CHAPTER 1

1. INTRODUCTION:

Plastic is wide range of synthetic or a semi synthetic material that are used in a huge and growing range of applications. The first plastic (parkesine) was invented by Alexander Parkesine 1862. Later in 20th century scientist named Leo Baekeland invented first fully synthetic plastic in 1907 called Bakelite. The word “Plastic” is originated from Greek word “Plastikos” which means “grow” or “form” [capable of being de-formed without any rupture].

1.1 PLASTIC CONTENT:

Globally, plastic production was estimated to be 380 million tonnes in 2018. Since 1950 to 2018, plastics of about 6.3 billion tonnes have been produced worldwide, 9% and 12% of which have been recycled and incinerated, respectively. Plastics of about 5 million tonnes are yearly consumed in UK alone, India generates 62 million tonnes of waste each year. About 43 million tonnes (70%) are collected, of which about 12 million tonnes are treated, and 31 million tonnes are dumped in landfill sites and Karnataka generates around 2.96 lakh tonnes of plastic waste annually. However, out of the 2.96 lakh tonnes, only about 73,000 tonnes of plastic waste is recycled. While over 50 thousand tonne plastic is being incinerated, around 1.75 lakh tonnes of trash is unaccounted for with only about one-quarter recycled, and the rest landfilled. It has been suggested by researchers that by 2050, oceans might contain more plastics than fish in terms of weight. Yearly, approximately 500 billion plastic bags are used out of which an estimated 13 million tonnes ends up in the ocean, killing approximately 100,000 marine lives Plastics have become essential part in today’s life. Due to their durability, fire resistance, weather resistance, moisture resistance, ductility, light weight, these plastics are employed in entire industrial and domestic areas. Plastics are non-biodegradable polymers containing carbon, hydrogen and few other elements like nitrogen. Due to non-biodegradable it leads to problem of waste management. Most of plastics are used in packaging of food items. The project is about, to investigate the conversion of plastic waste to liquid fuel by using thermal Micropyrolysis process. Both temperature and the pressure in cylinder is maintained by pressure and temperature gauge. State of liquid changes to vapour. This vapour is then passed with conical opening pipe from the upper end and gets condensed in the condenser and finally oil is collected in the flask. The produced hydrocarbon fuel is further used in IC Engine.

1.2 TYPES OF PLASTIC

Table 1.1: Detail about types of plastic, properties of plastic, recycle and common use

Symbols	1 PET	2 HDPE	3 PVC	4 LDPE	5 PP	6 PS	7 OTHER
Types of Plastics	Polyethylene Terephthalate	High Density Polyethylene	Polyvinyl chloride	Low Density Polyethylene	Polypropylene	Polystyrene	Others
Properties	Clear, tough, solvent resistance, barrier to moisture and fire, softens at 80 degrees.	Hard to semi flexible, resistance to chemicals and moisture, waxy surface, opaque etc.	Strong, tough, can be clear and solvent welded, softens at 80 degrees.	Soft, flexible, waxy surface, translucent, softens at 70degrees, scratches easily.	Hard but still flexible, waxy surface, softens at 140 degree, Translucent, versatile etc.	Clear, glassy, rigid, opaque, Semi-tough, Softens at 95 degrees, Resistant to alkalis, etc.	Includes all the resins and multi materials Such as Laminates.

Common Uses	Soft drink and water bottles, High heat resistance food trays, medicine jars Fibers for clothing.	Milk bottles, water bottles, Bleach & Chemical bottles, shopping bags.	Pipes, Fittings, Window/door Frames, thermal Insulation and automotive parts.	Bread bags, sandwich bags, ice-cream containers, bin bags, black plastic sheets.	Straws, Ketchups, bottle tops, plant pots, biscuit wrappers, syrup Bottles etc.	Egg boxes, food boxes, disposable cups, CD cases, food trays etc.	Nylon used for fiber textiles, used in cups and bottles etc.
Recycled as: -	Soft drinks Detergent bottles, Carpet Fibers etc.	Plastic timber and pipes, bucket etc.	Flooring, speed bumps Mud flap sand mats, sheets cables etc.	Pallets sheets and bin bags	Car battery cases, oil funnels, trays etc.	Picture frames, seed trays, building products etc.	Automotive components and plastic timber
Pictures							

The problems of waste plastics can't be solved by land filling or incineration, because the safety deposits are expensive and incineration stimulates the growing emission of harmful greenhouse gases like CO_2, NO_2, SO_2 and etc. These types of disposals of the waste plastics release toxic gas which has negative impact on environment. Plastic wastes can also be 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, further more 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 thermo-sets. Thermoplastics are composed of polyolefins such as polyethylene, polypropylene, polystyrene and polyvinyl chloride and can be recycled. On the other hand, thermos sets mainly include epoxy resins and polyurethanes and cannot be recycled.

1.3 MUNICIPAL PLASTIC WASTES:

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a house hold wastes. The various sources of MPW plastics includes domestic items such as food containers, milk covers, water bottles, packaging foam, disposable cups, plates, cutlery, etc. and agricultural items such as feed bags, fertilizer bags, 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.

1.4 INDUSTRIAL PLASTIC WASTES:

Industrial plastic wastes are those arising from the large plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly constitutes 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.

Fig 1.1: industrial plastic waste

1.5 IMPACT ON THE ENVIRONMENT:

The major impact of plastic bags on the environment is that it takes many years to decompose. In addition, toxic substances are released into the soil when plastic bags perish under sunlight and, if plastic bags are burned, they release a toxic substance into the air causing ambient air pollution. The owing to the unregulated accumulation of carcinogenic compounds, the use of plastic bags may all owing roads into cancerous diseases. Plastic bags are dumped indiscriminately into landfills worldwide that occupy tons of hectares of land and emit dangerous methane and carbon dioxide gases as well as highly toxic leachates from these landfills during their decomposition stage.

