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Utilization of Plastic Waste as a Fuel

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Abstract – *The demand for plastic is ever-increasing, resulting in a massive amount of waste. Plastics have now become indispensable materials in the modern world, and their use in industry is growing at an exponential rate. The qualities of the oil created from waste plastics were investigated, and it was discovered that it is identical to diesel. The performance characteristics of waste plastic oil as a fuel in a D.I. diesel engine were analysed and compared to diesel fuel operation. It has been discovered that the engine can run on 100 percent waste plastic oil and can be utilised as diesel fuel. Without any modifications to the engine, the oil generated by pyrolysis of waste plastics can be used as an alternative fuel for diesel engines. The ASTM standard test procedures were used to evaluate the gasoline quality. At pyrolysis temperatures, pyrolysis oils were generated from polymers in this study. The oils were then put through their paces in an IC engine, with performance, combustion, and emission characteristics compared to mineral diesel. When compared to straight plastic oil, emissions were significantly reduced when employing blends. This project has prepared a study on various operating parameters in order to gain a better understanding of the operating conditions and constraints for waste plastic pyrolysis oil of the fuel and its blends used in compression and spark ignition engines. Some observations on the comparison of fuel with all attributes have been made, and conclusions have been drawn.*

Key Words: Plastic waste, Plastic oil, Alternate fuel, Pyrolysis, Engines, Etc.

1.INTRODUCTION

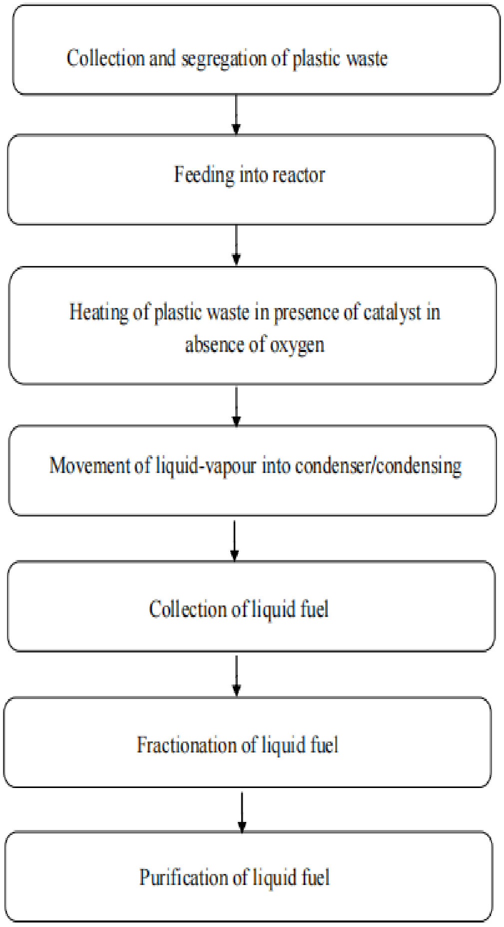
Plastics are organic molecules with long hydrocarbon chains that are made from petroleum sources. Because of their incomparable usability, wide variety of uses, non-degradable nature, and low cost, these polymers have become crucial materials, and their industrial applications are steadily rising. At the same time, waste plastics have posed a severe environmental threat due to their large quantities and difficult disposal. Plastic waste is a particularly critical problem in developing cities, where there is a lack of integrated solid waste management, as well as a unique set of socio-economic, pervasive poverty, and environmental injustices. Instead of biodegrading, plastic trash undergoes photo-degradation, resulting in plastic dusts that can enter the food chain and cause serious health problems for Earth's inhabitants. The primary concerns of gasoline in automobiles are also a key issue with this topic. The fundamental difficulty with automotive gasoline is that it is not available anywhere and that the amount of fuel on the planet is limited. Because of this, environmental concerns about automobile fuel have led to the development of alternative fuel. Although diesel and gasoline engines are the most efficient prime movers, it is vital to create alternative fuels with attributes comparable to petroleum-based fuels in order to maintain the global environment and provide long-term energy security. Despite efforts to develop futuristic biodegradable plastics, there have been few conclusive steps toward resolving the current challenge. The method of transforming waste plastic into value-added fuels is described here as a potential option for plastic recycling. As a result, two universal problems, such as waste plastic and fuel shortages, are being addressed at the same time. Working on alternate fuels for automobiles is quite beneficial. The best approach to solve all fuel concerns is to use fuel made from plastic trash. Plastic wastes were pyrolyzed to produce fuel oil with the same physical qualities as gasoline, diesel, and other gasoline-like fuels. One of the most important pre-conditions for efficient and successful conversion of waste plastics into a resource is adequate technology selection. The purpose of this compendium is to aid in the choosing of such technologies. The compendium's geographical reach is global. As a result, the technologies included range from extremely advanced equipment from developed countries to simple technology from underdeveloped countries. The information that can be created within the time and financial constraints is limited by the technologies described in the Compendium. As a result, the greatest technology for alternative fuel is pyrolysis of plastic trash. Depolymerization, pyrolysis, thermal cracking, and distillation are used to extract different value-added fuels such as gasoline, kerosene, and diesel from waste plastics. As an alternative fuel, waste plastic pyrolysis oil, waste plastic pyrolysis oil of petrol and diesel grades, and their blends with diesel and petrol have been presented in this research. At pyrolysis temperatures, pyrolysis oils were generated from polymers in this study. To determine its acceptability for diesel engines, the parameters of the liquid fuel generated by pyrolysis were compared to those of commercial transportation fuel. The oils were then put through their paces in an IC engine, with performance, combustion, and emission characteristics compared to vehicle fuel and conventional gasoline.

