EXPERIMENTAL STUDY ON PREFORMANCE AND EXTRACTION OF FUEL FROM WASTE PLASTIC

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Abstract: Plastics are an integral part of our modern life and are used in almost all daily activities. Since plastics are synthesized from non-renewable sources and are generally not biodegradable, waste plastics are the cause of many of the serious environmental problems the world faces today. Due to depletion of fossil fuel reserves and increasing cost of the petroleum products are the big troubles of today's world .from past to present, tendency of oil price have increased consecutively, Especially in India has deficient amount of fossil fuel .for this reason, India has to import fossil fuel, such as petroleum for domestic demand the waste can then be converted into hydrocarbon fuel either in the collection vessel itself or in off-shore facilities, using established technology.

Keywords- *Waste plastic, fuel, diesel oil, petrol oil, and pyrolysis.*

I. INTRODUCTION

Due to the fossil fuel crisis in past years, mankind has to focus on creating alternate energy sources such as biomass, hydropower, geothermal energy, wind energy, solar energy, and nuclear energy. The developing of alternative-fuel technologies are investigated to deliver the replacement of fossil fuel. The focused technologies are bio-ethanol, bio-diesel lipid derived bio-fuel, waste oil recycling, Pyrolysis, gasification, di-methyl ether, and biogas. On the other hand, appropriate waste management strategy is another important aspect of sustainable development since waste problem is concerned in every city.

The waste to energy technology is investigated to process the potential materials in waste which are plastic, biomass to bio-oil. Pyrolysis process becomes an option of waste-to-energy technology to deliver bio-fuel to replace fossil fuel. Waste plastic are investigated in this research as they are the available technology. The advantage of the Pyrolysis process is its ability to handle un-sort and dirty plastic. The pre-treatment of the material is easy. Tire is needed to be shredded while plastic is needed to be sorted and dried. Pyrolysis is also no toxic or environmental harmful emission unlike incineration.

Economic growth and changing consumption and production patterns are resulting into rapid increase in generation of waste plastics in the world. For more than 50 decades the global production of plastic has continued to rise.

Some 299 million tons of plastics were produced in 2013, representing a 4 percent increase over 2012. Recovery and recycling, however, remain insufficient, and millions of tons of plastics end up in landfills and oceans each year

Approximately 10–20 million tons of plastic end up in the oceans each year. A recent study conservatively estimated that 5.25 trillion plastic particles weighing a total of 268,940 tons are currently floating in the world's oceans.

And since plastic being a non-biodegradable material it remains into the soil, thereby polluting the environment. In India alone, the demand for the plastics is about 8 million tons per year. More than 10,000 metric tons per day plastics are produced in India and almost the same amount is imported by India from other countries. The per-captiaconsumption of plastics in India is about 3kg when compared to 30kg to 40kg in the developed countries. Most of these come from packaging and food industries. Most of the plastics are recycled and sometimes they are not done so due to lack of sufficient market valve. Of the waste plastics not recycled about 43% is polyethylene, with most of them in containers and packaging.[1]

1.1 Types of Plastics

The types of the waste plastics are LDPE, HDPE, PP, PS, and PVC. The problems of waste plastics can't be solved by land filling or incineration, because the safety deposits are expensive and incineration stimulates the growing emission of harmful green house gases like COx, NOx, SOx and etc. These types of disposal of the waste plastics release toxic gas which has negative impact on environment. Plastic wastes can also classified as industrial and municipal plastic wastes according to their origins, these groups have different qualities and properties and are subjected to different management strategies. Plastic wastes represent a considerable part of municipal wastes furthermore huge amounts of plastic waste arise as a by-product or faulty product in industry and agriculture. The total plastic waste, over 78% weight of this total corresponds to thermoplastics and the remaining to thermosets. Thermoplastics are composed of polyolefin such as polyethylene, polypropylene, polystyrene and polyvinyl chloride and can be recycled. On the other hand thermosets mainly include epoxy resins and polyurethanes and cannot be recycled.[1][2][5]