1.6 EFFECTS OF PLASTIC ON ANIMALS:

Aquatic life: Blue whales could be accidentally eating 10 million pieces of microplastic every day, according to new research suggesting filter-feeding whales could be the most vulnerable marine species to plastic pollution. Like other filter-feeding whales, also known as baleen whales, blue whales use bristly baleen plates to sift, sieve or trap krill, plankton and small fish from ocean waters.

Fig 1.2: The image depicts effect on consuming plastics by blue whale

Faridabad: A team of veterinarians in Faridabad in Haryana extracted 71 kilograms (156.5pounds) of plastic, nails and other garbage from a pregnant cow, but both the animal and her baby died. The case has highlighted the country's twin problems of pollution and stray cattle. An estimated five million cows roam in India's cities, with many gorging on the vast amounts of plastic litter on the streets. This cow was rescued after a road accident in late February by the People for Animals Trust Faridabad. A vet soon noticed the pregnant bovine was struggling. In a four-hour operation on February 21, vets found nails, plastic, marbles and other garbage in its stomach. They also attempted a premature delivery. "The baby did not have enough space to grow in her mother's belly so the cow also died.

Fig 1.3: Pregnant cow, baby die due to 71kg of plastic waste found in stomach

CHAPTER 2

2. LITERATURE SURVEY

2.1 LITERATURE REVIEW:

1. B. Saha et al (2007).,: He optimum catalyst composition is around 20% wt, where the reduction in the maximum decomposition temperature is around 70°C in presence of ZSM-5 and the temperature varies between 29.85°C to 599. 85°C.The residue was obtained about 25.17%.

2. M.Z.H.Khan et al (2016).,: Waste Plastic Oil and its diesel blend fuel Characterization. The main objective was the production & characterization of fuel from HDPE waste plastics and to compare pyrolyzed oil by conventional process with standard Petro diesel oil. The gas produced were of Hydrogen, Carbon dioxide, Carbon Monoxide, Methane, Ethane etc. Distillation was carried out to separate the lighter and heavier fraction of hydrocarbon presenting oil. High volatile products are obtained at low temperature and physiochemical properties of oil can be blended with other petroleum products to get highly efficient fuel.

3. Supattra Budsaereechai et al (2019).,: Catalytic pyrolysis of plastic waste for the production of liquid fuel for engines. The experiment concludes that no wax formation was observed when using the bentonite clay pellets as a catalyst in the pyrolysis process, this was attributed to the high acidity of the catalyst (low SiO2:Al2O3 ratio) of bentonite. Catalytic oil produced from PS resulted in higher gasoline engine power, while catalytic oils from PP, LDPE and HDPE demonstrated similar values when compare with commercial fuels.

4. George Kofi Parku et al (2020).,: This study compared the pyrolysis of waste polypropylene into fuel products. Four different temperatures (450,488,525ºC), Among all the temperatures,488 and 525ºC generated promising yields of condensable products with total yields in range of 81-93wt%. The calorific value between 41and 46MJ/kg.

5. B.S.S. Phanisankar et al (2020).,: The existing studies had a certain intention of the analysing and fetch farther the catalytic conversion of waste and standard plastic into liquid hydrocarbons fuel and the experiments were effectively conceded during the research. The temperature ranges of 350–500 °C caused in the disintegration reactions of the plastics, to provide dissimilar hydrocarbons, which produced up to 80% of liquid products mentioned to as crude fuel oil. 12–13% of the enduring solid product and up to 7% of gases.

6. Nandakumar Jahnavi et al (2020). Among the prevalent methods already in existence for the plastic waste management, catalytic pyrolysis has been proved to be an efficient one. The research work involved the synthesis of the catalyst from eucalyptus seeds, a commercially available agricultural waste product aided in pyrolysis. The raw eucalyptus seeds were cleaned, powdered, and surface-modified using sulphuric acid. Hence, the prepared catalyst was used in the pyrolysis process and its performance was compared with that of the commercial activated carbon and zeolite. Zeolite Y generally lowers the temperature of the pyrolysis reaction to 180–190 °C, while the produced catalyst made the pyrolysis reaction possible between 120 and 130 °C. The oil was found to have a composition between C_6 and C_{20}, which includes petroleum, kerosene, and diesel. Hence, the oil obtained was proven to be more useful, as a fuel for locomotive and reheating purposes.

7. Ganjarfadillah et al (2021).,: Recent Progress in Low-Cost Catalysts for Pyrolysis of Plastic Waste to Zeolite (ZSM-5) has been widely reported as an effective material catalyst for producing biofuel through the thermocatalytic reaction. Zeolite catalyst reduces the time required for heating of the plastic. Besides its catalyst base, ZSM-5 is a low-cost catalyst for the conversion of plastic waste to biofuel. The ZSM-5 catalyst also presents thermal stability, good selectivity, activity, and deactivation by coke. In thermocatalytic reactions, the ZSM-5 effectively enhances the deoxygenating and cracking reaction to produce stable oil.

8. F. Faisal et al (2023).,: In recent years, about 370 million tonnes of waste plastic are generated annually with about 9 % recycled, 80 % landfilled and 11 % converted to energy. As recycling of waste plastics are quite expensive and labour-intensive, the focus has now been shifted towards converting waste plastics into energy products. Pyrolysis of waste plastic generates liquid oil (crude), gas, char and wax among which liquid oil is the most valuable product. In this review, emphasis has been given on the pyrolysis products yield from both thermal and catalytic pyrolysis and the factors that affect pyrolysis products yield. This study also thoroughly reviewed physico-chemical properties of WPPO to understand their thermal stability, elemental composition, and functional groups. Although liquid oil exhibits comparable heating value with commercial fuel(diesel/petrol), for example higher heating value of Polypropylene (PP) and Polyethylene (PE) are 50 and 42 MJ/kg which is between 42 and 46 MJ/kg for commercial diesel the other properties depend on several parameters such as plastic and pyrolysis reactor types, temperature, feed size, reaction time, heating rate and catalysts.

