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# "Thermo Fuel from Waste Plastic"

**Rajeshwari Nikam[1], Mansi Bhole [2], Pournima Bhosale [3], Trupti Shinde[4], Prof. Arun Kumar Battu[5]**

*[1234] Students,[5] Professor, Department of Mechanical Engineering, Dr. D. Y. Patil College of Engineering, Pune*

## Abstract

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***Keywords**:* Plastics, Unrecyclable, Municipal solid waste management, Pyrolysis, Sludge

## 1. Introduction

Plastic could be a high mass weight material that was invented by Alexander Parkes in 1862. Plastics also are called polymers. The term polymer means a molecule made up by repetition of easy simple unit. For example, the structure of polystyrene can be written in a form as shown in Figure 1.1 or in Figure 1.2.

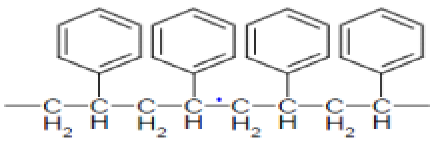

**Fig. 1.1** Common expression of polystyrene molecular structure

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The repeating unit of the polymer is within the brackets with a subscript, n, to represent the number of the unit during this polymer molecule. Plastic is one among the foremost commonly used materials in lifestyle which might be classified in many ways like supported its chemical structure, synthesis process, density, another property. So as to help recycling of the waste plastic, Society of Plastic. Industry (SPI) defined a resin identification code system that divides plastics into the following seven groups based on the chemical structure and applications:

1. PET (Polyethylene Terephthalate)
2. HDPE (High Density Polyethylene)
3. PVC (Polyvinyl Chloride)
4. LDPE (Low Density Polyethylene)
5. PP (Polypropylene)
6. PS (Polystyrene)
7. Other

The above seven types of plastics are marked on various plastic products as follows:


**Fig. 1.2** Marks of seven types of plastics on various plastic products

The process is actually simple; it's almost like how alcohol is created. If you warmth plastic waste in non-oxygen environment, it'll melt, but will not burn. After it's has melted, it'll start to boil and evaporate, you only must to put those vapours through a cooling pipe and when cooled the vapours will condense to a liquid and a few of the vapours with shorter hydrocarbon lengths will remain as a gas. The exit of the cooling pipe is then probing a bubbler containing water to capture the last liquid sorts of fuel and leave only gas that is then burned. If the cooling of the cooling tube is sufficient, there'll be no fuel within the bubbler, but if not, the water will capture all the remaining fuel which will float above the water and might be poured off the water. On the underside of the cooling tube may be a steel reservoir that collects all the liquid and it has a release valve on the underside in order that the liquid fuel can be poured out. This device works on electricity (3 phase), it's has six nichrome coils as heating elements and consumes a complete of 6kW (1kW each coil). The coils are turned on and off by three solid state relays, one for every phase, the relays are controlled by a digital thermostat with a temperature sensor just a touch below the lid, in order that the vapor temperature can be monitored. You wish to heat the plastic slowly to about 350 degrees and just wait till it does the magic. Our device incorporates a capacity of 50 litres and may hold about 30 kg of shredded plastic. The method takes about 4 hours, but it can be shortened considerably by tweaking the look a touch. As said, this makes a liquid fuel which will be used as