1.2 Municipal Plastic Waste

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household wastes. The various sources of MPW plastics includes domestic items (food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, CD and cassette boxes. fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinks bottles, plumbing pipes and guttering, flooring. cushioning foams, thermal insulation foams, surface coatings, etc.), agricultural (mulch films, feed bags, fertilizer bags, and in temporary tarpaulin-like uses such as covers for hay, silage, etc.), wire and cable, automobile wrecking, etc. Thus, the MPW collected plastics waste is mixed one with major components of polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, etc. The percentage of plastics in MPW has increased significantly.[3]

1.3 Industrial Plastic Waste

Industrial plastic wastes are those arising from the large plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly constitute plastics from construction and demolition companies (e.g. polyvinylchloride pipes and fittings, tiles and sheets) electrical and electronics industries (e.g. switch boxes, cable sheaths, cassette boxes, TV screens, etc.) and the automotive industries spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills). Most of the industrial plastic waste has relatively well physical characteristics i.e. they are sufficiently clean and free of contamination and are available in fairly large quantities.

II. OBJECTIVE

- To establish the basis for the development and implementation of waste plastics recycling with the application of environmentally sound technologies (EST) to promote resource conservation and greenhouse gases (GHG).
- To raise awareness in developing countries like INDIA on plastic waste and its possible reuse for conversion into diesel or fuel, this could be generated and marketed at cheaper rates compared to that of the available diesel or oil in the market.
- To reduce the dependency on gulf countries for fossil fuels, thereby contributing to the Economic growth of the country.
- This project attempts to show how human has been utilizing the energy and explore prospects of optimizing the same one of the alternative fuels is household plastic waste oil. Fuel obtained from pyrolysis process shows nearly same properties as that of Petrol fuel. So we can use plastic oil as alternative fuel. The objectives of this project are given below.
  - To collect the household plastic waste from different places.
  - Drying and Storing of plastic waste.
  - To develop and fabricate the pyrolysis unit to produce liquid fuel from plastic waste.
  - Conversion of household plastic waste in to liquid fuel.
  - To purify the produced liquid fuel by water washing method.
  - To conduct the different experiments to determine the different properties of liquid fuel.
  - Compare the properties of liquid fuel with diesel fuel.

III. MATERIALS AND METHODOLOGY

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household plastic wastes. The various sources of MPW plastics includes domestic items like food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, CD and cassette boxes. Fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinks bottles, plumbing pipes and guttering, flooring.

In this project work pyrolysis method is used to convert household plastic wastes like food containers, milk covers, water bottles, packaging foam, and waste cooking oil cover. Nearly 15 tons of plastic cover is wasted in single village. This waste plastic cover is also used in Belagavi, Udupi, Dakshina Kannada, Mysore district's etc. This highest portion of plastic is disposed to landfill. By survey nearly 150 tons to 200 tons of plastic cover is disposed into land in single district. By estimating 5000 tons to 6000 tons of plastic will be wasted from household sources in the state. Waste plastics have been shredded and washed before pyrolysis. The above factors from municipal plastic waste have been used as raw materials in our Project. Waste plastics have been washed before pyrolysis. In our work milk plastic cover and Plastic water bottles are selected as feed stocks to convert waste plastic into useful liquid fuel compounds.[4]

3.1 Raw Materials Used To Produce Liquid Fuel.

Fig 3.1.1 Milk covers used in the project

Fig 3.1.2 Waste plastic bottles used in the project

The above figures show the milk plastic covers and waste plastic bottles which are majorly used in this project. We choose these plastics because these are the plastics which could be seen anywhere and which are easy to get. The plastic wastes used should be shredded and then cleaned with acetylene before feeding to the reactor.

3.2 Design Parameters of Pyrolysis Unit.

- **Melting Point of the Material Used for Reactor**
  If melting point is high, substance easily vaporizes & more oil is obtained.
- **Density**
  If density is lower, substance easily vaporizes & more oil is obtained.
- **Quality of Material Used for Reactor**
  More the quality of the material more is the yield of the oil.
- **Moisture Content**
  Moisture content should be less to get good yield.
- **Reactor Temperature**
  Reactor temperature should be high to get good yield.
- **Heating Rate**
  Heating rate should be consistent and good.
- **Reactor Size**
  Bigger the reactor size more the fuel can be extracted.
- **Condenser Design**
  Condenser design also affects the production of the fuel.