9. F. Faisal et al (2023).,: The properties of PPOs depend on parameters such the plastic and pyrolysis reactor types, temperature, reaction time, heating rate, etc. This study reviews the performance, emissions, and combustion characteristic of diesel engines fuelled with neat PPO, PPO and diesel blends, and PPO with oxygenated additives. PPO has higher viscosity and density, higher sulphur content, lower flash point, lower cetane index and an unpleasant odour. PPO displays a higher delay in ignition during the premixed combustion phase. The literatures reported that diesel engines can run with PPO without any modification to the engine. This paper reveals that the brake specific fuel consumption can be lowered by 17.88 % by using neat PPO in the engine. Brake thermal efficiency can be reduced by 17.26 % while blends of PPO and diesel are used. Some studies say NOx emission can be reduced up to 63.02 %, however, others indicate that it can be increased up to 44.06 % compared to diesel when PPO is used in engines. The highest reduction in CO_2 emission was found to be 47.47 % using blends of PPO and diesel; conversely, the highest increase was documented as 13.04 % when only PPO is used as fuel. In summary, PPO has very high potential as a substitute for commercial diesel fuel through further research and by improving its properties through post-treatment processing such as distillation and hydrotreatment.

CHAPTER 3

3. PROBLEM FORMULATION AND PROPOSED WORK

3.1 OBJECTIVES:

- To collect and segregate different types of plastic waste.
- To modify the micropyrolysis reactor.
- To get the optimization of plastic and chemical mixture.
- Performing the tests on different types of plastics.
- Characterization of crude oil.

3.2 PROPOSED WORK:

- The fig 3.1 shows the experimental setup of thermal micro-pyrolysis process.
- The apparatus was designed to operate at high temperature and atmospheric pressure.
- The experimental apparatus is vertical tubular reactor. A feeder was attached to the reactor supper end & the lower end of inner cylinder through an outlet, this enabled to control amount of plastic pellets to be added before or during operation.
- Furnace is attached to the bottom of reactor as shown in figure.
- Gas is used as a heating source to heat the reactor. Due to increase of temperature in the reactor plastic starts to evaporate, these vapours leaving the reactor and passes into outlet in the form of liquid.
- Temperature pressures are monitored continuously by using temperature indicator.
- To conduct the experiment to determine different properties of liquid fuels.
- Compare the properties of liquid fuel with diesel fuel.

