Conversion of plastics into fuels

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ABSTRACT

Polymers are finding extensive application in our day to day life. The low density, high strength to weight ratio, ease of processing etc. make them attractive over other conventional materials. The various fields of applications of polymers include different sectors such as structural and non-structural, automobile, medical, aerospace etc. Extensive use results in accumulation of waste plastics. The safe disposal of waste plastics is a major problem faced by the polymer industry. The combustion of polymers can release so many toxic gases to the atmosphere and can lead to major environmental hazards. Since crude oil is the starting material for the production of plastic, the reverse processing of plastic back to crude oil is an innovative method for better disposal of plastics. Waste plastics are heated in a reactor at a temperature of about 350- 450 degree centigrade provided with an inert atmosphere.

The waste plastics used include Polyethylene, Polypropene and Polystyrene .The long chain molecules of these plastics is first broken into shorter chain molecules in the reactor and then broken into small molecules in the catalytic cracker. The final product is mixed oil that consists of gasoline, diesel oil, kerosene and the like. The machine and process for making oil are totally based on environment-friendly concept. Plastics suitable for converting into oil are PP (Garbage bag, cookie bag, CD case, etc.), PE (Vinyl bag, medical product, cap of PET bottle etc.) and PS (Cup Noodle Bowl, lunch box, Styrofoam etc.)

1. Introduction

Plastics have become an indispensable part of today's world. Due to their light weight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas. Plastics are non-biodegradable polymers of mostly containing carbon, hydrogen, and few other elements such as chlorine, nitrogen etc. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of Municipal Waste Management1. In our country, only 60% of waste plastic is recycled, balanced 40% was not possible to dispose off plastics.

Fig.1:Waste Plastic in river

The plastics industry is in constant development, with technology evolving in response to ever-changing demand. Some trends that emerge clearly are continued innovation and improvements such as weight reduction of individual items, increasing use of plastics (and bioplastics) in vehicle manufacturing, a shift in primary plastic production to transition and emerging economies, and continued growth in the market share of bioplastics (despite some sorting and price barriers). Societies are increasingly reliant on plastics, which are already a ubiquitous part of everyday life. As the development of new materials is ongoing, limiting their detrimental effects poses new challenges for policy makers 9. Regulatory instruments designed to mitigate the effects of plastics on human health and the environment must evolve in line with trends in production, use and disposal

1.1 Need for concern:-

The increasing quantities of plastics waste and their effective safe disposal has become a matter of public concern. The increasingly visible consequences of Indiscriminate littering of plastics wastes (in particular plastic packaging wastes and discarded bags) has simulated public outery and shaped policy 13. Littering also results in secondary problems such as drain becoming clogged and animal health problems (both domesticated and wild).As a consequence, many big cities (e.g. Mumbai, Bangalore) and some of the states (e.g. Delhi, Uttar Pradesh) have already banned the use of thin plastic bags. The consumption of plastics will increase about six-fold between 2000 and 2030.The share of ployolethins in India will remain at about 60%, a percentage comparable to that of Western Europe7.

Literature review

The recovery and recycling of plastic waste disposed of in landfill has been the subject of effort over in the decades, if it is seen as valuable resource and is high in public's perception on what waste that is. Progress had been made of the mechanical recycling on post-commercial, industrial and pre-sorted post-consumer waste, often the recovery of value to low-grade mixed plastic waste plastics had always presented technical and economic difficulties. The conversion on plastic into oil products requires the long polymer chains that are characteristic of plastics to be broken into shorter chains typical of compounds present in crude petroleum. This depolymerisation to be achieved on heating the materials for moderate or high temperatures, and zeolite 10

3. Plastic:

As a brief introduction to plastics, it can be said that plastics are synthetic organic materials produced by polymerization. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance and/or reduce costs. These polymers can be moulded or extruded into desired shapes. Monomers of Plastic are either natural or synthetic organic compounds it is polymers of mixing several elements with strong and elastic compond .

Thermosets or thermosettings can melt and take shape only once. They are not suitable for repeated heat treatments; therefore after they have solidified, they stay solid. Examples are phenol formaldehyde and urea formaldehyde 6.

3.1 Common uses of plastics

Polypropylene (PP)
Food containers, appliances, car fenders (bumpers), plastic pressure pipe systems.
Polystyrene (PS)
Packaging foam, food containers, disposable cups, plates, cutlery, CD and cassette boxes.
Polyethylene terephthalate (PET)
Carbonated drinks bottles, jars, plastic film, microwavable packaging.
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Polyvinyl chloride (PVC)
Plumbing pipes and guttering, shower curtains, window frames, flooring.
Polyurethanes (PU)
Polyvinylidene chloride (PVDC) (Saran)
Food packaging.
Polyethylene (PE)
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3.2 Plastic identification code

Symbol	Acronym	Full name and uses
1	PET	Polyethylene terephthalate - Fizzy drink bottles and frozen ready meal packages.
2	HDPE	High-density polyethylene - Milk and washing-up liquid bottles
3	PVC	Polyvinyl chloride - Food trays, cling film, bottles for squash, mineral water and shampoo.
4	LDPE	Low density polyethylene - Carrier bags and bin liners.
5	PP	Polypropylene - Margarine tubs, microwave-able meal trays.
6	PS	Polystyrene - Yoghurt pots, foam meat or fish trays, hamburger boxes and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.
7	Other	Any other plastics that do not fall into any of the above categories. For example melamine, often used in plastic plates and cups.

