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Diesel from Plastic Waste

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Abstract: This document The present rate of economic growth is unsustainable without saving of fossil energy like crude oil, natural gas, or coal. There are many alternatives to fossil energy such as biomass, hydropower, and wind energy. Also, 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. Plastics have been one of the materials because of their wide range of applications due to versatility and relatively low cost. India generates close to 26k tones of plastic a day, according to CPCB (Central pollution control board).

Moreover, 10k tones a day of plastics remains uncollected. Also India is the 15th biggest plastic polluter globally which accounts for nearly 11kg per capita plastic consumption.

We will grow to 22 million tones per year by 2020 from 13.4 million tonnes in 2015.We will grow to 22 million tones per year by 2020 from 13.4 million tonnes in 2015. The best and optimum way to convert waste plastic is to do pyrolysis process or similar of that pyrolysis but at lower temperature by creating zero oxygen atmosphere. This one is the effective measures is by converting waste plastic into combustible hydrocarbon liquid as an alternative fuel for running diesel engines.

Keywords--*Pyrolysis, waste plastic, characterization, petrol oil, fuel oil and diesel oil.*

I. INTRODUCTION

As industrialization occurred and the modern world emerged, the reliance on fossil fuels such as crude oils have become ever increasing. This crude oil is refined through many processes to produce a range of commercial grade fuels (about 87%) for energy production, 4% of the crude oil portion is used for production of plastics. Plastic waste is viewed as a possibly modest wellspring of synthetic substances and vitality.

Bunches of us have experienced an assortment of items that utilization plastic materials today.

Plastics are produced majorly with a single use application and thus left in landfills of used plastic which are continuously increasing. Plastic materials are a type of material that cannot be decomposed easily in a short period of time. Generous amounts of plastic have aggregated in the indigenous habitat and in landfills. Those wastes can be classified according to their origins. They are

A. Municipal
B. Industries

These gatherings have various characteristics and properties and are exposed to various administration methodologies. Immense measures of plastic squanders emerge as a result or damaged item in industry and agribusiness.

The conventional MSW removal strategy is landfill. In light of the life span of plastics, removal to landfill may essentially be putting away issues for what's to come. For example, plasticizers and other additive chemicals have been shown to leach from landfills. The extent of varies accordingly, particularly pH and organic content. It is predicted that between 2013 and 2030 the demand for diesel will increase by 7.5 million barrels per day to approximately 34 million barrels per day, and with that a large problem emerges. Global demand for plastic production has reached 322million tonnes in 2015, nearly a 50% increase since 2002 when it was at 200million tones. As the world increases its demand on supply and production rates of plastics at an exponential rate not enough has been done in regards to the recycling.

On the verge of depletion of fossil fuel reserves by the expert scientist and increasing cost of the petroleum products are the big troubles of today's world from past to present, tendency of oil price have increased consecutively. Especially in India has deficient amount of fossil fuel for this reason, India has to import fossil fuel, such as petroleum for domestic as well industrial demand.

1) *Plastics:* A brief intro to plastics, it can be said that plastics are synthetic organic materials produced by polymerization. They are commonly of high sub-atomic mass, and may contain different substances other than polymers to improve execution as well as lessen costs.

These polymers are made of a series of repeating units known as monomers. Therefore polymers can be molded or extruded into desired shapes. There are two main types of plastics:

a) Thermoplastics: These plastic can over and over relax and dissolve if enough warmth is applied and solidified on cooling, with the goal that they can be made into new plastics items. Examples are polyethylene, polystyrene and PV.
b) Thermosets or thermosetting plastics: These plastic can melt and take shape only once. They are not appropriate for rehashed heat medications; in this manner after they have cemented, they remain strong. Examples are phenol formaldehyde and urea formaldehyde.

Society of plastic industry (SPI) characterized a gum recognizable proof code framework that partitions plastics into the accompanying seven gatherings dependent on the substance structure and applications(Table 1.1)

Plastic group	Plastic source
PET (Polyethylene Terephthalate)	Plastic water bottle, sports drinks
HDPE (High Density Polyethylene)	Milk, water and juice containers, laundry soap
PVC (Polyvinyl Chloride)	Bottles with handles
LDPE (Low Density Polyethylene)	Shopping bags, bread bags, plastic sheeting
PP (Polypropylene)	Food containers
PS(Polystyrene)	Egg cartons, cups, plates
Others	Specialized packaging products

Table 1. Plastic group and source

II. EXPERIMENTAL ANALYSIS

A. Selection of Waste plastics

Major factors to be considered while selections are:

1) Smooth feeding for process.
2) Effective conversion.
3) Well-controlled combustion.

