Conversion of Plastic Waste into Eco-Friendly Fuels

Prapti Deshmukh[1] Adesh Raut[2] Chetan Akhand[3] Hemlata Yadav[4] Prof.Mrs.Amruta Mundle[5]
[1,2,3,4]Student [5]Faculty
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]NIT Polytechnic Nagpur, India

Abstract— Plastic was invented by Alexander Parkes in 1860. Plastics have become a crucible part in today's world. Due to their light weight, durability, design flexibility, they are excessively used in industry as well as household and other fields. The demand for plastic is increasing day by day which now pose a tremendous threat to the environment. The study focus on the design and fabrication of machine to convert plastic into oil as an effort in finding environment-friendly means of waste recycling by means of pyrolysis. The waste plastics are subjected to depolymerisation, pyrolysis, catalytic cracking and fractional distillation to obtain different value added fuels such as petrol, kerosene, and diesel. Pyrolysis process becomes an option of waste-to-energy technology to deliver bio-fuel to replace fossil fuel. The advantage of the pyrolysis process is its ability to handle unsort and dirty plastic. The pre-treatment of the material is easy. Plastic is needed to be sorted and dried. Pyrolysis is also nontoxic or non-environmental harmful emission unlike incineration. In this investigation, plastic waste (poly propylene) are utilized for pyrolysis to get fuel oil that has comparable physical properties as the energizes like petroleum, diesel and so on Converting waste plastics into fuel hold great promise for both the environmental and economic scenarios.

Keywords: Waste plastics, pyrolysis, catalytic cracking, depolymerisation, fractional distillation

I. INTRODUCTION

Plastics are one of the most commonly used materials in our daily life and offer remarkable contribution to the society. They are widely used in packaging and manufacture of products including electronic, automotive, etc. Plastics are light weight and can be simply formed. They show non-corrosive behavior. They are reusable and conserve natural resources. Resultantly, there has been a quick development in plastic utilization and plastics have been utilized as substitution to wood and metals.

Plastic was invented by Alexander Parkes in 1860 and has high molecular mass. They are synthetic organic materials produced by polymerization. They may contain other substances besides polymers to reduce costs and to improve performance. Desired shape can be given to these polymers by molding or by extrusion Pyrolysis involves the heating and degradation of the polymeric materials at temperatures between 250°C and 350°C without oxygen bringing about the arrangement of a carbonized singe (strong deposits) and an unpredictable division which might be isolated into condensable hydrocarbon oil and a non-condensable high caloric esteem gas. Scheirs expressed that gases framed amid the pyrolysis of natural material incorporate carbon monoxide, hydrogen, methane, carbon dioxide, water, and hydrocarbons, similar to ethane, ethane, propane, propane, butane, and so forth. The temperature and heating rates can be controlled to produce desired solid, gas and liquid products because they have considerable influence in the pyrolysis process.

II. DIFFERENT TYPES OF PLASTICS

A. Polyethylene Terephthalate (PET)

PET has become the great choice for plastic packaging for various food products, mainly beverages such as mineral water, soft drink bottle and fruit juice containers. This is due to its intrinsic properties that are very suitable for large-capacity, lightweight and pressure-resistant containers. Different utilizations of PET incorporate electrical protection, printing sheets, attractive tapes, X-ray and other photographic film.The extensive applications of PET would cause an accumulation of PET waste in the landfill. Recycling PET waste was the current practice of handling accumulated plastic waste.

B. High-Density Polyethylene (HDPE)

HDPE is characterized as a long linear polymer chain with high degree of crystallinity and low branching which leads to high strength properties. Because of its high quality properties, HDPE is generally utilized as a part of assembling of drain bottles, cleanser bottles, oil compartments, toys and the sky is the limit from there. The various applications contribute about 17.6% in plastic waste category which is the third largest plastic type found in municipal solid waste (MSW).