3.3 Plastic waste recycling:

Plastics are durable and degrade very slowly; the molecular bonds that make plastic so durable make it equally resistant to natural processes of degradation 13. Since the 1950s, one billion tons of plastic has been discarded and may persist for hundreds or even thousands of years. In some cases, burning plastic can release toxic fumes. Burning the plastic polyvinyl chloride (PVC) may create dioxin. Also, the manufacturing of plastics often creates large quantities of chemical pollutants. By 1995, plastic recycling programs were common in the United States and elsewhere 2. Thermoplastic wastes can be recycled (remelted and reused). Recycling of thermosetting materials is more difficult because of the properties of these materials, but they are recycled as fuel and are used sometimes, by grinding, as fillers in the new thermosetting materials. For example, large volumes of tyres from cars, bicycles and tricycles, find application as materials for calorific utilization. In contrast to siting of new landfills or incinerators facilities, recycling tends to be a politically popular alternatives for the most part. At industrial scrap level, recycling of plastics grew rapidly after the increase in oil prices of themed 1970s and it now occupies a common place 9.

Plastic recycling requires information in following three areas:
Collection and Separation of plastic wastes
Reprocessing technology
Economic viability of the recycled products
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4. Experimental Description

The process is really simple, it is similar to how alcohol is made. The waste plastic is sorted on the physical properties such as hardness, softness, films etc. Size reduction is carried out using shredder and graded to uniform size. The graded feed is mixed with catalyst and fed into the container and an oxygen free chamber is created by using a vacuum pump. Then it is heated up to a temperature of about 400ºC by using an electric heater, then it will melt, but will not burn. After it has melted, it will start to boil and evaporate, we need to put those vapors .it has a release valve on the bottom so that the liquid fuel can be poured out 14 .

4.1 Experimental setup:-

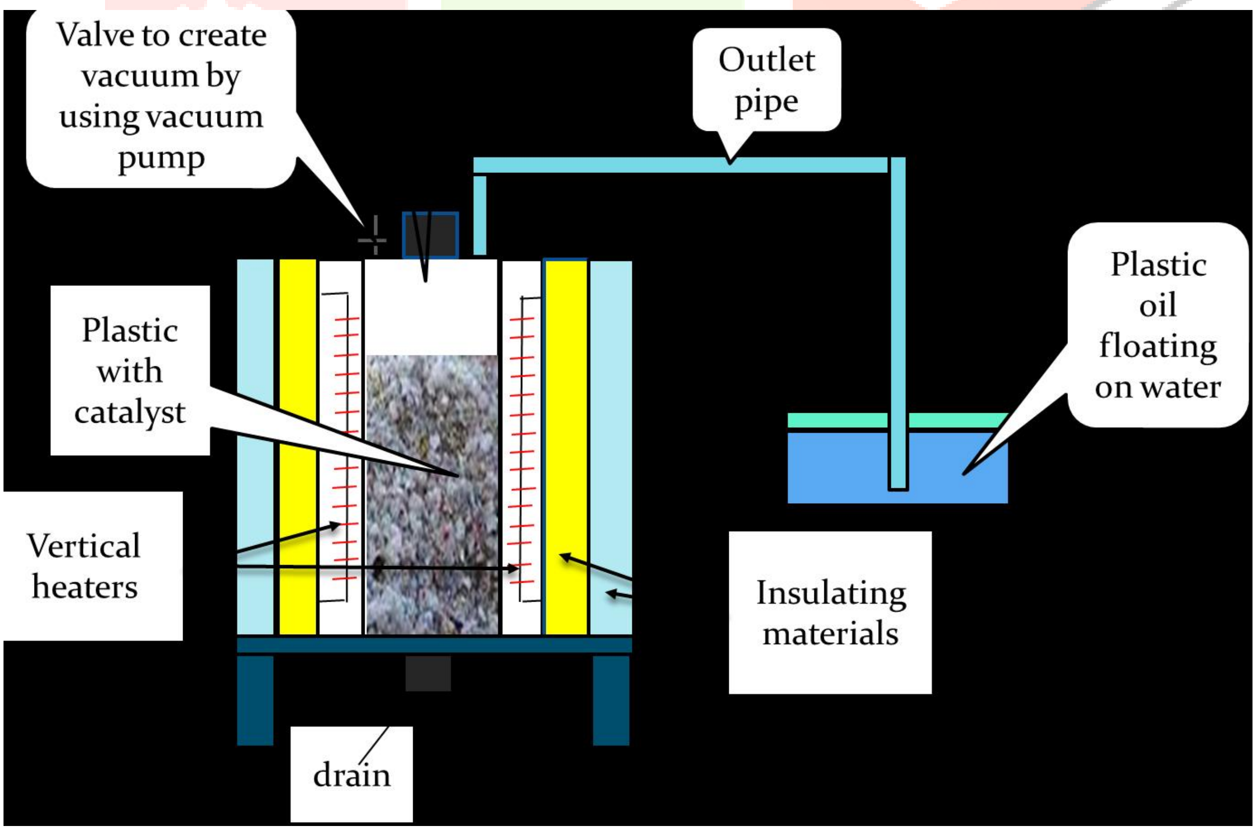


Fig.2 Fabricated Model
Fig.3: Diagrammatic representation of each part

As shown in the above figure we have placed shredded plastic with catalyst into the container. Then we have closed the inner container with the dummy. We have connected the vacuum pump to the valve provided beside the inlet. By switching on the pump we have extracted the air from the inner cylinder. After this we have closed the vacuum so that again air should not enter into the container. The container starts heated up by the electric heaters which is placed in between inner and outer cylinder. Around 450 degree centigrade plastic starts melting and evaporates. The evaporated vapour is allowed to pass through the cold water so that to convert hot vapour to liquid. This is known as condensation. This liquid is the final output.