For our experiment, we took Polypropylene and polyethylene as the raw material for the following reasons and factors.

a) One of major factor to consider PP and PE is the carbon footprint.
b) The carbon footprint of PE is almost about 6 kg CO_2 / kg of plastic.
c) PE is abundantly used in Plastic bags, plastic bottles and PP is abundantly used in food containers so raw material is easy to get.
d) PE fuel has more calorific value than all fuels.

As a result we preferred Polyethylene and Polypropylene over and other polymers.

B. Waste Plastic to Pyrolysis Oil

1) Thermal Pyrolysis: The basic plastic waste preferred for Pyrolysis is Polyethylene Terephthalate (PET) bottles or Polyethene (PE) bags which are cleaned and shredded into small pieces. This helps to easily melt the plastic and to form hydro-carbons in the form of liquid state or gaseous state depending on the output required.

The second and the important step among them is the Pyrolysis process. This process requires a setup with some equipment's, the equipment's required are as follows,

a) A metal container.
b) A condenser.
c) A vessel to store the fuel.

The metal container which will be used should withstand high temperature as the pyrolysis process starts at 450 ^{0}C. The metal container should be provided with suitable heat source, the heat source should be good enough to attend high temperature in very short time as all the above conditions are satisfied, the cleaned and shredded plastic waste are transferred inside the container for further process.

As the Cleaned and Shredded plastic waste is transferred into the container, the container is then heated by the preferable source of heat in the absence of oxygen. When the waste plastic is burnt in the absence of oxygen it will not catch fire, instead it will burn and forms gaseous state. From the container the gaseous fuel is then sent to condenser to cool down the temperature, when the temperature cools down the gaseous state changes to liquid state which is partial fuel.

After the extraction of partial fuel from waste plastic the fuel is then sent to the container where distillation process takes place. Distillation process is done because the partial fuel which we get after pyrolysis process does not have similar properties as Diesel or Gasoline, to get the properties of the fuel approximate similar to Diesel or Gasoline this process is done. In this process the partial fuel which we get again undergoes heating at lower temperature compared to pyrolysis process.
At last the fuel produced from the container after distillation process is contained in a Vessel for storage. This vessel can be of any material.

Jerome et al. 2019 has a give following comparison :

Sl.No.	Specifications	Regular Petrol	Waste Plastic Fuel
1.	Flash Point	23	22
2.	Pour Point	< -20 ^{0}C	< -20 ^{0}C
3.	Cloud Point	< -20 ^{0}C	< -20 ^{0}C
4.	Octane Rating	83	95

Table 2. Comparison between regular petrol and waste plastic fuel

Sl. No.	Property	PPO700	PPO900	Diesel
1.	Density@ 150C(kg/l)	0.927	0.9813	0.8398
2.	Kinematic Viscosity@ 40 0C	2.9	1.918	2.62
3.	Aromatic Content (%)	53	65.5	29.5

Table 3. Comparison between regular diesel and PPO (polypropylene pyrolysied oil at 700 & 9000C

Jerome et al. 2019 has concluded that the use of plastic pyrolysis oil in diesel engine with respect to technical and economical is compared and found that oil is able to replace the diesel oil. In spite of the fact that the plastic pyrolysis oil offers lower motor execution, the plastic waste sum is huge and it should have been procedure to decrease the natural issues. Additionally, the motor can be alter follow the burning state of plastic pyrolysis oil. The waste plastic used in the process must be PE or PET in order to protect the contamination of chlorine in the oil.

2) *Catalytic Pyrolysis:* So as to advance plastic pyrolysis responses and change the appropriation of pyrolysis items, impetuses are broadly utilized in look into and mechanical pyrolysis forms. Some catalysts are applied specifically to reduce the unsaturated hydrocarbons and promote the yield of aromatics and naphthenes which are sources of petroleum products. This can significantly increase the stability, cetane and octane number according to requirement of the oil products. Moreover, it is reported that Activation energy (E_a) measured in the PE pyrolysis with catalysts (such as HZSM-5, HY, and MCM-41) were much lower than those when no catalyst was added. Catalytic pyrolysis using an In suit process mode occurs in single reactor where feedstock and catalyst are mixed thoroughly. Primary pyrolysis vapour almost instantly diffuse into catalyst pores where they are catalytically cracked.

C. Different Types of Catalyst used in Catalytic Pyrolysis

A wide range of catalysts have been employed in plastic pyrolysis processes, but the most extensively used catalysts are HZSM-5, ZSM-5, zeolite, Y-zeolite, modified natural zeolite(NZ), and MCM-41 all are heterogeneous catalyst and these dissimilar catalyst used for different type as well as dissimilar characteristic of pyrolysied oil. Many of the scientist/professor almost from 1993 conducted test on catalyst cracking using several solid acid catalysts such as HY, REY-Zeolite, HZSM-5 zeolite and silica-alumina

(SA). Songip et al. examined the transformation of polyethylene to transportation fuel utilizing HY, uncommon earth metal traded Y-type (REY), and HZSM-5 zeolites and silicaalumina (SA). It was discovered that REY zeolite was the most reasonable impetus delivering plastic oil with the most elevated octane number and fuel yield. REY had huge pores and had appropriate acidic quality which made it the most reasonable one.