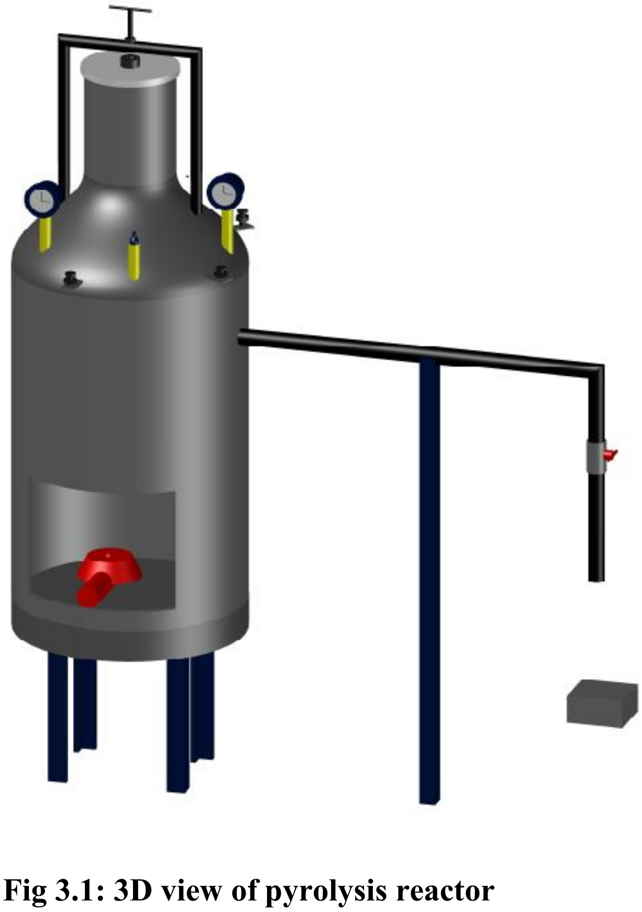


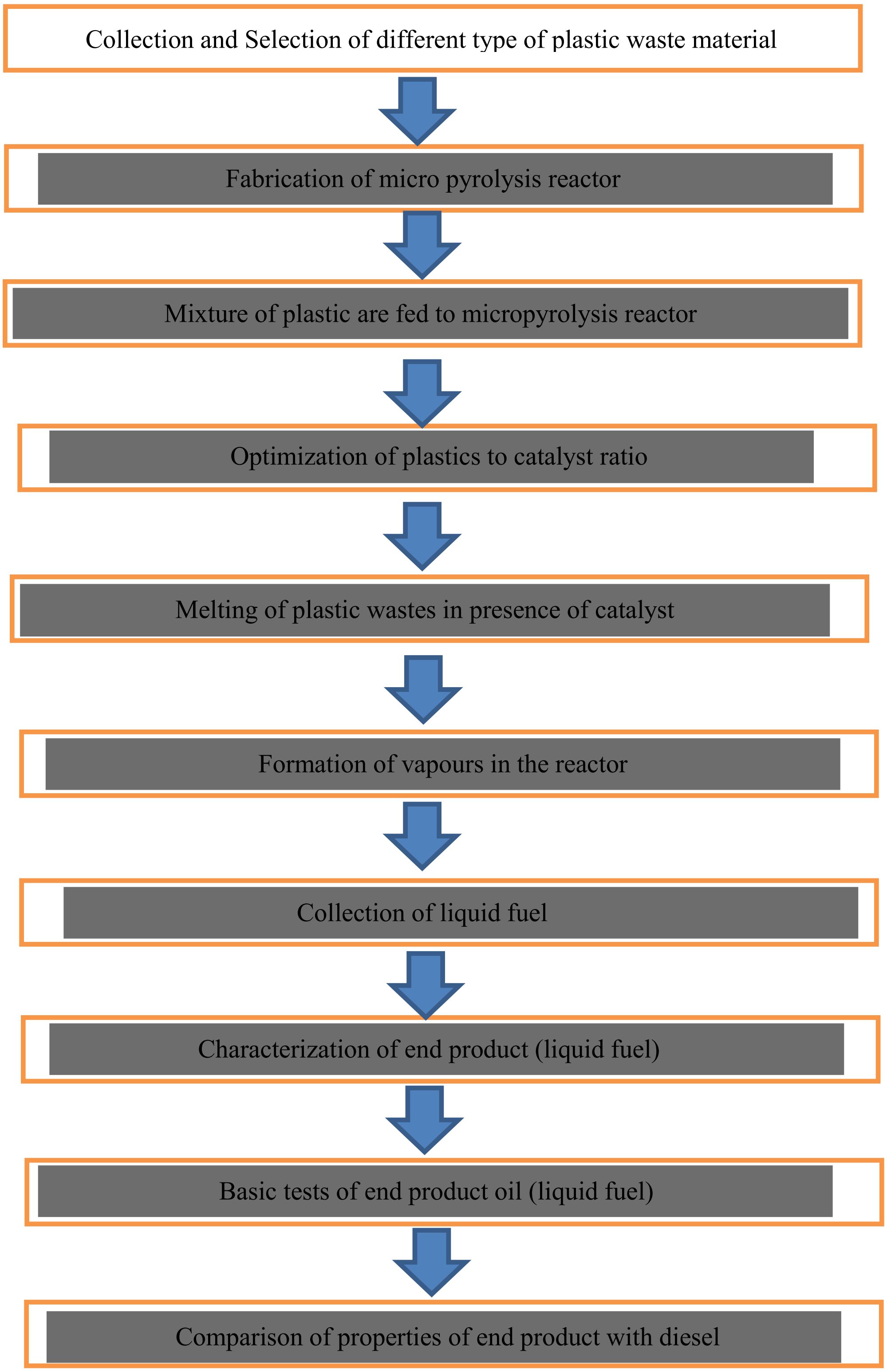
Fig 3.1: 3D view of pyrolysis reactor

CHAPTER-4

4. METHODOLOGY

4.1 FLOW CHART

This chapter includes process of conversion of waste plastic to liquid fuel.



4.1.1 Collection and selection of different type of plastics waste material:

Sample Collection:

Collection of different types of wastes plastics were done nearby our location (Navanagar, Bagalkot). Different types of waste plastics were separated based on their characteristics such a waxy surface, hard, opaque, rough etc. and categories such as HDPE, LDPE, PVC, PP, PS, PET Others. Collection of waste plastics was done with all preventive measures.

Among the above 7Plastic categories, PP, PVC,HDPE plastics have chosen for tests.

Fig 4.2 (a): Collection of waste plastic

Fig 4.2 (b): HDPE category

Fig 4.2 (c): PP category

Fig 4.2 (d): LDPE category

Fig 4.2 (e): PVC category

4.1.1 Fabrication of Micropyrolysis reactor:

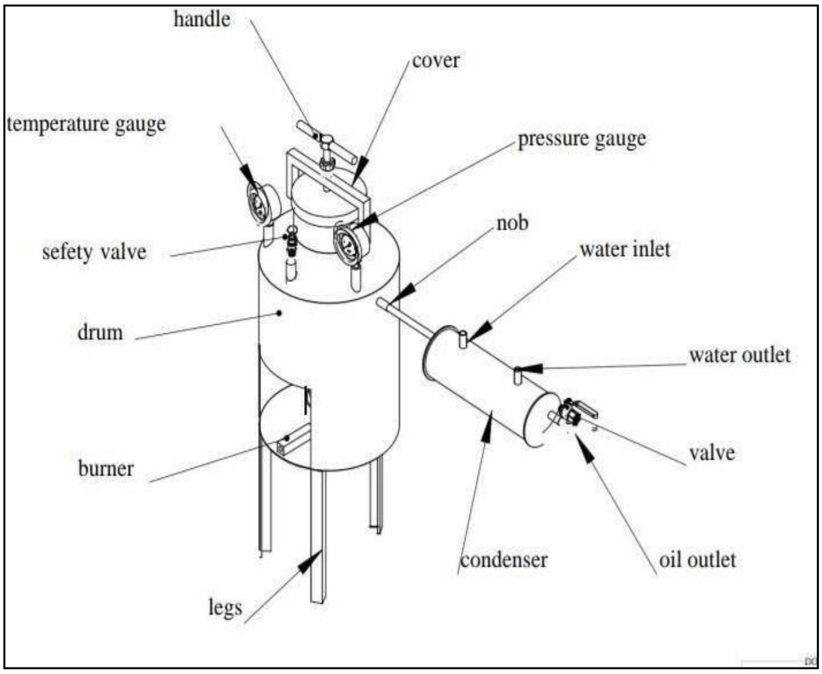


Fig 4.3: Schematic representation of reactor design

1. Pressure Gauge: Range:0-250Psi.
2. Temperature gauge: Range:0-300 degree Celsius.
3. Pressure relief: Range: 300Psi safety pressure.
4. Outlet pipe: Outer Diameter=25mmInner Diameter=22mm.
5. Water inlet & outlet pipe Outer Diameter: 18mm Innerdiameter:13mm.
6. Ball valve: ½inch.
7. Burner size: medium.

