PYROLYSIS OF WASTE PLASTIC INTO FUEL

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Abstract:- *Truly said necessity is the mother of all invention today in this fast-growing world environment is left suffering. We need to save its resources live crude oil gas or coal because life without resources is incomplete. Though, the world is moving at great pace leading development in each and every part of the world but it is indirectly generating hazardous waste and one such kind of waste generated is the plastic waste. The plastic generation has a serious impact on our environment. Many steps like land filling, recycling etc. are being done for the disposal of the plastic waste but the plastic waste generation is far more than disposal. We need to look for an alternate technique for the disposal of the waste plastic and use it efficiently. Advanced research in the field of chemistry has shown that plastic can be used as a great source for conversion into fuel. Furthermore, enhancement of the research would be an award for the society as it would help conserving natural resources and lead to safe easy and fast disposal plastic waste.*

According to the present research given on producing fuel from plastic using pyrolysis and analysing the pros and cons of the performance characteristics of fuel produced by testing it into a compression engine. Moreover, the fuel properties and performance of fuel produced by plastic are discussed.

We look forward to improve the environment balance as plastic has an adverse effect on the environment. Thus, an attempt was made to address the problem of plastic waste disposal as a partial replacement of the depleting fossil fuel with the hope of promoting a sustainable environment [4].

Keywords- Pyrolysis, Compression ignition engine, Disposal of waste, Performance of Fuel, Replacement of fossil fuel

Introduction

Plastic waste production and consumption is increasing at an alarming rate, with the increase of human population. Over 1.3 billion metric ton of plastic is being manufactured every year to meet demands of modern world. Plastic is material consisting of any of a wide range of synthetic or semi-synthetic organic compounds so can be molded into solid objects. Plastics are typically organic polymers of high molecular mass [8]. Due to their low cost, ease of manufacture, and various other properties plastics are used in many products. Until now, utilization of plastic materials in modern human life is increasingly widespread and cannot be avoided, and this results in plastic production globally increasing annually from various industries and households.

In the world of total 100 million tons of plastic is manufactured to meet global demand this much production consumption of plastic is a threat to environment. Right now, many other prosses are used to decomposes the plastic and to recycled also like land filling, mechanical recycling, biological recycling which takes several years. So, alternatives with more benefits are needed to increase the decomposition of plastic waste into a needed product or something. So, a recycling process is found and worked on to decompose waste plastic into value added product that is fuel. The process is known as pyrolysis.

Pyrolysis is the thermal decomposition of plastic at high temperatures in an inert atmosphere. It involves a change of chemical composition of plastic to hydrocarbon compounds and is irreversible. Applications of pyrolysis are waste plastics back into usable oil, or waste into safely disposable substances. The growing of plastics demand affects the petroleum resources availability as non-renewable fossil fuel since plastics were the petroleum-based material. Non-renewable fossil fuels are those which can't be renewed in nature or take millions of years and due to their high demand in this growing world they are vanished slowly.

As a result, the plastic waste conversion into fuel was developed. Since plastics were part of petroleum, the oil produced through the pyrolysis process was said to have high calorific value that could be used as an alternative fuel [9]. Plastic is made from crude oil. Its price and production are dictated by the petrochemical industry and the availability of oil [10]. As oil is a finite natural resource in nature, the most sustainable option would be to reduce crude-oil consumption by recycling the waste plastic and recovering as much of the raw material as possible. There are different processes by which this can be done here we use the pyrolysis. In pyrolysis, plastic waste is heated in the absence of oxygen, which produces mixture of oil(fuel). This can be further refined into transportation fuels [11]. Pyrolysis and its effectiveness on resolving the both issues of waste plastic management and the requirement of a good alternative fuel for use [12].

The objective of our study is the production, characterization and evaluation of alternative diesel fuel from pyrolysis of Polyethylene, Polypropylene. PE is divided into categories based on density and molecular branching frequency. The two types most important to production of plastic bags are low density PE (LDPE) and high-density PE (HDPE) [5]. The subject of the paper is the investigation of the cracking behavior of municipal plastic waste.