3.3 Pyrolysis Process.

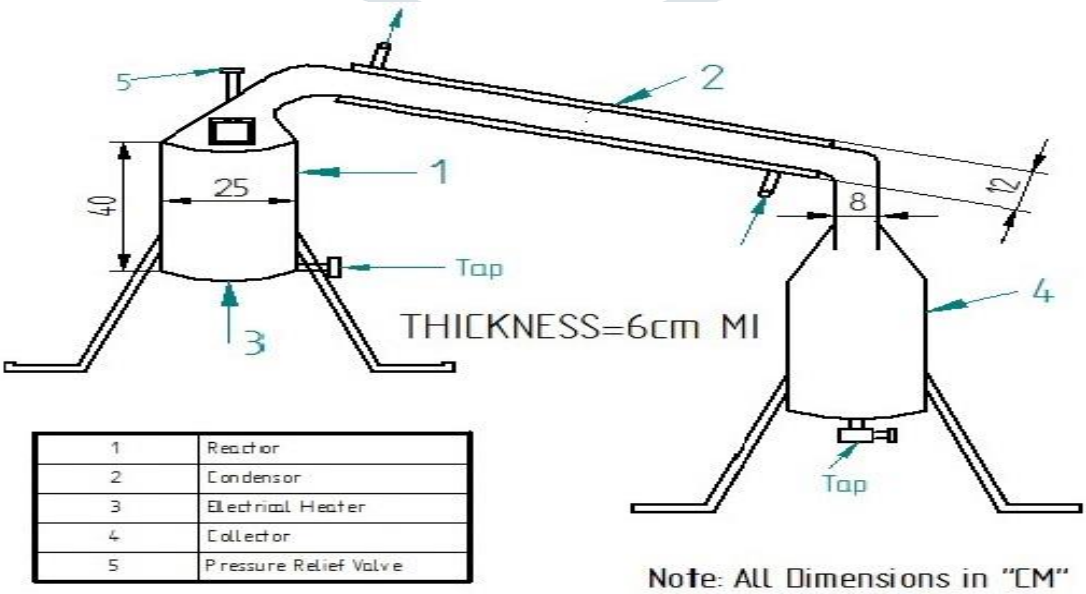

Fig 3.3 Pyrolysis Process Principle

The principle of Pyrolysis process is similar to Distillation process, the only difference is in Pyrolysis process the heating is done in vacuum but in case of distillation process there is no need of heating in vacuum it is optional. There are four main parts in the Pyrolysis process as shown in the above figure.

- Reactor
- Condenser
- Electrical Heater
- Collector
- Pressure Relief Valve

Reactor is the main component of Pyrolysis process, it is the component where the plastic wastes are feed and is heated in vacuum. But inside the reactor 100% of vacuum is not created as the plastic which is feed also have oxygen content.

Condenser is the second most important component in this process, after the reactor reaches around 400ºC to 450 ºC it starts realizing fumes which are then condensed and the semi-solid fuel is extracted.

Electrical Heater is the source of heat to the reactor, the electric heater should be capable of producing heat around 400ºC to 450 ºC. The electrical heater could be an electric coil or an electric stove whichever preferable.

Collector is a compartment where we can store the semi-solid fuel after condensing, It is not necessary that it has to be attached to condenser we could use any vessel to collect it.

