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Plastic Waste Recycling by using Pyrolysis Process

Prof R. N. Pantawane[1], Jayesh Sune[2], Deepika Shukla[3], Sakshi Yende[4], Sakshi Jadhao[5], Nayana Meshram[6],Aniket Jogdand[7], Rushikesh Thakare[8], Yash Yadav[9], M Mujahid M Sajid Shaikh[10]
Assistant Professor, Department of Civil Engineering[1]
Students, Department of Civil Engineering[2,3,3,4,5,6,7,8,9,10]
Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, Maharashtra, India

Abstract: *Plastic is a type of inorganic trash or other material that does not break down quickly. More than 500 years were required for the inorganic waste to decompose effectively. Examples of inorganic garbage include plastic, glass, or glass bottles, aluminum or cans, dust, metal, and other food wrappers. One of the biggest environmental problems we have today is plastic garbage. Urbanization and population growth are to blame for the daily rise in plastic garbage. Waste made of plastic can have a bad effect on the environment and people's health. Plastic pollution occurs when a lot of plastic waste accumulates in one place or when it is handled inappropriately. The sluggish rate at which plastic garbage decomposes is the primary cause of pollution. Although there are several ways to handle and get rid of plastic garbage, each approach has significant drawbacks. The Pyrolysis technique can then be used to recycle plastic waste in this project in order to address these types of challenges. One efficient and environmentally beneficial method for managing and reducing inorganic plastic waste is pyrolysis. With this technique, plastic waste is thermally degraded at high temperatures in an inert environment. When plastic trash is cooked to high temperatures, pyrolytic oil and fumes are produced. After that, this pyrolytic oil is transformed into diesel-like pyrolytic fuel and gasoline. The calorific value of pyrolytic oil is identical to the calorific values of diesel and gasoline, according to the analysis of numerous research papers. We can research the pyrolysis process for recycling plastic waste since it allows us to identify the best alternate fuel and gasoline sources and reduces the environmental impact of plastic waste.*

Keywords: Plastic waste, Pyrolysis process, Plastic waste management, Pyrolytic oil & gasoline

I. INTRODUCTION

The accumulation of plastic objects (such as plastic bottles and other items) in the Earth's environment, commonly referred to as plastic pollution or plastic waste, has a detrimental effect on people, animals, and their ecosystems. The English word "plastic" originates from the Greek word "Plastikos," which meaning "to mould." Due to its low cost, light weight, and durability, plastic has become a material that is frequently used in recent years. Water bottles, clothing, food packaging, medical supplies, electronics, and building materials are just a few examples of the many uses for the synthetic organic polymers that go into making plastics. Plastics include all synthetic and semi-synthetic organic polymers. In other words, carbon and hydrogen are constant components of plastics, regardless of the presence of other elements. Plastic can be made from practically any organic polymer;however, petrochemicals are the main source of industrial plastic. Thermoplastics and thermosetting polymers are the two categories of plastic.

Plasticity, as the word "plastic" suggests, is the ability of a substance to deform without breaking. Plastic waste's natural degradation could take several years. Plastic waste will become hazardous toxins if it is simply thrown out into the environment. We must reduce the use of plastic waste and increase awareness of plastic recycling if we are to continue combating the problem of plastic trash and reduce pollution in the world. Although there are many various types of plastic, we'll be using PETE, HDPE, PVC, and PP for this project.

1. Polyethylene terephthalate (PETE):A wrinkle-free fibre is another name for polyethylene terephthalate (PETE), generally known as PET. Due to its powerful capacity to stop oxygen from penetrating and tainting the goods inside, this type of plastic polymer is typically used for drink and food packaging. Moreover, it aids in preventing the escape of carbon dioxide from carbonated beverages. The fact that they have a high strength-to-weight ratio makes them the most popular plastic in the entire world

