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Pyrolysis of Waste Plastic into Fuel

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Abstract: Due to the current continued use of fossil fuels such as crude oil, natural gas and coal, the current economic growth rate is unstable. Therefore, renewable energy sources are being exploited, but some resources, such as plastic waste, need to be developed into a full-fledged economic activity. Modernization and development have led to a huge increase in the production of all types of plastics, which have their widespread applications and low cost. The landscape of plastic recycling practices is reviewed in this paper. Its aim is to provide an in-depth analysis of the pyrolysis of plastic waste obtained in current recycling technology. Since the calorific value of the plastic is equal to the value of the hydrocarbon fuel, it provides a good opportunity to use the fuel generated waste from the plastic waste and generate the fuel. The technique of fueling plastic waste through the pyrolysis process is discussed. Therefore, efforts have been made to overcome the problem of plastic waste and the shortage of fossil fuels by creating fuel from plastic waste. We look forward to improving the environmental balance as plastic has a negative impact on the environment. Therefore, an attempt has been made to address the issue of plastic waste disposal as a partial alternative in hopes of promoting a sustainable environment for decaying fossil fuels [4].

Keywords: Pyrolysis, Polymer, Review, Fuel, Plastics.

I. INTRODUCTION

With the increase of the human population, the use and production of plastic waste is increasing at an alarming rate. To meet the demands of the modern world, over 1.3 billion metric tons of plastic are produced each year. Plastic is a material that contains a wide range of semi-synthetic or synthetic organic compounds that can be made into various materials. Plastics are usually organic polymers of high molecular mass [8]. Plastics are used in many products due to their low cost, ease of manufacture and many other features. The use of plastics in modern life is widespread and constantly increasing and cannot be avoided, resulting in an increase in the production of plastics worldwide from various industries and households.

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Around 100 million tons of plastic are manufactured in the world to meet global demands, so the production and consumption of plastic is a big threat to the environment. Many processes, such as landfilling, mechanical recycling, and biological recycling are used to recycle the amount of plastic produced, which can take many years.

Therefore, we need to look for more profitable alternatives to increase the decomposition of plastic waste into new and useful products. So, a new recycling process is used, and waste plastics are researched to fuel a value-added product and decompose the process, called pyrolysis.

Pyrolysis is the process of thermal decomposition of plastics in an inert atmosphere and at a high temperature. In this process the chemical composition of plastics is converted to hydrocarbon compounds and is an irreversible process. The use and application of the pyrolysis process is that they can be used to convert waste plastics into useful oils or safely disposable materials. The growing demand for plastics affects petroleum and renewable fossil fuels because plastics are based on petroleum-based materials. Renewable fossil fuels can take millions of years to replenish or cannot be replaced, and they gradually disappear due to their high demand in this growing world and this creates a big problem for the future.

Because of this problem, converting plastic waste into fuel has been developed as a solution to the problem. Because plastics are part of petroleum, the oil produced by the pyrolysis process has high caloric value, which can be used as an alternative fuel. Made of plastic from crude oil. Its price and production are determined by the petrochemical industry and the availability of oil [10]. Because oil is limited in nature, the most sustainable option is to reduce crude oil consumption so that waste plastics can be reused and recycled as much as possible. There are various processes that can do this. Here we use pyrolysis. In pyrolysis, plastic waste is heated in the absence of oxygen, which produces an oil (fuel) mixture. It can be further refined in transport fuels [11]. Its effectiveness in solving two problems of pyrolysis and good alternative fuel for the management and use of waste plastic [12].

The purpose of our study is to characterize, produce and evaluate alternative diesel fuels from pyrolysis of polyethylene and polypropylene. PE is divided into categories based on the density and frequency of molecular branches. Two important types of plastic bags are low density PE (LDPE) and high-density PE (HDPE) [5]. The subject of the paper is an investigation into the breakdown behavior of unwanted plastic waste.