Pressure Relief Valve is just a valve used to release the pressure from the reactor when the pressure inside the reactor is more than needed, it could also be used to check the pressure built inside the reactor to get a clear idea of the heating.[9]

3.4 Steps Involved In Pyrolysis Process.

1. **Feeding-** Feed the feedstock's to reactor through feeder and closes the feeder inlet.
2. **Heating:** To increase the temperature of reactor, heat the product of reactor inside by using heating source.
3. **Condensing:** The plastic get evaporated at high temperature, this vapor is condensed to atmospheric temperature by using straight and spiral tube condensers.
4. **Semi-solid Fuel Collection:** Out coming product from the condenser is collected in a container. At the end of condenser the semi-solid fuel is collected and is taken for Distillation process.
5. **Distillation Process:** In this process the semi-solid fuel is heated in presence of oxygen and at a constant temperature. The outcome of the process is a liquid fuel whose properties are similar to that of petrol.
6. **Filtration:** The extracted fuel is then filtered by filter paper and sent for testing.
7. **Testing of Fuel:** Various tests are conducted like Viscosity test, Fire and Flash Point test, IR test, Gas Chromatography, Engine testing, etc. These tests are done to check the efficiency and properties on the fuel.

3.5 Plastic Pyrolysis Oil

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived elements pyro "fire" and lysis "separating".

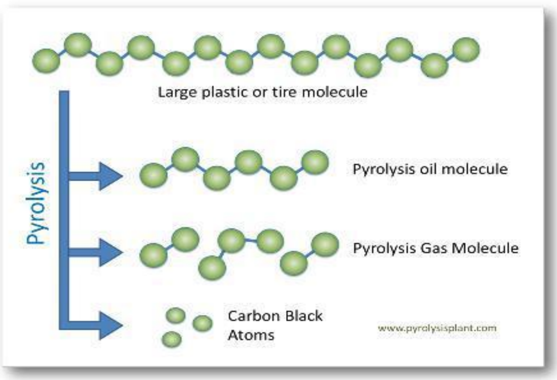

Fig 3.5 Pyrolysed oil formation

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it usually does not involve reactions with oxygen, water, or any other reagents. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. Bio-oil is produced via pyrolysis, a process in which biomass is rapidly heated to 450–500°C in an oxygen-free environment and then quenched, yielding a mix of liquid fuel (pyrolysis oil), gases, and solid char. Variations in the pyrolysis method, biomass characteristics, and reaction specifications will produce varying percentages of these three products. Several technologies and methodologies can be used for pyrolysis, including circulating fluid beds, entrained flow reactors, multiple hearth reactors, or vortex reactors. The process can be performed with or without a catalyst or reluctant.

The original biomass feedstock and processing conditions affect the chemical properties of the pyrolysis oil, but it typically contains a significant amount of water (15%– 30% by weight), has a higher density than conventional fuel oils, and exhibits a lower pH (2– 4). The heating value of pyrolysis oil is approximately half that of conventional fuel oils, due in part to its high water and oxygen content, which can make it unstable until it undergoes further processing. Bio-oil can be hydro-treated to remove the oxygen and produce a liquid feedstock resembling crude oil (in terms of its carbon/hydrogen ratio), which can be further hydro-treated and cracked to create renewable hydrocarbon fuels and chemicals.

Hydro-treating stabilizes the bio-oil preventing molecule-to-molecule and molecule-to-surface reactions and eventually produces a finished blend-stock for fuels. Bio-oil can be deoxygenated from its high initial oxygen content of 35-45 percent by weight (wt.%) on a dry basis all the way down to 0.2 wt.%.

Donglei Wu produced experimental setup for low temperature conversion of plastic waste into light hydrocarbons. For this purpose 1 litre volume, energy efficient batch reactor was manufactured locally and tested for pyrolysis of waste plastic. The feedstock for reactor was 50 g waste polyethylene. The average yield of the Pyrolytic oil, wax, pyro gas and char from pyrolysis of PW were 48.6, 40.7, 10.1 and 0.6%, respectively, at 275 ◦C with non-catalytic process.[8][10]

3.6 Distillation Setup

Fig 3.6 Distillation setup

Distillation is the second stage of our project, where we have to heat the semi-solid fuel at constant temperature with or without presence of oxygen. The above figure shows the distillation of the semi-solid fuel and extraction of pure form of fuel. The apparatus in the above figure is an open type of distillation setup, in other words it allows oxygen to react with the fuel. The basic principle of this distillation setup is similar to the pyrolysis setup, where the semi-solid fuel is heated at constant temperature. The fumes created would be condensed in the condenser and the pure form of the waste plastic fuel is extracted. This process takes comparatively more time than a closed distillation process (pyrolysis process), But is very easy to extract and comparatively reliable.