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2. High-Density Polyethylene (HDPE):High-Density Polyethylene (HDPE) is a type of thermoplastic polymer that goes by the name of the same name. Since HDPE's polymer chain is practically unbranched and lengthy, it makes it thicker and more durable than PET. Among its numerous applications are supermarket bags, bottles of shampoo, opaque milk, and juice, andwith a medicine container. Compared to PET, HDPE is more stable.
3. Polyvinyl chloride (PVC): Also known as PVC, polyvinyl chloride is a type of "thermoplastic" substance. Toys, blister wrap, cling wrap, detergent bottles, loose-leaf binders, blood bags, and medical tubing are among the common uses for PVC. Before, polyethylene was the most popular plastic resin in the world, followed by this particular sort of plastic. PVC is a desirable material for use in plumbing, building, and other industrial applications because of its great durability and light weight.
4. Polypropylene (PP): PP is frequently used to make containers for hot food. It is midway between LDPE and HDPE in terms of strength quality. PP is regarded as a safer plastic alternative for use with food and beverages. As long as the milk bottle is made of food-grade plastic, it is a good material.

Pyrolysis is a combination of the Greek words for fire and separation, lysis. The thermal degradation of biomass known as pyrolysis occurs at greater temperatures in a close atmosphere. A change in chemical composition is involved. Pyrolysis a term used to describe the heat breakdown of large organic molecules into smaller hydrocarbons. Torrefaction is yet another name for pyrolysis. Torrefaction is normally carried out in the absence of oxygen at relatively modest pyrolysis temperatures (200-300°C). The process of pyrolysis is largely impacted by temperature. The pyrolysis method is divided into three categories throughout processing based on temperature and time: slow pyrolysis, quick pyrolysis, and flash pyrolysis.

1. Conventional/slow pyrolysis: This type of pyrolysis is distinguished by extended solids and gas residence durations, low temperatures, and sluggish biomass heating rates. It is employed to reduce oil production and change the solid Substance. Nevertheless, quick and ultra-fast (flash) pyrolysis increases the amount of gases and oil produced.
    - Moderately warm (400–500 °C)
    - Residence: Prolonged (5-30 min).
2. Rapid/ Fast pyrolysis: Fast pyrolysis is the name given to the rapid thermal degradation of carbon-containing materials at moderate to high heating rates in the absence of oxygen. It is the strategy that is most frequently used in both academic settings and daily life. The main component is bio-oil. Pyrolysis is an endothermic reaction. Massive amounts of char accumulate and need to be frequently cleared.
    - Warm (between 400 and 650 °C)
    - Extended duration of stay (0.5-2sec)
3. Ultra-fast/flash pyrolysis: This method of thermal decomposition is carried out at a very high heating rate. Gases and bio-oil are the principal outputs. In comparison to gradual pyrolysis, flash pyrolysis yields far less gas and tar.
    - High temperature (700–1000 °C)
    - Residence: Prolonged (less than 0.5 sec).

1.1 Benefits of the Pyrolysis Technique

1. It is a straightforward, low-cost technique that can handle a wide range of feedstocks and the valuable crude oil derivatives produced by the pyrolysis of non-recyclable waste decreases.
2. Pyrolysis might significantly lower the amount of landfill. By doing this, greenhouse gas emissions are decreased and toxic waste from harming the environment is prevented.
3. The quantity and variety of polymers that can be recycled are both dramatically increased by pyrolysis.
4. The primary benefit of a plastic pyrolysis plant is that it may produce renewable energy sources like plastic pyrolysis oil, carbon black, and combustible gas in addition to being ecologically benign. It also possesses the qualities of high productivity, low consumption, and high oil production.
5. It lesser the chance of water pollution, and this method can be utilized to transform waste products into beneficial process flows.

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In the pyrolysis process, plastic waste is heated at high temperatures, which can result in the production of gases, char, and liquid bio-oil, or pyrolytic oil. The pyrolytic oil is then transformed into gasoline and pyrolytic fuel. This is identical to the diesel. Moreover, the calorific value of pyrolytic fuel and diesel are identical. Pyrolysis can be used to reduce the amount of plastic waste by identifying fuel substitutes. Because of this, pyrolysis is one of the sustainable options that can reduce environmental issues, notably in terms of waste minimization, while also being commercially successful on extremely large stages. Pyrolysis is one example of the thermal technology that has been developed for environmental preservation and waste reduction.

1.2 Objective

1. To learn more about the current environmental problem with plastic trash. Plastic garbage that is inorganic waste.
2. To examine how plastic garbage affects the environment negatively.
3. To recognize the Pyrolysis process as a means of managing plastic waste
4. Making valuable products out of discarded plastic.
5. To reduce the amount of plastic garbage.
6. To use the pyrolysis technology to extract a valuable product from the waste plastic.