7. Drum

Material: Mild steel

Size: Diameter =300 mm, Length=380mm.Thickness= 5mm

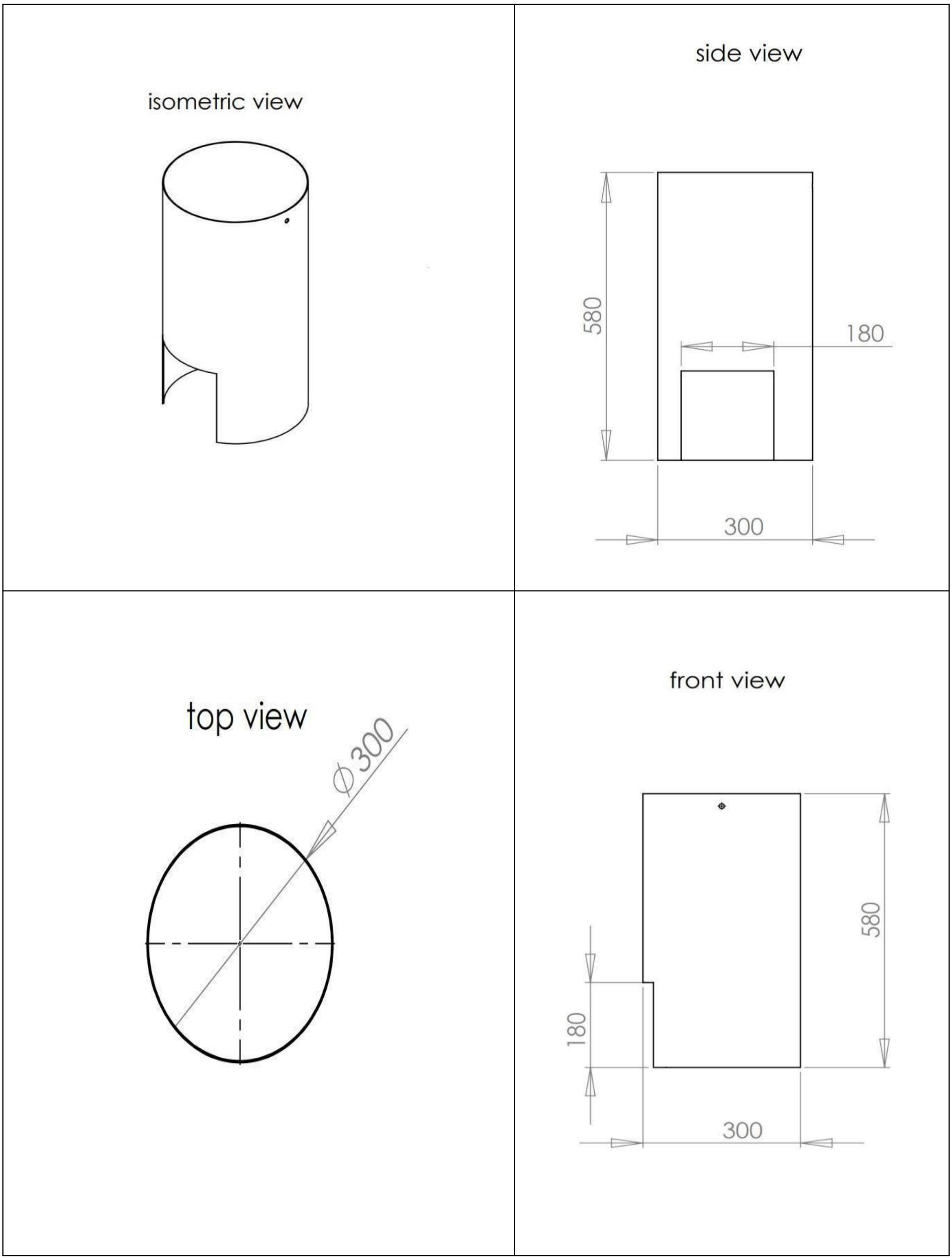


Fig 4.4: Diagram of Drum

8. L-angle

Material: Mild steel

Dimension: (25X25X5) mm Unit weight: 1.5kg

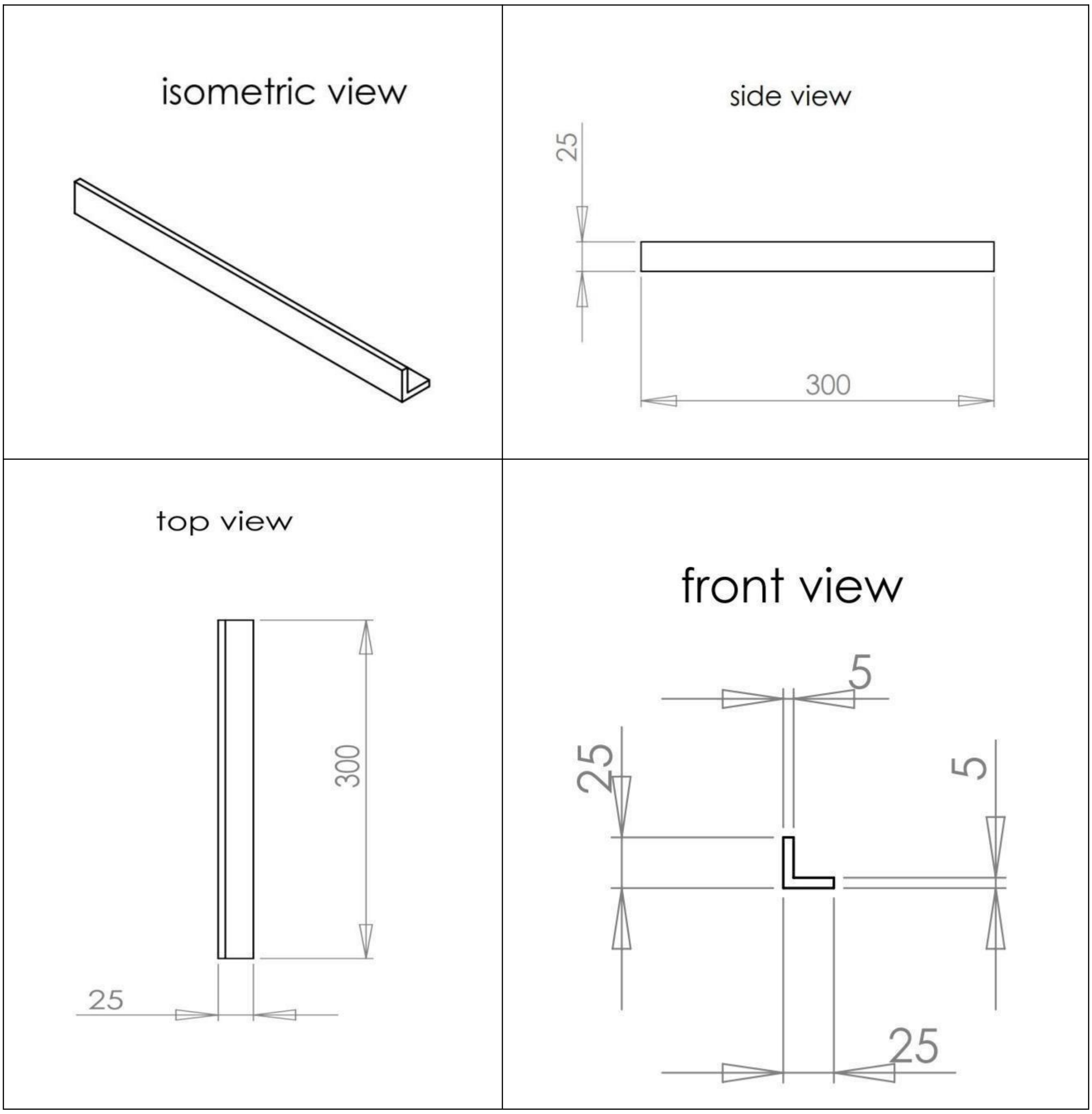


Fig 4.5: Diagram of L–Angle

Thermal Pyrolysis reactor was designed according to standard dimensions as referred in the literature review (Paper-3). Specific dimensions of the reactor are:

1. Pressure Gauge Range:0-500kg/cm^2
2. Temperature gauge Range:0-300 degree Celsius
3. Pressure relief Range:300Psi safety pressure
4. Out let pipe,
   a) Outer Diameter=25mm.
   b) Inner Diameter=22mm.
5. Water inlet & outlet pipe,
   a) Outer diameter:18mm.
   b) Inner diameter: 13mm.
6. Ball valve ½ inch.
7. Burner size medium
8. Drum
   Diameter=300 mm, Length=400 mm. Thickness = 5 mm
9. L- angle
   Dimension: (25X25X5) mm
10. Length: 300mm

4.1.1 Mixture of Plastics are fed into micropyrolysis reactor:

Steps Involved:

- A Plastic shredder machine is a preliminary machine used to cut waste plastic into small pieces before turning it into useful products. Different types of plastics based on categories (HDPE,PP,PVC) were crushed in crushing unit of desired size as designated by a screen filter that is fitted beneath the cutting chamber. [Fig (a)]
- The crushed waste plastics or scraps which consists of recyclable materials, left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. [Fig (b)]
- The plastic scraps were weighed according to the requirement. [Fig (c)]
- Weighed scraps were dumped into the reactor with all preventive measures such as gloves, mask etc.[Fig (d)]

Fig 4.7 (a) Plastic shredder