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multifuel, that means it will be used on diesel engines and also on gasoline engines, but we still need to test it'll work on gasoline. It works for diesel engines just fine, that has already been tested. There is a difference in what plastic you employ, if you employ polyethylene (plastic cans, plastic foil, and every one quite flexible non break plastics) you may get out liquid fuel that may solidify because it cools into paraffin, it's still good for diesel engines as long as you employ a heated fuel tank, because it needs to be heated almost at 30 degrees Celsius to be liquid and transparent. If you do not want that, you'll be able to put the paraffin through the device for yet one more time and you may chop those hydrocarbons even smaller and half of the paraffin will turn to liquid fuel and partner will remain a paraffin, but much denser and can melt at higher temperatures, this is often the things you'll can make candles out of and it doesn't smell in any respect when burned, maybe a small amount like candles All you wish is simply filter the fuel out of solids and you good to travel and put it in your gas tank. We've got the analysis and it's almost the right diesel fraction. It has no acids or alkaline in it, like fuel from tires does. The unit in the pictures can convert about 60 kg of plastic into 60 litres of fuel in someday. Other methods of heating the reactor can be employed, electricity is simply easier to figure with and control. Some Japanese companies manufacture such devices, but their prices for this size unit is over than 100 000$, our home-made device cost us 900$ max. We use aluminium oxide bricks to insulate the warmth, they are light as foam and may be easily cut in any shape, but any quite insulator is used. The bricks make the very best costs for this device. It may also be made using liquid fuel burners to heat the reactor, this will enable to create the device self-sustainable by using about 10-15% of the produced fuel together with the produced gas. a little farm can use a device this size and make fuel for itself by converting plastic waste to fuel, farms have very much plastic waste and it's an enormous problem, a minimum of in my country. Our next goal is to create the same thing possible using biomass, every farm could then use old leaves, wet grass, saw dust and every one quite biomass and gasify it into tar like substance that can then be put through the pyrolysis device and was biodiesel. But we'll see this. With heavy consumption of fossil energy and fuels, the globe are faced with shortage of energy and environmental concerns within the near future if no other solutions are to be found. On the opposite hand, renewable energy sources and waste streams can be processed for production of energy and fuels. Pyrolysis of waste plastic is a cost-effective method to solve waste plastic problem and to supply quality liquid fuel which might have similar properties to the commonly used petroleum fuels.

**Why plastic to oil**

- It's an alternative energy investment that makes sense.
- It stimulates local economies and strengths communities.
- It creates partnership for sustainable energy production.
- It's an innovation that redefines recycling for a greener future

**1.1 Factors affecting Plastic pyrolysis**

The major factors influencing the plastic pyrolysis process and pyrolysis product molecular distribution include chemical composition of the feedstock, cracking temperature and heating rate, operation pressure, reactor type, duration time and application of catalyst.

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**1.2 Variety of reactor**

The reactor type for the plastic pyrolysis significantly influences on the warmth transfer rate, mixing of plastics with pyrolysis products, continuance and also the reflux level of she primary products. Reactors is classified into batch, semi-batch and continuous or classified supported styles of reactor bed

**1.3 Residence time**

The definition of duration time differs in various studies. In fast pyrolysis or continuous pyrolysis process, it refers to the contact time of the plastic on the hot new surface throughout the reactor. However, in slow pyrolysis and batch process, the duration time means the duration from the time when feedstock plastic start to be heated to the time when the products are removed. Longer duration time favour's further conversion of the first products thus yielding more thermal stable products such as light mass weight hydrocarbons, non-condensable petroleum gases. During a slow pyrolysis, long continuance encourages the carbonization process and produces more tar and char within the products.

**1.4 Use of catalyst**

In order to optimize plastic pyrolysis reactions and modify the distribution of pyrolysis products, catalysts are widely used in research and industrial pyrolysis processes. Petroleum fuels, like LPG, petrol, kerosene, and diesel, are hydrocarbons from C1 to C24. The PE pyrolysis products are mainly straight hydrocarbons from C1 up to C80, which contain much heavier relative molecular weight components. One among the most purposes of using catalysts is to shorten the carbon chain length of the pyrolysis products and thus to decrease the boiling point of the products. Catalysts are found to be mainly applied to PE pyrolysis because the first product from other plastics, such as PP and PS, are mainly light hydrocarbons, with similar carbon chain length to the range of economic fuels.

**1.5 Other Influencing factors**

There are variety of other factors which also affect pyrolysis process to a specific extent. For example, reactive additives like air, oxygen, or hydrogen are sometimes present in the reaction an for various purposes, which can interfere with the reactions and affect the quality of the products.

