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Design And Fabrication Of Pyrolysis Unit For Generation Of Fuel From Plastic Waste

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Abstract

Liquid fuel i.e. hydrocarbon fuel is obtained from four different types of waste plastics, those are low density polyethylene and high density polyethylene (LDPE and HDPE), polypropylene (PP) and polystyrene (PS) were carried out in a reactor stainless steel system. Each of the plastics has different chemical and physical properties so the experiments were carried out individually for each of them.
LDPE is used for manufacturing of Containers, Dispensing bottles, etc. HDPE used for production of plastic bottles, Corrosion resistant pipes, etc. PP is used for Packaging in Consumer products, etc. PS is used for producing Disposable plastic cutlery and dinnerware, etc.
Simple thermal degradation was used to melt the plastics at temperature ranging from 120 to 400°C. Vapour condensation from the melted plastics produced the liquid hydrocarbon product. Similar standards were followed for each of the plastics during the production process. The effect of reaction on quality and yield of the product were investigated.
The chemical properties of the liquid product had varied from each plastic. Each of the liquid products contained low sulphur but each of them varied from each other. The waste plastics can also be randomly mixed with each other prior to the liquid production process. The results of mixed plastics production process indicates higher yield percentage than when they are done separately.

INTRODUCTION

1.1 Problem Statement

Around 40% of the Waste plastic on Earth is dumped off, and is never used. Hence to reuse this waste plastic the ideology of Plastic Fuel is achieved. Our aim is to create Best from Waste.

1.2 Objectives

1. To produce Fuel from Plastic waste by the technique of Pyrolysis.
2. To achieve different properties of the fuel, by using different types of waste plastic.
3. To reduce the plastic waste pollution by recycling waste plastic.
4. To protect the environment and for the health and safety of population.
5. To build an effective and cost-efficient model to produce plastic fuel.

1.3 Scope

According to a recent study, in India, 30 million tons of total plastic is produced every year, with only about 4% now being recycled. The rest of the waste plastics either end up in land or incineration. When incinerated, waste plastics release toxic gases such as carbon monoxide (CO), which causes health hazards, sulphur dioxides (SO2), which contributes to acid rain, nitrogen oxides (NOx) which contribute to ozone depletion and acid rain, and carbon dioxide (CO2), greenhouse gases that contribute to global warming.
Many researches have been conducted to convert waste plastics into renewable energy sources. This is possible because plastics are originally made from crude oil. Crude oil is a very limited natural resource that is used to make transportation fuel, plastics and other products. Crude oil is a non-renewable energy source and since it is a natural resource it will deplete in the near future. Successful methods have been carried out to convert waste plastics into liquid based fuels. These methods include various procedures to convert the waste plastics such as Pyrolysis, in which the contents of

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waste plastics are thermally degraded to produce liquid-based fuels and other products without the presence of oxygen.

1.4 Methodology

In this work, waste plastics are selected as feed stocks to convert waste plastic into useful liquid fuel compounds. Recycling methods used to convert waste plastics are – Mechanical Recycling, Chemical recycling.

Pyrolysis

Pyrolysis is the thermal degradation of waste in an oxygen-starved environment in which the oxygen content is low for gasification to take place. Pyrolysis liquefaction is a non-combustion heat treatment that catalytically (chemically) decomposes waste material by applying heat, directly or indirectly to the waste material in an oxygen free environment. Pyrolysis method is used to convert household plastic wastes like food container, milk covers, water bottles, packaging foam and waste cooking oil cover into vapours which are then condensed to form a liquid compound which is used as fuel.

1.5 Materials

Plastics are classified on the basis of the polymer from which they are made, therefore the variety of plastics is very extensive. The types of plastics that are most commonly reprocessed are polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET) and polyvinyl chloride (PVC). The different plastics used in day to day life are :-