C. Polyvinyl Chloride (PVC)

Unlike other thermoplastics such as polyethylene (PE), polystyrene (PS) and polypropylene (PP) which can be softened by heating and solely derived from oil, PVC is exceptional since it is manufactured from the mixture of 57% chlorine (derived from Industrial grade salt) and 43% carbon (derived from hydrocarbon feedstock such as ethylene from oil or natural gas) . The chlorine property makes PVC an excellent fire resistance, thus very suitable for electrical insulation. The compatibility PVC to be mixed With many additives makes it a versatile plastic.

D. Low-Density Polyethylene (LDPE)

As opposed to HDPE, LDPE has all the more stretching that outcomes in weaker intermolecular power, in this manner bring down elasticity and hardness. Be that as it may, LDPE has preferable flexibility over HDPE since the side stretching makes the structure be less crystalline and simple to be shaped. It has a superb protection from water, along these lines generally connected as plastic sacks, wrapping foils for bundling, waste packs and significantly more.

E. Polypropylene (PP)

PP is a saturated polymer with linear hydrocarbon chain that has a good chemical and heat resistance. Unlike HDPE, PP does not melt at temperature below than 160°C. It has a lower

thickness than HDPE yet has higher hardness and unbending nature that makes it ideal in plastic industry. PP contributes around 24.3% in plastic squanders class which are the biggest measure of plastics found in MSW.

F. Polystyrene (PS)

PS is made of styrene monomers obtained from the liquid petrochemical. The structure consists of a long hydrocarbon chain with phenyl group attached to every other carbon atom. PS is naturally colorless but it can be colored by colorants. It is warm flexibility and it offers sensible sturdiness, quality and delicacy that make this polymer alluring to be utilized as a part of assortment of areas, for example, in nourishment bundling, hardware, development, medicinal, apparatuses and toys.

G. Mixed Plastics

As already said, pyrolysis process has an additional favorable position over the reusing procedure since it needn't bother with an extreme arranging process. In recycling process, most plastics are not compatible with each other to be processed together during recycling. For example, a slight measure of PVC contaminant introduce in PET reuse stream will debase the entire PET gum by getting to be yellowish and weak that requires reprocessing.

III. PYROLYSIS PROCESS:

Pyrolysis is the chemical decomposition of organic substances by heating the word is originally coined from the Greek-derived elements pyro "fire" and pyrolysis "decomposition". Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, cloth, like wood, and paper, and also of some kinds of plastic. Anhydrous Pyrolysis process can also be used to produce liquid fuel similar to diesel from plastic waste. Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350ºC. Now a days plastics waste is very harmful to our nature also for human beings .plastic is not easily decomposable its affect in fertilization ,atmosphere ,mainly effect on ozone layer so it is necessary to recycle these waste plastic into useful things .so we recycle this waste plastic into a useful fuel.

IV. LITERATURE REVIEW:-

A. Achyut K. Panda, R.K. Singh, D.K. Mishra (et al):-

"Thermolysis of waste plastics to liquid fuel". In this research projects he used wide range of old and new technologies for chemical recycling of waste plastic to liquid fuel.

B. Tiwari D.C., Ejaz Ahmad, Kumar Singh K.K 2009(et al):-

wrote on catalytic cracking process in which waste plastic is melted and cracked in the absence of oxygen and at very high temperature, the resulting gases were cooled by condensation and resulting crude oil was recovered. From this crude oil various products petrol, diesel and kerosene etc. can be obtained by distillation.

C. Antony Raja and Advaith Murali (ët al):-

Conversion of Plastic Wastes into Fuels".He concluded that we can convert all types of waste plastic into hydrocarbon fuel at the temperature profile 350ºC to 500ºC through pyrolysis process.

D. Wenger Jorn.Investigated (et al):-

The pyrolysis of waste plastics (HDPE and polypropylene) in a tubular reactor at 500 °C temperature in the presence and absence of Y-zeolite catalyst. It was found that the yields of gases, gasoline and light oil could be increased in the presence of catalyst.

