EXTRACTION OF FUEL FROM RECYCLING WASTE PLASTIC

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Abstract: *Plastics are used to describe a wide range of synthetic or semi-synthetic materials that are used in a huge and growing range of applications in the world. Due to their lightweight, durability, design flexibility, they are excessively used in industry as well as household and other fields. The demand for plastic is increasing day by day which damages the environment and causes global pollution. The study focuses on the production of convert plastic into oil and gaseous fuel as an effort in finding environment-friendly means of waste recycling employing pyrolysis. It is an alternative solution to decreasing the problem of waste disposal. The pyrolysis process becomes an option of waste-to-energy technology to deliver bio-fuel to replace fossil fuel. It keeps running without oxygen and in temperature of around 300°C by that gas is extracted from liquid plastic, these gases are allowed to copper pipe and condensed employing water then finally fuel is obtained.*

Keyword: *Plastic, Recycle, Durability, Pyrolysis, Productivity*

1. INTRODUCTION

Plastics have become an indispensable part of today’s world. Due to their lightweight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in industrial and domestic areas. Plastics are produced from petroleum derivates and are composed primarily of hydrocarbons but also contain additives such as antioxidants, colorants, and other stabilizers. Disposal of the waste plastics poses a great hazard to the environment and an effective method has not been implemented. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and few other elements like nitrogen. Due to its non-biodegradable nature, plastic waste contributes significantly to the problem of waste management. According to a nationwide survey which was conducted in the year 2000, approximately 6000 tonnes of plastic were generated in India, and only 60% of it was recycled, the balance of 40% could not be disposed of. Today about 129 million tonnes of plastics are produced annually all over the world, out of which 77 million tonnes produced from petroleum. In India alone, the demand for plastics is about 8 million tonnes per year. More than 10,000 metric tonnes per day plastics are produced in India and almost the same amount is imported by India from other countries. The per capita consumption of plastics in India is about 3kg when compared to 30kg to 40kg in the developed countries. Most of these come from the packaging and food industries. Most of the plastics are recycled and sometimes they are not done so due to a lack of sufficient market valve. Of the waste plastics not recycled about 43% is polyethylene, with most of them in containers and packaging.

2. MOTIVATION AND OBJECTIVES

2.1. Motivation

The present rate of economic growth is unsustainable without saving of fossil1energy like crude oil, natural1gas, or coal. International1Energy Outlook 2010 reports1the world consumption of liquid and1petroleum products grows from186.1 million barrels per day in 2007 to 92.1 million barrels per day in 20201and1110.6 million barrels per day in12035 and natural gas consumption increases from1108 trillion cubic feet in 20071to 156 trillion cubic feet in 2035. This way, the oil and gas reserve available can meet only 43 and 1671years further. Thus, mankind has1to rely1on the alternate/renewable1energy sources like biomass, hydropower, geothermal1energy, wind1energy, solar1energy, nuclear1energy, etc. Waste plastic to liquid1fuel is also an alternate energy1source path, which can1contribute to depletion of fossil1fuel as in this process1liquid. Fuel with similar properties1as that of petrol fuels1is obtained. Of course, it would be best if there were widespread environmentally friendly plastics in use, but in the meantime, recycling existing plastics into fuel would keep the plastics out of our waterways. This process is also excellent for difficult to recycle PP and PE plastics like bottle caps, appliance plastics, nursery planters, and dirty plastics such as meat wrappings. This process is not suitable for PVC or polystyrene. This technology could also reduce carting issues, as companies that deal with plastic waste could build mini-burners on location and it is most efficient and least polluting. Recycling of plastics should be carried in a manner to minimize pollution during the process and enhance efficiency and conserve energy. There is a different type of technology includes the following aspect:

- Mechanical Recycling- Recycling of plastics waste into a reusable product.
- Chemical Recycling – Gasification, blast furnace
- Incineration- Burning of waste plastics to obtain energy.
- Pyrolysis – conversion of waste plastics into liquid fuels.