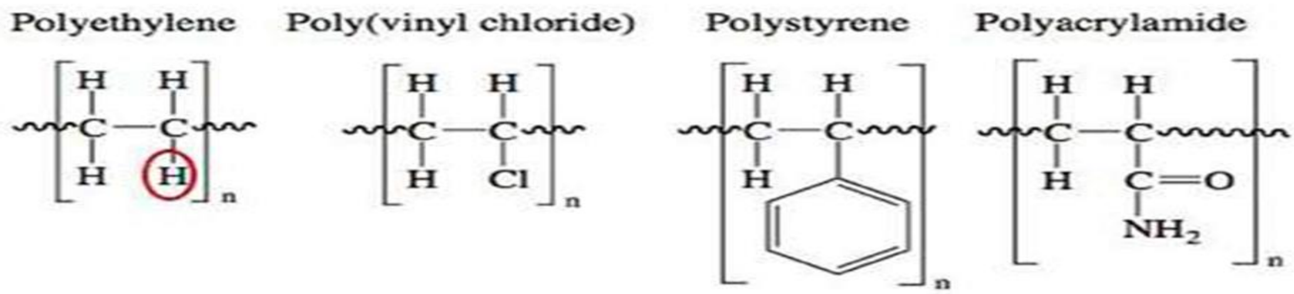

Fig.[1]

Polyethylene (PE) -The two main types of polyethylene are low-density polyethylene (LDPE) and high-density polyethylene (HDPE). LDPE is soft, edible and easy to cut, example; candle wax. When it is very thin it is transparent; when thick it is milky white, unless a pigment is added. HDPE is thermoplastic polymer. It is used to produce milk containers, soap bottles, etc.

Polypropylene (PP) - Polypropylene is more rigid than PE, and can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong mouldings such as car battery housings and other parts.

Polystyrene (PS) - In its unprocessed form, polystyrene is brittle and usually transparent. It is often blended (copolymerized) with other materials to obtain the desired properties. It is used to produce disposable plastic cutlery and dinnerware.

Polyethylene Terephthalate (PET) PET exists as an amorphous (transparent)and as a semi-crystalline (opaque and white) thermoplastic material. Generally, it has good resistance to mineral oils, solvents and acids but not to bases. It is used to produce bottles for water and cold drinks.

Polyvinyl chloride (PVC) - Polyvinyl chloride is a hard, rigid material. Common applications for PVC include thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels, etc.

High Impact Polystyrene (HIPS) - used in fridge liners, food packaging, vending cups.

Acrylonitrile butadiene styrene (ABS) - used in electronic equipment cases (e.g. computer monitors, printers, keyboards), drainage pipe.

Polyester (PES) - used in fibers, textiles.

Polyamides (PA) (Nylons) - used in fibers, toothbrush bristles, cushioning line, under the-hood car engine mouldings.

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Polyurethanes (PU) - used in cushioning foams, thermal insulation foams, surface coatings, printing rollers.
Polycarbonates (PC) - used in CDs, eyeglasses, riot shields, security windows, track lights, lenses.
Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) - A blend of PC and ABS that creates a stronger plastic. Used in car interior and exterior parts and mobile phone bodies.

Fig.2

LITERATURE REVIEW:-

Polyfuel - A fuel from waste plastics
Y.P.Chauhan, O. R. Jadhav, U. B. Chougule, S. D. Patil, O. J. Kadam
Year of Publishing - 2019
Conversion of waste plastics into liquid fuel (Polyfuel) can solve the problem of plastic waste recycling and the shortage of liquid fuel in developing countries like India. So it can be concluded that the "Poly-fuel" may be an alternative fuel of the future. The residue produced can be used in road making process. As no waste is generated during the process, it can be called as zero discharge process or green process which avoids the pollution.

Pyrolysis of plastic waste for liquid fuel production as prospective energy resource
SDA Sharuddin, F Abnisa, W M A W Daud and M K Aroua
Year of Publishing - 2018
Pyrolysis process was chosen by most researchers among other thermal treatment technologies mainly because of its potential to convert the most energy from plastic waste to valuable liquid oil, gaseous and char. The flexibility that it provides in terms of product preference could be achieved by adjusting the parameters accordingly. With the pyrolysis method, the waste management becomes more efficient, less capacity of landfill needed, less pollution and also cost effective. Moreover, with the existence of pyrolysis method to decompose plastic into valuable energy fuel.
Pyrolysis of Plastic waste into fuel and other products

B. Chiwara, E. Makhura, G. Danha, S. Bhero, E. Muzenda, P. Agachi
Year of Publishing - 2017
We co-pyrolised the two classes of plastics in order to have enough material to use as feed, that will help in pressuring the reactor to the desired experimental pressure. Our results show that there are more than a hundred different liquid components in the pyrolysis oil. The high number of organic components obtained could have resulted from the fact that different pigmented plastics were used as feed material. The other reason for the high number of organic components could have been because the sample was heated to higher temperatures and high temperatures gave high conversions of more than 80 %. High pyrolysis temperatures and pressure also ensured that less gaseous components are formed as they are converted into liquid products.

