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PYROLYSIS PROCESS FOR CONVERSION OF PLASTIC WASTE INTO LIQUID FUEL

Pratikesh J. Khutle[1], Mayuri S. Deshmukh[2], Harshada Gaikwad[3], Nandini Madane[4], Prof.Sneha Hirkane[5], Dipika Patil[6]

[1,2,3,4]B.E Student, Dept. of Civil Engineering, Vishwaniketan College, Khalapur, Maharashtra, India
[5]Professors, Dept. of Civil Engineering, Vishwaniketan College, Khalapur, Maharashtra, India
[6]Biology Lab Assistant, Vithoba khandappa junior college, Panvel, Maharashtra, India

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Abstract - *In 21st century, the generation of plastic waste has been increasing day by day in metric tonnes, and also increased in pollution due to plastic waste has mainly affected ocean .So many methods are adapted to minimizee the generation of plastic waste but there results and methods are not convenient for environment . The method of pyrolysis is not only used for minimizing the volume of plastic waste but also used for converting it into liquid fuel. This method is performed in the absence of oxygen with the high temperature ,and the final result we get in this process are liquid fuel, synthetic gases, and solid residual of char which is 5-10 % of plastic waste. Pyrolysis process is good oil extraction alternative option for fossil fuels, as we know that natural resources are getting depleting day by day pyrolysis can used as an alternative for producing oil without any harm to environment for future days.*

Key Words: **Plastic Waste Pyrolysis Process, Fuel Production, Energy Recovery, Environment, Pollution**

1. INTRODUCTION

In past some decades our world has increased the use of plastic on a large scale. Plastic is especially used as packaging material for food, couriers, accessories, carry bags, etc, now each day we all are busy improving our technology, but somewhere we forget to take care of the balance that should be maintained by us for clean environment.Due to increasing generation in plastic waste, we know are facing major problems because of plastic waste .As we know plastic materials are lightweight, easily available, and less in cost,therefore the industries of plastic has grown on large scale. The demand for plastic is increasing year by year. Worldwide plastic market size was valued at 568.9 billion (US Dollars) in 2019 and perhaps it grows at a compound annual rate of growth (CAGR) of three .2% from 2020 to 2027. Over 300 million years plenty of plastic are produced due to which not only environment has affected but also the life cycle of aquatic animals due to increased in BOD(biological oxygen demand) in lakes, sea. From total amount of plastic generation minimum 8 million of plastic we can find you in our oceans per annum. The floating plastic is currently the most observed litter found in marine seashore. Marine wildlife like seabirds, whales, fishes, and turtles are dying unfortunately due to plastic waste within the ocean which has some toxic elements and also decreased in oxygen has affected the living of aquatic animals . Not only it has affected the ocean life but human beings are also suffering from the same.

Our country generates 15 million tonnes of plastic waste per annum but only one-fourth of this is often recycled due to the shortage of correct disposal method of plastic waste. This results in a burden on the landfills and as we know plastic does not get depleted in soil for years. We have proposed some alternative and economical method for proper disposal of plastic waste.

1.1 Pyrolysis

Pyrolysis is the thermal degradation of plastic waste at high temperature this process is done in absence of oxygen. The word pyrolysis is derived from the Greek word pyro means “fire” and lysis means“separating”. The products formed at the highest temperature of pyrolysis process include solid coal (char), liquid pyrolysis oil, and gas. Pyrolysis liquid and gas products are often used for power generation in engines and turbines. Therefore, the pyrolysis of biomass could also be a used as alternative method for energy sources. This method takes place at high temperaturee in absence of oxygen where it goes through chemical and physical separation into different atoms and molecules. The critical temperature ranges for obtaining pyrolysis products are between 350 and 500°C, the process can use for production of raw oil or gas. This technique is usually performed by consuming less energy from the surface. There are two types of pyrolysis method which can be done first is by slow pyrolysis method and second is by fast pyrolysis method. But we have used the slow pyrolysis method by which we get solid char, raw petrol, diesel and gas.