2.2. Objectives

The objective of the process is to retain some energy which is used for plastic production to attain financial advantages. Unlike primary recycling, the secondary recycling process can use contaminated or less separated waste. However, this waste has to be cleaned. The recycling process involves different products and is different compared to the original production process. The objectives targeted in this project are listed below:

- To reverse the process and from flammable fuel from Plastic waste.
- To convert the plastic waste into liquid hydrocarbon fuel.
- To convert the household plastic waste into liquid fuel.
- To purify the produced liquid fuel by water washing method.

3. LITERATURE REVIEW

Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic & Rubber waste is continuously treated in a cylindrical chamber and the pyrolytic gases are condensed in a specially-designed condenser system. This yields a hydrocarbon distillate comprising straight and branched-chain aliphatic, cyclic aliphatic, and aromatic hydrocarbons [1]. Pyrolysis of waste plastic affords high rates of conversion into liquid fuels that are an effective way to convert waste plastics into environmental and industrially useful [2]. As polyolefins need stronger thermal or catalytic treatments to be converted back into an acid solid, it is an interesting alternative, which allows to increase the conversion [3]. The gasification agent allows the feedstock to be quickly converted i nto gas employing different. So, a suitable process that can convert waste plastic to hydrocarbon fuel is designed [4]. The increasing amount of plastic waste often creates chronic problems for the environment. Many efforts have been made to reduce, as well as to reuse, the plastic waste. This study investigated the use of pyrolysis of plastic waste to produce fuel oil. Plastic carrier bags, considered a low-density polyethylene (LDPE), were used as feed material. A commercial natural zeolite was used as a catalyst to enhance the oil conversion. research is focused on the conversion of waste plastic into low-emissive hydrocarbon fuel by two processes namely vacuum and catalytic cracking (activated carbon, activated carbon with granulated charcoal and activated carbon with calcium oxide). Waste plastic materials viz., polyethylene, polypropylene, polystyrene, and polyethylene terephthalate were collected from local convenience store packing [5]. The light fractions of pyrolysis oil (LFPO) derived from waste automobile tires in a pilot plant possess properties similar to diesel fuel and hence the LFPO can be used in combustion devices. In the present work, lower proportions (ie 5 to 20% at a regular interval of 5% on a volume basis) of LFPO collected from a commercial pyrolysis plant were blended with 95 to 80% diesel respectively, and used as alternative fuels in a diesel engine [6]. Conversion of waste to energy is one of the recent trends in minimizing not only the waste disposal but also could be used as an alternate fuel for internal combustion engines. Waste plastics are indispensable materials in the modern world and application in the industrial field is continually increasing [7]. Establishing a sustainable supply chain requires a solid and stable corporate foundation – a foundation that enables all processes to be designed or optimized, making sustainable action a reality. Stakeholders are increasingly demanding sustainable supply chains [8]. Also, a suitable waste management strategy is another important aspect. Development and modernization have brought about a huge increase in the production of all kinds of commodities, which indirectly generate waste [9]. Creating sustainable energy and environment, alternative energy is needed to be developed instead of using fossil fuels [10]. Environmental sustainability and energy efficiency factors are key factors for the better utilization of the resources [11]. The objective of the work is the conversion of waste plastics into fuel oil. Plastic wastes such as polypropylene, low-density polyethylene, high-density polyethylene, polystyrene are the most frequently used in everyday activities and disposed of to the environment after service [12]. The properties of rubber pyrolysis oil were determined to check the suitability of the oil as fuel in the diesel engine. It was concluded that rubber pyrolysis oil has properties similar to that of diesel fuel and could be used as a substitute for diesel [13]. The effectiveness of productive effort, especially in industry, as measured in terms of the rate of output per unit of input [14]. The process of waste plastics to liquid fuel: a suitable method for plastic waste management and manufacture of value-added products [15]. we suggested the machine and restarted the process of converting plastic to fuel.