Study on Conversion of Municipal Plastic Wastesinto Liquid Fuel Compounds
Divakar Shetty A. S, Ravi Kumar R, Kumarappa S, Antony A.J
Year of Publishing – 2016
By adopting this technology, efficiently convert weight of municipal waste plastics into 65% of useful liquid hydrocarbon fuels without emitting much pollutant. Engine test carried out with plastic liquid

fuel blends which are obtained from the municipal waste plastic pyrolysis process. The results shows, better engine performance than diesel fuel operation. The fuel consumption of the engine was somewhat lower as compared to diesel fuel. Knocking is not observed for the tested fuel at all operating conditions. The emissions of engine like carbon monoxide (CO), hydrocarbon (HC) and nitrogen oxide (NOX) is increases when the engine runs with plastic fuel blends.

Waste plastic to fuel

Rajaram.T.Karad, Sagar Havalammanavar

Plastics present a major threat to today's society and environment. Over 14 million tons of plastics are dumped into the oceans annually, killing about 1,000,000 species of oceanic life. In this regard, the catalytic Pyrolysis studied here presents an efficient, clean and very effective means of removing the debris that we have left behind over the last several decades. By converting plastics to fuel, we solve two issues, one of the large plastic seas, and the other of the fuel shortage. This dual benefit, though will exist only as long as the waste plastics last, but will surely provide a strong platform for us to build on a sustainable, clean and green future. By taking into account the financial benefits of such a project, it would be a great boon to our economy.