Y zeolite and ZSM-5 zeolite produced oils having a high research octane number comparable to that of the oil by REY zeolite, but the gasoline yield by the Y zeolite and ZSM-5 was significantly low as compared to REY zeolite. Although Marcilla in 2003 proposed that catalytic pyrolysis of LDPE (low density polyethylene) and HDPE (high density polyethylene) plastic waste with HZSM-5 catalyst in a batch reactor and observed that the yield and composition of the products depends on the type of polyethylene used. HDPE gave higher N-paraffin's and iso-paraffin's while LDPE gave higher olefins at lower temperatures.

AchyutK.Pandaet al. 2013 conducted catalytic pyrolysis using kaoline and silica alumina as catalysts. Yield up to 91% was acquired and silica alumina was discovered better when contrasted with kaolin in fluid yield.

Hazrat al. has found the mixture of LDPE, HDPE, PP and PS with catalyst ZnO 20% wt ratio in steel bench top reactor at temperature about 200-400^{0}C gives 87.18% yield. During the process of catalytic pyrolysis a continuous liquid distillation process occurs and it can reduce the formation of gas in the liquid yield.

Farhat Ali et al. were found that the PS material with ZSM-5 catalyst produced higher yield of 91.5% of pyrolysed oil at 430^{0}C temperature, where as the result of mixed plastic material (HDPE, LDPE, PS and PP) with ZSM-5 catalyst gives the better result of 78.5% oil yield compared to other single material like HDPE, LDPE and PP. Lin et al. (2004) used different kinds of catalysts and reported even mixing of HZSM-5 with mesoporous SiO_2-Al_2O_3 or MCM-41 which leads to the maximum production of liquid oil with minimal gas production.

Aguado et al. (1997) reported the production of aeromatics and aliphatic compounds from the catalytic pyrolysis process of PE with HZSM-5, while the use of mesoporous MCM-41 decrease the aeromatic compounds produced due to its low acid catalytic activity. The utilization of manufactured impetuses upgraded the general pyrolysis process and improved the nature of created fluid oil. Be that as it may, the utilization of engineered impetus expanded the expense of the pyrolysis procedure.

The NZ (Natural Zeolite) catalysts can be used to overcome the economic challenges of catalytic pyrolysis which comes with the use of expensive catalysts. In recent years, NZ has gained significant attention for its potential environmental application. Naturally, NZ is found in Japan, USA, Cuba, Indonesia, Hungary, Italy and the Kingdom of Saudi Arabia (KSA). The deposits of KSA mostly lies in Harrat Shama and Jabbal Shama and mainly contain minerals of mordenite with high thermal stability, making it suitable as a catalyst in plastic waste pyrolysis.

Several modification of NZ from Sukabumi Indonesia by depositing transitional metals such as Ni, Co, Mo and carried out pyrolysis of low density polyethylene (LDPE). Saudi natural zeolite catalyst was modified via novel thermal activation (TA-NZ) at 550^{0}C and acid activation (AA-NZ) with HNO_3 to enhance its catalytic properties.

D. Conclusion

It has been observed that different catalyst used for pyrolysis has limitations such as some has gasoline yield only(by Sonpig et al), others have less yield(by Farhat et al). if yield increase, then cost increases. In order to obtain both economical and technical convenience, it is very obvious to use the catalyst which has prominent yield. For instance, Achyut k used kaolin as catalyst and has achieved the yield as 91%. Also, the removal of dioxin and furan toxic gases, which are carcinogen in nature, it is necessary to opt for economical yet best catalyst that can give us satisfactory result.

III.CONCLUSIONS

The rapid growth of industrialization and urbanization lead use of plastic has been extensively increased, and the problem has emerged as global concern since the per capita consumption of plastic has been increasing extensively. It is obvious to deplete rate of plastic in order to maintain sustainable environment.

Also the concern of reducing the fossil fuel is immense. It is important to produce fuel oil to fulfill energy requirements. Thus, scientists and researcher are working to find the solution which can deplete the plastic as well as produce some useful fuel. Since, plastics are made up of hydrocarbon, it is easy to make fuel by cracking, but production of toxic gases and carcinogen nature has limited its use.

The cracking with little modification can be used to yield fuel oil with commercial grade. Some other way by which the high yield can be obtained by lowering temperature.