4. METHODS AND METHODOLOGY

4.1. Pyrolysis

Pyrolysis is generally defined as the controlled heating of a material in the absence1of oxygen. In plastics Pyrolysis, the macromolecular structures of polymers are broken down into smaller molecules and sometimes monomer units. Further degradation of these subsequent molecules depends on several different conditions including (and not limited to) temperature, residence time, presence of catalysts, and other process conditions. The Pyrolysis reaction can be carried out with or without the presence of a catalyst. Accordingly, the reaction will be thermal and catalytic Pyrolysis. Plastic waste is continuously treated in a cylindrical chamber at 300-500 degrees.

4.2. Methodology

The thermal cracking process without a catalyst was used in converting waste plastic into liquid fuel. Only one type of waste plastic is selected for this particular experiment i.e., Low-density polyethylene. Waste plastic is a solid soft form. Collected waste plastic1was cleaned using liquid soap and water. Washed waste plastics are cut into 3-5 cm size to fit into the reactor conservatively. For the experimental purpose, we used 6.5 Kg of LDPE. The experiment is carried out under a closed air system with no1vacuum process applied during this thermal cracking1process. We used low-density polyethylene plastics in a batch process system because conversion temperatures for these plastics are relatively low. Heat is applied from 100°Cat start to begin melting the waste plastics, the melted waste plastic turn into liquid slurry form when the temperature is increased1gradually. When temperature is1increased to 270° C liquid slurry turns into vapor and the vapor then passes through a condenser unit. In the end, we collect liquid fuel. Between 100º C and 250º C around 20 -30% of the fuel is collected and then when raised to 325º C the next 40% is collected and finally when held at 400º C the yield is fully completed. During the thermal cracking process plastic portions are not and finally when held at 400º C the yield is fully completed. During the thermal cracking process plastic portions are not broken down immediately because plastics have short-chain hydrocarbon to long-chain hydrocarbon. 1st stage of heat applied breaks down only the short-chain hydrocarbon. When temperature profile is increased the plastic carbon-carbon bond breakdown slowly. As the temperature is increased the long chains are breakdown step by step. During this thermal cracking process, some light gas such as methane, ethane, propane1and butane is produced. These compounds are not able to condense because they have a negative boiling point. These light gases could be an alkane or alkene group and it can also contain CO1or CO_2 emissions. The light gas production percentage is about 6%. This gas portion analysis is under consideration. The method which is considered for treating light gas is an alkali wash system. After the experiment is concluded some solid black residue is collected from the reactor. This solid black residue percentage is about 4%. The liquid fuel yield percentage is 90%. To purify the liquid fuel a purification system to remove water portion and ash or fuel sediment are used and it is also filtered with filter paper to remove some solid waste mixed in fuel while collecting in bottle. Liquid fuel density is 775kg/m3. Finally, we obtained 4 liters of plastic fuel. The flow chart of the process is shown in Figure 1. The process design is shown in Figure 2.