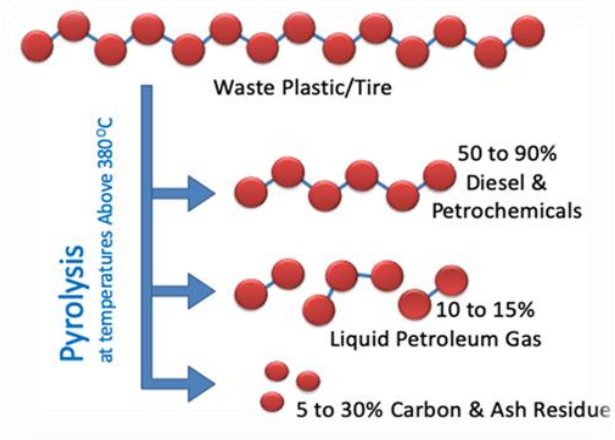

Fig- 1: Molecules Break Downs [2]

[1]The characteristics of fuel obtained from plastic-like density, viscosity, octane–cetane number, ash content, and calorific value have similar properties with those of fossil fuels. [5] Its worth mentions to notify that not only pure plastics but also plastics during which additives were used are often treated to form equally good oil. [3]Conversion of waste to energy is one in all the recent trends in minimizing not only waste disposal but also may be used as an alternate fuel for combustion engines. [4] Plastics are placed during a landfill, it becomes a carbon sink, Incineration, furnace, gasification aren't the much-appreciated solution to the matter, as toxic gases are produced and their cost of production is the type of high. Pyrolysis of waste plastics into fuel is one in every of the best means of conserving valuable petroleum resources additionally to shield the environment. [6] The drastic increase in plastics production naturally leads to an outsize amount of plastic waste that endangers the environment thanks to their disposal problems. The conversion of plastic to high-quality liquid oil through the pyrolysis process is incredibly advisable because the oil produced has high calorific value than that of economic fuel.

7] The methodology with subsequent hydro treating and hydro cracking of waste plastic pyrolysis oil can reduce unsaturated hydrocarbon bonds which could improve the combustion performance in diesel engines as an alternate fuel. [8] However, oil from most pliable waste features a complex chemical structure and will contain other groups of unidentified chemicals like sulfur, nitrogen, and oxygen-containing hydrocarbons. this can be often why a more in-depth and accurate chemical analysis is required to completely understand the chemistry of pyrolysis oil [9] the fundamentals of pyrolysis, its latest developments, the varied conditions of the method, and its residues are of great importance in evaluating the applicability of the pyrolysis process within the waste management sector and in waste treatment. especially, the varieties of residue and their further use or treatment are of utmost interest as they could become the source of secondary raw materials or be used for energy generation in waste treatments [10] Gas chromatography results of the plasma- pyrolyzed , simulated medical waste (Table 1) reveal those typical gaseous products formed are rich in hydrogen and carbon monoxide gas, with some lower hydrocarbons. in step with the literature review, it's confirmed that after the burning of plastic waste at high temperatures the ultimate product contains similar characteristics like fossil fuels, But the PH value of pyrolysis oil isn't checked.PH value is determined where its store for a protracted period, if their PH Value but 7 it's going to be acidic or quite 7 it should be alkaline. If the pH is smaller than 7, the fuel is acidic. It's needed to scrub with water, again and again, to pH value of oil to 7

Table -1: Gases after Pyrolysis [10]

Gas	Quantity (%)
N2	45.0351
H2	22.6305
CO	26.6525
NH4	1.5073
CO2	4.20215
C2–C5 (hydrocarbons: C2H6, C3H8, NC4, IC5, NC5)	0.4511

2. METHODOLOGY

Burning of plastic within the out-of-doors is harmful to the environment. Recycling of plastic is difficult and also dangerous for environment. Plastic is non-degradable and thus causes pollution. It is ddifficult to dispose and it takes 100 years to dispose into the soil. Plastic {(Polyethylene Terephthalate) (PET)(C10H8O4)n} is employed during this pyrolysis process having a density of 1.38 g/m3. Plastic Melting point is >2500C & Boiling point >3500C have to heated plastic above the boiling point to evaporate it. Plastic is the only single material we have used during this process.

2.1 Stepwise Procedure of Pyrolysis Process

2.1.1 Collection- Plastic waste is collected from households and public places. We collected waste plastic of drinking water & soft drink bottles from the near area.

