“PRODUCTION AND PURIFICATION OF LIQUID FUEL FROM HOUSEHOLD PLASTIC WASTE FOR CI ENGINE”

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VISVESVARAYA TECHNOLOGICAL UNIVERSITY
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Project Report
On

"PRODUCTION AND PURIFICATION OF LIQUID FUEL FROM HOUSEHOLD PLASTIC WASTE FOR CI ENGINE"
(SPONSERED BY KSCST AND KSBDB)

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A Project report submitted to the Visvesvaraya Technological University, Belagavi in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING
In
MECHANICAL ENGINEERING

Under the Guidance of

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DEPARTMENT OF MECHANICAL ENGINEERING
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DEPARTMENT OF MECHANICAL ENGINEERING

CERTIFICATE

This is to certify that the Project work entitled **"Production and Purification of Liquid Fuel from Household Plastic Waste for CI Engine" (Sponsored by KSCST)** Carried out by **Mr. Mahesh B Kutoli (2VS12ME020), Mr. Kallappa S Shegunshi (2VS12ME015), Mr. Mithun A Imagoudanavar(2VS12ME022), Mr. Amit S Malaji (2VS12ME007)** are bonafide students of **VSM Institute of Technology** in partial fulfillment for the award of **Bachelor of Engineering** in **Mechanical Engineering** of the **Visvesvaraya Technological University, Belagavi** during the year 2015-16. It is certified that all corrections/suggestions indicates during Internal Assessment have been incorporated in the project report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said degree.

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OUR BELOVED INSPIRATION

DEDICATED TO

BELOVED

PARENTS AND

TEACHERS

DECLARATION

We, **Mr. Mahesh B Kutoli(2VS12ME020), Mr. Kallappa S Shegunshi(2VS12ME015), Mr. Mithun A Imagouadanavar(2VS12ME022), Mr. Amit S Malaji (2VS12ME007)**. Students of eighth semester B.E. in Mechanical Engineering, VSM Institute of Technology, Nipani, hereby declare that the project work entitled **"Production and Purification of Liquid Fuel from Household Plastic waste for CI Engine"** has been carried out and duly executed by us at VSMIT, Nipani, under the guidance of **Prof.,** Assistant Professor and submitted in partial fulfillment of the requirements for the award of degree in **Bachelor of Engineering in Mechanical Engineering** by **Visvesvaraya Technological University, Belagavi** during the academic year 2015-2016.

Date:-20/05/2016
Place:-Nipani.

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ABSTRACT

Plastics have woven their way into our daily lives and now pose a tremendous threat to the environment. Over 100 million tons of plastics are produced annually worldwide, and the used products have become a common feature at over flowing bins and landfills. Though work has been done to make futuristic biodegradable plastics, there have not been many conclusive steps towards cleaning up the existing problem. Here, the process of converting waste plastic into value added fuels is explained as a viable solution for recycling of plastics. Pyrolysis runs without oxygen and in high temperature of about 300°C which is why a reactor was fabricated to provide the required temperature for the reaction. Converting waste plastics into fuel hold great promise for both the environmental and economic scenarios. Thus, the process of converting plastics to fuel has now turned the problems into an opportunity to make wealth from waste. The conversion of oil from plastic has dual benefits. First of all the oil produced can be used as a fuel for domestic purposes and also in vehicles and industries when further refined. Secondly the various types of pollution caused due to waste plastics can be minimized. Plastic in the first place is manufactured from natural gas specifically from ethane which is a constituent of natural gas. Therefore the waste plastic can be converted back into it.

Increase in energy demand, stringent emission norms and depletion of oil resources have led the researchers to find alternative fuels for internal combustion engines. On the other hand waste plastic pose a very serious environment challenge because of their disposal problems all over the world. Plastics have now become indispensable materials in the modern world and application in the industrial field is continually increasing. In this context, waste plastic solid is currently receiving renewed interest. The properties of the oil derived from waste plastics were analyzed and compared with the petroleum products and found that it has properties similar to that of diesel.

In this project work an attempt has been made to investigate the conversion of household waste plastic into liquid fuel by using pyrolysis process, a pyrolysis unit is designed, fabricated and evaluated for various kinds of plastic wastes, properties of liquid fuels obtained are determined.