II. PROPOSED METHODOLOGY

2.1 Procedure

Carried out step-by-step approach, that is;

1. The collection of waste made of plastic, such as PETE, HDPE, PVC, and PP. These samples of garbage were gathered in the Yavatmal district.
2. After cleaning the trash bottle, make sure it is clear of contaminants like sand, soil, and dried materials since if it is, it will reduce productivity.
3. Plastic garbage is then chopped into little pieces.
4. The reactor is then fed with small-sized plastic garbage.

2.2 Working of Pyrolysis

The apparatus consists of a fabricated Reactor, in which whole process done. In this experiment we can use stainless steel Reactor of 5 mm thick, It has Trapped Circular cross section and it covered with glass wool because it's good for insulation. The hopper was then properly sealed to avoid leakage before switching on the heater. The reactor having diameter 15.5cm and length 50.5cm, provided with flange of diameter 20.35cm. from where plastic waste can be feeded in the reactor. Plastic bottle strip waste is feeded in the reactor by the weight of 200 gm. For the heating of Reactor Ceramic band heater of 150mm X 225mm of 3.5kW used. Then reactor is heated at the temperature of 400℃ at the voltage of 120 to 200 volt. The voltage is regulated manually by the Dimmer-stat from 0V to 280V. Also, the temperature of inside the reactor Can be measured by thermocouple, the temperature variation shown in the digital monitor. In the set-up of Pyrolysis condenser is connected at the outlet of Reactor at One opening and another opening is provided in the reactor for the removal of Tar, for that purpose valve is provided.

Thermal pyrolysis process is mostly gaseous. After that switch on the heater and Slow pyrolysis is done with temperature heated at a range of 20℃/min to 500℃, then the final temperature was fix for 30 min, at that Time raising the temperature upto 135℃. Plastic waste Start melting, by the melting of plastic waste gases start to immet. Gas has been started to immet from condenser after that 5 minutes start the flow of water to cool down the temperature of gases, prevented its to get volatilized. And these noncondensible gases are collected in the Tedlar bags, then these gases send to the analysis by gas chromatography process. Along with Gases some condensable vapour release that known as bio-oil, bio-crude, etc. Which has low calorific value fuel same as calorific value of diesel and gasoline. The resulting product for pyrolysis liquids, Gases, Wax and char.

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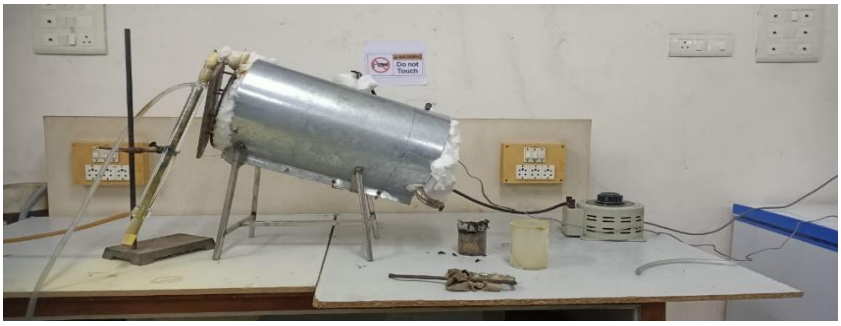
2.3 Set-up of Pyrolysis

The arrangement of set-up is shown here;



2.4 Unit's Required in Pyrolysis:

1) Reactor
2) Band Heater
3) Dimmer-stat
4) Thermo-couple

III. LITRATURE REVIEW

1) Ram Jatan Yadav, Shivam Solanki, SarthakSaharna, Jonty Bhardwaj, Ramvijay "Pyrolysis of Waste Plastic into Fuel" International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878 (Online), Volume-9 Issue-1, May 2020.