2. LITERATURE REVIEW

Raj Kumar Yadav et al. found that heating the close chamber with a thousand-watt heater in the temperature range of 200 to 350 degrees Celsius yielded around 560 ml fuel oil. A layer of oil emerges on the water level after roughly 45 minutes of combustion heating. We obtain 500 ml of fuel oil after two hours. The 100 cc Bajaj Discover bike operates for one minute on 10 ml of this oil, at an average speed of 45 km/hr. It is concluded that waste plastic oil is a good alternative fuel. According to Vijaykumar B Chanashetty and colleagues, the qualities of the fuel generated from plastics are similar to those of gasoline, and that more research in this field could provide superior results.

Anup T J et al. investigated and discovered all of the emission and performance characteristics of plastic and gasoline grade fuel. The qualities of petrol and diesel grade plastic fuel were compared to those of diesel and petrol, leading to the conclusion that plastic fuel is a viable alternative to fossil fuel. According to Vikas Mukhraiya et al., the process of converting waste plastic to reusable oil is a current research issue based on studies on the synthesis of energy fuel from waste plastic and appraisal of its potential as an alternative fuel for diesel engines. The manufacture of diesel blends with varied quantities of waste plastic oil produced by thermal pyrolysis, as well as the examination of viscosity and density of these blends, are discussed in this paper. The practicality of waste plastic oils generated from PVC plastics as an alternative transportation fuel is also tested by doing a performance test on a single cylinder Kirlosker diesel engine with electrical loading set to 50% of the engine maximum load, or 3.7 kW. The oil produced by the pyrolysis process was analysed using the mass spectrometry approach by Vishvanathkaimal et al. More than 70% of the fuel is made up of smaller carbon chains comparable to those found in diesel fuel, with the remaining 30% ranging from C20 to C30.

3. METHODOLOGY



3.1 Types of Plastics

LDPE, HDPE, PP, PS, and PVC are the different types of waste plastics. Land-filling or incineration will not solve the waste plastics problem because safety deposits are expensive and incineration encourages the release of damaging greenhouse gases such as COx, NOx, SOx, and others. These methods of waste plastic disposal generate poisonous gas, which has a harmful influence on the environment. Plastic wastes are divided into two groups based on their origins: industrial and municipal plastic wastes. These groups have varied qualities and attributes and are subjected to different treatment procedures. Plastic garbage makes up a significant portion of municipal waste, and vast volumes of plastic waste are generated as a by-product or faulty product in industry and agriculture. Thermoplastics account for about 78 percent of all plastic waste, with thermosets accounting for the remainder. Polyolefins such as polyethylene, polypropylene, polystyrene, and polyvinyl chloride make up thermoplastics, which can be recycled. Thermosets, on the other hand, are made up primarily of epoxy resins and polyurethanes, and therefore cannot be recycled.

As they are dumped and collected as household plastic wastes, municipal plastic wastes (MPW) usually remain a part of municipal solid wastes. Domestic products such as food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, and CD and cassette cases are among the different sources of MPW plastics. Refrigerator liners, vending cups, electronic equipment cases, drainage pipes, fizzy beverage bottles, plumbing pipes and gutters, and flooring. Food containers, milk covers, water bottles, packing foam, and waste cooking oil covers are all converted using the pyrolysis methodology. Before pyrolysis, waste plastics were shredded and washed. Plastic garbage from the city has been utilised as a source of raw materials. Before pyrolysis, waste plastics were washed. Milk plastic covers and edible oil covers were chosen as feed-stocks for converting waste plastic into useful liquid fuel molecules in this work.