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01. INTRODUCTION

Plastic were invented in 1860, but have only been widely used in the last 30 years plastic are light, durable, modifiable and hygienic. Plastic are made of long chain of molecule called Polymers. Polymers are made when naturally occurring substance such as crude oil or petroleum are transformed into other substance with completely different properties. These polymers can then be made into granules, powders and liquids, becoming raw materials for plastic products.

Plastics have become an indispensable part in today's world. Due to their light weight, durability, energy efficiency, coupled with faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas. Plastics are produced from petroleum derivates and are composed primarily of hydrocarbons but also contain additives such as antioxidants, colorants and other stabilizers. Disposal of the waste plastics poses a great hazard to the environment and effective method has not been implemented. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and few other elements like nitrogen. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of waste management. According nationwide survey which was conducted in the year 2000, approximately 6000 tones of plastic were generated in India, and only 60% of it was recycled, the balance of 40% could not be disposed off. Today about 129 million tones of plastics are produced annually all over the world, out of which 77 million tonesproduced from petroleum.

In India alone, the demand for the plastics is about 8 million tonesper year.More than 10,000 metric tonesper day plastics are produced in India and almost the same amount is imported by India from other countries. The per captiaconsumption of plastics in India is about 3kg when compared to 30kg to 40kg in the developed countries. Most of these come from packaging and food industries. Most of the plastics are recycled and sometimes they are not done so due to lack of sufficient market valve. Of the waste plastics not recycled about 43% is polyethylene, with most of them in containers and packaging.

1.1 Types of Plastics

The types of the waste plastics are LDPE, HDPE, PP, PS, and PVC [10]. Theproblems of waste plastics can‘t be solved by landfilling or incineration, because the safety deposits are expensive and incineration stimulates the growing emission of harmfulgreenhouse gases like COx, NOx, SOx and etc. These types of disposal of the waste plastics release toxic gas which has negative impact on environment. Plastic wastes can also classified as industrial and municipal plastic wastes according to their origins, these groups have different qualities and properties and are subjected to different management strategies. Plastic wastes represent a considerable part of municipal wastes furthermore huge amounts of plastic waste arise as a by-product or faulty product in industry and agriculture. The total plastic waste, over 78% weight of this total corresponds to thermoplastics and the remaining to thermosets. Thermoplastics are composed of polyolefins such as polyethylene, polypropylene, polystyrene and polyvinyl chloride and can be recycled. On the other hand thermosets mainly include epoxy resins and polyurethanes and cannot be recycled.

1.2 Municipal Plastic Wastes

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household wastes. The various sources of MPW plastics includes domestic items (food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, CD and cassette boxes. fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinks bottles, plumbing pipes and guttering, flooring. cushioning foams, thermal insulation foams, surface coatings, etc.), agricultural (mulch films, feed bags, fertilizer bags, and in temporary tarpaulin-like uses such as covers for hay, silage, etc.), wire and cable, automobile wrecking, etc. Thus, the MPW collected plastics waste is mixed one with major components of polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, etc. The percentage of plastics in MPW has increased significantly.

1.3 Industrial Plastic Wastes

Industrial plastic wastes are those arising from the large plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly constitute plastics from construction and demolition companies (e.g. polyvinylchloride pipes and fittings, tiles and sheets) electrical and electronics industries (e.g. switch boxes, cable sheaths, cassette boxes, TV screens, etc.) and the automotive industries spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills). Most of the industrial plastic waste has relatively well physical characteristics i.e. they are sufficiently clean and free of contamination and are available in fairly large quantities.

02. LITERATURE SURVEY

1. **Achyut K Panda(et al.)**:- Plastic recycling, continuous to progress with wide range of old and new technologies. Many research projects have been undertaken on chemical recycling of waste plastic to liquid fuel. **[1]**

2. **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 350-500c.**[3]**

3. **MiskolcziaN(et al)**:- Thermal degradation of plastic waste for production of liquid fuels. It is a endothermic process requiring temperature of 350-500c. The gaseous products obtained by thermal pyrolysis are not suitable for use as fuel produts, further refining is required.**[4]**

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8. **B. Csukas (et al):-**Investigated pyrolysis temperature range was 465-545c, and raw material feeding rate was between 620g/min.