**1.5.1 Multi-factor effect on pyrolysis process**

It is difficult to directly compare the merchandise yields obtained for a specific plastic indifferent research because the operating conditions and reactors can be very different. In general pyrolysis processes, thermal degradation occurs within the initial stages of the pyrolysis with absence of oxygen. The pyrolytic products immediately after the pyrolysis accommodated solid residue, oil vapour and non-condensable gases among which the oil vapour will become liquid after cooling down. In keeping with the duration time or the heating rate during the pyrolysis process, the pyrolysis are often classified into slow carbonization, slow pyrolysis, fast pyrolysis, and flash pyrolysis

## 2. Problem Definition

Plastics became an important part in today's world thanks to its various advantages. But it's so harmful as its decomposition period is several million years. Indiscriminate littering of unskilled recycling/reprocessing and non-biodegradability of Plastic waste raises the environmental issues so to avoid this or to attenuate this the

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effective thanks to recycle the plastic is that the main concern. hence waste solid plastic is converted into thermo fuels by using various method. Indiscriminate littering of unskilled recycling/reprocessing and non-biodegradability of Plastic waste raises the subsequent environmental issues:

1. Indiscriminate dumping of plastic waste on land makes the land infertile because of its barrier properties.
2. Lead and Cadmium pigments, commonly employed in LDPE, HDPE and PP as additives are toxic and are known to leach out.
3. During polymerization process fugitive emissions are released.
4. During product manufacturing various varieties of gases are released.
5. Non-recyclable plastic wastes like multilayer, metalized pouches and other thermoset plastic poses disposal problems.
6. Sub-standard plastic carry bags, packaging films (<40µ) etc. pose problem in collection and recycling.
7. Burning of plastics generates toxic emissions like Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1, 3-butadiene, $CCl_4$, and Acetaldehyde.
8. Littered plastics give anaesthetic look within the city, choke the drain and will cause flood during monsoon.
9. Recycling industries operating in non-conforming areas are posing threat to environment to unsound recycling practices.

## 3. Objective

### 3.1 Primary objective

The primary objective in our project is to convert waste plastic into oil. Plastics from used bottles, milk bags etc. are made up of virgin plastics meaning we will recycle it again to make plastics, so from that we are going to make oil, recycled plastics are worthier than making oil. But after recycling number of times the time comes when plastic cannot be further recycled. This plastic has no option except to eliminate or we are able to throw away which can be like throwing money and it will create environmental issues. So, from this type of plastics we are going to make oil. For instance, the waste and number of your time reused plastics from injection moulding company. This oil will be the mixture of assorted hydrocarbons like naphtha, petrol, diesel, kerosene etc.

### 3.2 Secondary objective

The oil collected from waste plastic is mixture of number of fuels which might be used for burning, it can replace furnace oil. Furnace oil is dark viscous residual fuel obtained by blending mainly heavier components from crude distillation unit, short residue and clarified oil from fluidized chemical reactor cracker unit