2.1.2 Cutting- After collecting the plastic bottles we have cut it into very similar size of pieces. The dimension of the plastic crush is min 2 cm strips. After cutting the plastic crush we have heated it in normal temperature up to 55 to 70 c, for removing its moisture content from plastic

2.1.3 Filling- The plastic which we have cut into pieces we have taken 2 kg of plastic crush to fill within the iron reactor.

2.1.4 Heating- The heat is provided to the reactor continuously with increasing temperature of 100 to 200 C and last temperature is up to 700C. Where the plastic starts to melt, this heating process is done in absence of the ooxygen.

2.1.5 Condensing- The plastic gets evaporated at extreme temperature,and this vapor is condensed to atmospheric temperature by using straight and spiral tube condensers.

This process takes minimum 30-45 min for plastic crush to get it melted and evaporated into gas.

2.1.6 Breaking of Hydrocarbon chain in Pyrolysis Process- [Figure:1] Pyrolysis differs from other high-temperature processes like combustion and hydrolysis therein it always doesn't involve reactions with oxygen, water, or the other reagents. In practice, it's impossible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a touch low amount of oxidation occurs. Bio-oil is produced via pyrolysis, a process during which biomass is rapidly heated to 450–500°C in an oxygen-free environment then quenched, yielding a mixture of liquid fuel (pyrolysis oil), gases, and solid char. Changing within the pyrolysis method, biomass properties, and reaction specifications will generate varying percentages of those three products. Different new technology and methods are used for pyrolysis, including circulating fluid beds, entrained flow reactors, multiple hearth reactors, or vortex reactors. the tactic could even be performed with or without a catalyst or reluctant.

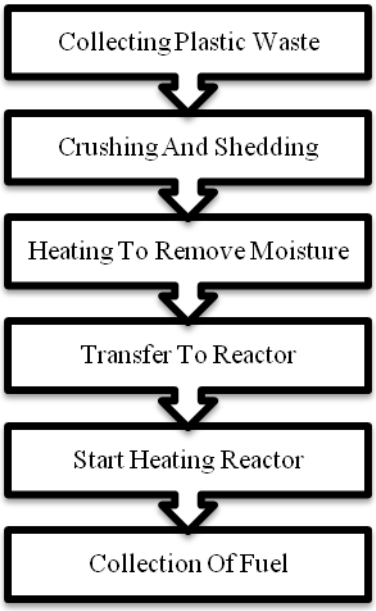

Chart -1: Work Flow Chart

2.1.7 Liquid Collection- The product from the condenser is collected at the liquid collector, and at the end of the condenser we have provided a cyclone separator to separate the plastic liquid fuel and gases. These unit gases are reused to heat the pyrolysis process again.