Fig. 1: Waste Plastic to Fuel [2]

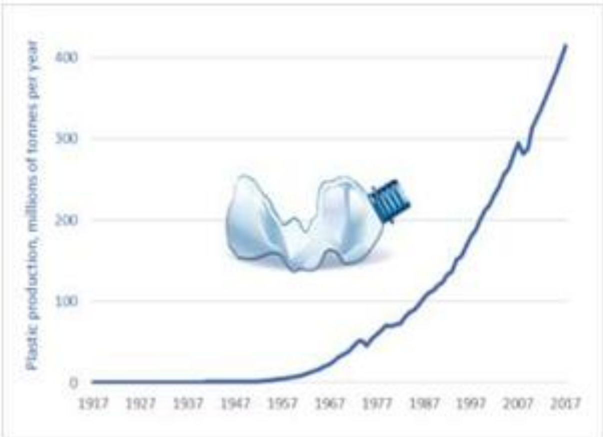

Fig. 2: Statistics of consumption and generation of plastic waste [13]

II. METHODOLOGY

A. Material

For our experiment we have collected waste plastic which is high-density polyethylene, PET, PS, PP because pyrolysis cannot be performed on all types of plastic. The plastic waste found at retailers' shop, single-time use plastic bottles and all sort of plastic waste which can be used are being collected as the material for the experiment.

We also need a container which can be heated to a very high temperature, a pyrolysis device, catalyst like silica alumina, zeolite etc. (not mandatory), tubes or pipes for dividing the impurity and fuel and a column for distillation and in some cases, we might need a condenser also.

B. *Experimental Setup*

The experimental setup is shown in fig 3. A container, a pyrolizer, test tubes/pipes, collector in which the fuel will collected. The main design details of the instrument are listed in the Table 1.

Table 1: Design details of the instruments [1]

1	Material	Stainless Steel
2	Top diameter	25cm
3	Bottom diameter	25 cm
4	Depth	40 cm
5	Volume	19634 ^3 cm
6	Diameter of outlet	2.54 cm
7	Weight of mould	14 kg
8	Digital thermometer (up to 2000 degree)	---------
9	Test tubes	2.5 mm

The container to be heated is kept on the fire with the test tubes or pipes connected to the container, a digital thermometer is used for measuring the temperature of the container(if needed), the test tubes are further divided for different separation and at the end of the test tube a container in which the fuel will collected is connected, a condenser(in some cases or if needed) is kept surrounded to the test tube for condensing the fuel and a pyrolizer for the process of pyrolysis.

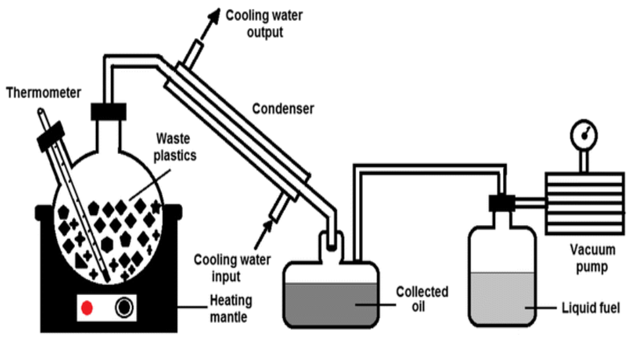

Fig. 3: Experimental Setup [3]

C. *Plastics Used*

The plastic used throughout experiments are given below***:***

(PE) – Polyethylene is the type of plastic used to make poly bags, plastic toys etc. It has a very simple structure and is versatile.

(PP) – Polypropylene properties are similar to polyethylene but it is more heat resistant and mechanically rugged due to its structure.

(HDPE) – High density polyethylene is a thermoplastic produced from the monomer ethylene and it is used for making bottles, fuel tanks etc.

(LDPE) - Low density polyethylene is a thermoplastic which is made from the monomer ethylene and it is used for making trays, general-purpose containers, juice and plastic cartons etc.