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## 4. Working Methodology

The process is absolutely simple; it's same as how alcohol is formed. If you warmth plastic waste in non-oxygen environment, it'll melt, but won't burn. After it's melted, it'll start to boil and evaporate, you only must put those vapours through a cooling pipe and when cooled the vapours will condense to a liquid and a few of the vapours with shorter hydrocarbon lengths will remain as a gas. The exit of the cooling pipe is then longing a bubbler containing water to capture the last liquid varieties of fuel and leave only gas that is then burned. If the cooling of the cooling tube is sufficient, there'll be no fuel within the bubbler, but if not, the water will capture all the remaining fuel which will float above the water and might be poured off the water. On the underside of the cooling tube may be a steel reservoir that collects all the liquid and it's a release valve on the underside so that the liquid fuel can be poured out. This device works on electricity (1 phase), it's nichrome coils as heating elements and consumes a complete of 1 kW. The coils are turned on and off by three solid state relays, one for every phase, the relays are controlled by a digital thermostat with a temperature sensor just a small amount below the lid, so the vapor temperature is monitored. You need to heat the plastic slowly to about 310 degrees and just wait till it does the magic The device includes a capacity of 5 litres and may hold about 3 kg of shredded plastic. The process takes about 2 hours, but it may be shortened considerably by tweaking the planning a bit. As I said, this makes a liquid fuel that may be used as multifuel, meaning it are often used on diesel engines and also on gasoline engines, but we still must test it'll work on gasoline. It works for diesel engines just fine, that has already been tested. There is a difference in what plastic you employ, if you utilize polyethylene (plastic cans, plastic foil, and all quite flexible non break plastics) you may get out liquid fuel that may solidify because it cools into paraffin, it's still good for diesel engines as long as you employ a heated fuel tank, because it has to be heated almost at 30 degrees Celsius to be liquid and transparent. If you do not want that, you'll be able to put the paraffin through the device for yet another time and you will chop those hydrocarbons even smaller and half the paraffin will address liquid fuel and partner will remain a paraffin, but much denser and can melt at higher temperatures, this is often the things you'll be able to make candles out of and it doesn't smell in any respect when burned, maybe a touch like candles. But if you utilize polypropylene (computer monitor cases, printer cases, other plastics that break easily), you get out only liquid fuel, no paraffin at all. All you wish is simply filter the fuel out of solids and you good to travel and put it in your gas tank. We've made the analysis and it's almost the proper diesel fraction. It has no acids or alkaline in it, like fuel from tires does. Other methods of heating the reactor can be employed, electricity is simply easier to figure with and control. Some Japanese companies manufacture such devices, but their prices for this size unit is quite 100 000$, our home-made device cost us 900$ max. We use alumina bricks to insulate the warmth, they are light as foam and might be easily cut in any shape, but any quite insulator are often used. The bricks make the very best costs for this device. It can even be made using liquid fuel burners to heat the reactor, this can enable to create the device self-sustainable by using about 10-15% of the produced fuel together with the produced gas. A little farm can use a device this size and make fuel for itself by converting plastic waste to fuel, farms have very much plastic waste and it's an enormous problem, a minimum of in my country. Our next goal is to form the same thing possible using biomass, every farm could then use old leaves, wet grass, saw

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dust and every one reasonably biomass and gasify it into tar like substance that may then be put through the pyrolysis device and was biodiesel. The subsequent figure shows actual model of converting fuel from waste plastic.

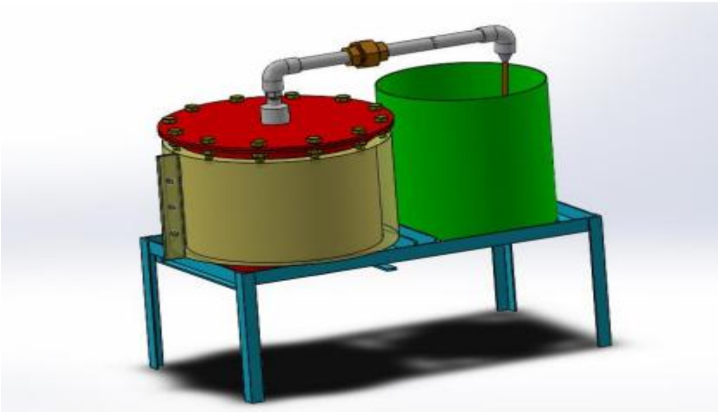

**Fig. 4.1** 3D modelling of the system

## 5. Design Calculation

| SR.NO | PART NAME | MATERIAL | QTY |
|---|---|---|---|
| 1 | FRAME | MS | 1 |
| 2 | TANK | MS | 1 |
| 3 | HEATING COIL 2KW | STD | 1 |
| 4 | INSULATION | GLASS WOOL | 2 KG |
| 5 | HEATING CHAMBER | MS | 1 |
| 6 | CONDENSOR | MS | 1 |
| 7 | TOP CIRCLE | MS | 1 |
| 8 | WIRING | STD | 1 |
| 9 | NUT BOLT WASHER | STD | 12 |
| 10 | REDOXIDE | STD | 1 |

**Table 5.1** Bill of Material

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## 5.1 Material Selection

**5.1.1 Mild Steel C-45:**

1. Easily available in all sections.
2. Welding ability
3. Machinability
4. Cutting ability
5. Cheapest in all other metals.