4. PYROLYSIS PROCESS

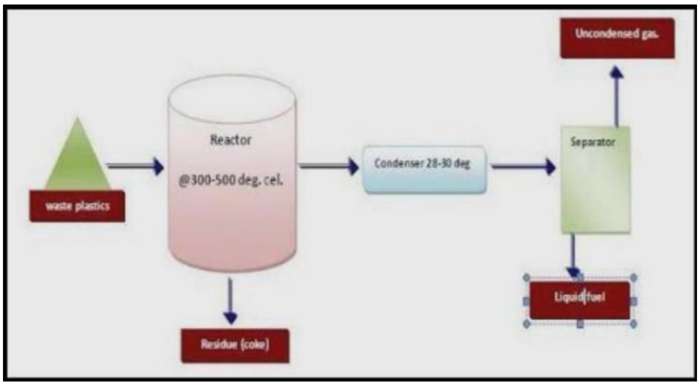


Fig. 1: Pyrolysis Process

4.1 Steps in Pyrolysis Process

1. Feed-stocks are fed to the reactor through a feeder, which is then closed.
2. Heating- To raise the temperature of the reactor, use a heating source to heat the reactor's product within.
3. Condensing- After the plastic has vaporised at a high temperature, the vapour is condensed at room temperature using straight and spiral tube condensers.
4. Liquid collection: The liquid collector collects the condenser's output product. Provide a cyclone separator at the condenser's end to separate the plastic liquid fuel from non-condensable gases. The pyrolysis unit is heated using these non-condensable gases.
5. Water wash, purification, and pH test- This process entails a number of purification steps. In this procedure, we mix equal parts plastic fuel and water in a container and shake it thoroughly before allowing it to settle for 5-7 hours. Water, along with a few crystals, is now gathered at the bottom of the container, while pure plastic fuel is collected at the top.
6. Purification- Use filter sheets and filters to purify the plastic fuel.
7. pH Test- After purification, use a pH metre to determine the pH value of the plastic fuel. The fuel is acidic in nature if the pH is less than 7. To bring the pH value of the oil to 7, it must be washed several times with water.

5. PLASTIC PYROLYSIS OIL

Pyrolysis is the thermochemical breakdown of organic matter in the absence of oxygen at high temperatures (or any halogen). It is irreversible and entails a simultaneous shift in chemical composition and physical phase. The word pyrolysis is derived from the Greek words pyro "fire" and lysis "separating."

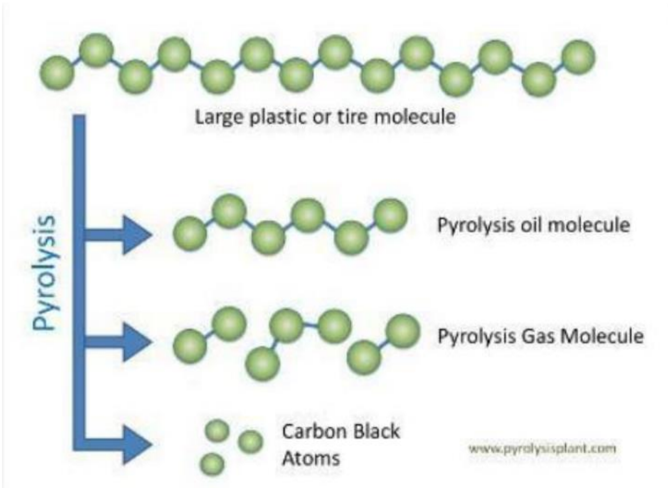


Fig. 2: Breaking of Hydrocarbon Chain

Pyrolysis is distinguished from other high-temperature processes like as combustion and hydrolysis by the absence of reactions involving oxygen, water, or other reagents. It is impossible to achieve a completely oxygen-free environment in practise. A limited degree of oxidation happens in each pyrolysis system since oxygen is present. Pyrolysis produces bio-oil by rapidly heating biomass to 450–500°C in an oxygen-free atmosphere and then quenching it, releasing a mixture of liquid fuel (pyrolysis oil), gases, and solid char. The percentages of these three products will vary depending on the pyrolysis process, biomass qualities, and reaction conditions. Pyrolysis can be accomplished using a variety of technologies and approaches, such as circulating fluid beds, entrained flow reactors, multiple hearth reactors, or vortex reactors. The reaction can be carried out with or without the use of a catalyst or reductant.