IV. RESULTS AND DISCUSSION

4.1 Rheological Test Report

After conducting various tests on "Waste Plastic Fuel", it was found that properties of Waste plastic fuel are very much similar to the properties of the petrol.

The following test results are comparison of pure Waste plastic fuel with the readily available petrol.

Table 4.1 Rheological test results

Properties	Waste Plastic Fuel	Petrol
Kinematic Viscosity @ 40°C (Poise)	1.3	1.1
Density (g/cc)	0.7285	0.7489
Specific Gravity	0.728	0.739
Calorific Value		
Flash Point (°C)	43	48
Fire Point (°C)	49	53

The above results show that the properties of Waste plastic is very much similar to available Petrol and can be used as an alternative for it. These are the results which we got without blending it with the petrol; it is the pure form of the Waste plastic fuel which we have extracted.

4.2 Fourier Transform Infrared Spectroscopy (FTIR)

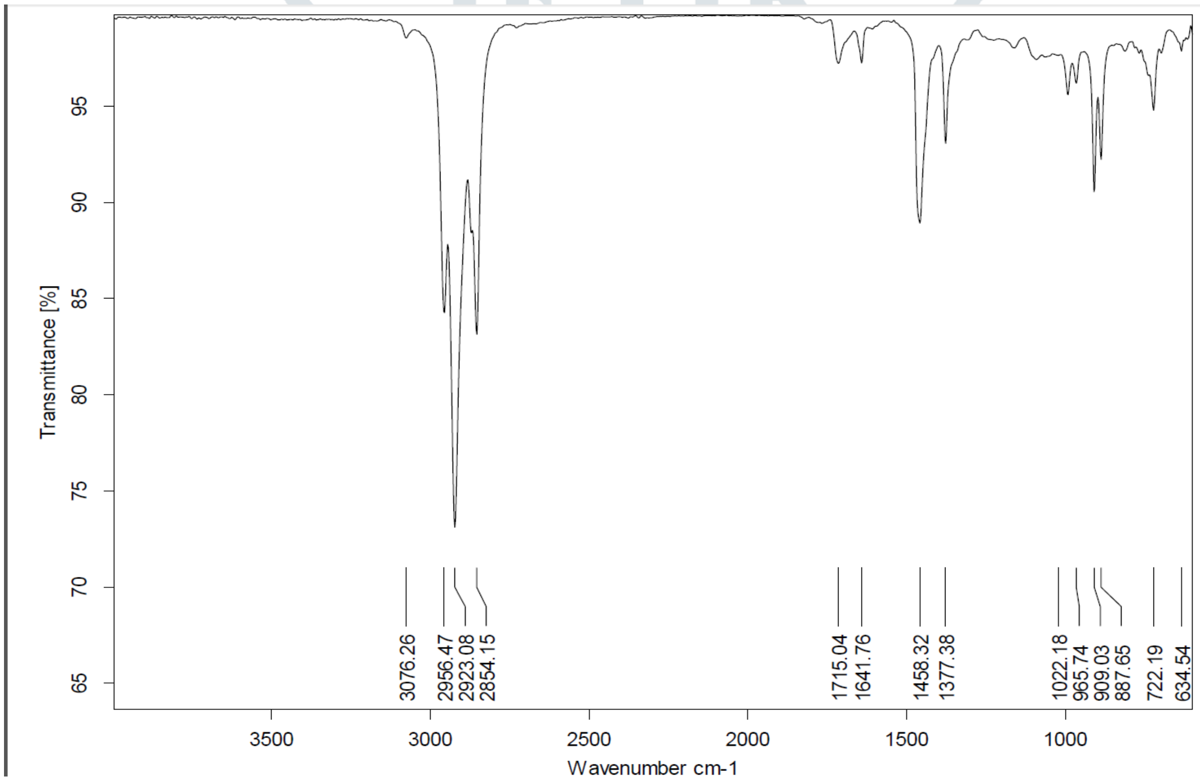

Fig 4.2 FTIR test result

4.3 Emission Testing

	Pressure Standard	Measured Level
CO	3.5	00.402
HC	4500	00262
CO_2	--	04.54
O_2	--	14.25

Table 4.3 Emission Test Results

V. CONCLUSION AND FUTURE SCOPE

Conclusion

According to the current statistics, there is continuous rise of consumption and thus cost of petroleum oil, International Energy Outlook 2008 reports the world consumption of petroleum oil as 84 million barrels per day. The conversion of waste plastics to liquid hydrocarbon fuel was carried out in thermal pyrolysis unit.