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HDPE (high density polyethylene)	Milk, water and juice containers, liquid detergent bottles, laundry soap containers and ice cream containers, bottle caps	2 HDPE
LDPE (low density polyethylene)	Shopping bags, bread bags, frozen food bags, and dry-cleaning bags. Plastic sheeting, packaging film and sheeting	4 LDPE
PP (polypropylene)	Food containers	5 PP

Table 2: Plastic used [14]

III. PREPARATION OF FUEL FROM WASTE PLASTIC

Pyrolysis is a process of heating of material in the absence of oxygen and can also be defined as the controlled burning of plastic waste into fuel. The macromolecular structure of the plastic polymer is broken into smaller molecules. Different conditions in which the process is happening can tell us whether the molecules of plastic waste can be further degraded or not which include the presence of catalyst, residence time, temperature and other process conditions. The process of pyrolysis which is carried out in the presence of catalyst is known as catalytic pyrolysis and the process which is carried out normally without the help of any catalyst is known as thermal pyrolysis. Although, there are many ways of plastic waste management like recycling, land filling, depolymerization etc. which can be used for the disposal of the plastic waste but pyrolysis is a process which can not only solve our problem of the disposal of waste plastic but also find a substitute for the fuel as the fuel from the natural resources are very limited and will be finished super soon if continuously used with current consumption rate. The other reason for choosing this pyrolysis process is that the properties of the fuel obtained by pyrolysis are merely same as that of the natural extracted fuel. And after analyzing the parameters, production of fuel from waste plastic by the process of pyrolysis is done. The plastic which is used in this process are mainly HDPE, PP, PE and LDPE which being converted into the fuel. These are the plastic which are found abundantly on our planet Earth. The process used for converting plastic into fuel is further explained. We need a container to store all the waste plastic which will be burnt for the process of pyrolysis to happen and convert the waste plastic into useful product which is fuel. For the extraction of the fuel the pyrolysis device is connected to the container with help of pipes or tubes. The vapors which is released from the burning of plastic waste will further transfers with the help of tubes connecting the pyrolysis device to the container.

The vapor generates when the container is heated at 500 degrees. Then these vapors will further send with the help of pipes which is then divided into two or more segments as one is used to carry impunity and the other carries fuel vapors. The working of the instrument is shown below through the image given below. Some plastic fuel which is obtained after the pyrolysis process is burnt to check whether the fuel obtained is useful or not and it is one of the most important steps after the process.

Fig. 4 [1]
(Experimental setup of trial test conducted, wherein 380 grams of plastic was dumped into closed container and is heated.)

Fig. 5 [1]
(Semi liquid fuel obtained after burning the waste plastic, which can be further processed into diesel.)

Fig. 6 [1]
(Efficient burning of the obtained fuel with a clear blue flame and minimum emission of CO_2.)

Fig. 7 [1]
(Distilled fuel obtained from waste plastic)

After carrying out the experiment we get to know about the physical properties of diesel grade of waste plastic as shown in Table 3**.**

S.No.	Characteristics	Diesel grade fuel
1	Flash point (deg. C)	81
2	Fire point (deg. C)	90
3	Viscosity @ (40 deg. C)	3.812
4	Density kg/m3	823
5	Calorific Value kJ/kg	46888

Table 3 [1]

IV. PERFORMANCE CHARACTERISTICS

Brake thermal efficiencies

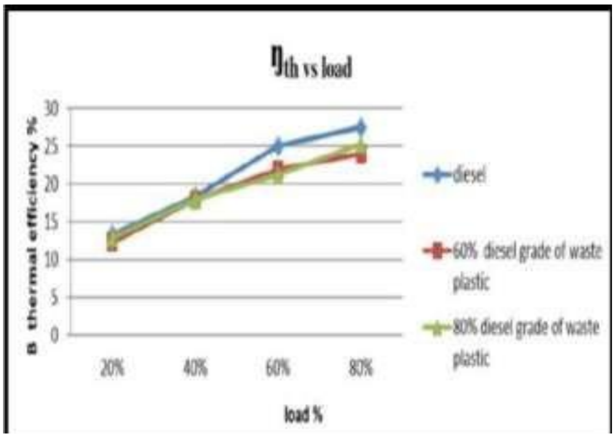

Fig. 8 [1]

