SUBSTITUTE TO CONVENTIONAL FUEL

EFFECTIVE UTILIZATION OF WASTE PLASTICS- A REVIEW

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ABSTRACT- The increased demand and high prices for energy sources are driving efforts to convert organic compounds into useful hydrocarbon fuel. It is a fuel obtained by processing waste plastics. It is a valuable liquid hydrocarbon product that can be utilized as energy source for many purposes such as in diesel engines, generators, vehicles and etc. The gaseous by-product obtained in the process can be used for combustion purposes in the plant itself and also to run gas turbines. Thus this waste plastic fuel can be effectively converted in to an alternative energy source. In the present paper the main aim is to provide the reader the knowledge of suitable plastics for the process and in depth knowledge regarding the recycling techniques of waste plastic with current scenario of the plastic consumption. So the methods of converting plastic into fuel, specially pyrolysis and catalytic degradation, are discussed in detail and a brief idea about the output characteristics is also included. Thus, we attempt to address the problem of plastic waste disposal and shortage of conventional fuel and thereby help in promotion of sustainable environment and helping Nation to be energy secured.

Index Terms- Alternative fuel, Pyrolysis, Recycling waste, Waste plastic fuel

I. INTRODUCTION

The disposal of waste plastics has become a major environmental problem all over the world. The recent strategic survey by Central Pollution Control Board reveals that, INDIA generates 5.6 million metric tons of plastic waste annually [1]. And it's increasing exponentially. Also their disposal creates large problems for the environment. These do not biodegrade in landfills, are not easily recycled, and gets degrade in quality during the recycling process. Instead of biodegradation, plastics waste goes through photo-degradation and turns into plastic dusts which can enter in the food chain and can cause complex health issues to earth habitants.

Government has adopted several methods to reduce the pollution caused by plastics and its constituents. The major step was the introduction of recycling. It includes all those processing which attempt to convert the plastic wastes to basic chemicals by the use of chemical reactions such as hydrolysis, methanolysis and ammonolysis for condensation of polymers and to fuels with conventional refinery processes such as pyrolysis,
catalytic cracking, gasification and hydrocracking. Pyrolysis and catalytic conversion of plastic is a superior method of reusing the waste.

Fig. 1 Present Scenario of Plastic Waste

The distillate product is an excellent fuel and is one of the best, economically feasible and environmentally sensitive recycling systems in the world today. It can be used in any standard diesel engine, trucks, buses, trains, boats, heavy equipment and generators.

A. *Plastics suitable for process:*

As a rule of thumb, approximately 950ml of oil can be recovered from 1kg of plastics such as polyethylene, polypropylene or polystyrene. Although not suitable, the process can nevertheless tolerate small quantities of plastics containing heteroatoms. These are other than carbon and hydrogen such as chlorine, sulphur and nitrogen. Since heteroatoms are heavier than the light elements; these increases the density of the plastic and makes the molten paste highly toxic. Polyolefin gives the best yield of distillate due to their straight-chain hydrocarbon structure. Polystyrene contributes aromatic character to the distillate, improves the pour point properties and so it's beneficial in the mix.

B. *Typical examples of waste plastics for the process:*

Waste plastic fuel can process mixture from miscellaneous waste plastics such as:

1. Low Density Polyethylene (LDPE): Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles.
2. High Density Polyethylene (HDPE): Carry bags, bottle caps, house hold articles etc.
3. Polyethylene Teryphthalate (PET): Drinking water bottles etc.
4. Polypropylene (PP): Bottle caps and closures, wrappers of detergent, biscuit, Vapors packets, microwave trays for readymade meal etc.
5. Polystyrene (PS): Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc.

II. PYROLYSIS OF PLASTIC

A. *Introduction*

- Pyrolysis is the thermochemical decomposition of organic substances.
- The word is originally coined from the Greek-derived elements pyro means "fire" and lysis means "decomposition".
- Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, like wood, paper and also some kinds of plastic.
- Anhydrous Pyrolysis process can also be used to produce liquid fuel similar to diesel or petrol from plastic waste.

Basic Components:

1. In-feed system,
2. Pyrolysis gasification chamber,
3. Catalytic converter,
4. Condensers,
5. Gas scrubber,
6. Centrifuge,
7. Oil recovery line,
8. Off-gas cleaning.