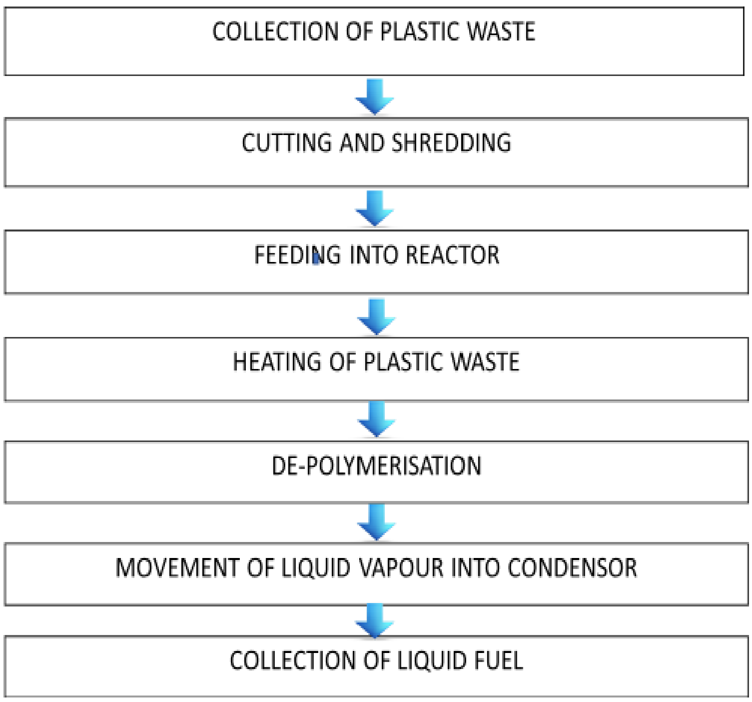

Fig. 1. The Process Flow chart

5. RESULTS AND DISCUSSION

This project attempts to show how humanity 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 the pyrolysis process shows nearly the same properties as that of diesel fuel. So we can use plastic oil as an alternative fuel.

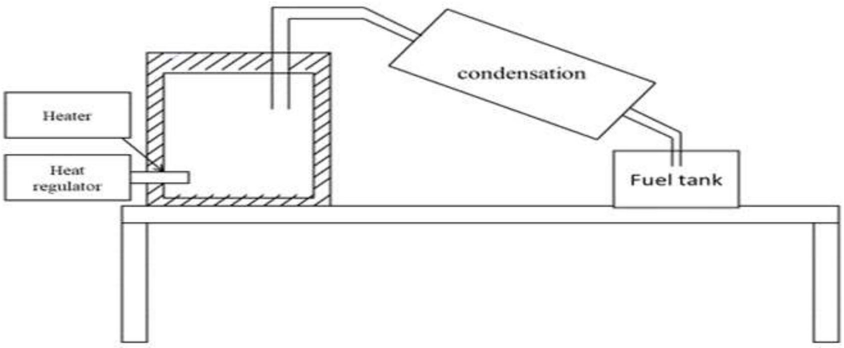

Fig. 2. The Process Design

5.1. Effect of Temperature on Product Yield

The products are separated into gas, oil, and char residue by pyrolysis of waste plastic. About 38.5% of WPPO was obtained at temperature 330°C as presented in the figure. The oil percentage increased constantly to 76.0% at 425°C. The gases produced through plastic pyrolysis consist principally of hydrogen (H_2), carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), ethane (C_2H_4), and butadiene (C_4H_6), with trace amounts of propane ($CH_3CH_2CH_3$), propene ($CH_3CH=CH_2$), n-butane ($CH_3(CH_2)_2CH_3$), and other miscellaneous hydrocarbons. The effect of temperature on the product yield is shown in Figure 3.

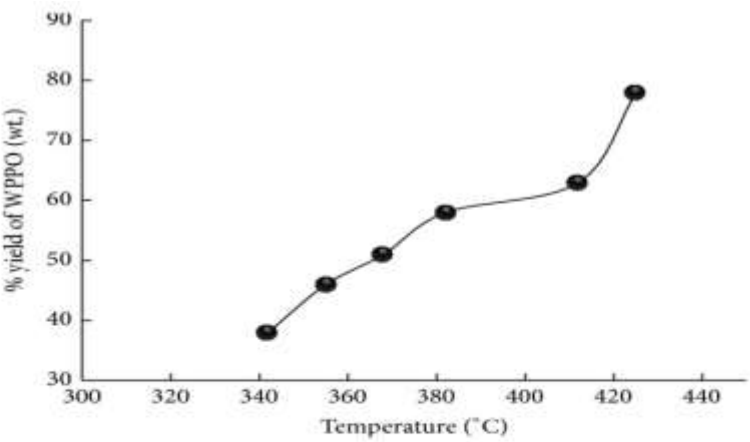

Fig. 3. Effect of temperature on product yield

5.2. Effect of Distillation Temperature on Crude WPPO

Distillation is carried out to separate the lighter and heavier fraction of hydrocarbon present in waste plastic pyrolysis oil. The distillation is operated between 116°C and 264°C; 73.5% of WPPO is distilled out. At the temperature of 116°C only about 10.0% of distilled WPPO was achieved as shown in the figure. However, the percentage of WPPO increased constantly to 73.5% at a temperature of 264°C from 10% at a temperature of 116°C. The effect of temperature on distillate product yield is shown in Figure 4.