2.1 Outcome of literature survey

- Thermolysis of waste plastics to liquid fuel a suitable method for plastic waste management and conversion of waste plastic into liquid hydrocarbon by using new technology we can convert all types of waste plastic into hydrocarbon fuel at the temperature profile 350ºc to 500ºc.
- Addition of catalyst enhances the conversion and fuel quality. As compared to the purely thermal pyrolysis, the addition of catalyst in polyolefin pyrolysis. Significantly lowers pyrolysis temperatures and time. A significant reduction in the degradation temperature and reaction time under catalytic conditions resultsin an increase in the conversion rates for a wide range of polymers at much lowertemperatures than with thermal pyrolysis.
- Fuel obtained from pyrolysis process shows nearly same properties as that ofdiesel fuel oil. So we can use plastic oil as alternative fuel.

03.OBJECTIVES

This project attempts to show how human has been utilizing the energy and explore prospects of optimizing the same one of the alternative fuels is household plastic waste oil.Fuel obtained from pyrolysis process shows nearly same properties as that of diesel fuel. So we can use plastic oil as alternative fuel. The objectives of this project are given below.

- To collect the household plastic waste from different places.
- Drying and Storing of plastic waste.
- To develop and fabricate the pyrolysis unit to produce liquid fuel from plastic waste.
- Conversion of household plastic waste in to liquid fuel.
- To purify the produced liquid fuel by water washing method.
- To conduct the different experiments to determine the different properties of liquid fuel.
- Compare the properties of liquid fuel with diesel fuel.

04.MATERIALS AND METHODS

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household plastic wastes. The various sources of MPW plastics includes domestic items like food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, CD and cassette boxes. Fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinks bottles, plumbing pipes and guttering, flooring.

In this project work pyrolysis method is used to convert household plastic wastes like food containers, milk covers, water bottles, packaging foam, and waste cooking oil cover. Nearly 15 tonnes of plastic cover is wasted in single village. This waste plastic cover is also used in Belagavi, dharawad, hubli, vijayapur, karwar district‘s etc. for the period of 4 months that will leads to mass plastic waste. This highest portion of plastic is disposed to landfill. By survey nearly 150 tonnes to 200 tonnes of plastic cover is disposed into land in single district. By estimating 5000 tonnes to 6000 tonnes of plastic will be wasted from household sources in the state. Waste plastics have been shredded then washedbefore pyrolysis.From above factors from municipal plastic waste havebeen used as raw materials.Waste plastics have been washed before pyrolysis. In this work milk plastic cover and edible oil covers are selected as feed stocks to convert waste plastic into useful liquid fuel compounds.

4.1 Raw Materials Used To Produce Liquid Fuel

Fig 4.1 Edible oil waste packets fig 4.2 Milk waste packets

The above Figure.4.1 and Fig 4.2 shows the Edible oilplastic wastes and milk plastic wastes respectively, these are used as feed stocks to produce liquid fuel compounds. Plastic cover and edible oil covers are selectively collected from local hotels and hostels.

4.2 Design parameters of a Pyrolysis unit

Desirable parameters for the design

a) Melting point of the substance

If melting point is high, substance easily vaporizes & more oil is obtained.

b) Density

If density is lower, substance easily vaporizes & more oil is obtained.

c) Quality of substance

More is quality, more is the yield of oil.

d) Moisture content

More is moisture, less is the oil yield.

e) Reactor Temperature

More is the reactor temperature, more is the yield.

f) Heating rate

More is the heating rate, more is the yield.

g) Reactor size

There is an optimum for the reactor size to get maximum oil yield.

h) Feed rate

Feed rate is given according to the demand for the oil.

f) Maintaining a uniform temperature

For continuous production it should maintain a uniform temperature.