4.2 Fabrication Details:

4.2.1 Inner Cylinder:-

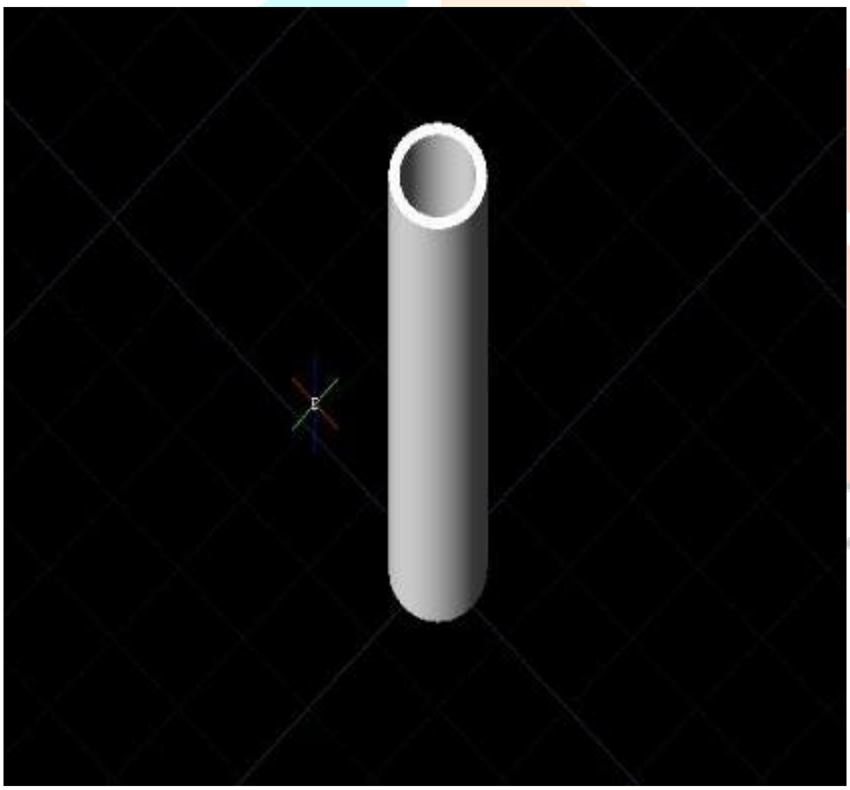
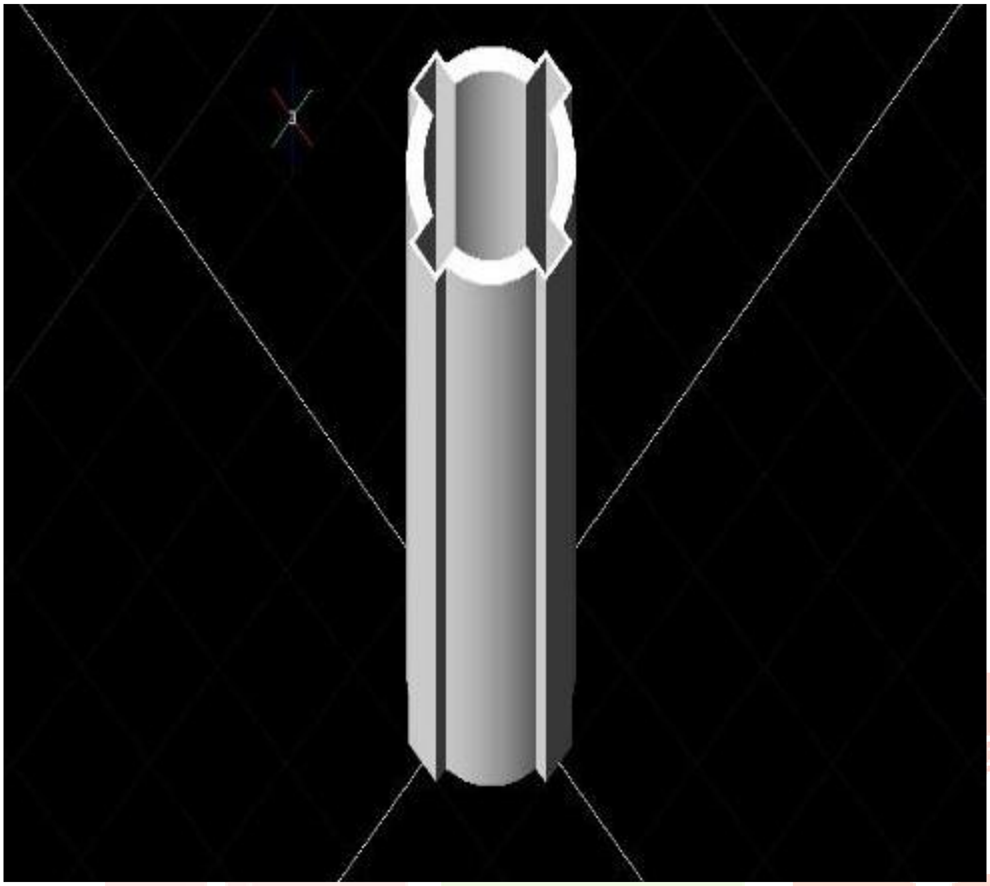