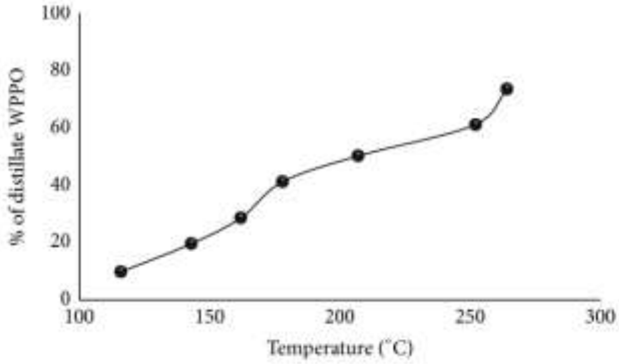

Fig. 4. Effect of temperature on distillate product yield

5.3. Analysis of Waste Plastic Pyrolysis Oil

The waste plastic has high volatile content 77.03% by weight which is suitable for pyrolysis conversion of organic solid wastes to liquid product. The characteristics of waste plastic pyrolysis oil obtained at 425°C.

5.4. Characteristics of waste plastic pyrolysis oil

The properties of the developed fuel are listed in Table 1.

Table 1. The properties of the generated fuel

Properties	WPPO
Viscosity at 40°C (cSt)	1.980
Density at 40°C (g/cc)	0.7477
Carbon residue (wt%)	0.5
Ash content (%)	0.036
Sulfur content (% of wt.)	0.246
Flashpoint (°C)	15
Pour point (°C)	<−15
Fire point (°C)	20
Calorific value (kcal/kg)	9829.35

5.4.1. Viscosity

Viscosity varies with feedstock, pyrolysis conditions, temperature, and other variables. The higher the viscosity, the higher the fuel consumption, engine temperature, and load on the engine. On the other hand, if the viscosity of the oil is too high, excessive friction may take place. The viscosity was measured by the IP-50 methodology at a temperature of 40°C. From fig, it is observed that the viscosity of waste plastic pyrolysis oil obtained at 425°C pyrolysis temperature was 1.98 CST which was comparably higher than kerosene and lower than diesel. Graphical comparison of viscosity different oil. Diesel oil is 100% distillate oil, whereas light diesel oil is a mixture of distillate oil and residual oil. The graphical composition of the viscosity of different oils is shown in Figure 5.

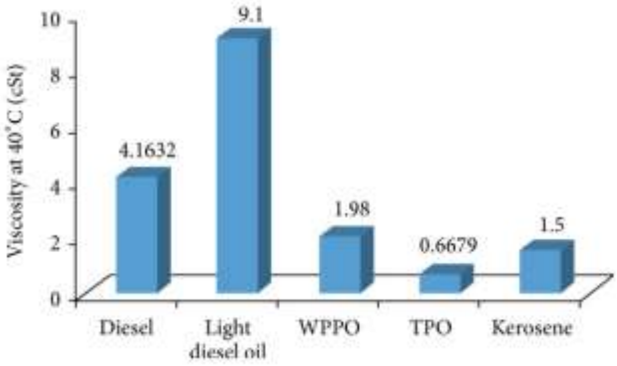

Fig. 5. Graphical comparison of viscosity different oil

5.4.2. Density

Density is an important property of fuel oil. If the density of the fuel is high; the fuel consumption will be less. On the other hand, the oil with low density will consume more fuel which may cause damage to the engine. Therefore, too low or too high a density of fuel oil is not desirable. It is clear from a fig that the densities of WPPO and WPPO50 were found to be 0.7477 g/cc and 0.7943 g/cc, respectively, which is close to the density of kerosene, diesel, and gas oil. The density of the various oils is shown in Figure 6.