g) Types of condenser used

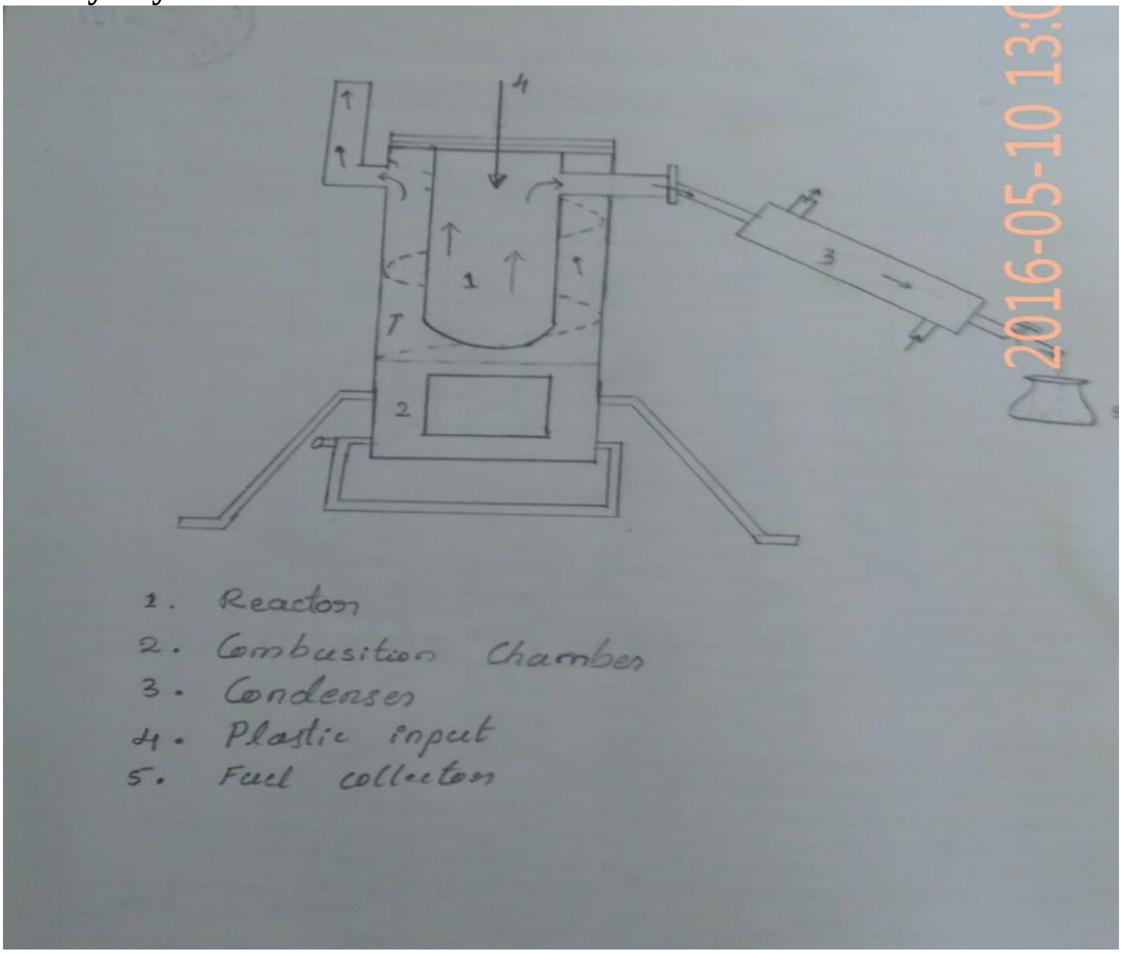
Condenser design also effects the production of maximum product yield.

4.3 Fabrication of Pyrolysis unit

Fig 4.3 Pyrolysis unit

Pyrolysis unit developed from MS materials with 3mm thickness. By using arc and gas welding technology, we are fabricated the above pyrolysis unit. The experiments carry out with high temperature and atmospheric pressure so unit must be withstanding to high temperature. Thermocouples, pressure gauge and safety valves are provided to reactor. Reactor welded by using gas welding to prevent the leakage of vapours. The safe and efficient pyrolysis unit is shown in the above Fig.4.3.

4.4. Pyrolysis Process



1. Reactor
2. Combustion chamber
3. Condense
4. Plastic input
5. Fuel Collection

Fig 4.4 Line diagram of pyrolysis unit

Fig.4.4 shows, the experimental setup of pyrolysis process. The apparatus was designed to operate at high temperatures and atmospheric pressure. The heart of the experimental apparatus was a vertical tubular reactor. A feeder was attached to the reactor‘s upper end; this enabled controlled amounts of plastic pellets to be added before or during operation. At the bottom of the reactor attached a furnace for the purpose of heating the reactor. Biomass and charcoal with blower is used as a heating source to heat the reactor. Due to increasing reactor temperature the plastic starts to evaporate, these Vapors leaving the reactor and passed into a condenser, condenser maintained at atmospheric temperature. The cyclone separator is provided at the end of condenser to separate the gaseous and plastic liquid fuel compounds. The gas is reused to heat the pyrolysis unit and another end of cyclone separator is connected to a flask in which the liquid hydrocarbon product was collected. Temperatures and pressure were monitored continuously by using thermocouples and pressure gauge.