B. *Operation:*

Initially the plastic waste so accumulated is preferably tested and only those which are suitable for processing is sorted out. This sorted out plastic is passed through crushers and then to drier. The dried granulated plastic is then fed into the chamber. It's the heart of entire system; prime chamber, which performs the essential functions of homogenisation, controlled decomposition and outgassing in a single process. In it plastic waste is treated at the temperature range of 370˚C – 500˚C. Waste plastics are loaded via a hot-melt infeed system using an extrusion device and are fed directly into this chamber[2]. The chamber can generally be filled within few hours depending upon its capacity. Another efficient role to carryout is to ensure that the plastic is heated uniformly and rapidly. If temperature gradients are developed in the molten plastic mass then different degrees of cracking will occur and products with a wide distribution of chain lengths will be formed. The whole process of heating plastic is to be carried out in the absence of oxygen. When the chamber temperature is raised, agitation commences to even the temperature distribution and homogenise the feedstock.

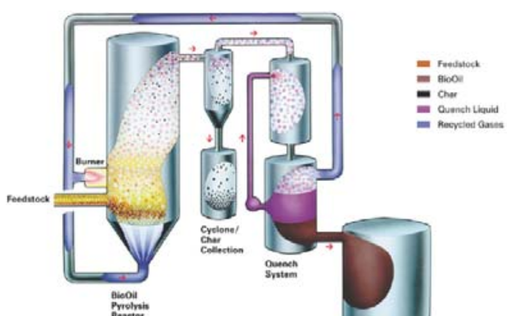

Fig. 2 Basic Process

Pyrolysis then commences to the point of product gasification. It uses a slight positive pressure (about 1.08 bar) ensuring that these gases are quickly removed from the process chamber thereby reducing the incidence of secondary reactions. Non-plastic materials fall to the bottom of the chamber.

The gas goes through the catalytic converter and is converted into the distillate fractions by the catalytic cracking process; to give a low sulphur content distillate. The liquid distillate then passes into the operating tank after cooling in the distillation tower. From the operating tank, the product is sent to a hydro-cyclone to remove contaminants such as water or carbon. The cleaned distillate is then pumped to the quality tank, then to the storage tanks.

In terms of the catalyst, Kaolin is a clay mineral, containing aluminium and silicon. It acts as a catalyst by providing a large reactive surface on which the polymer molecules can sit and so be exposed to high temperature inside the batch reactor, which breaks them apart. They could boost the yield to almost 80 per cent and minimize reaction times, but this required a lot more catalyst like about one kg of kaolin for every 2 kg of plastic.

The process requires minimal maintenance and produces consistent quality distillate. However as pyrolysis of mixed plastics with nitrogen-containing plastics produces the corresponding liquid fuel with nitrogen compounds, which in turn produces nitrogen oxide in the flue gas at combustion. Similarly, liquid fuel derived from waste plastics containing chlorine, bromine or fluorine will cause corrosion to the reactor and burner and it will form hydrogen compounds and dioxins. So the flue gas treatment should be considered to avoid the potential risks that those chemicals pose to workers and local residents. And also prior proper suited plastics should be only selected that contains negligible or no amount of halogens; i.e. like polyvinyl chloride (PVC). It is not being preferred as it contains high amount of chlorine.

III. Operating Features of Plant

- Process operates at high temperature and slightly above the ambient pressure.
- Coking occurs in the prime gasification chamber. The system should be properly designed so that the waste plastic gets fully and uniformly heated. The periodic maintenance tasks like cleaning and inspection may be run daily or less often as per the capacity of plant.
- Input feedstock plastics are required to be sorted according to the suitability of processing. Also followed by passing

through driers, to remove present moisture.

- Catalyst-free process can be achieved by reusing the treated residue, under certain specific conditions.
- Plastic fuel produces extremely low level of emissions, due to the capture of almost all of the output, both liquids and gases, inside the system for the sake of co-generation.
- Less moving parts in system provides the advantage of less noise and vibrations.