PYROLYSIS UNIT ELEMENTS:-

3.1 Element No. 1 :- Reaction Chamber
Outer Chamber – Stainless Steel
Reaction Chamber – Mild Steel

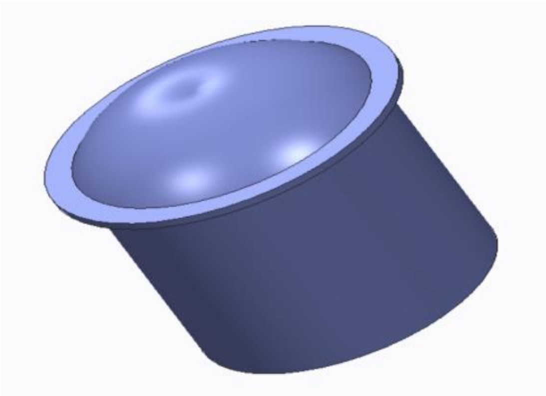


Fig.3

3.2 Element No. 2 :- Condenser
Condenser – Stainless Steel

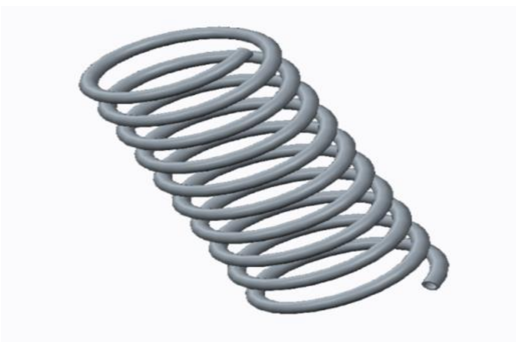


Fig.4

3.3 Element No. 3 :- Connecting Pipe
Connecting Pipe – Mild Steel

Fig.5

3.4 Element No. 4 :- Collecting Tank
Collecting Tank – Mild Steel

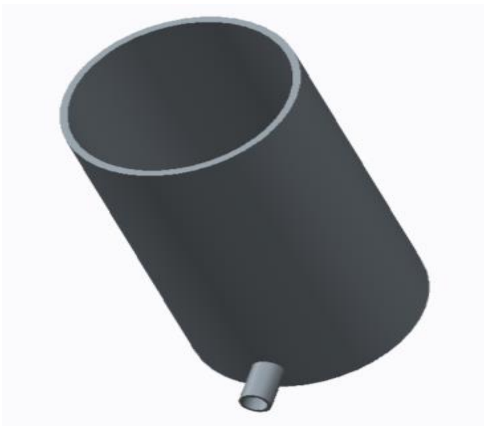
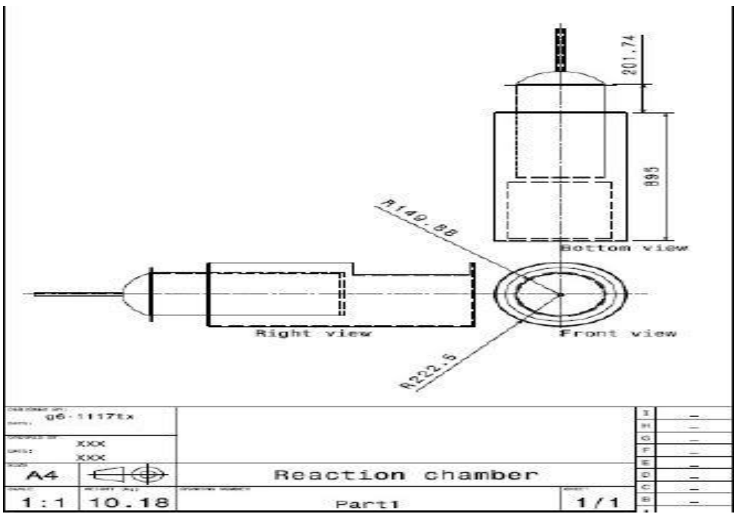
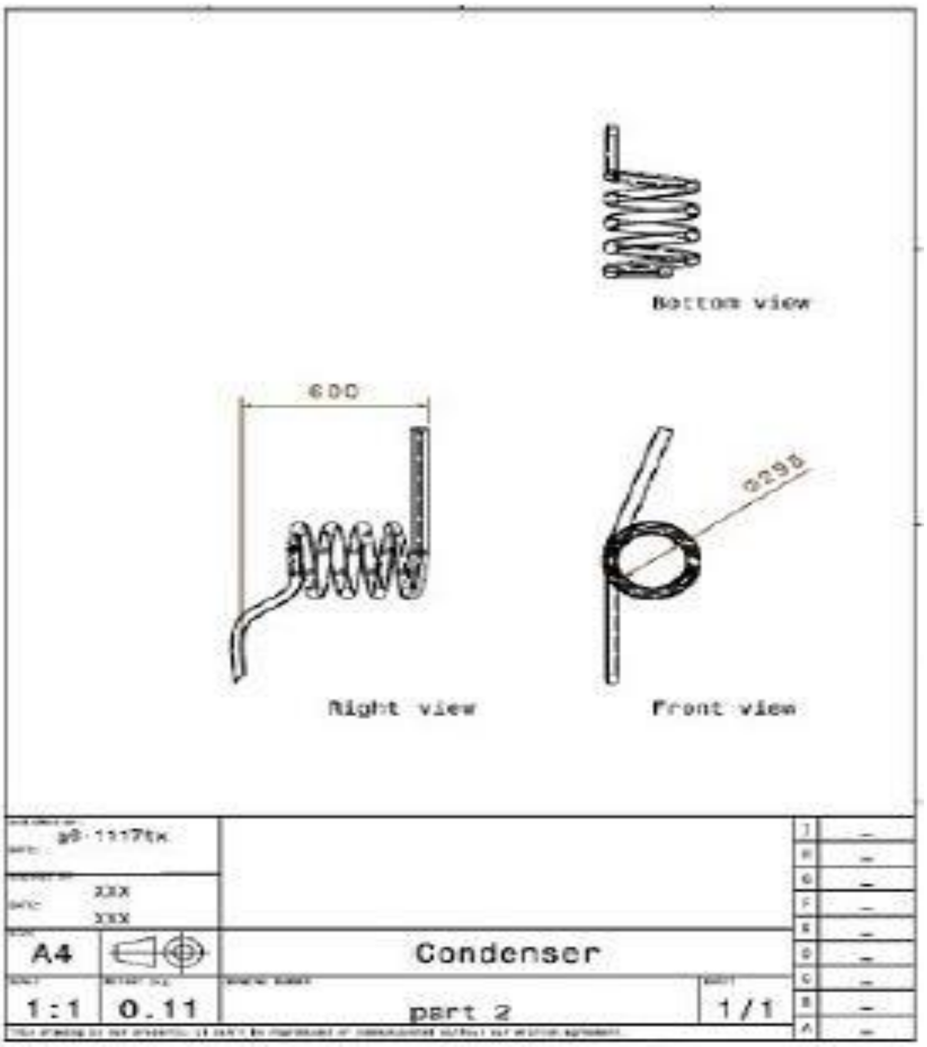