Assumption: FOS - 2 σt = σb = 540/FOS = 270 N/mm2
σs = 0.5 σt =0.5 x 270
σs = 135 N/mm2

**5.2 Design of heating chamber**

P: design pressure, MPa
D1: inside diameter of the vessel, mm
D2: outside diameter of the vessel, mm
R1: inside radius of the vessel, mm
R2: outside radius of the vessel, mm
S: maximum allowable stress, N/mm2
E: Joint efficiency, %
T: required the thickness, mm

The pipe used for heating chamber is 150 mm inner diameter and 156 mm outer diameter So, we will check for its failure

Material for shell selected = C45 = 0.45 % carbon.
Design pressure pi = 4 bar = 0.4 N/mm2 Material C45 – 0.45 % carbon
FOS for pressure vessel, take = 4
Now,
σ t = σ b = 540/ FOS = 135 N/mm.
Joint efficiency of fillet welding ήT: 80%
Thickness of shell obtained from formulas:
Based on theory of Thin cylinders with modifications

$$t = (Pi\ x\ Di) \div (2\ x\ \sigma t\ x\ ή t) = (0.4\ x\ 260) \div (2\ x\ 135\ x\ 0.8)$$

$$t = (104) \div (216) = 0.481 \text{ mm}$$

Based on theory of Thin cylinders with modifications

$$t = (Pi\ x\ Di) \div ((2\ x\ \sigma t\ x\ ή t) - Pi) = (0.4\ x\ 260) \div ((2\ x\ 135\ x\ 0.8) - 0.4)$$

$$t = (104) \div (215.6) = 0.482 \text{ mm}$$

But we are using 5 mm thick pipe, hence safe.
From below table the bottom plate used in our project is 18-gauge, 1.02 mm so this is also safe.

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| Gauge | Inches | Millimeters | |
|---|---|---|---|
| 10 | 0.102 | 2.59 | Shop 10 Gauge Wire |
| 11 | 0.091 | 2.31 | |
| 12 | 0.081 | 2.06 | Shop 12 Gauge Wire |
| 13 | 0.072 | 1.83 | Shop 13 Gauge Wire |
| 14 | 0.064 | 1.63 | Shop 14 Gauge Wire |
| 15 | 0.057 | 1.45 | |
| 16 | 0.052 | 1.29 | Shop 16 Gauge Wire |
| 17 | 0.045 | 1.14 | |
| 18 | 0.04 | 1.02 | Shop 18 Gauge Wire |
| 19 | 0.036 | 0.91 | Shop 19 Gauge Wire |
| 20 | 0.032 | 0.81 | Shop 20 Gauge Wire |

**Table 5.2** Gauge measurement

**5.3 Design of Condenser**

Power at top cone Q =30 watt

T1: Temp. at inlet of Condenser tube = 1000 c

T2: Temp. at outlet of Condenser tube = 400 C

Tatm: Temp. of water =300 C

We know that, $Q = U * A * \Delta T$

Where, U =Overall heat transfer

Then, $\Delta T = ((\Theta i - \Theta o)/(\ln (\Theta i / \Theta o)))$

$\Theta i = T1 - Tatm = 100 - 30 = 70$

$\Theta o = T2 - Tatm = 40 - 30 = 10$

Put in above equation, we get, $\Delta T=(70-10)/ \ln(70/10) =30.830$ C

Taking, U=28 w/m2 0 C will be the best selection (from Heat &Mass transfer handbook)

Therefore $Q = U * A * \Delta T$

$30 = 28 \times A \times 30.83$

A contact = 0.0347 m2

Now, Acontact = Π * Dtube * Ltube Take diameter of tube = 6.35 mm

0.03 = Π x 6.35 x 10-3 x L tube :. L tube =1.5 m

For design purpose,

:. Ltube=1500 mm

Now since, Ltube = Perimeter x number of turns

Take. Perimeter = Π x 150

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1500 = 471 x number of turns

Number of turns = 3.1

**6.4 Design of Frame leg**

Let the total weight (P) of our machine be 15 kg, now this 15 kg weight is kept on four angles,

P = 15 kg = 15 x 9.8 = 147 N.