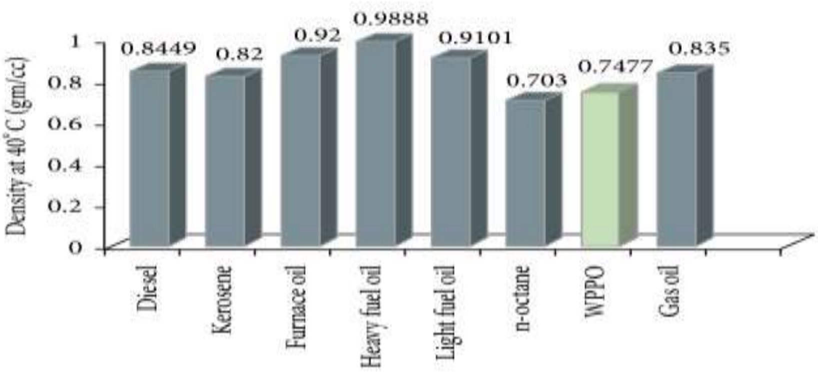

Fig. 6. Graphical representation of the density of different types of fuel

5.4.3. Flash Point

Flashpoint is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Flashpoint is used to characterize the fire hazards of fuels. The flashpoint of WPPO was measured according to ASTM D 93-62 method. The flashpoint of WPPO was about 15°C. A low flash point indicates the presence of highly volatile materials in the fuel that is a serious safety concern in handling and transporting. The flashpoint of furnace oil, diesel, and kerosene is higher than WPPO which indicates that these are easy to handle. By removing lighter components (such as naphtha/gasoline) the flashpoint of WPPO will be increased. The graphical presentation of various flashpoints of oils is shown in Figure 7.

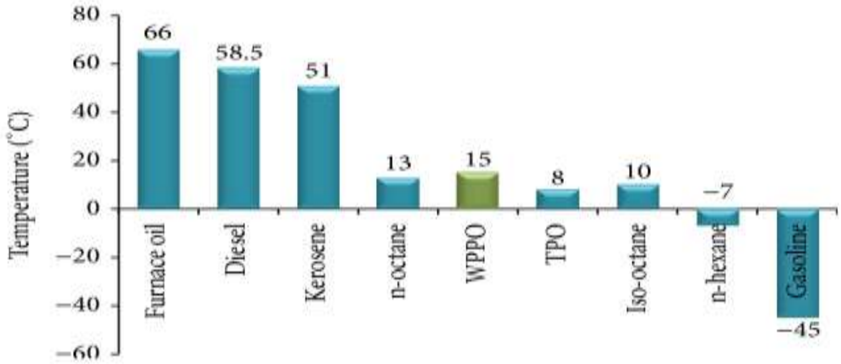

Fig. 7. Graphical presentation of flashpoints of different oil.

5.4.4. Fire Point and Pour Point

The fire point of a fuel is the temperature at which it will continue to burn for at least 5 seconds after ignition by an open flame. The fire point is used to assess the risk of the materials' ability to support combustion. Generally, the fire point of any liquid oil is considered to be about (5–10) °C higher than the flashpoint. The fire point of waste plastic pyrolysis oil was 20°C.

The pour point is the temperature at which the oil will just cease to flow when cooled at a standard rate in a standard apparatus. Pour point determines the suitability of oil for low-temperature installations. The pour point of WPPO was measured by using ASTM D 97-57 methodology. The pour point was <−15°C. The low pour point value of WPPO indicates that it is not suitable in cold weather country.