Fig. 1: Waste Plastic to Fuel [2]

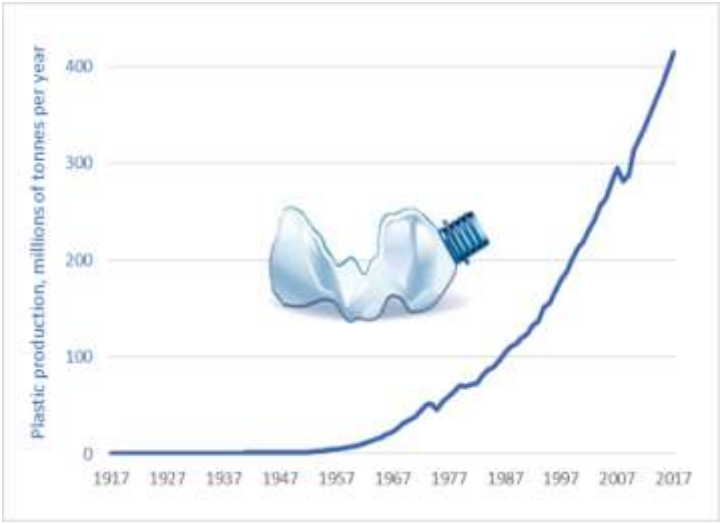

Fig. 2: Statistics of consumption and generation of plastic waste [13]

Methodology

Materials

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

We also need a container which can be heated to a high temperature, a pyrolysis device, catalyst like silica alumina, zeolite etc, tubes for dividing the impurity and fuel and a fractioning column for proper distillation and in some cases, we might need a condenser as well.

Experimental Setup

The experimental setup is shown in fig 2. A container, a pyrolizer, test tubes, collector in which the fuel is to be collected, a condenser were used for study. The main design details of the instrument are listed in the Table 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

Table 1: Design details of the instruments [1]

The container to be heated is kept on the flame with the test tubes connected to the container, a digital thermometer is used for constantly measuring the temperature of the container, the test tubes are further divided for pure and impure separation and at the end of the test tube a container in which the fuel is to be connected is kept, a condenser is kept surrounded to the test tube for condensing the fuel and a pyrolizer for the process of pyrolysis.

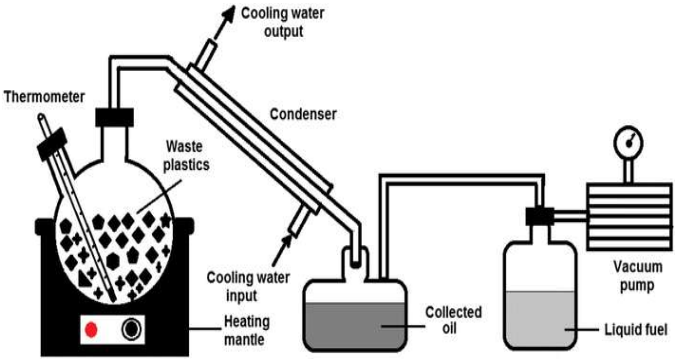

Fig. 3: Experimental Setup [3]

Plastics Used

The plastic used throughout experiments are given below:

(PE) – Polyethylene is the type of plastic that we use in our day to day life like poly bags, plastic toys etc. It has a simple structure and is versatile.

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

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

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

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]

Preparation of fuel from waste plastic

Pyrolysis is the process of heating of a material in the absence of oxygen and can also be defined as the controlled burning of plastic waste into fuel. The macromolecular structure of plastic polymer is broken into smaller molecules or oligomers. Different conditions in which the process is happening can tell us whether these molecules can be further degraded or not which include the presence of catalyst, residence time, temperature and other process conditions. The pyrolysis process 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 catalyst is known as thermal pyrolysis. Although there are many ways of like recycling, land filling, depolymerization etc. which can be used for the disposal of the plastic but pyrolysis is process which can not only solve our problem of the disposal of plastic but find a substitute for the fuel as the fuel from the natural resources are very limited. The other reason for choosing this process or working on this idea 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 bio diesel by the process of pyrolysis is done. The plastic all mainly HDPE, PP, PE and LDPE are being converted into the fuel these are the plastic which are found abundantly on our earth. The process used for converting plastic into fuel is given below. We need a container to store all the waste plastic which can be burnt for the process of pyrolysis to happen and convert the waste plastic into fuel. For the extraction of the fuel the pyrolysis device is connected to the container. The vapors' released from the burning of plastic waste transfers with the help of tubes connecting the pyrolysis device to the container.

The vapor reaches the pyrolysis device when the container is heated at 500 degrees which is then divided into two or more segments as one is used to carry impunity and the other collects the waste plastic. The working of the instrument is shown below through appropriate diagram. Some plastic fuel which is obtained after pyrolysis is burnt to check whether the fuel obtained is useful or not and it is one of the most important steps in 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 CO2.)