2.1.8 Burning and Store Access Gas- Burning the Access gas out from the pipe to testing of which gas is produced.

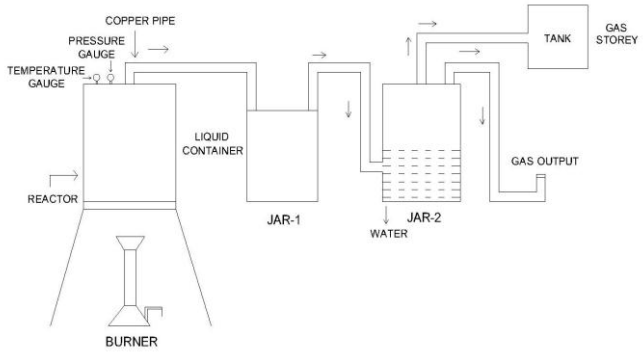

Fig- 2: Systematic Representation of Pyrolysis Process

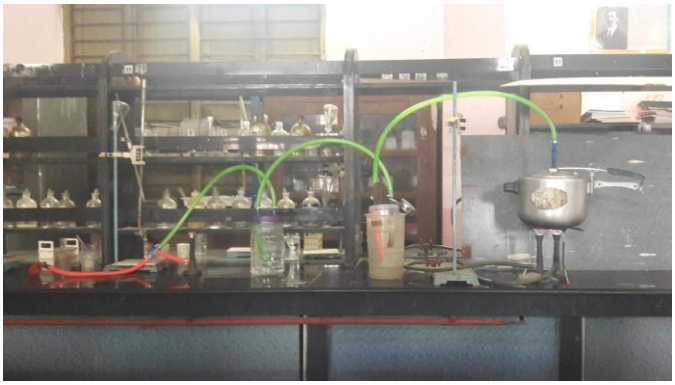

Fig- 2: Experimental Setup of Pyrolysis Process

3. TESTING ON PYROLYSIS OIL

3.1 pH Test

Dependent upon the conditions of pH and water content, acidic petroleum may form a special kind of emulsions with different stability [11]. pH value is that the foremost vital property of fuel, by this value we discover it acidic or alkaline. pH is that the degree of acidity and alkalinity of the answer. When pH 7.0 is neutral, it becomes acidic because it goes below it, and alkalinity increases because it goes above it. Most of the water-soluble oils are slightly alkaline, pH 8.5 to 9.0[12]. We take some 05ml samples of pyrolysis oil to hunt out ph value. possibly ph value takes after purification, except for knowing the initial stage value of pyrolysis .finding ph value we use the universal pH paper, Having values 1- 10 with each No. indicated different color shade. Ph value we get is 1, dark red color.

3.2 Density

The density, of a substance, is its mass per unit volume. The symbol most frequently used for density is ρ, although the Latin letter D also can be used. Mathematically, density is defined as mass divided by volume: where ρ is that the density, m is that the mass and V is that the volume [13]. Taking empty containers having net weight 10.1 gm (w1), 5 ml of pyrolysis oil sample (v), and after taking wt. of the container with a pyrolysis oil (w2) is adequate to 11.6 gm. Putting all value within the below formula.

ρ or d = M/V

ρ or d = w2-w1/v

ρ or d =11.6-10.1/5

ρ or d =0.3mg/l

3.3 Flame Test

A flame test an analytical procedure employed in chemistry to detect the presence of certain elements, primarily metal ions, supported each element's characteristic spectrum. The color of flames generally also depends on temperature; see flame color. The test involves introducing a sample of the element or compound to a hot, non-luminous flame, and observing the color of the flame that results.

Figure No 4: Flame after Burning Pyrolysis Oil

4. RESULTS AND DISCUSSION

The pyrolysis process takes around 30 to 45 min to evaporate plastic waste within the reactor, depending on the warmth provided to them. After this steam is made and because of a cooling tank connecting to the reactor steam converted into liquid flow through the pipe is collecting in an empty container.

At the time of liquid flame test when fire is creating loud sound (fat). Liquid is not burning continuously after source of fire is removed, might be some impurity present on liquid this will be happened. pH value was showing pyrolysis oil is acidic in nature before its refine. Aafter the testing on oil we got some results, which are below with the comparisons of other fuel. (Table No.2)

Sr. No	Fuel	pH(30°C)	Density	Flame	Rate/lit
1	Pyrolysis oil (Raw)	1	0.3mg/ml	Yellow, orange green	35 (Pure)
2	Petrol	5.7	0.715mg/ml	Yellow orange	85-90
3	Diesel	6.3	0.875mg/ml	Orange	75-79
4	Kerosene	6.1	0.775mg/ml	Blue	22-30

Table 2: Comparing Pyrolysis Oil with Fossil Fuels [14] [15]

5. CONCLUSION

Due to daily rising values of fuel and also increasing pollution because of plastic waste, the pyrolysis oil may be a good alternative to take space of this commercial fuel. Compared to other fuels refinery setup of the pyrolysis process is up to 80-90k which can be one time investment and the profit we get is higher than anything. Mainly during this process, the quantity of plastic waste is minimized up to 90-95%. The raw material of this process can be purified and freely available and is easy to handle that's why its generation cost is economical and is easy to handle with lesser consumption of energy.

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BIOGRAPHIES

Mr. Pratikesh J. Khutle
Bachelors of engineering
Department of Civil Engg.
Vishwaniketan Collage (iMEET),
Khalapur, Maharashtra.

Miss. Mayuri S. Deshmukh
Bachelors of engineering
Department of Civil Engg.
Vishwaniketan Collage (iMEET),
Khalapur, Maharashtra.

Miss. Harshada Gaikwad
Bachelors of engineering
Department of Civil Engg.
Vishwaniketan Collage (iMEET),
Khalapur, Maharashtra.

Miss. Nandini Madane
Bachelors of engineering
Department of Civil Engg.
Vishwaniketan Collage (iMEET),
Khalapur, Maharashtra.