricating oil is a resource that cannot be disposed of randomly due to the presence of pollutants. In response to economic problems and environmental protection, there is a growing trend to regenerate and reuse waste lubricants. The recovery techniques discussed in this paper are reprocessing, re-refining and incineration of waste lubricating oil. The major objective of this paper is to analyze and compare the regenerative technologies, thus creating the foundation for government, the private sector and other stakeholders in policy formation and selection of recovery techniques.

They concluded that Recycling of waste lubricants could result in both environmental and economic benefits. Re-refining of waste oil to manufacture base oil conserves more energy than reprocessing the waste oil for use as a fuel. The energy required to manufacture re-refined oil from used oil is only one-third of the energy required to refine crude oil to produce virgin base oil. Therefore, re-refining is considered by many as a preferred option in terms of conserving resources, as well as minimizing waste and reducing damage to the environment.

P. Navaneetha Krishnan *et al*. (2014-15) [4] had studied on this Performance, Combustion and Emission Characteristics of Variable Compression Ratio Engine Fuelled with Biodiesel.In the present investigation experimental work has been carried out to estimate the performance, combustion and emission characteristics of a single cylinder, four stroke variable compression ratio multi fuel engine fuelled with tamanu oil methyl ester blended with standard diesel. Tests has been conducted using the biodiesel blends of 10%, 20%, 40% and 60% biodiesel with standard diesel, with fixed compression ratio 19, and an engine speed of 1500 rpm at different loading conditions. The performance parameters includes brake thermal efficiency (BTE), specific fuel consumption (SFC), brake power (BP), indicated mean effective pressure (IMEP), mechanical efficiency and exhaust gas temperature. The exhaust gas emission is found to contain carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx) and carbon dioxide (CO2). The result of the experimental works has been compared with standard diesel and it concludes considerable improvement in the performance parameters, heat release rate as well as exhaust emissions. From the result the emission rate of carbon monoxide, hydrocarbon and carbon dioxide are reduced with the increase of nitrogen oxides emissions. The combustion characteristics of tamanu oil methyl ester and its diesel blends are closely follows the standard diesel.

They concluded that a detailed experimental study was conducted to evaluate and analyze the performance, exhaust emission level and combustion of tamanu oil biodiesel and diesel blends in a fully instrumented single cylinder, variable compression ratio multi fuel engine. The conclusions are summarized as follow: As load applied to the engine increases brake thermal efficiency of the fuel blends also increases. The maximum brake thermal efficiency is 41.72% for B40 at full load, which is 5.2% higher than standard diesel. As the load increases specific fuel consumption of the engine decreases gradually. At full load conditions the specific fuel consumption for the blends B20 and B40 is 0.2234 kg/ kWh, 0.2268 kg/ kWh respectively whereas for standard diesel it is 0.2201 kg/ kWh · As load applied increases exhaust gas temperature get decreased. Lower calorific value of the blended fuel than standard diesel and lower temperature at the end of compression leads to reduction in exhaust gas temperature. As load increases mechanical efficiency of the blended fuel shows steady increase. At full load condition the maximum mechanical efficiency obtained from blend B20 and B40 is 93.77% and 87.62 % respectively · From the analysis of exhaust emission of the blends, it has found that at higher load condition except B20 all other blends having higher hydrocarbon emission. At lower loads except B40 all other blended fuel having higher NOx emission than standard diesel. The carbon monoxide emission is closer to standard diesel at full load and it is higher for light and medium loads. · Due to longer ignition delay of the blended fuel B40, it gives higher combustion pressure. The heat release rate the blended fuel decreases at the start of combustion and increases further gradually. This may be due to effect of viscosity of the blends and the air entrainment combined with lower air/fuel mixing rate. At full load condition, the mass fraction burnt for blends is slightly higher than that of diesel.

Mohd. Nematullah Nasim *et al*. (2014) [5] had studied on this Recycling waste automotive engine oil as alternative fuel for diesel engine.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 oilspose 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, it is estimated that crude oil will last only for roughly 80 more years, gaseous fuels for about 150 years, and coal for 230 years. Therefore, scientists and researchers all over the world are now working hard to discover new sources of energy for the future, and also try to develop new technologies that allow recycling or reusing waste material as a source of energy. 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.

They concluded that 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.

Vipin Mohta1 *et al*. (2015) [6] had studied on this Review on Preparation of Alternative Fuel from Waste Transformer Oil and Studying Performance Characteristics on Diesel Engine for Different Blends. Reuse and recycling are better options to derive energy or value added products from waste substances and to minimize the disposal problems. Transformer oil is generally used as a coolant in welding transformers, power transformers and electromotive units. After a prolonged use in these devices, the transformer oil becomes waste and is disposed of. The disposal of waste transformer oil (WTO) causes an environmental pollution. However, the WTO has properties that are similar to that of diesel fuel with a marginally higher viscosity and lower calorific value. The present investigation is aimed to reuse the WTO as a possible source of energy to run a small powered, single cylinder, four stroke, and diesel engine. Different techniques such as blending, operating the engine with different injection timings, nozzle opening pressures, compression ratios, preheating and dual fuel mode were adopted to study the engine behavior in terms of combustion, performance and emission when the engine is fueled with the WTO. The results are analyzed and compared with diesel operation of the same engine.

They concluded that the objective of this experiment was to use transformer oil as an alternative fuel. The pure diesel was used as base fuel for comparing the properties and performance parameters.

3. Conclusion

It concluded that Conversion of waste lubrication oil can be made into useful fuel that is diesel like fuel (DLF) through the pyrolysis process.

Diesel like fuel can be prepared from waste lubrication oil and to study the analysis of the performance and emission characteristics of the diesel like fuel and comparing with petroleum diesel. The tests will be carried out on a four stroke single cylinder, direct injection, Air-cooled or water cooled diesel engine. The fuel properties of diesel like fuel from 20 to 100% by volume will be studied by using results. Engine tests will be carried out with the aim of obtaining comparative measures of Brake power, specific fuel consumption and emissions such as CO_2, CO, HC and NOx to evaluate and compute the behavior of the diesel engine.

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