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)	87
2	Fire point (deg. C)	92
3	Viscosity @ (40 deg. C)	3.8
4	Density kg/m3	800
5	Calorific Value kJ/kg	46988

Table 3 [1]

Performance Characteristics:

- **Brake thermal efficiency**:

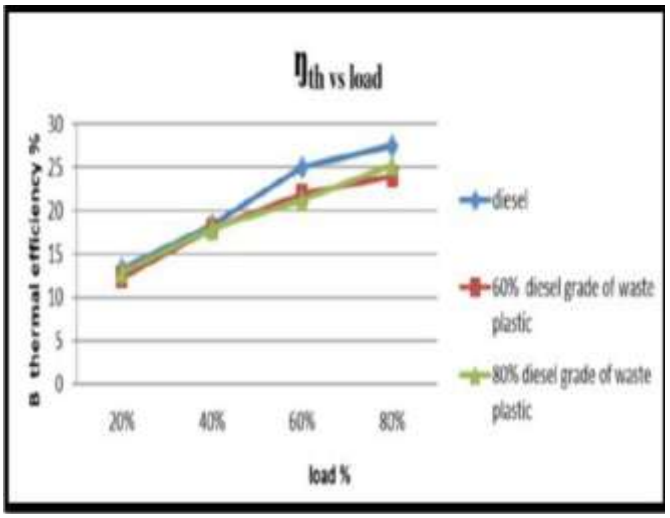

Fig. 8 [1]

- **Brake specific fuel consumption**:

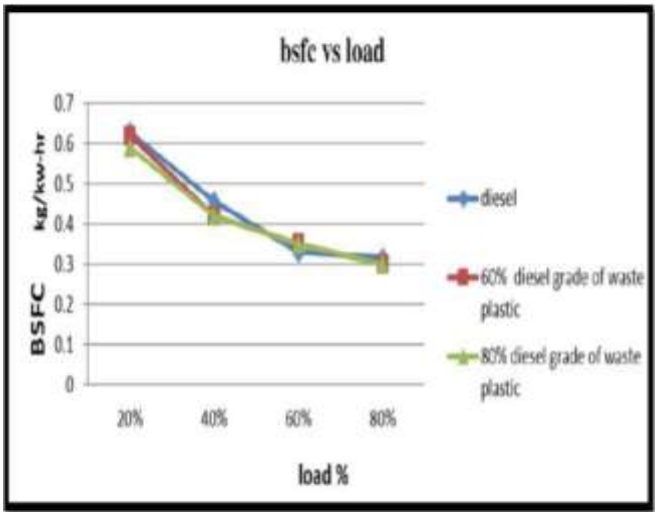

Fig. 9 [1]

Emission characteristics:

- **Hydrocarbon emission**

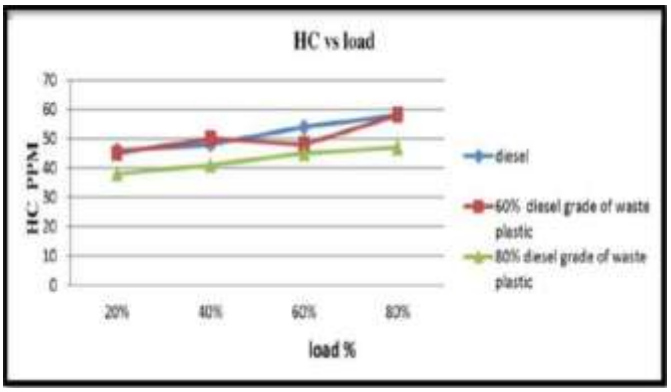

Fig. 10 [1]

- **Carbon Monoxide emission**

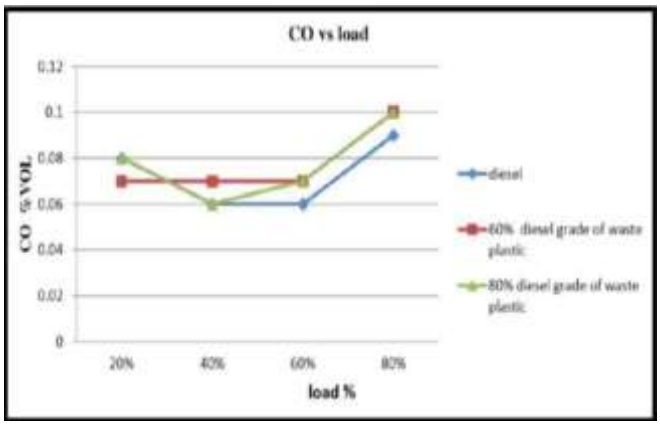

Fig. 11 [1]