E. Manish Chand Sharma, Neelesh Soni (et al):-

Issued a paper in 2013 on "Production of alternative fuel from waste oil and comparison with fresh diesel". This research paper compares the diesel obtained from pyrolysis of plastic oil with conventional diesel oil.

F. Alkazadagaonkar (et al):-

The experiments on conversion waste plastic into liquid fuels using new technology. We can convert all types of waste plastics into liquid fuels at a temperature of 350^0C-500ºC.

G. M.fAli:-

Reported that the high yields of liquid fuels in the boiling range 100°C– 480°C and gases were obtained along with a small amount of heavy oils and insoluble material such as gums and coke. The results obtained on the co-processing of polypropylene with coal and petroleum residues are very encouraging as this method.

V. EXPERIMENTAL SETUP

Plastic was cut into a number of small pieces. The plastic chips were washed, dried, and fed into a pyrolysis melting chamber unit. The pyrolysis melting chamber used in this process was in cylindrical chamber. The electric heater is placed inside the melting chamber fitted such type heater does not meet the plastic material. The heater has a capacity of 3KW. Electrical power supplied to heater and it's achieve the required temperature range. The process was carried out between the temperature ranges of 250oC-350oC inside the melting chamber for 1 hours and 30 minutes. The products of

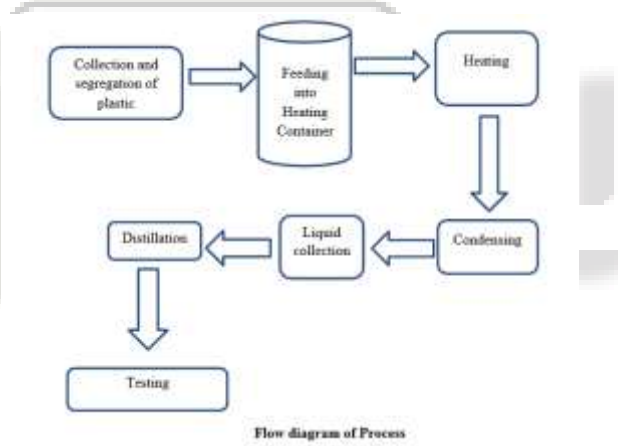
pyrolysis is in the form of vapour were send to a water cooled condenser and the condensed liquid was collected as a fuel.

VI. PYROLYSIS OF PLASTIC

Production of fuel from waste plastic involves pyrolysis process. In this process, plastic is rapidly heated to 250º-350°C in a reactor in the absence of oxygen. The temperature required depends on the types of plastics used. Once the melting point is reached, the plastics melts and the vapour rise up and is collected in the condensing unit. Water is used to condense the vapour. The condensed vapour is collected above the water due to the density difference of the oil and water. Finally, the oil is poured out of the condensing unit through the tap provided. The pyrolysis of plastic gives out the mixture of fuel, gases and solid char. Variation of the pyrolysis process, type of plastic used and the temperature will produce the varying percentage of these three products.

Various technologies and methodologies can be used for the pyrolysis process such as batch reactor, semi batch reactor, fluidised bed reactor, fixed bed reactor etc. The process can be performed with or without the use of catalyst. The different types of catalyst that can be used for plastic pyrolysis are zeolite, alumina (Al_2O_3), silica (SiO_2), etc.

VII. STEPS INVOLVED IN PROCESS:-



Flow diagram of Process

VIII. RESULTS AND DISCUSSION:

1) Flash Point: - Plastic liquid fuel is poured into the flash point apparatus up to the line marked in the apparatus. Then the oil is heated and check the temperature at regular interval. The outside fire is introduce till the flash is obtained. Once the flash is obtained the reading is noted down. Flash point is obtained at temperature 28ºC.
2) Fire point: - After recorded the flash point continuous give the external fire until the fire point obtained. Once the fire point obtained the temperature is recorded. At 32ºC temperature the fire point is obtained.
3) Kinematic Viscosity (γ):- Viscosity is an important property of fuel. It is fluid's resistance to the flow at a given temperature.