Fig 4.7 (b) Plastic scrap.

Fig 4.7 (c) Weighed plastic

Fig 4.7(d)

Fig 4.7: Plastics fed into thermal pyrolysis reactor.

Melting of plastic wastes in presence of catalyst:

The catalyst used are ZSM-5 and Bentonite clay pellets.

ZSM-5 (Zeolite Socony Mobil-5): ZSM-5 has been widely used for biomass pyrolysis. Zeolite catalyst reduces the time required for heating of the plastic. It also presents excels lent thermal stability, good selectivity, activity, and deactivation by coke. In thermocatalytic reactions, the ZSM-5 effectively enhances the deoxygenating and cracking reaction to produce stable oil.

Bentonite: The use of catalyst pellets eliminated the pressure drop and reducing pyrolysis processing time to only 10 minutes for 1 kg plastic wastes. No wax formation was observed when using the bentonite clay pellets as a catalyst in the pyrolysis process, this was attributed to the high acidity of the catalyst

Steps Involved**:**

- About 7.5% of the catalyst was weighed. [Fig (a)]
- Both the catalyst were simultaneously added to the reactor with uniform mixing. [Fig (b)]
- Mixture of both catalysts and plastic scraps was properly mixed in the reactor and was set to melting process via burner.[Fig (c)]
- The mixture was heated up to certain temperature and was melted in the absence of oxygen.[Fig (d)]

Fig (a)

Fig (b)

Fig (c)

Fig (d)

Fig 4.8: Catalysts involved in micropyrolysis process

4.1.5 Collection of liquid fuel:

The flow of steam from drum was collected from outlet of the reactor to the container. The gaseous vapors were collected from the outlet in a container, collection of these gaseous fumes turned into a liquid form called as crude oil or pyrolyzed crude oil.