Result and discussion

From our experiment we can see that by burning 1 kg of plastic we can obtain 600 to 750 ml of diesel fuel. By converting the plastic into fuel, we can reduce the emission of CO2 in the environment by 80% whereas burning 1 kg of plastic in an open environment can produce up to 3kg of CO2. The waste plastic pyrolysis oil produces less emission of unburnt Hydrocarbons as compared to that of diesel. One of the most important things about this experiment is that the waste plastic fuel obtained has a higher efficiency compared to that of the fuel available in market and the cost of production is also 30% to 40% low than other mode of production. The above figures show the graph of performance characteristics as well as emission characteristics. The Brake thermal efficiency of performance characteristics observes that the thermal efficiency is 27.5% at full load in compression ignition engine.

It is also observed that the engine fueled WPO 60 and WPO 80 of diesel grade gives brake thermal efficiency of 24% and 25.3% respectively at full load. Also brake specific fuel consumption shown above in the Fig. 8 measures how efficiently the engine is using the fuel supplied to produce the work. Similarly, the emission characteristics shows that in hydrocarbon emission of diesel grade fuel of waste plastic un burnt hydrocarbons vary from 36ppm at low load to 58ppm at full load. The un burnt hydrocarbon in waste plastic oil is higher due to higher fumigation rate and non-availability of oxygen relative to market diesel. Lastly in Carbon Monoxide emission CO varies from 2.40% vol. at low load to 7.60% vol. at full load in diesel whereas under waste plastic oil CO varies from 0.08% vol. at low load to 0.10% vol. at high load. Hence, the CO of emission of waste plastic oil is higher than diesel.

Conclusion and Future scope

This project analysis has observed the use of waste plastics in developing and growing world. It is very difficult to find out any alternative of plastic because plastic has so many properties and uses. Even plastic´s demand is increasing every day and with growing rate of plastic demand their waste is also growing or increasing. The growing amount of plastic waste is generating more and more environmental problems worldwide [7]. It is easily assumed that, when the use of waste plastic will increase then the solid waste management will search more ways to collect them. The products of plastic pyrolysis process could be utilized as fuels or chemicals [6]. It also reduces the problem of decomposing of waste plastic. In this work, pyrolysis of waste plastic is carried out because use of catalyst is costly and regeneration of catalyst is a difficult task. Pyrolysis of plastic yields a mixture of oil and gas and produces very small amount of char. The implementation of this project can develop so many opportunities in the growing world. It can be a solution to control waste plastic, and detect the source of diesel for the country.

According to the current statistics, there is continuous rise of consumption of crude oil and thus cost of crude oil, although there has been a temporary drop in demand growth due to the international financial crisis. This way, the oil and gas reserve available can meet only few years like 100. On the other hand, the use of plastics cannot be reduced due to its vast applications and thus results in increase in plastics waste. However, the huge amount of plastic wastes produced may be treated with suitably designed method to produce value added fuels which can be a substitute of fossil fuel. The use of plastic pyrolysis oil in diesel engine as a diesel fuel in the aspect of technical and economical is compared and found that oil is able to replace the diesel oil. Though the plastic pyrolysis fuel offers lower engine performance, the plastic waste amount is enormous and it needed to be process to reduce the environmental problems like pollution due to plastic waste. Moreover, the engine can be modified follow the combustion condition of plastic pyrolysis fuel. The waste plastic used in the process must be Polyethylene, Polypropylene or Low-density polyethylene in order to protect the contamination of chlorine in the fuel.

The method should be superior in ecological and economical respects. So, a suitable method which can convert waste plastic to hydrocarbon fuel if designed and implemented, and that is a cheaper partial substitute of the petroleum with decomposing of waste plastic and without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil from other countries. The analysis of different methods described in the section indicate mechanical recycling is widely adapted method by different countries in the world, however the pyrolysis of plastic to fuel is gaining momentum and being adopted by many countries recently due to its efficiency over other process in all respects. In addition, this method would produce a substitute for the fossil fuel like crude oil, so be an alternate source of energy. The improvement in this technique is in demand at this stage due to the depletion of non-renewable source of energy such as fossil fuels. So, further studies are necessary to utilize this oil as fuel or feedstock. This sets the future trends in plastic waste recycling as an Industry.

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