The chemical parameters of pyrolysis oil are affected by the initial biomass feedstock and processing conditions, although it often contains a large quantity of water (15–30% by weight), has a higher density than traditional fuel oils, and has a lower pH (2–4). Pyrolysis oil has about half the heating value of traditional fuel oils, owing to its high water and oxygen content, which might make it unstable until it is further processed. Bio-oil can be hydro-treated to remove the oxygen and produce a liquid feedstock with a carbon/hydrogen ratio similar to crude oil, which can then be hydro-treated and cracked to produce renewable hydrocarbon fuels and chemicals.

Hydro-treating the bio-oil stabilises it, preventing molecule-to-molecule and molecule-to-surface interactions, and eventually yields a completed fuel blend-stock. On a dry basis, bio-oil can be deoxygenated from its high initial oxygen content of 35-45 percent by weight (wt%) all the way down to 0.2 wt%.

DongleiWu created an experimental set-up for converting plastic trash into light hydrocarbons at low temperatures. A 1 litre capacity, energy efficient batch reactor was built locally for this purpose and tested for pyrolysis of waste plastic. The reactor's feedstock was 50 grammes of discarded polyethylene. With a noncatalytic method, the average yields of pyrolytic oil, wax, pyrogas, and char from pyrolysis of PW were 48.6, 40.7, 10.1, and 0.6 percent, respectively, at 275°C.

5.1 Purification set-up

In this procedure, we mix equal parts plastic fuel and water in a container and shake it thoroughly before allowing it to settle for 5-7 hours. Water, along with a few crystals, is now gathered at the bottom of the container, while pure plastic fuel is collected at the top. In the meantime, use a pH metre to evaluate the pH of the plastic oil. If it is acidic in nature, it will need to be washed numerous times with water to bring the pH to 7.

Fig. 3: Purification of Plastic Oil

5.2 Properties with Compare to Conventional Fuels

Table - 1: Comparision of Diesel Grade Plastic Fuel

Sr. No.	Properties	Diesel Grade plastic fuel	Diesel fuel
1	Density(kg/m^3)	800-850	820-900
2	Calorific Value(kJ/kg)	43000	42500
3	Viscosity	1.1	1-3.9
4	Flash Point (0 c)	50	41
5	Fire Point (0 c)	56	49

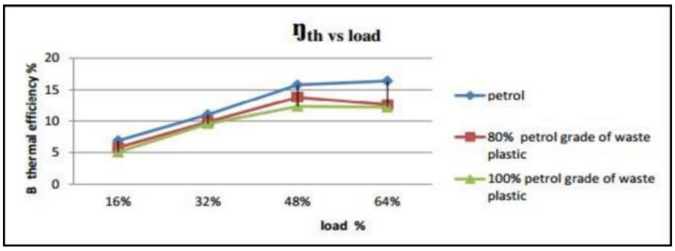
Table - 2: Comparision of Petrol Grade Plastic Fuel

Sr. No.	Properties	Petrol Grade plastic fuel	Petrol Fuel
1	Density(kg/m^3)	750-800	711-737
2	Calorific Value(kJ/kg)	47000	45500
3	Viscosity	0.8	1.5-4
4	Flash Point (0 c)	29	22
5	Fire Point (0 c)	33	25

5.3 Performance Characteristics

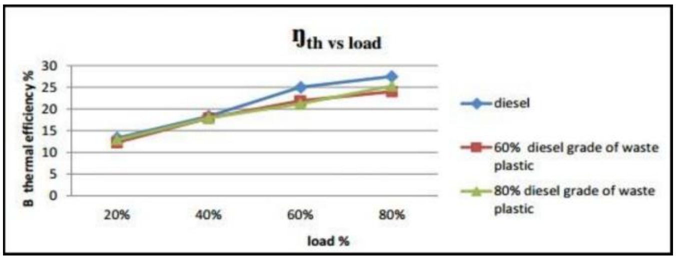
5.3.1 Brake Thermal Efficiency

A single cylinder, four-stroke, air-cooled DI diesel engine and an air-cooled spark ignition engine with waste plastic oil were used in the experiment. Diesel and gasoline fuels are more efficient at full load. This is because, when compared to diesel and petrol, the exhaust gas temperature and heat release rate for waste plastic oil are slightly higher at full load.



Graph - 1: BP Thermal efficiency vs Load (Petrol)

In an experimental investigation using waste plastic oil and petrol fuel blends in a spark ignition engine, the thermal efficiency of petrol was found to be 16.4 percent at full load (Graph 1). At full load, an engine running on WPO100 and WPO80 petrol grade has a brake thermal efficiency of 12.6 percent and 12.2 percent, respectively.