Brake specific fuel consumptions

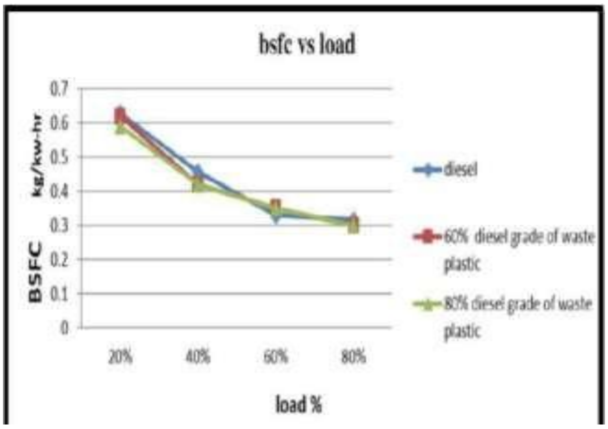

Fig. 9 [1]

V. EMISSION CHARACTERISTICS

Hydrocarbon emissions

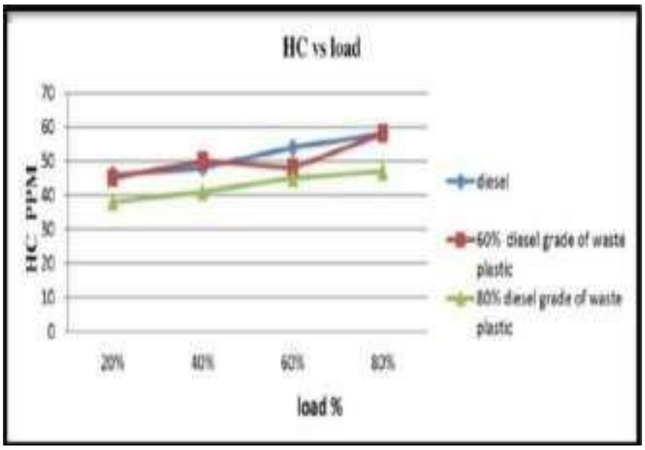

Fig. 10 [1]

Carbon monoxide emissions

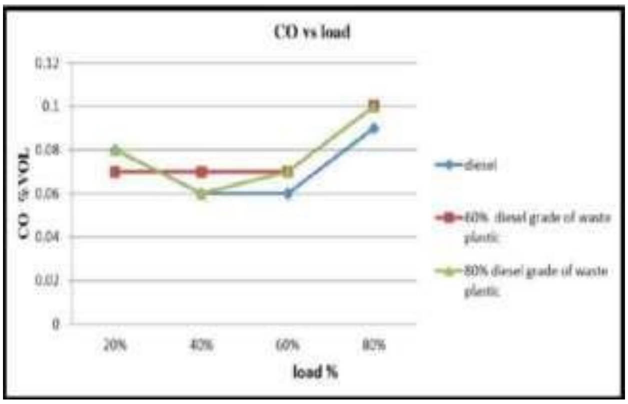

Fig. 11 [1]

VI. RESULT AND DISCUSSION

From our experiment it can be concluded that burning 1 kg of plastic can easily yield 600 to 750 ml of diesel fuel. By turning plastic into fuel, we can reduce atmospheric CO2 emissions by 80% and burn 1 kg of plastic in the open atmosphere to produce up to 3 kg of CO2, thus solving both problems. Could. Waste plastic conversion oil releases unbalanced hydrocarbons less than diesel fuel. An important point of this experiment is that the obtained waste plastic fuel has a higher efficiency than the available fuel in the market and the cost of production is 30% to 40% lower than other fuel production methods. The above figures also depict performance characteristics and emission characteristics graphs. The brake thermal efficiency of the performance features ensures that the compression ignition engine has a thermal efficiency of 27.5% at full load.