Due to the current continued use of fossil fuels Such as crude oil, natural gas and coal, the current Economic growth rate is unstable. Therefore, renewable Energy sources are being exploited, but some resources, such as plastic waste, need to be developed into a full-Fledged economic activity. The landscape of plastic recycling practices is Reviewed in this paper. Its aim is to provide an in-depth Analysis of the pyrolysis of plastic waste obtained in current Recycling technology. Since the calorific value of the plastic Is equal to the value of the hydrocarbon fuel, it provides a good opportunity to use the fuel generated waste from the Plastic waste and generate the fuel. The technique of Fuelling plastic waste through the pyrolysis process is Discussed. Therefore, efforts have been made to overcome the problem of plastic waste and the shortage of fossil fuels by creating fuel from plastic waste.

2) Umesh Pandey, Jan ArildStormyr, AlirezaHassani, RajanJaiswal, Hildegunn H. Haugen & Britt M. E. Moldestad "Pyrolysis of Plastic Waste To Environmentally Friendly Products" Wit Transactions on Ecology and the Environment, Vol 246.

According to author Pyrolysis of plastics is one of the efficient ways to recover plastic waste. The pyrolysis process can thermally degrade plastics or a Mixture of biomass and plastics (co-pyrolysis) in the absence of oxygen. Temperature has the most Impact on pyrolysis. Other processes to use in the conversion of plastic wastes into valuable products, Are steam cracking and gasification. The objective of this study is to find the best operation conditions For conversion of plastic wastes in a fluidized bed reactor. In this study author Concludes that thermal co-pyrolysis or co-gasification of biomass and plastics at temperatures above 600°C using sand as the bed material and steam as the fluidizing gas give reliable operating conditions for the future studies.

3) Ademiluyi, Adebayo, "Fuel gases from pyrolysis of waste Polyethylene sachets"JasemIssn, J. Appl. Sci. Environ. Manage. June, 2007 Vol. 11 (2) 21 – 26.

In this paper author can discuss about the Evaluation of fuel gases produced from pyrolysis of waste polyethylene was carried out. Waste Polyethylene was pyrolysed at low and high temperatures. Pyrolysis of the waste for 300secs at Temperatures of 250℃ -1400℃ produced 2.53% ethane, 21.67% propane and 75.82 % propylene. Fresh samples of the waste were Pyrolysed at higher temperature range from 50℃ – 250℃ and cooled in a condenser. The non-condensable

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gas Produced were collected and analysed with Shimadzu gas chromatography. The analysis shows that C1 – C6, and other alkenes and isoparaffins (18 ethylene monomers) were produced. Above 300℃ the flame becomes More luminous and production of fuel gases stops at 550℃.Production of fuel oil from waste polyethylene led to Production of large volume of gaseous products, some of which are non-condensable at room temperature. TheGaseous products can serve as feedstock and as fuel gas.

4) Rashid Miandad, Mohammad Rehan, Mohammad A. Barakat, Asad S.Aburiazaiza, HizbullahKhan, Iqbal M. I. Ismail , Jeya Dhavamani, JabbarGardy, Ali Hassanpourand Abdul-SattarNizami. "Catalytic Pyrolysis of Plastic Waste: Moving Toward Pyrolysis Based Biorefineries" Frontiers in Energy Research March 2019 | Volume 7 | Article 27.
In this study, the catalytic pyrolysis of different types ofplastics wastes (PS, PE, PP, and PET) as single or mixed in different ratios, in thepresence of modified natural zeolite (NZ) catalysts, in a small pilot scale pyrolysis reactorwas carried out. The NZwas modified by thermal activation (TA-NZ) at 550℃ and acidactivation (AA-NZ) with HNO3, to enhance its catalytic properties. The catalytic pyrolysisof PS produced a higher liquid oil (70 and 60%) than PP (40 and 54%) and PE (40 and42%), using TA-NZ and AA-NZ catalysts, respectively. The gas chromatography-massspectrometry (GC-MS) analysis of oil showed a mixture of aromatics, aliphatic and otherhydrocarbon compounds. The TA-NZ and AA-NZ catalysts showed a different effecton the wt.% of catalytic pyrolysis products and liquid oil chemical compositions, withAA-NZ showing higher catalytic activity than TA-NZ. FT-IR results showed clear peaksof aromatic compounds in all liquid oil samples with some peaks of alkanes that furtherconfirmed the GC-MS results. The liquid oil has a high heating value (HHV) range of41.7–44.2 MJ/kg, close to conventional diesel. Therefore, it has the potential to be usedas an alternative source of energy and as transportation fuel after refining/blending withconventional fuels.