4.5 Steps involved in process

1. **Feeding-** Feed the feedstock‘s to reactor through feeder and closes the feeder inlet.

2. **Heating-** To increase the temperature of reactor, heat the product of reactor inside by using heating source.

3. **Condensing-** The plastic get evaporated at high temperature, this vapor is condensed to atmospheric temperature by using straight and spiral tube condensers.

4. **Liquid collection-**Out coming product from the condenser is collected at liquid collector. At the end of condenser provide a cyclone separator to separate the plastic liquid fuel and noncondensible gases. These noncondensible gases are reuses to heat the pyrolysis unit.

5. **Water wash, Purification and pH test**- This involves many purification processes. In this method we take equal proportion of plastic fuel and water in a container and shake well, allow it for 5-7 hours to settle down. Now water along with some crystals is collected at bottom and pure plastic fuel is collected at the top container.

6. Purification- Purify the plastic fuel by using filter papers and filters.

7. pH Test- After purification measure the pH value of plastic fuel by using pH meter. If the pH is less than 7, the fuel is acidic in nature. It is needed to wash with water many times to bring pH value of oil to 7.

4.6 Flow diagram of Conversion of Plastics waste into Liquid Fuel

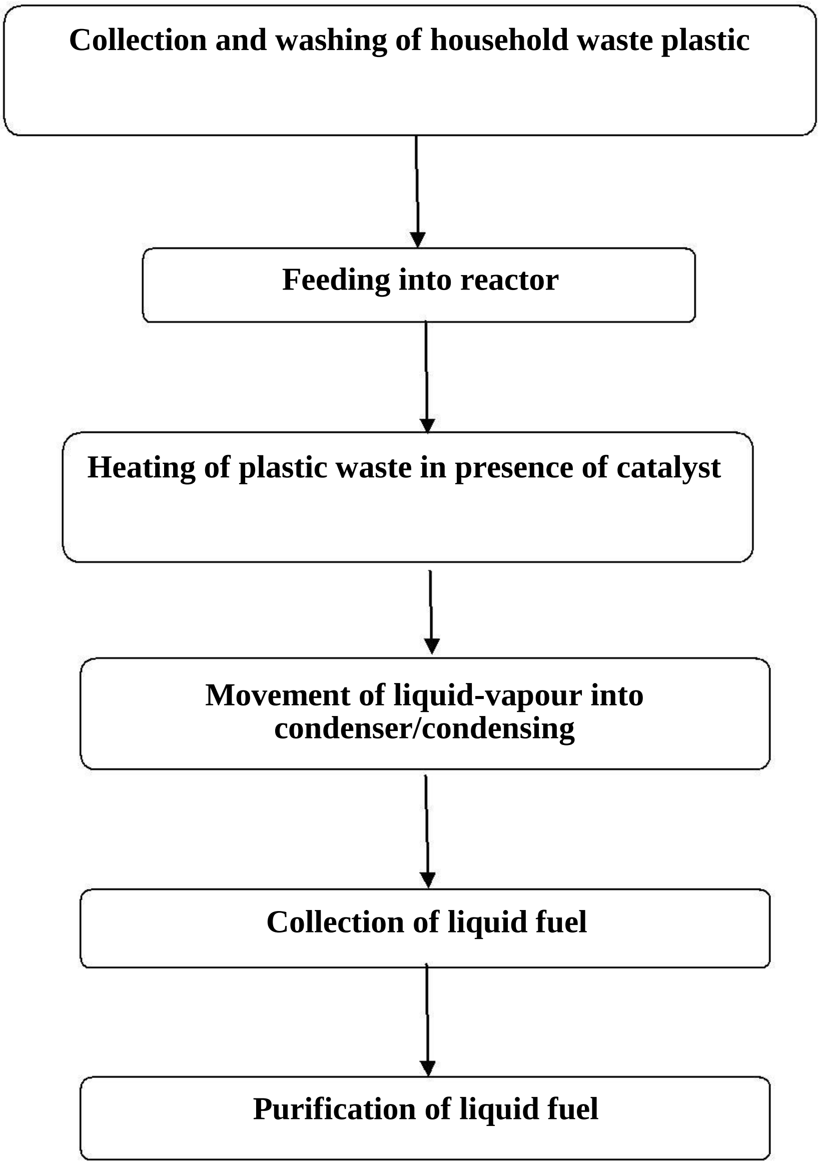


Fig 4.5 Flow diagram of Conversion of Plastics waste into Liquid Fuel

4.7 Plastic Pyrolysis oil

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived elements pyro "fire" and lysis "separating".