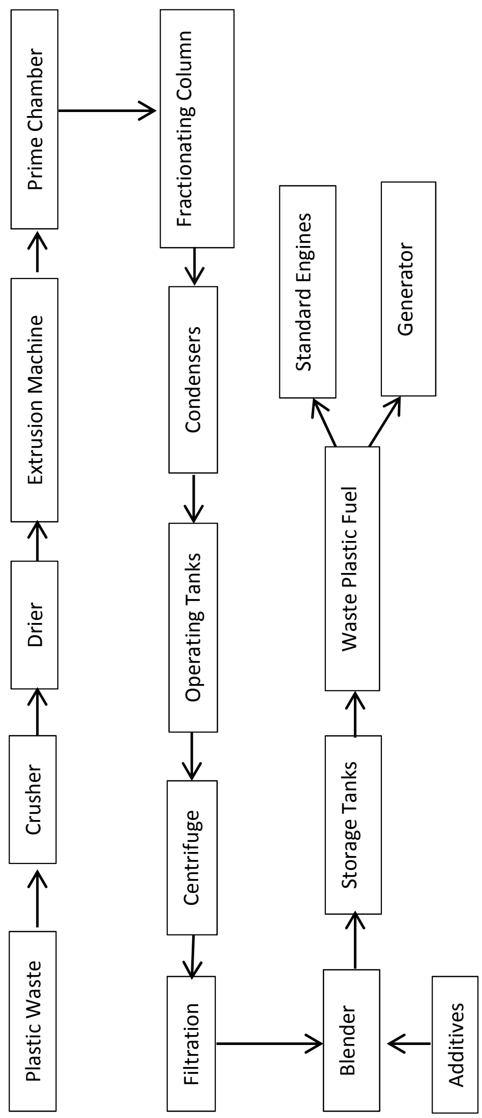

Fig. 3 Schematic Diagram of Process

- The proposed design should have resistance or ability to cope up with foreign matters like soil, sand, papers or organic materials adhered to plastics.
- The main problems associated with the use of neat plastics oil in standard engines are high smoke levels and relatively low thermal efficiency due to high viscosity and carbon residue as compared to diesel.
- Reutilization of non-condensable gas so obtained as a by-product while processing can be used to feed the prime combustion chamber.

IV. PROPERTIES OF OUTPUT FUEL

The output from the typical mass polyolefin plastic entering the process comprises of different constituents like hydrocarbon distillate, char, losses in the desulphurization process, losses of non-condensable gases and which is captured and resembles properties commonly available with liquefied petroleum gas. The non-condensable gases from the processing plant are passed through water scrubbers and then fed back into the natural gas flow to the thermal oxidizer, which heats the unit, meaning there are minimal net hydrocarbon emissions. A comparison of the distillate produced from a commingled plastic mix compared with regular diesel has been conducted by gas chromatography, and shows excellent similarity between waste plastic fuel and diesels.

According to IIP Director M.O. Garg, the fuels obtained (gasoline and diesel) through the process employed in the technology meet Euro-III standards and are of ultra-high-quality.

With almost nil sulphur content, the diesel obtained through the process is said to be of high quality. It will lead to vastly reduced emissions from engines. It is also important to emphasize that the fuel obtained possesses high lubricity. In diesel engines some components, including fuel pumps and injectors, are lubricated by the fuel, so good lubricity is key element in reducing wear on these parts.

Sr. No.	Properties	Waste Plastic fuel	Diesel
1	Color	Pale black	Orange
2	Specific Gravity (at 30˚ C)	0.8355	0.84-0.88
3	Gross Calorific Value($kJkg^{-1}$)	44340	46500
4	Kinematic Viscosity (at 40 ˚C)	2.52	2.0
5	Cetane number	51	55
6	Sulphur Content (%)	<0.002	<0.035
7	Flash Point (˚C)	42	50
8	Fire Point (˚C)	45	56
9	Pour point (˚C)	<7	6

The brake thermal efficiency of the waste plastic fuel is closer to diesel up to certain rated power, beyond which it starts decreasing. At full load, the efficiency is higher for diesel fuel. This is due to the fact that at full load, the exhaust gas temperature and the heat release rate are marginally higher for waste plastic fuel compared to diesel. An experimental study on waste plastic oil and diesel fuel blends in compression ignition engine proved that the thermal efficiency is 28% at full load for diesel. The total heat release for waste plastic fuel blends is lesser than diesel. Hence, the brake thermal efficiency is lower for the plastic fuel blends than diesel. Because of the changes in composition, viscosity, density and calorific value the brake thermal efficiencies are low particularly at full load.

V. CONCLUSION

Recycling of waste plastics is an effective way to improve the environmental performance of the polymer industry. Based on the reviewed paper for the effective utilization of waste plastic and making alternative fuel from the same, it is concluded that the fuel obtained from this method is a good option of quality fuel for industrial use and also for power production. At the same time great issue of plastic waste can be resolved. Further it is concluded that Developed technology will prove to be beneficial to the country for the purpose of catering increasing demand of fuel / energy and will save millions of foreign exchange. The produced distillate is designed to operate in any diesel engine. The fuel can be used in furnaces, generator sets having mixed fuel combustion options or further refined to obtain petrol, kerosene, diesel and light diesel oil.

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