This method is superior in all respects (ecological and economical).By adopting this technology, efficiently convert weight of waste plastics into 75% of useful liquid hydrocarbon fuels without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil. Depletion of non-renewable source of energy such as fossil fuels at this stage demands the improvements of this technique. Based on the properties of the Plastic fuel and Diesel fuel the all properties are nearer hence concluded that Waste plastic fuel represents a good alternative fuel for diesel engine and therefore it can be used for diesel engine vehicles for the transportation purpose.

Future Scope

- The obtained fuel with some modification could be utilized in diesel generators, vehicles such as tractors and also passenger vehicles such as cars.
- The fuel can be refined at the industrial establishments, based on the results of which small scale industry can be established.
- As there is high demand of crude oil and due to the sky reaching prices, we could take up this project to setup large or small scale industries and produce the waste plastic fuel locally at much cheaper rates directly benefiting National economy and also a step towards SWAACH BHARAT by recycling the waste plastic.
- The application of this project could help in reducing dependency on the gulf countries and promote a step towards innovation.

REFERANCES

[1] Mochamad Syamsiro, Fuel Oil Production from Municipal Plastic Wastes in Sequential Pyrolysis and Catalytic Reforming Reactors, Conference and Exhibition Indonesia Renewable Energy & Energy Conservation [Indonesia EBTKE CONEX 2013].

[2] Muhammad Kunta Biddinika & Mochamad Syamsiro, Technology for public outreach of fuel oil production from municipal plastic wastes, 9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK.

[3] M. A. Hazrat & M. G. Rasul, Utilization of polymer wastes as transport fuel resources a recent development, The 6th International Conference on Applied Energy – ICAE2014.

[4] Edy Hartulistiyoso & Febri A.P.A.G. Sigiro, Temperature distribution of the plastics Pyrolysis process to produce fuel at 450oC, The 5th Sustainable Future for Human Security (SustaiN 2014).

[5] Songchai Wiriyaumpaiwong, Distillation of Pyrolytic Oil Obtained from Fast Pyrolysis of Plastic Wastes, 2017 International Conference on Alternative Energy in Developing Countries and Emerging Economics 2017 AEDCEE, 25-26 May 2017, Bangkok, Thailand.

[6] Antony Raja and Advaith Murali, Conversion of Plastic Wastes into Fuels, Journal of Materials Science and Engineering B 1 (2011) 86-89, Formerly part of Journal of Materials Science and Engineering, ISSN 1934-8959.

[7] Vijaykumar B. Chanashetty & B.M.Patil, Fuel from plastic waste, International Journal on Emerging Technologies (Special Issue on NCRIET-2015) **6**(2): 121-128(2015).

[8] Moinuddin Sarkar & Mohammad Mamunor Rashid, First Simple and Easy Process of Thermal Degrading Municipal Waste Plastics into Fuel Resource, IOSR Journal of Engineering (IOSRJEN).

[9] Aditya Machiraju & V. Harinath, Extraction of Liquid Hydrocarbon Fuel From Waste Plastic, National Conference On Trends In Science, Engineering & Technology by Matrusri Engineering College & IJCRT.

[10] Rajaram.T.Karad & Sagar Havalammanavar, Waste Plastic to fuel-Petrol, Diesel, Kerosene, International Journal of Engineering Development and Research ISSN: 2321-9939.

[11] Ioannis Kalargaris & Guohong Tian, The Utilisation of Oils Produced from Waste at Different Pyrolysis Temperatures in DI Diesel Engine, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, GU2 7XH, United Kngdom.