fig.4: Auto Cad model of inner cylinder

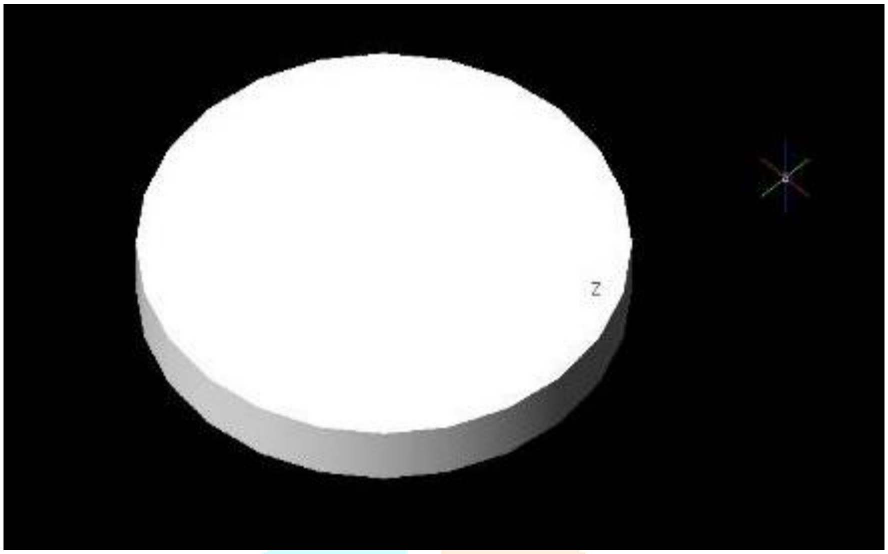
Material :Mild Steel
Diameter: 20 cm
Height : 40 cm
Thickness : 3 mm

4.2.2 Outer Cylinder:-



Material : Mild Steel
Diameter: 30 cm
Height : 40 cm
Thickness : 4 mm

4.2.3 Cylindrical Plate (Base):-



Material : Mild Steel
Diameter : 60 cm
Thickness : 3 mm

First we have placed an inner cylinder on the base plate and after that we have placed outer cylinder on it. In the outer cylinder we have provided slots so that we can put heaters between inner and outer cylinders. At the same time it will be very easy to remove heaters whenever something goes wrong like if heaters are damaged due to over load. After assembling all this, there is some space on the base plate which we used to provide insulation so that the heat can concentrate towards the inner cylinder.

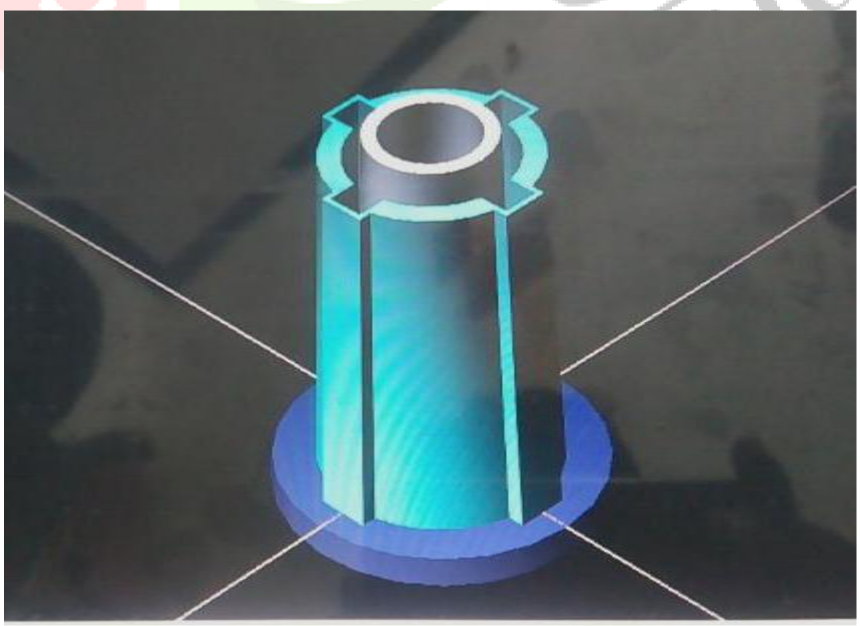


Fig.7: Auto Cad model of our device

4.3 Experimental Details:

This part deals with the principle of the machine, process carried out in the machine, pyrolysis process, catalyst that can be used.

4.3.1 Principle of the Machine:

All plastics are polymers mostly containing carbon and hydrogen and few other elements like chlorine, nitrogen, etc. Polymers are made up of small molecules, called monomers, which combine together and form large molecules, called polymers. When this long chain of polymers breaks at certain points, or when lower molecular weight fractions are formed, this is termed as degradation of polymers. This is reverse of polymerization or de-polymerization. If such breaking of long polymeric chain or scission of bonds occurs randomly, it is called Random depolymerization. Here the polymer degrades to lower molecular fragments. In the process of conversion of waste plastics into fuels, random depolymerization is carried out in a specially designed reactor in the absence of oxygen and certain catalytic additives.

4.3.3 Pyrolysis:-

Pyrolysis is a process of thermal degradation in the absence of oxygen. Plastic & Rubber waste is continuously treated in a cylindrical chamber and the pyrolytic gases are condensed in a specially-designed condenser system. This yields a hydrocarbon distillate comprising straight and branched chain aliphatic, cyclic aliphatic and aromatic hydrocarbons.pyrolysis is the process of making the plastic and rubber which is heated fastly by high temperatures

The resulting mixture is essentially the equivalent to petroleum distillate. The plastic / Rubber is pyrolised at 350-450ºC and the pyrolysis gases are condensed in a series of condensers to give a low sulphur content distillate.