5.4.5. Calorific Value

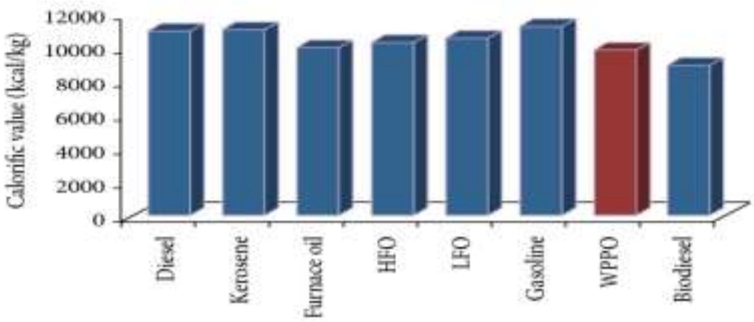

Fig. 8. Comparison chart of calorific value of oil

The calorific value is defined as the energy given out when the unit mass of fuel is burned completely insufficient air. The calorific value of WPPO was estimated according to IP 12/58 method. The calorific value of WPPO was 9829.3515 kcal/kg. Fig represents the comparison of the calorific value of WPPO with other kinds of oil. The calorific values of various oils are shown in Figure 8.

5.4.6. Sulphur and Ash Content

The presence of Sulphur in vehicle fuels causes SO_x emissions that are an environmental issue. High Sulphur content decreases the catalytic conversion capacity of a system, thus increasing the emissions of nitrous oxides (NO_x), carbon monoxide (CO), hydrocarbons, and volatile organic compounds (VOCs). The Sulphur content of WPPO was measured by using ASTM D 129-00 methodology. The Sulphur content of waste plastic pyrolysis oil was 0.246%. The sulfur content of WPPO is slightly higher than gasoline (0.014%), diesel (0.15%), and other types of fuel oil because waste plastic contains some contamination figure. The ash content of the oil is the non-combustible residue. The ash content of distilled tire pyrolysis oil (DTPO) and DTPO50 (50% DTPO : 50% diesel) was measured by using the IP 04/58 test methodology. From the figure, it is clear that the ash content of WPPO was 0.0036% comparatively higher than diesel, light fuel oil, and kerosene. So it can be used as an alternative to furnace oil and heavy fuel oil (HFO). The sulfur contents of different fuel oils are shown in Figure 9.

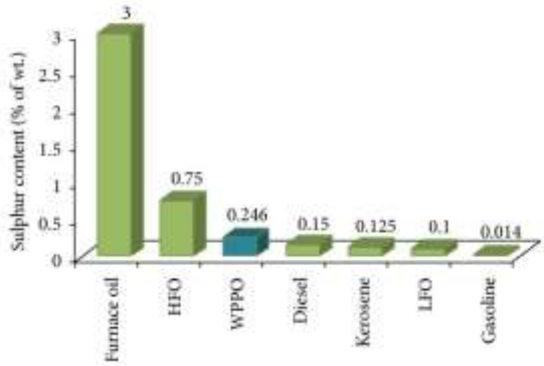

Fig. 9. The sulphur content of different types of fuel oil.

6. CONCLUSION

The thermal pyrolysis of mixed plastic leads to the production of fuel oil which is a valuable resource recovery. It also reduces the problem of disposal of waste plastic. In this work, the thermal pyrolysis of waste plastic is carried out because the use of catalysts is costly and regeneration of catalyst is a difficult task. Mixed plastic pyrolysis yields a mixture of oil and gas and produces a very small amount of char. Higher pyrolysis temperature and longer reaction times increase the gas yield and decrease char production. Highly volatile products are obtained at low temperatures. Liquid yield increases as the holding time increase from 1 hr to 2 hr, but as the holding time increases from 2 hr to 3 hr, the liquid yield decreases. The maximum oil yield was 77.03% at 2 hr. The liquid obtained in this process is relatively greater volume and low boiling range. Distillation of fuel-like liquids shows more light fractions at a higher temperature and longer time. Physicochemical properties of obtained fuel oil can be exploited to make highly efficient fuel or furnace oil after blending with other petroleum products. However, further studies are necessary to utilize this oil as fuel or feedstock.