5) Sreejith K.V1, Ashique P.T2, Abhijith B3, Mohamed Suaib4. "Study On Plastic Recyling Using Pyrolysis And Catalyst Cracking" International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 06 | Sep-2015.
In this research paper author can discuss about a nationwide survey, conducted in the year 2004, approximately 10,000 tones of plastic waste were generated every day in our country, and only 60% of it was recycled, balance 40% was not possible to dispose off. Waste plastic disposal and excessive use offossil fuels have caused environment concerns in the world. Both plastics and petroleum derived fuels are hydrocarbons that contain the elements of carbon and hydrogen. The difference between them is that plastic molecules have longer carbon chains than those in LPG, petrol, and diesel fuels. Therefore, it is possible to convert waste plastic into fuels.Therefore, the energy profit is very high for this process.

IV. CONCLUSION

The main goal of this research is to recycle plastic trash without harming the environment and to use that waste to produce pyrolytic fuel, an alternative source of energy. The thermal breakdown of waste material known as pyrolysis occurs at high temperatures in a small space. The pyrolysis technology effectively reduces the initial volume of garbage without harming the environment. Three types of byproduct from pyrolysis can be distinguished: char, gas, and oil.And its byproducts are crucial in determining if the pyrolysis process is appropriate for waste treatment and waste management. Initiation, propagation, and termination are the three successive steps in the pyrolysis reaction. The formulas found in other works of literature, and the alleged energy required according to equations from other texts, 1 kilogram of PE should be pyrolyzed at 1.047 MJ of theoretical energy. Around 43.3 MJ/kg is the estimated calorific value of the items. Which figure is comparable to diesel's calorific value

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BIOGRAPHY

- I am Mrs R.N. Pantawane, assistant professor and head of civil department (HOD) at Jawaharlal Darda Institute of Engineering and technology, Yavatmal. I have specialization in environmental engineering. I have presented 9 papers in National/ International conferences and 17 papers in various National/International journals. I am life member of Indian society of technical education.

- I am mrsJayeshSune, Under graduate scholar, pursuing Bachelor of Engineering (BE), Department of Civil Engineering JDIET Yavatmal. I completed 12th in 2018 from AMV College Yavatmal. My date of birth is 4th November 2000.

- I am Miss Deepika Shukla, Under graduate Scholar, Pursuing Bachelor of Engineering (BE), Department of civil Engineering JDIET Yavatmal. She has completed Diploma in civil Engineering in 2020 from GPW. She was born on 13 July 2001.

- I am Miss Sakshi Yende, Under graduate scholar, pursuing Bachelor of Engineering (BE), Department of Civil Engineering JDIET Yavatmal. I completed 12th in 2019 from SSJC. My date of birth is 10th August 2001

- I am Miss Sakshi Jadhao, under graduate scholar, pursuing Bachelor of Engineering (BE), department if Civil Engineering JDIET Yavatmal. I completed Diploma in Civil engineering in 2019 from GPY. My date of birth is 7 may 2000.

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- I am Miss Nayana Dinesh Meshram, Under graduate Scholar, Pursuing Bachelor of Engineering (BE), Department of civil Engineering JDIET Yavatmal. I am completed Diploma in civil Engineering in 2020 from GPY. My date of birth is 02 July 2001.

- I am Mr AniketJogdand Under graduate Scholar, Pursuing Bachelor of Engineering (BE), Department of civil Engineering in JDIET Yavatmal. My date of birth is 16 Nov 2000.

- I am Rushikeshthakare, Under graduate scholar, pursuing Bachelor of Engineering (BE), Department of Civil Engineering JDIET Yavatmal. I completed 12th in 2017 from SNVMAS.

- I am MrYash Yadav Under graduate Scholar, Pursuing Bachelor of Engineering (BE), Department of civil Engineering in JDIET Yavatmal. My date of birth is 27 june 2001.

- I am Mr.Mujahid Shaikh Under graduate Scholar, Pursuing Bachelor of Engineering (BE), Department of civil Engineering in JDIET Yavatmal. My date of birth is 5 April 2000