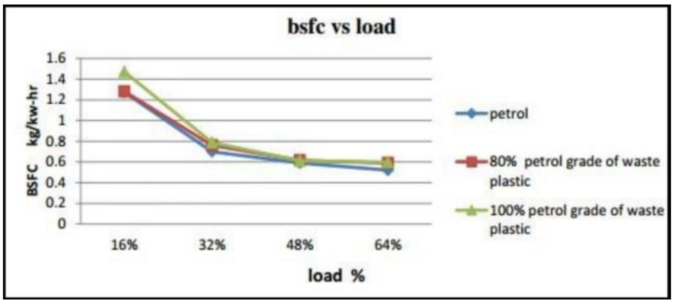
Graph - 2: BP Thermal efficiency vs Load (Diesel)

An experimental investigation on waste plastic oil and diesel fuel blends in compression ignition engines revealed a thermal efficiency of 27.5 percent at full load, as shown in Graph 2. At full load, the engine fuelled with WPO60 and WPO80 of diesel grade has a brake thermal efficiency of 24 and 25.3 percent, respectively. Each WPO-

DF blend has a lower overall heat release than diesel. As a result, the WPO-DF and WPO-PF blends have worse brake thermal efficiency than diesel and petrol, respectively. The braking thermal efficiencies of WPO-DF and WPO-PF blends are poor, especially at full load, due to variations in composition, viscosity, density, and calorific value of WPO-DF blends.

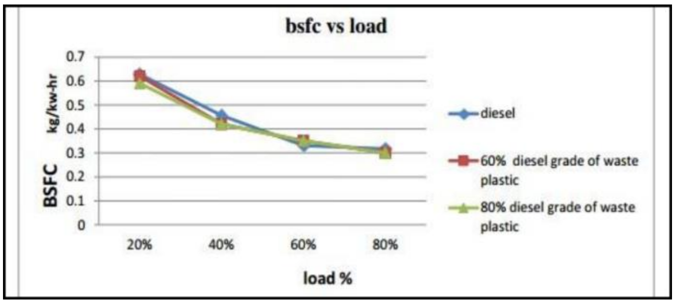
5.3.2 Brake Specific Fuel Consumption

The efficiency with which an engine uses the fuel supplied to accomplish work is measured by brake specific fuel consumption. Thermal efficiency is inversely proportional to it.



Graph - 3: BSFC vs Load (Petrol)

The brake specific fuel consumption for the 80 percent and 100 percent petrol grade waste plastic oil varies from 01.28kW to 0.59 kW at full load and 1.474 KW to 0.598KW for petrol engines, as shown in Graph 3. As the load increases, the BSFC for all fuel mixes falls.



Graph - 4: BSFC vs Load (Diesel)

WPPO blends have a greater specific fuel consumption than diesel at full load, as seen in graph 4. The fundamental explanation for this could be that the percentage increase in fuel required to operate the engine is less than the percentage increase in brake power since heat losses at higher loads are generally smaller.

6. CASE STUDY

We get around 560 ml fuel oil by heating the close chamber with a thousand Watt heater in the temperature range of 200 to 350 degrees Celsius. A layer of oil emerges on the water level after roughly 45 minutes of combustion heating. We obtain 500 ml of fuel oil after two hours. It is established that waste plastic oil is a best alternative fuel after using 10 ml of this oil on a 100 cc Bajaj Discover bike for one minute at an average speed of 45 km/hr.

6.1 Application of Theory and Future Scope

a. The obtained fuel might be used in diesel generators, tractors, and passenger vehicles such as automobiles.
b. The fuel must be refined in industrial facilities, with the output allowing a small-scale company to be formed.
c. Given the tremendous demand for crude oil and its sky-high pricing, we may use this idea to establish up large or small-scale enterprises to generate the fuel locally at much lower prices, so boosting the national economy and taking a step toward SWAACH BHARAT by recycling waste plastic.
d. The use of this approach could aid in lessening reliance on Gulf countries while also encouraging a move toward innovation.

7. CONCLUSIONS

1. It might be a way to reduce waste plastic, develop a new technique or idea, and find out where the country's diesel comes from.
2. The usage of plastic pyrolysis oil in diesel engines is compared from a technical and economic standpoint, and it is discovered that the oil can substitute diesel oil.
3. Engines powered by waste plastic pyrolysis oil have a better thermal efficiency than petrol engines, reaching up to 50% of the rated power.
4. A diesel engine powered by waste plastic pyrolysis oil has a higher thermal efficiency of up to 75 percent of the rated power.
5. To protect the oil from chlorine contamination, the waste plastic used in the process must be PE, PP, or LDPE.
6. Emissions from the engine were significantly reduced when plastic oil mixtures were used. PO25 had the best emission characteristics of all the test fuels. At maximum load, the smoke and NOX were reduced by 22% and 17%, respectively, for the PO25 blend.

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