7. REFERENCES

[1]. Panda, A. K., Singh, R. K., & Mishra, D. K. (2010). Thermolysis of waste plastics to liquid fuel: A suitable method for plastic waste management and manufacture of value-added products—A world perspective. *Renewable and Sustainable Energy Reviews*, *14*(1), 233-248.

[2]. Kadam, P. G. (2011). Plastic: Waste to Fuel. *The Bombay Technologist*, *61*, 151-172.

[3]. Aguado, J., Sotelo, J. L., Serrano, D. P., Calles, J. A., & Escola, J. M. (1997). Catalytic conversion of polyolefins into liquid fuels over MCM-41: comparison with ZSM-5 and amorphous SiO2−Al2O3. *Energy & Fuels*, *11*(6), 1225-1231.

[4]. Kumar, P. S., Bharathikumar, M., Prabhakaran, C., Vijayan, S., & Ramakrishnan, K. (2017). Conversion of waste plastics into low-emissive hydrocarbon fuels through catalytic depolymerization in a new laboratory-scale batch reactor. *International Journal of Energy and Environmental Engineering*, *8*(2), 167-173.

[5]. Kumar, P. S., Bharathikumar, M., Prabhakaran, C., Vijayan, S., & Ramakrishnan, K. (2017). Conversion of waste plastics into low-emissive hydrocarbon fuels through catalytic depolymerization in a new laboratory-scale batch reactor. *International Journal of Energy and Environmental Engineering*, *8*(2), 167-173.

[6]. Tudu, K., Murugan, S., & Patel, S. K. (2014). Light Oil Fractions from a Pyrolysis Plant–An Option for Energy Use. *Energy Procedia*, *54*, 615-626.

[7]. Anup, T. J., & Watwe, V. (2014). Waste plastic pyrolysis oil as an alternative for SI and CI engines. *International Journal of Innovative Research in Science, Engineering and Technology*, *3*(7), 14680-14687.

[8]. Viswanth, V. S., Ramanujam, R., & Rajyalakshmi, G. (2019). Application of MQL for Developing Sustainable EDM and Process Parameter Optimization using ANN and GRA. *International Journal of Business Excellence*, *19*(1):1, 125-133.

[9]. Patni, N., Shah, P., Agarwal, S., & Singhal, P. (2013). Alternate strategies for the conversion of waste plastic to fuels. *ISRN Renewable Energy*, *2013*.

[10]. Wongkhorsub, C., & Chindaprasert, N. (2013). A comparison of the use of pyrolysis oils in the diesel engine. *Energy and Power Engineering*, *5*(04), 350.

[11]. Viswanth, V. S., Ramanujam, R., & Rajyalakshmi, G. (2018). A review of research scope on sustainable and eco-friendly electrical discharge machining (E-EDM). *Materials Today: Proceedings*, *5*(5), 12525-12533.

[12]. Abatneh, Y., & Sahu, O. (2013). *Preliminary study on the conversion of different waste plastics into fuel oil*. GRIN Verlag.

[13]. Murugan, S., Ramaswamy, M. C., & Nagarajan, G. (2009). Assessment of pyrolysis oil as an energy source for diesel engines. *Fuel processing technology*, *90*(1), 67-74.

[14]. Viswanth, V. S., Ramanujam, R., & Rajyalakshmi, G. (2020). Performance study of eco-friendly dielectric in EDM of AISI 2507 super duplex steel using Taguchi-fuzzy TOPSIS approach. *International Journal of Productivity and Quality Management, 29*(4), 518-541.

[15]. Mishra, D. K., Panda, A. K., & Singh, R. K. (2010). Thermolysis of waste plastics to liquid fuel. A suitable method for plastic waste management and manufacture of value-added products-A world prospective. *Renew. Sustain. Energy Rev*, *14*(1), 233-248.