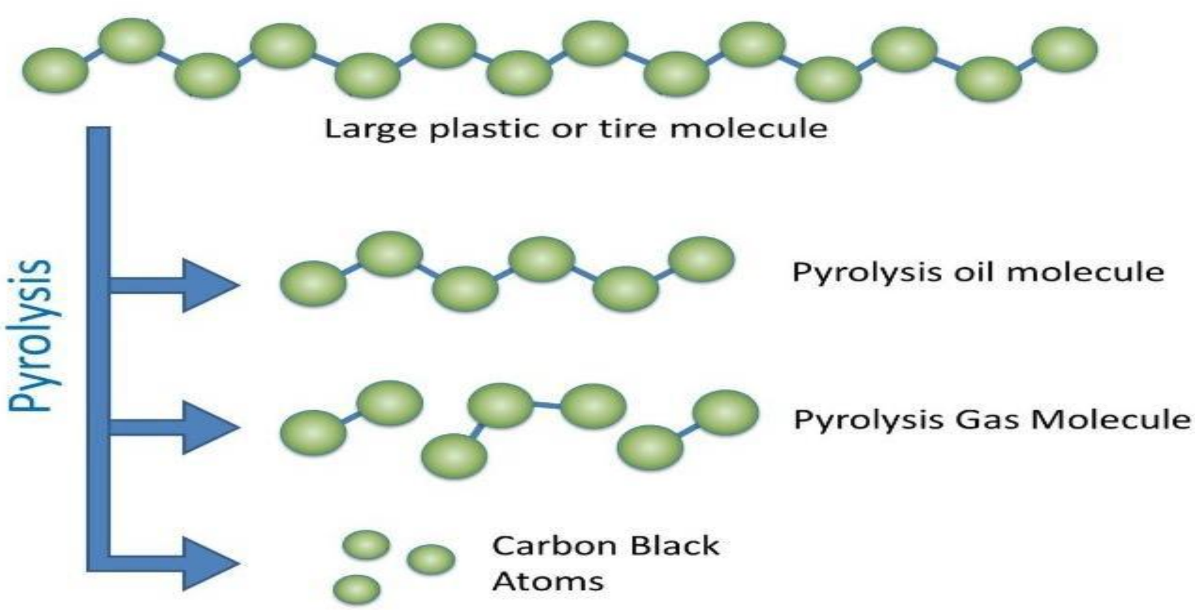


Fig.8: Pyrolysis process

4.3.4 Pyrolysis flow chart:

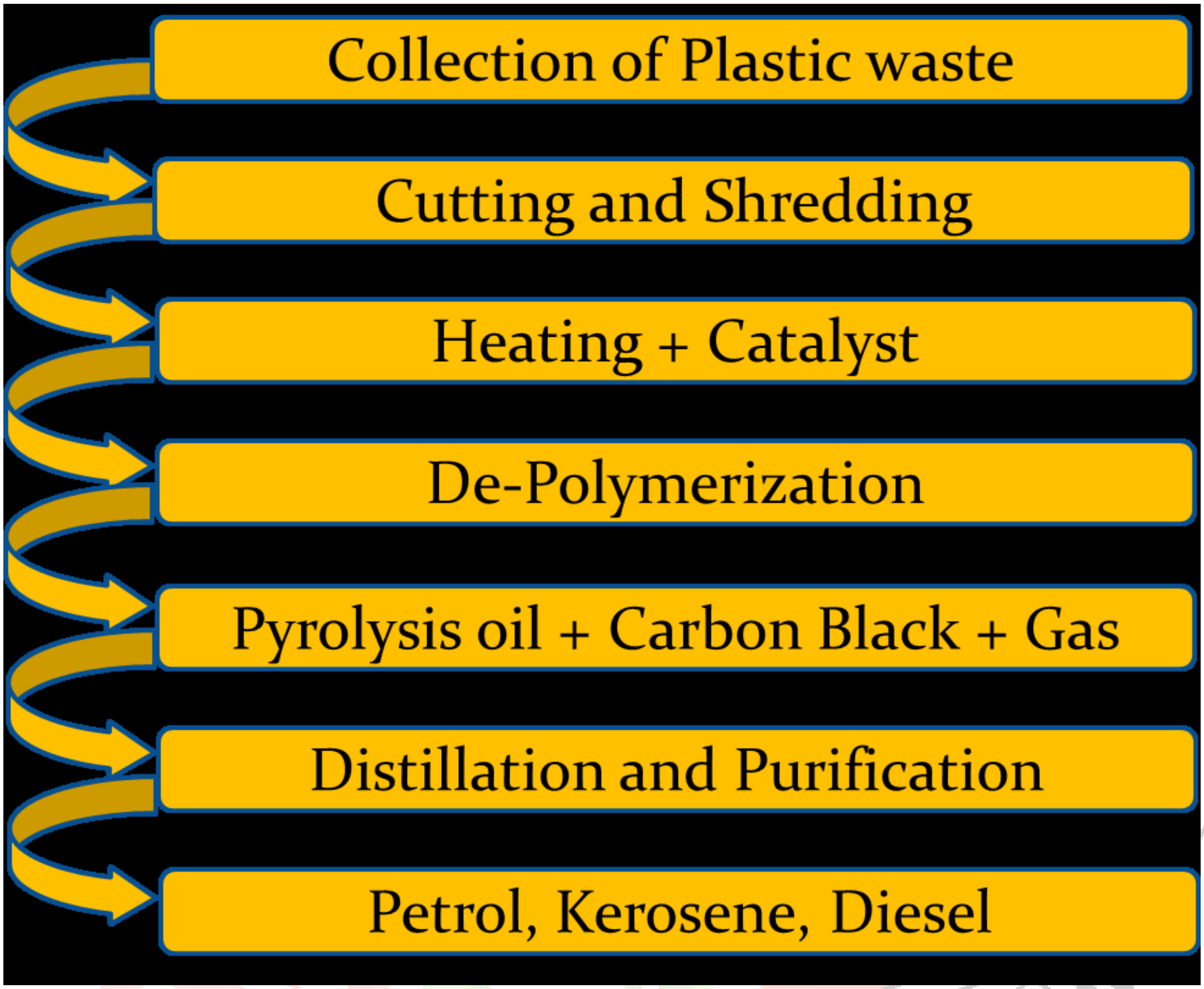


Fig.9: Pyrolysis flowchart

4.3.5 Process Description:-

The process is really simple, it is similar to how alcohol is made. The waste plastic is sorted on the physical properties such as hardness, softness, films etc. Size reduction is carried out using shredder and graded to uniform size. The graded feed is mixed with catalyst and fed into the container and an oxygen free chamber is created by using a vacuum pump. Then it is heated up to a temperature of about 400ºC by using an electric heater, then it will melt, but will not burn. After it has melted, it will start to boil and evaporate, we need to put those vapors through a cooling pipe and when cooled the vapors will condense to a liquid and some of the vapors with shorter hydrocarbon lengths will remain as a gas. The exit of the cooling pipe is then going through a bubbler containing water to capture the last liquid forms of fuel. If the cooling of the cooling tube is sufficient, there will be no fuel in the bubbler, but if not, the water will capture all the remaining fuel that will float above the water and can be poured off the water. On the bottom it has a release valve on the bottom so that the liquid fuel can be poured out.