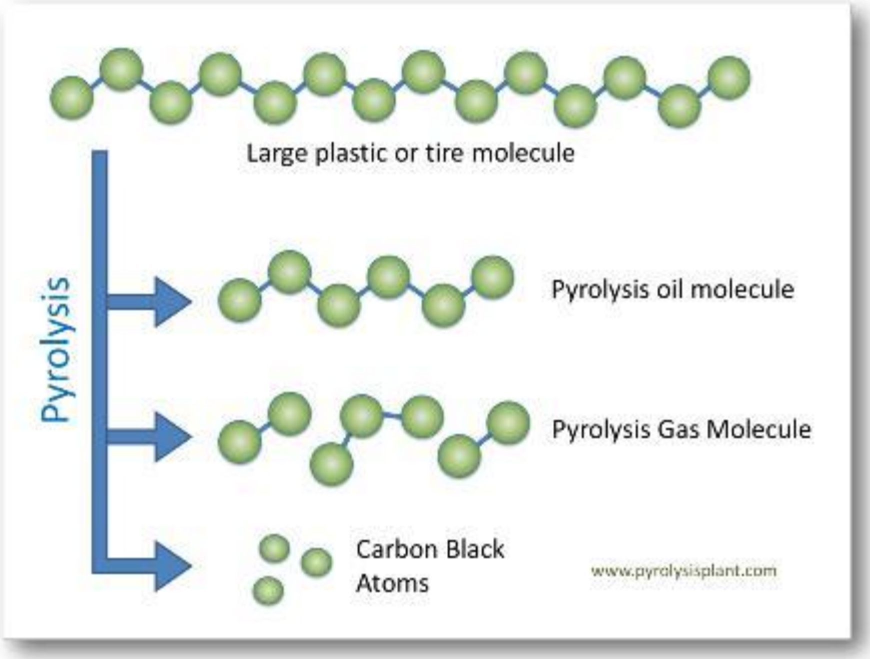


Fig 4.6 Breaking of Hydrocarbon chain in Pyrolysis Process

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it usually does not involve reactions with oxygen, water, or any other reagents. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. Bio-oil is produced via pyrolysis, a process in which biomass is rapidly heated to 450–500°C in an oxygen-free environment and then quenched, yielding a mix of liquid fuel (pyrolysis oil), gases, and solid char. Variations in the pyrolysis method, biomass characteristics, and reaction specifications will produce varying percentages of these three products. Several technologies and methodologies can be used for pyrolysis, including circulating fluid beds, entrained flow reactors, multiple hearth reactors, or vortex reactors. The process can be performed with or without a catalyst or reductant.

The original biomass feedstock and processing conditions affect the chemical properties of the pyrolysis oil, but it typically contains a significant amount of water (15%–30% by weight), has a higher density than conventional fuel oils, and exhibits a lower pH (2–4). The heating value of pyrolysis oil is approximately half that of conventional fuel oils, due in part to its high water and oxygen content, which can make it unstable until it undergoes further processing. Bio-oil can be hydro-treated to remove the oxygen and produce a liquid feedstock resembling crude oil (in terms of its carbon/hydrogen ratio), which can be further hydro-treated and cracked to create renewable hydrocarbon fuels and chemicals.

Hydro-treating stabilizes the bio-oil preventing molecule-to-molecule and molecule-to-surface reactions and eventually produces a finished blend-stock for fuels. Bio-oil can be deoxygenated from its high initial oxygen content of 35-45 percent by weight (wt%) on a dry basis all the way down to 0.2 wt%.

DongleiWu produced experimental setup for low temperature conversion of plastic waste into light hydrocarbons. For this purpose 1 litre volume, energy efficient batch reactor was manufactured locally and tested for pyrolysis of waste plastic. The feedstock for reactor was 50 g waste polyethylene. The average yield of the pyrolytic oil, wax, pyrogas and char from pyrolysis of PW were 48.6, 40.7, 10.1 and 0.6%, respectively, at 275 ◦C with non-catalytic process. Using catalyst the average yields of pyrolytic oil, pyroga

4.8 Purification Setup

In this method we take equal proportion of plastic fuel and water in a container and shake well, allow it for 5-7 hours to settle down. Now water along with some crystals is collected at bottom and pure plastic fuel is collected at the top container. In mean time check the pH value of plastic oil by using pH meter if it is in acidic in nature it is needed to many times wash with water to bring the pH of oil to 7.