A. Expected Outcome of Pyrolysis Plant:

Particulars	Test 1	Test 1	Test 1
Mass of plastics used	600gm	800gm	1000gm
Total oil production	520ml	720ml	890ml
Total char production	75gm	76gm	105gm
Electric power supply	3kWh	3kWh	3kWh
Time of operation	1hr 30min	1hr 25min	1hr 30min

B. Comparison of Properties of Plastic with Diesel and Petrol:

Sr. No.	Properties	Plastic Oil	Petrol	Diesel
1	Density (Kg/m3)	760	740	832
2	Calorific value (KJ/Kg)	47528.55	45800	45500
3	Kinematic viscosity ($m^{2/s}$) @ 40º C	1.99×10^{-6}	2.1×10^{-6}	2.5×10^{-6}
4	Flash Point (º C)	28	29	48
5	Fire Point (º C)	32	33	55

IX. CONCLUSION:

Plastic bears a major threat to the current scenario and the environment. Millions of tonnes of plastics are produced on the daily basis and only few percentage of the waste plastic are being successfully recycled. Since, plastic takes long years to decompose, some alternative to plastic should be developed. Also, the world is facing the problem of shortage of petroleum.

Therefore, conversion of waste plastic into fuel can provide a better solution to the disposal problem of waste plastic as well as act as an alternative to fossil fuel. From the experiments and trials, we also found that by using pyrolysis method we were able to get recover 80-85% oil for polypropylene plastic. However, the output varies depending on the type of plastic used. Also, the plastic fuel showed properties similar to that of diesel fuel.

Hence, we can conclude that pyrolysis of plastic into fuel can solve both the problem of plastic waste management as well as shortage of fossil fuel if plant is set up at the commercial level.

X. APPLICATION OF PROJECT & FUTURE WORK:

1) It can be used as alternate source of fuel in diesel engines.
2) It can be used as a fuel in diesel generators.
3) It can be used for heating in sugar industry, steel industry, etc.
4) It can be used for heating boilers.
5) The application of this project could help in reducing the dependency on the gulf countries and promote a step towards innovation.

REFERENCES

[1] Achyut K. Panda, R.K. Singh, D.K. Mishra: - Thermolysis of waste plastics to liquid fuel. A suitable method for plastic waste management and manufacture of value added product A world prospectives, 2009; 1-6: 10-11
[2] Tiwari D.C., Ejaz Ahmad, Kumar Singh:- K.K. International Journal of Chemical Research, ISSN: 0975-3699, Volume 1,Issue 2, 2009, pp-31-36
[3] Antony Raja and Advaith Mural:- Journal of Materials Science and Engineering B1 (2011) page no.86-89
[4] Wenger Jorn Av.Venezuela 2007:- Asuncion/Paraguay Journal of Materials Science and Engineering A 5 (3-4) (2015) 178-180doi:10.17265/2161-6213/2015.3-4.011
[5] Manish Chand Sharma ,Neelesh Soni:-The International Journal Of Engineering And Science (IJES),Volume-3 (54-58),2013, ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805
[6] C.Wongkhorsub, N. Chindaprasert: - "A Comparison of the Use of Pyrolysis Oils in Diesel Engine", Energy and Power Engineering, July 2013).
[7] Elmo C. Rapsing:- Jr. Design and Fabrication of waste plastic into oil converter ,International journal of Interdisciplinary Research and innovation, Vol 4, issue 2,pp(69-77), month: April-June 2016
[8] Bockhorn H (et al.):- Kinetic study on the thermal degradation or thermal pyrolysis of plastic wastes. They concluded that, the temperature and reaction time thermal pyrolysis is slightly greater than the catalytic pyrolysis.
[9] J. Walendziewski, Engine fuel derived from plastics by thermal treatment, fuel 81 (2002) 473-481
[10] M. Mani, G. NagarajaN, Influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil Energy 34