L = 225 mm.

M = WL/4 = 147 × 225/4= 8286.5 N-mm

Section of modulus $Z = B^3/6 - b^4/6 \times B = 20^3/6 - 17^4/6 \times 20$

$= 1333.3-696.4$ $Z = 638$ $mm^3$

Bending stress, $\sigma = M/Z = 8286.5/638 = 12.96$ $N/mm^2$

As induced bending stress is less then allowable bending stress i.e. 270 N/mm2 design is safe.

6.5 Design of transverse fillet welded joint

Hence, selecting weld size = 3.2 mm

Area of Weld = 0.707 x Weld Size x L

= 0.707 x 3.2 x 20 = 45.248 mm2

Force Exerted = 15 x 9.81 = 147 N

Stress induced = Force Exerted / Area of Weld = 147 / 45.248 = 3.2 N/mm2

For fillet weld: Maximum Allowable Stress for Welded Joints = 21 N/mm2

Hence, selecting weld rod size = 3.2mm Area of Weld = 0.707 x Weld Size x L

= 0.707 x 3.2 x 25 = 56.56 mm2

Now, Stress induced = Force Exerted / Area of Weld 21

= F / 56.56 = 1187.76 N = 121.07 kg

Maximum Allowable Stress for Welded Joints = 21 N/mm2

**6.6 Design of bolt**

Bolt is to be fastened tightly also it will take pressure load due. Stress for C-45 steel ft =420 kg/cm2. Std nominal diameter of bolt is 9.31 mm. From table in design data book, diameter corresponding to M10 bolt is 8 mm.

Force = Area x Pressure = Π /4 x d2 x Pi F

= Π /4 x 180 x 0.4 F = 56.54 N

Also, P = Π /4 dc2 x σ

σ = 56.54 x 4 3.14 x (8)2

σ = 226.19/201 = 1.12 N / mm2

The calculated σ is less than the σ tensile and σ shear hence our design is safe.

## 7. Conclusion

The thermal pyrolysis of mixed plastic results in the assembly of heating oil which may be a valuable resource recovery. It also reduces the matter of disposal of waste plastic. Mixed plastic pyrolysis yields a mix of oil and gas and produces a little amount of char. The use of plastic pyrolysis oil in locomotive engine within the aspect of technical and economical is compared and located that the oil is unable to interchange the HSD as per the emission and safety norms. These drawbacks may be overcome by exploring various additives which may make the plastic pyrolysis products compatible with those norms. Though the plastic pyrolysis oil offers higher Sulphur content, the plastic waste amount is big and it needed to be process to cut back the environmental problems. Moreover, the engine is often modified following the combustion condition of plastic pyrolysis oil. The waste plastic used in the method must be PE or PP so as to shield the contamination of chlorine in the oil. Plastic pyrolysis offers comparable energy to diesel fuel but it's been questioned on the desulfurization process. Therefore, the event of the pyrolysis oil is depending on the price of desulfurization process. Additionally, by product of the pyrolysis plant carbon residue, there's a chance to process these by-products because of the quantity of the by product is correspondent to the oil product.

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### A Brief Author Biography

***Rajeshwari Nikam*** – Student of Mechanical Engineering from Dr, D. Y. Patil College of Engineering, Pune, interest in research area of waste management, renewable energy sources, etc.

***Mansi Bhole*** – Student of Mechanical Engineering from Dr, D. Y. Patil College of Engineering, Pune, interest in research area of waste management, artificial intelligence, etc.

***Pournima Bhosale*** – Student of Mechanical Engineering from Dr, D. Y. Patil College of Engineering, Pune, interest in research area of waste management, automobile engineering, etc

***Trupti Shinde*** – Student of Mechanical Engineering from Dr, D. Y. Patil College of Engineering, Pune, interest in research area of waste management, etc.