Fig 4.7 Purification setup

05. RESULTS AND DISCUSSION

5.1. Properties of plastic pyrolysis oil

1) Density:-

Density of fuel at different temperatures was measured by a standard 25 ml marked flask. Weight of the fixed volume of fuel (25 ml) was measured at different temperatures by an electronic balance which measures up to 0.0001 gm. The density values are reported in kg/m^3.

2) Calorific value:-

Determination of calorific value:

The calorific value of a fuel is the quantity of heat produced by its combustion at constant pressure and under normal conditions. Calorific value determined by using bomb calorimeter.

Procedure:

1. Weight the empty crucible.
2. Take approximately 0.5gm of liquid fuel in a crucible & reweight.
3. Place the crucible in its support and coil a small loop of the nicrome wire between the two conductors and a piece of thread is dipped into the fuel screw the cap firmly on to the body of the bomb and charge with oxygen until a pressure of 25 bar is obtained.
4. Lower the bomb into the calorimeter and connect the firing wire. Pour about 2.25 liters of water into the calorimeter so as to completely cover the bomb, fit a thermometer and stirrer. Press fire button to start the ignition, temperature of water starts to rise, note down the temperature of water for every 10 seconds.
5. Until the transfer of heat from bomb has ceased has indicated by fall in temperature reading.
6. Take down the maximum temperature for the calculation of calorific value by using below relationship.

3) Viscosity:-

Viscosity is an important property fuel and it is fluid's resistance to the flow (shear stress) at a given temperature. Fuel viscosity is specified in the standard for diesel fuel within a fairly narrow range. Hydrocarbon fuels in the diesel boiling range easily meet this viscosity requirement. The viscosity range for typical fuels overlaps the diesel fuel range with some fuels having viscosities above the limit. If fuel viscosity is extremely excessive, there will be a degradation of the spray in the cylinder causing poor atomization, contamination of the lubricating oil, and the production of black smoke. Kinematic viscosity takes into account the fluid density and centistokes is the engineering unit used to express the kinematic viscosity.

Procedure for calculation of viscosity:

- Instrument is leveled with the help of leveling screws.
- The kouhlrausch flask of 50 ml capacity is placed below the jet.
- Oil and water are kept stirred their respective temperature are noted.
- Valve ball is turned from agate jet oil is allowed to flow into the flask.
- Flow time for 50 ml of oil is noted with the help of stop watch.
- Calculate the kinematic viscosity by using below relation.

Kinematic viscosity= $(0.22*T - 135/T)*10^{-6}$

Where T – time in sec

T=30 sec

$V=(0.22*30 - 135/30)*10^{-6}$

$V=2.1*10^{-6}\ M^3/sec$

V=2.1 cst

4) Fire point test:-

Procedure: Measured plastic liquid fuel is poured up to the mark indicated in the flash point Apparatus. Then the oil is heated and stirred at regular interval. The external fire is introduced at the regular period till flash is observed. Once the flash is observed the temperature is recorded. Recorded temperature at the time of the fire starts to see continuously is the fire point of the plastic liquid fuel.

06. Comparision of Properties Of the Waste plastic fuel and Diesel Fuel

Sl. Nor.	Properties	Plastic Fuel	Diesel fuel
1	Density(kg/m^3)	821	812
2	Calorific Value(kJ/kg)	45,050	42,000
3	Kinematic Viscosity	2.1	3.05
4	Flash Point (^0c)	-	66
5	Fire Point (^0c)	38	74

07. Conclusion

According to the current statistics, there is continuous rise of consumption and thus cost of petroleum oil, International Energy Outlook 2008 reports the world consumption of petroleum oil as 84 million barrels per day. The conversion of waste plastics to liquid hydrocarbon fuel was carried out in thermal pyrolysis unit.

This method is superior in all respects (ecological and economical).By adopting this technology, efficiently convert weight of waste plastics into 75% of useful liquid hydrocarbon fuels without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil. Depletion of non-renewable source of energy such as fossil fuels at this stage demands the improvements of this technique.

Based on the properties of the Plastic fuel and Diesel fuel the all properties are nearer hence concluded that Waste plastic fuel represents a good alternative fuel for diesel engine and therefore it can be used for diesel engine vehicles for the transportation purpose.

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