IV. FUTURE SCOPE

A. The venture gives some light on the chance of assembling fluid powers which could be utilized as feed stock processing plant for additional adjustment or business use.
B. By utilizing this innovation we could take care of the waste plastic issue and furthermore fundamentally decrease the landfills- which are the reason for fruitlessness of Agriculture land.
C. Squander plastics can likewise turn into a generally excellent wellspring of vitality and an option in contrast to petroleum derivative which have caused a domain irregularity.
D. The fuel must be refined at the mechanical foundations, in light of the consequences of which little scope industry can be set up.
E. As there is an appeal of unrefined petoleum and because of its sky arriving at costs, we could take up this task to arrangement huge or then again little scope enterprises and produce the fuel locally at a lot less expensive rates legitimately profiting the National economy and furthermore a stage towards 'SWAACH BHARAT' by reusing the waste plastic.
F. The use of this venture could help in diminishing the reliance on the inlet nations and advance a stage towards advancement.

It could likewise be valuable for family purposes, as LPG it could likewise be condensed into gas and can be utilized with some impetus or mixing.

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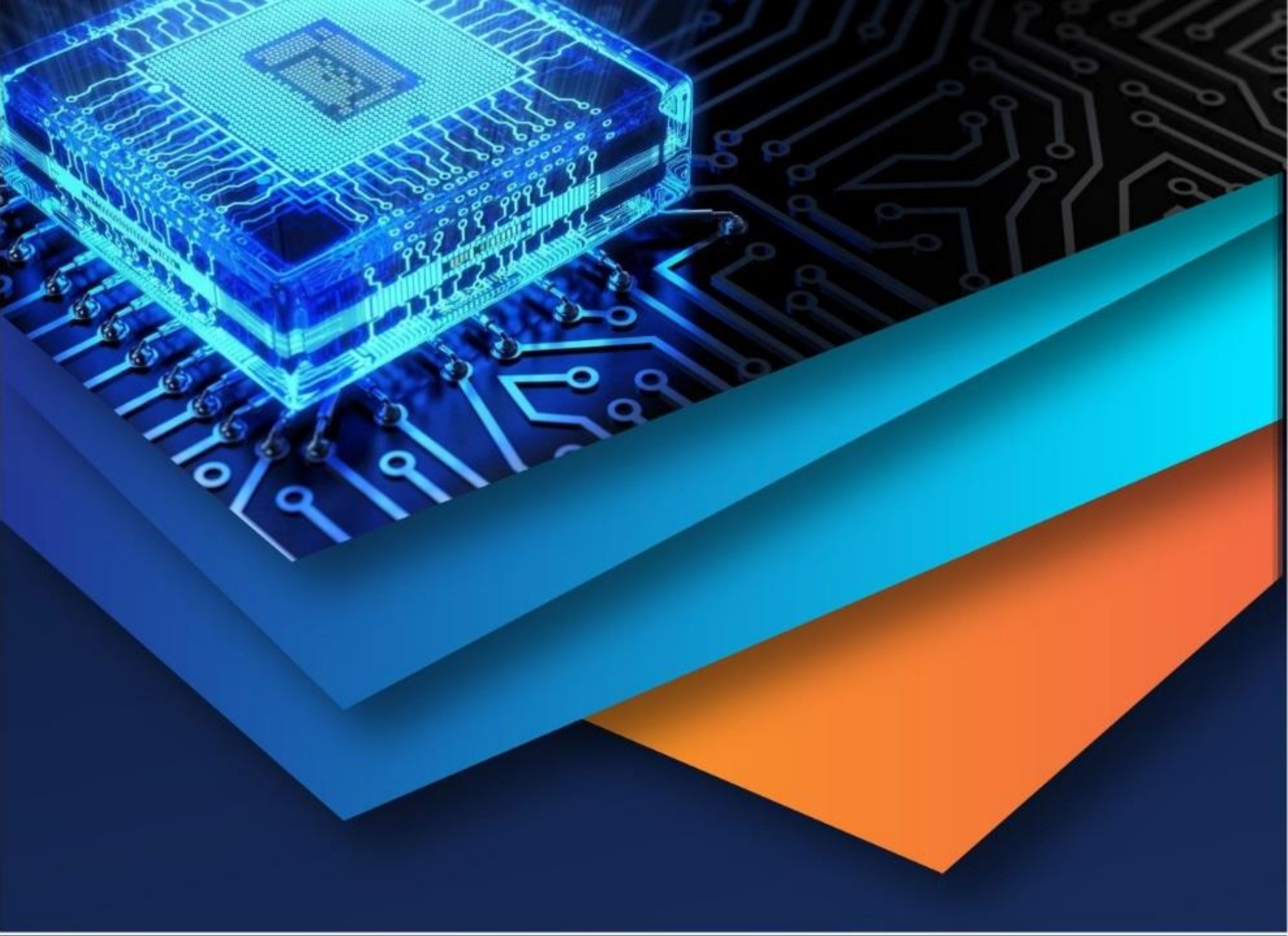

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