Fig.10: Waste plastic inside the cylinder

4.4 Catalyst:-

Features of Catalyst to be used:
Catalyst which is more selective to octanes
Catalyst which possess limited deactivation by coke
Coke is deposited on catalyst when vapors passes through them which may cause catalyst deactivation
Catalyst which possess high thermal stability
Vapors at high temperature is passing through the catalyst which will affect its Stability. Catalyst that can be used are

4.4.1 Kaolin:-

Kaolinite is a clay mineral, part of the group of industrial minerals, with the chemical compositionAl2Si2O5(OH)4. Rocks that are rich in kaolinite are known as kaolin or china clay.

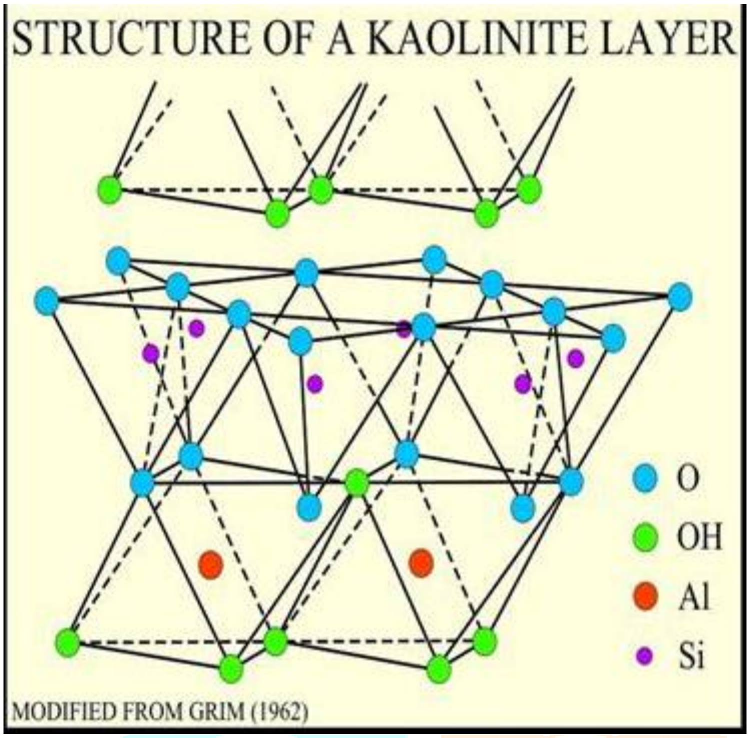
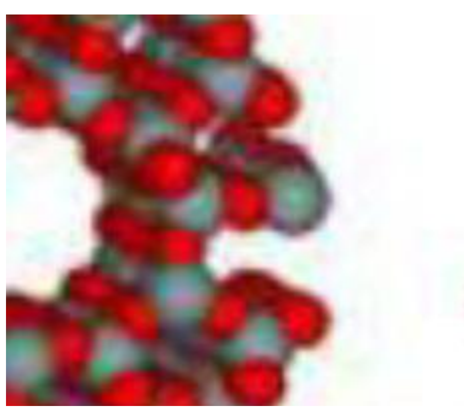


Fig.11: Kaolin structure

When kaolin is mixed with water in the range of 20 to 35 percent, it becomes plastic (i.e., it can be molded under pressure), and the shape is retained after the pressure is removed. With larger percentages of water, the kaolin forms a slurry, or watery suspension. The amount of water required to achieve plasticity and viscosity varies with the size of the kaolinite particles and also with certain chemicals that may be present in the kaolin.