Fig 4.9 (a)

Fig 4.9 (b)

Fig 4.9: Collection of liquid fuel

CHAPTER 5

5.1 Basic tests of pyrolyzed oil

5.1.1 Relative density of pyrolyzed oil:

Aim: To find the relative density of pyrolyzed oil.

Apparatus: Density bottle or pycnometer (100ml), weighing machine.

Theory: Density is a basic physical property of a homogeneous substances; it is an intensive property, which means it depends only on the substances composition and does not vary with size or amount. The determination of density is a nondestructive physical process for distinguishing one substance from another. Density is the ratio of substances mass to its own volume. If the density of fuel is high; the fuel consumption will be less. On the other hand, the oil with low density will consume more fuel which may cause damage to the engine. Therefore, toolow or too high density of fuel oil is not desirable.

Procedure:

1. Measure the mass of density bottle using physical balance (M1)[fig(b)].
2. Fill the density bottle up to the volume mark with the oil (50ml).
3. Measure the mass of oil+density bottle with physical balance (M2)[fig(a)].
4. Density = Mass/Volume = (M2-M1) / V.

Observations:

PLASTICS	M1(kg)	M2(kg)	M=M2-M1(kg)	ρ =M/V(kg/m^3)
PP	0.033	0.0685	0.036	720
PVC	0.033	0.0673	0.034	686
HDPE	0.033	0.0682	0.035	700

CALCULATION

1.POLPROPYLENE(PP)

Density = $(M_2 - M_1)/V$

= 0.036/0.00005

=720 kg/m^3

2.POLYVINYLCHLORIDE (PVC)

Density = (M2-M1)/V

=0.034/0.00005

=686 kg/m^3

3. HIGH DENSITY POLYETHYLENE (HDPE)

Density = (M2-M1)/V

=0.035/0.00005

=700kg/m

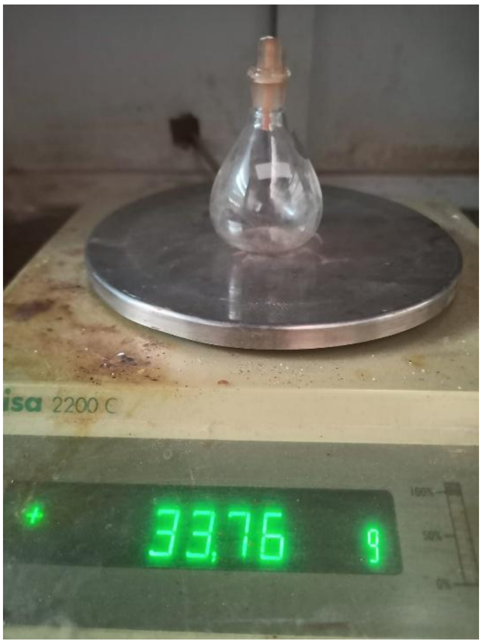


Fig 5.0 (a)

Fig 5.0 (b)

Fig 5.0: Relative density of pyrolyzed oil

5.1.2 Viscosity test on pyrolyzed oil:

Aim: To find the viscosity of a given sample oil at different temperature using redwood viscometer.

Apparatus: Redwood viscometer, stop watch, thermometer, 50ml standard narrow necked flask.

Description:

The redwood viscometer consists of vertical cylindrical oil cup with an orifice in the center of its base. The orifice can be closed by a ball. A hook pointing upward serves as a guide mark for filling the oil. The cylindrical cup is surrounded by the water bath. The water bath maintains the temperature of the oil to be tested at constant temperature. The oil is heated by heating the water bathby means of an immersed electric heater in the water bath. The provision is made for stirring the water, to maintain the uniform temperature in the water bath and to place the thermometer to record the temperature of oil and water bath. The cylinder is 47.625mm in diameter and 88.90mm deep. The orifice is 1.70mm in diameter and 12mm in length. This viscometer is used to determine the kinematic viscosity of the oil. From the kinematic viscosity the dynamic viscosity is determined.

Theory and Definition:

Viscosity is the property of fluid. It is defined as "The internal resistance offered by the fluid to the movement of one layer of fluid over an adjacent layer 'It is due to the Cohesion between the molecules of the fluid. The fluid which obey the Newton law of Viscosity are called as Newtonian fluid.

The dynamic viscosity of fluid is defined as the shear required to produce unit rate of angular deformation.

Procedure:

1. Clean the cylindrical oil cup and ensure the orifice tube is free from dirt [fig (a)].
2. Close the orifice with ball valve.
3. Place the 60 ml flask below the opening of the Orifice.
4. Fill the pyrolyzed oil in the cylindrical oil cup up to the mark in the cup.
5. Fill the water in the water bath.
6. Insert the thermometers in their respective places to measure the oil and water bath temperatures.
7. Heat the by heating the water bath, Stirred the water bath and maintain the uniform temperature.
8. At particular temperature lift the ball valve and collect the oil in the 50 ml flask and note the time taken in seconds for the collecting 50 ml of oil [fig (b)]. A stop watch is used measure the time taken. This time is called Redwood seconds

Observations:

Formula used:

Kinematic viscosity (ν) =0.22*T- 195/T.

Calculations:

5.1.3 Flash point and Fire point:

Aim: To determine the flash point and fire point of pyrolyzed oil.

Apparatus: Pensky Martens apparatus, thermometers.

Theory: The sample is heated in a test cup at a slow and constant rate with continuous stirring. A small test flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is taken as the lowest temperature at which the application of the test flame causes the vapour above the sample to ignite momentarily. It is used to determine the flash point of the lubricating oils, fuel oils, solvents, solvent containing material and suspension of solids.

Flash point is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Flash point is used to characterize the fire hazards of fuels. Allow flash point indicates the presence of highly volatile materials in the fuel that is a serious safety concern in handling and transporting.

Fire point is the lowest temperature at which the vapours of the oil burn continuously for at least five seconds when a tiny flame is brought near it.