The engine fuels the WPO 80 and WPO 60 diesel grades at full load, giving brake thermal efficiency of 24% and 25.3%, respectively. In addition, the brake specific fuel consumption is shown in fig. 8 measures how efficiently they use the fuel supplied to produce the product. Similarly, the hydrocarbon emissions characteristics of diesel grade fuels in waste plastics vary from less than 36 ppm to 58 ppm at full load.

Hydrocarbons burned in waste plastic oil are higher due to high smoking rates and lack of oxygen compared to market diesel. Carbon monoxide emissions vary by 2.40% of CO by volume. 7.60% volume at low load. But with a full load of diesel, waste plastic oil will change by 0.08% per CO volume. Up to 0.10% volume at low load. At higher loads. Therefore, the carbon monoxide emission of waste plastic oil is higher than that of diesel.

VII. CONCLUSION AND FUTURE SCOPE

This project explores the use of waste plastics in the growing and developing world. Other alternatives to plastic are difficult to find because plastic has many uses and different properties. Demand for plastics is also increasing day by day and with increasing plastic rate their waste is increasing or increasing. Increasing plastic waste is causing more environmental problems worldwide [7]. As the use of waste plastic grows, it is immediately believed that solid waste management will find more ways to collect them. Products of the plastic pyrolysis process can be used as fuels or chemicals [6]. It also reduces the problem of waste plastic decomposition. In this work, the pyrolysis of waste plastics is done because the use of catalysts is expensive and the reproduction of catalysts is a difficult task. Plastic pyrolysis produces a mixture of gas and oil and produces a very small amount of char. The implementation of this project in the real world develops many possibilities. This is a good solution for controlling waste plastics and finding a new diesel source for the country.

According to the current data, there is a continuous increase in crude oil consumption and thereby an increase in the price of crude oil, although there is a temporary decline in demand growth due to the international financial crisis and Kovid19. This way, the available gas and oil reserves will only be found for a few years. On the other hand, the use of plastics cannot be reduced due to its wide variety of applications and thereby increases plastic waste. However, large quantities of plastic can be combined in a precise and carefully designed way to produce value-added fuels that are an alternative to fossil fuels. Plastic pyrolysis oil in diesel engines is used as a diesel fuel from the point of view of economic and technical use, and it has been found to be capable of replacing diesel oil produced by pyrolysis. Although plastic pyrolysis fuel provides low engine performance, the amount of plastic waste is very large and requires a process that minimizes environmental problems such as pollution caused by plastic waste. Additionally, the engine can be modified to accommodate the combustion condition of the plastic pyrolysis fuel. The waste plastics used in the process must be polyethylene, polypropylene, or low-density polyethylene to avoid chlorine contamination in the fuel. This method should be superior in environmental, economic and technical matters. Proper design can turn waste plastics into hydrocarbon fuels and is a cheaper alternative to petroleum, in which waste plastics do not decompose and release pollutants. It also looks at hazardous plastic waste and reduces the amount of crude oil imports from other countries. Analysis of the various methods described shows that mechanical recycling is the most widely adopted method in many countries around the world, although most countries have had momentum due to its ability to perform other processes in all cases, from plastic to fuel. In addition, this method produces an alternative to fossil fuels such as crude oil and petroleum, and may be an alternative source of energy. Improvements in this technology are in demand at this level due to the rapid depletion of renewable energy sources such as fossil fuels. Therefore, further studies are needed and important to use this oil as fuel or feedstock. It represents the future trends of plastic waste recycling and is fueling an industry.

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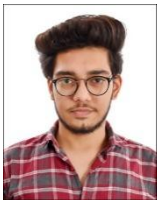

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