4.4.2 Zeolite:- ZSM-5

Zeolites have a porous structure that can accommodate a wide variety of cations, such as Na+, K+, Ca2+, Mg2+ and others. These positive ions are rather loosely held and can readily be exchanged for others in a contact solution.



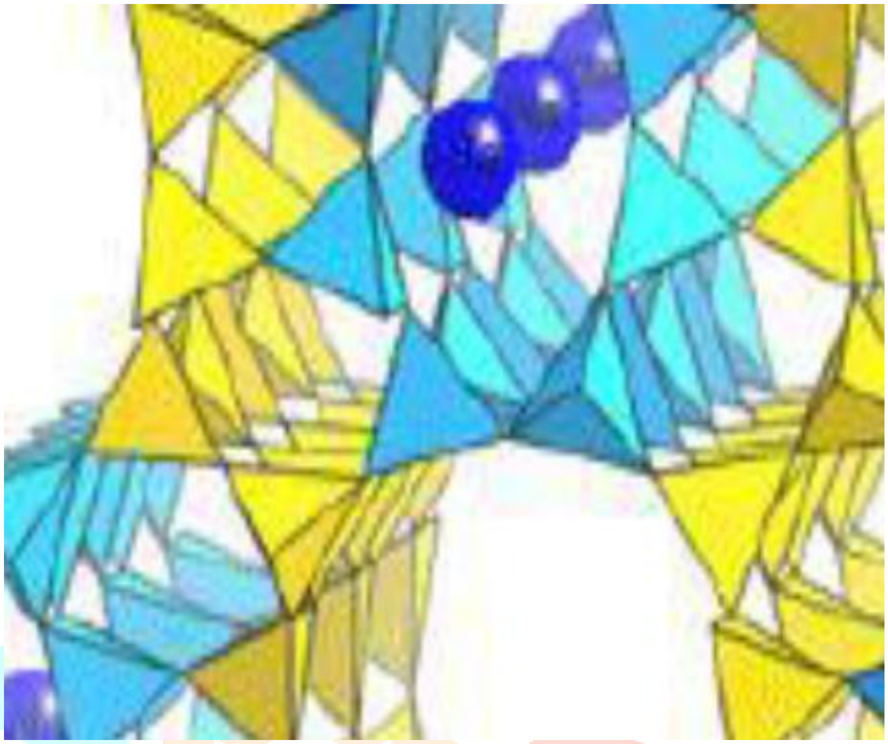


Fig .12 Zeolite structure

5 Materials used for fabrication

The following are the components are used in the project:
Insulators
Condenser
Containers
Pipes
Heater

5.1 Insulators:-

The heat that the material can withstand is:
Material
Temperature
Glass wool
230 - 260°C
Fiber glass wool
1200°C

5.1.1 Glass wool:-

Glass wool is thermal and acoustic insulation used around the world in homes, commercial and industrial buildings, vehicles and white goods.
. It consists of intertwined and flexible glass fibers, which causes it to "package" air, resulting in a low density.

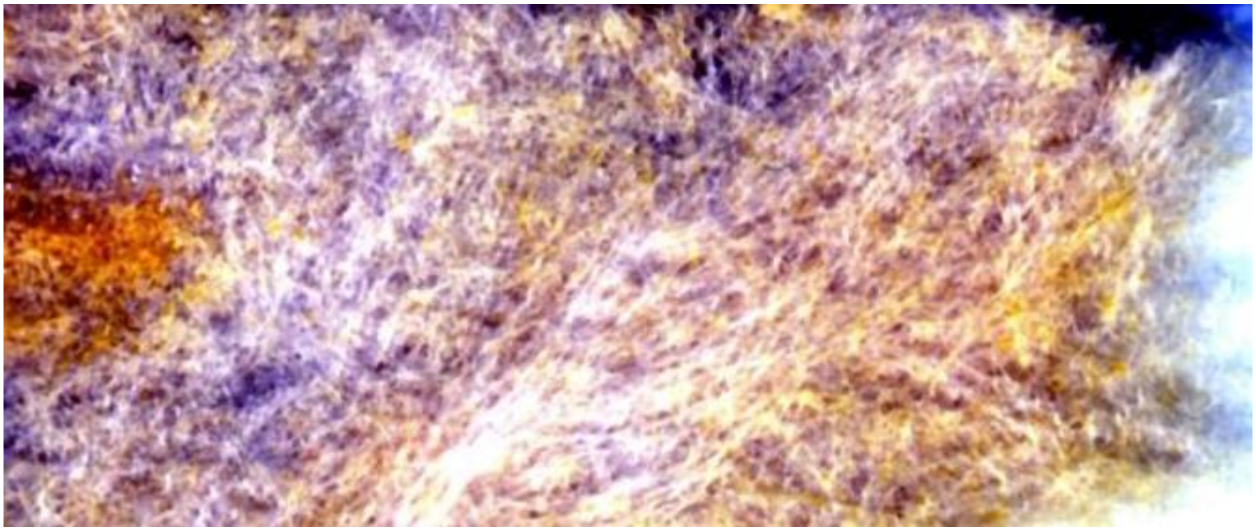


Fig.13: glass wool

5.1.2 Fiber glass Insulation:-

Fiber glass is a composite plastic reinforced by extremely fine glass fibers, making it very strong and flexible. It is an insulating material made from fibers of glass arranged into a texture similar to wool. Fiberglass is the most common type of insulation. It's made from molten glass spun into microfibers. It is often used to make yachts, canoes and light-weight vehicles.