Equipment description: It consists of an oil cup with a circular marking for oil level indication. A lid to cover the oil cup with sliding shutters with ports, oil stirring mechanism and dipping wick holder, cast iron oil cup holder (air bath), electric heater with control. It is used to determine the flash point of the lubricating oils, fuel oil.

It consists of three parts:

i) OIL CUP

ii) SHUTTER: The top of the cup a shutter is provided. By moving the shutter, opening in the lid opens and flame is dipped in to this opening, bringing the flame over the oil surface. As the test flame is introduced in the opening, it get extinguished, but when the test flame is returned to its original position, it is automatically lightened by the pilot burner

iii) STOVE: consists of air bath and top plate on which the flange of the cup rest.

Procedure:

7. Clean and dry all parts of the apparatus with the help of suitable solvent e.g. CCl_4, ether,petroleum spirit or benzene and dry it to remove any traces of solvent.
8. Fill the oil cup with the test oil up to the mark [fig (a)].
9. Fix the lids on the top through which are inserted a thermometer and a stirrer. Ensure thatthe flame exposure device is fixed on the top.
10. Light the test flame and adjust it to about 4 mm in diameter.
11. Heat apparatus as temperature of oil increases by 5 to 60 per min as stirrer iscontinuously rotated [fig (b)].
12. At every 10°C rise of temp introduce test flame into the oil vapour. This is done by operating the shutter. On moving knob of shutter, test flame is lowered in oil vaporsthrough opening.
13. When test flame causes a distinct flame in interior cup, note temperature whichrepresent the flashpoint
14. Further heat the oil at the rate of 10°C/min and continue applying the test flame asbefore.
15. The temperature at which the vapours of the oil give a clear and distinct blue flash forfive second sis recorded as the fire point of the oil.

Observation:

Table 5.1: Flash point and Fire point of pyrolyzed oil

Plastic	Flash point(◦C)	Fire point(◦C)
PP	27	30
PVC	NIL	NIL
HDPE	29	32

Results:

PP

1.The flash point Pyrolyzed oil with catalyst is observed at 27.

2.The fire point of Pyrolyzed oil with catalyst is observed at 30.

PVC

1.The flash point Pyrolyzed oil withcatalyst is observed was NIL.

2.The fire point of Pyrolyzed oil withcatalyst is observed was NIL.

HDPE

1.The flash point Pyrolyzed oil withcatalyst is observed at 29.

2.The fire point of Pyrolyzed oil withcatalyst is observed at 34.

Fig 5.1(a)

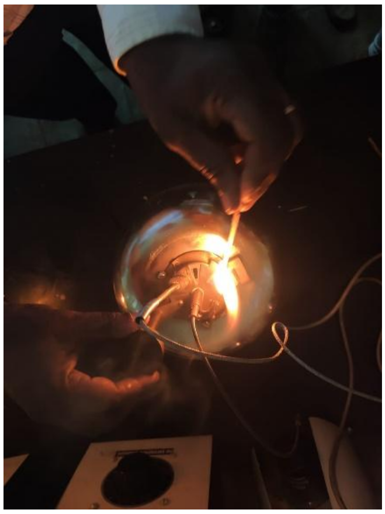


Fig 5.1(b)

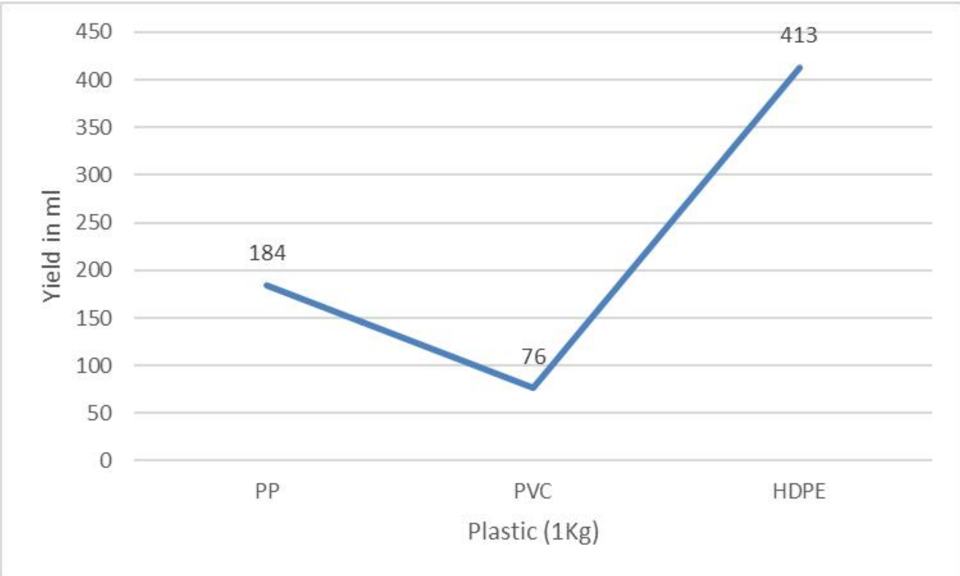
Fig 5.1: Flashpoint and Firepoint

- **Results and discussions**

  - The liquid yield was of obtained for the plastics PP, HDPE and PVC is shown below graph
  - In X axis different plastics in kg(1kg)
  - In Y axis yield obtained for different plastics in ml

Table 1.2. Plastics and there yield

Sl.No	Plastics	Yield (ml)	Weight of plastic (kg)
1	PP	184	1
2	PVC	76	1
3	HDPE	413	1



CHAPTER-6

6.1 CONCLUSION:

- Three plastics were pyrolyzed, they are HDPE, PP, PVC.
- HDPE plastic shows the highest yield amongst the other two plastics.
- The Flashpoint and firepoint for PP has more efficient values.
- PVC plastic has no properties of any fuel.

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