Fig.14: fiber glass wool

5.2 Heater:-

An electric heater is an electrical equipment that converts electric current to heat by means of resistors that emit radiant energy. .

Fig.15: electric heater without fins

5.3 Containers:

used:

GI sheet
Mild sheet
Stainless steel

5.3.1 Galvanized Plain Sheets:-

Fig.16: Galvanized plain sheet

5.3.2 Mild Steel Sheets.

Fig.17: Mild Steel sheet

5.3.3 Stainless Steel Sheets:-

Stainless Steel Sheet is the most cost effective of the steel sheets. These types of sheets show excellent resistance against chemicals, marine environment and industrial effects. There are wide applications of these sheets that include dairy, sanitary, product handling and processing, beverage and food, marine hardware, hospital equipment, back splashes and kitchen appliances.

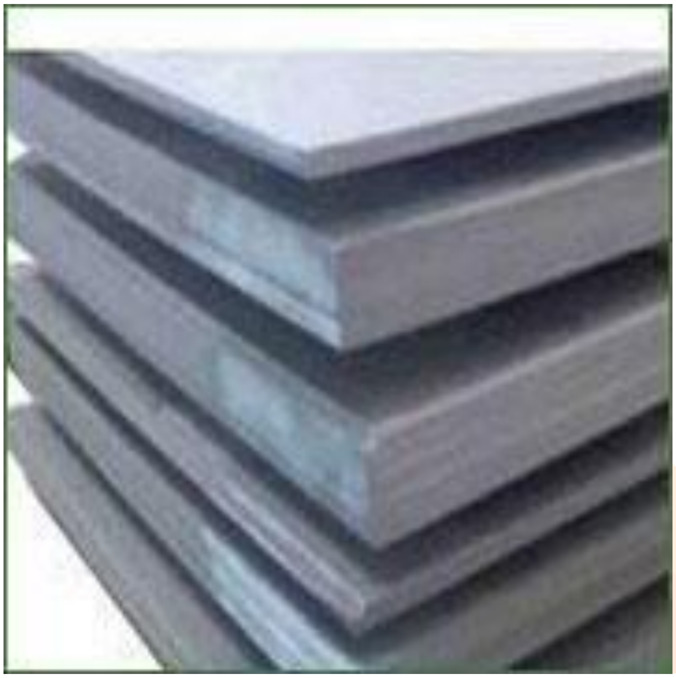


Fig.18: Stainless steel sheet

Stainless steel sheet From this three we have chosen mild steel for our container as it has high ductile nature and can withstand up to a high temperature.

5.4 Pipes:-

Here, we used stainless steel pipes of ½ inch diameter. Connected at outlet of the setup. The pipes are joined by adaptors and elbow couplings and they are made tightly sealed. So that no gases or vapors can escape from the pipes. A valve is also connected to the vacuum creation pipe to open and close when the vacuum pump is in operation.

Fig.19: Pipes

5.5 Condenser:-

A condenser is a piece of laboratory glassware used to cool hot vapors or liquids. A condenser usually consists of a large tube within which the hot fluids and vapours pass. Condensers are used in distillation to cool the hot vapors, condensing them into liquid for separate collection.

Here we used copper pipe as a condenser, the vapours from the melted plastic enters the condenser and get condensed by the atmospheric cooling

Fig.20: Condenser pipe

6. Results and Discussions:

This system will produce three outputs: natural gas, the fuel product and char. Some of the systems produce a gasoline-diesel fuel blend that needs further refining. Some generate a product similar to crude oil that needs to be refined, but can become a variety of products and other produce diesel fuel ready for use in vehicles. The char can be a powdery residue or substance that is more like sludge with a heavy oil component.

Fuel yield estimates will be different for each system, and each technology manufacturer notes that yields will vary from batch to batch depending on the quality of the feed contamination and non-resin materials present, the less the fuel yield will be.

Higher presence of PS, PP and PE, the higher and the yield will also be.

Plastic fuel floating on the surface of water

Fig: 21:Output fuel

7. ADVANTAGES OF THE PROCESS

- Resultant fuels are of high quality
- Health hazards and safety problems reduced to 90% as compared to regular refinery process
- Problem of disposal of waste plastic is solved.
- Waste plastic is converted into high value fuels.
- Environmental pollution is controlled.
- Industrial and automobile fuel requirement shall be fulfilled to some extent at lower price.
- No pollutants are created during cracking of plastics.
- The crude oil and the gas can be used for generation of electricity.

If we carried out this process with catalyst the following results can be improved
Calorific value will increase
Acid value will decrease
Viscosity will decrease
Density and specific gravity will decrease
Lastly, the model that we had fabricated is not that much economical so further studies are required in future for economic improvement. Though the processing cost is high it decreases the pollution and global warming created by plastics

8. Conclusion:

Cost for the fuel is increasing day by day and also the problem arising due to the improper waste disposal of plastics are increasing in our country. This plastic to fuel machine can solve both these problem in the most efficient manner. Thus this project is done because usage of plastics is high and there is no proper disposal for it and results in causing pollution and Global warming to the Environment. The main theme of the project is to dispose the waste plastics in a proper manner without getting any harmful gases from it, that effect to the ENVIRONMENTAL ASPECTS. The another advantage of the project that the byproduct obtained by disposed plastics can be used as fuel without emitting any harmful gases.

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