Fig.6

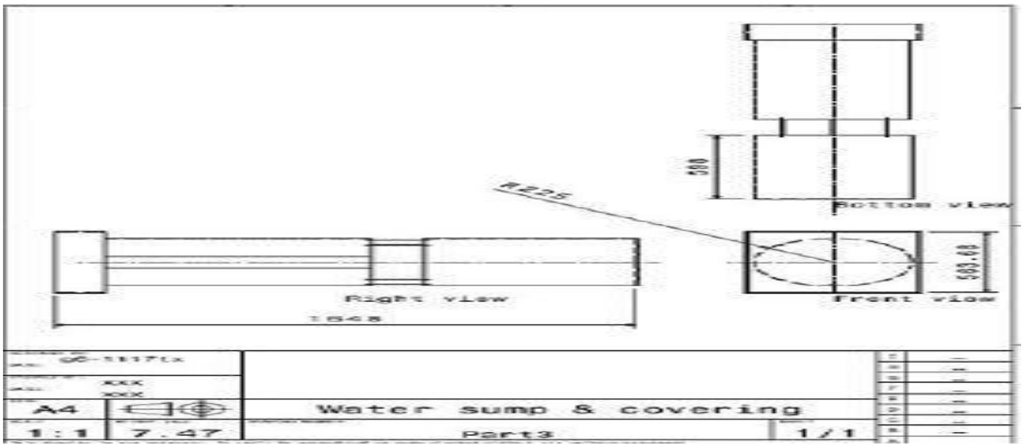
<u>Design Of Reaction Chamber</u>



Design of Condensor



Design of Water Sump and Condensor Covering



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Material & Dimensions of Pyrolysis Unit:-

Component	Material	Length	Diameter	Other remarks
Reaction Chamber	MS	670mm	450mm	
Condenser	SS	990mm	70mm	
Oil Reservoir Tank	MS	590mm	470mm	
Supply Line Pipe	Galvanized ion	900mm	70mm	
Insulating Material	GlassWool			40mm Thickness
Inner Reactor Chamber	MS	630mm	410mm	
Outer Reactor Chamber	MS	670mm	450mm	
Furnace Column		250mm Height	550mm	

Fig.7

Manufacturing Process Sheet:-

Process Sheet 1
Part name - Reaction chamber
Material - Mild steel
Quantity – 1

Operation Number	Job Description	Machine used	Tool Used	No of Operation	Time Required (Min)
1	Cutting	Power Saw	HSS cutting Blade	2	60
2	Bending	Power Bender		1	40
3	Welding	Welding Machine 300 amp	Electrode Rod	1	50
4	Grinding	Hand Grinder	Grinder Wheel	3	20
Total Time Required					170

Process Sheet 2
Part name - Outer Chamber
Material -Stainless steel
Quantity –1

Operation Number	Job Description	Machine used	Tool Used	No of Operation	Time Required (Min)
1	Cutting	Power Saw	HSS cutting Blade	2	80
2	Bending	Power Bender		1	40
3	Welding	Welding Machine 300 amp	Electrode Rod	1	50
4	Grinding	Hand Grinder	Grinder Wheel	3	20
Total Time Required					190

Process Sheet 3
Part name –Oil Reservoir Tank
Material - Mild steel
Quantity – 1

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Operation Number	Job Description	Machine used	Tool Used	No of Operation	Time Required (Min)
1	Cutting	Power Saw	HSS cutting Blade	1	15
2	Bending	Power Bender		1	20
3	Welding	Welding Machine 50 amp	Electrode Rod	1	10
4	Grinding	Hand Grinder	Grinder Wheel	2	15
Total Time Required					60

Pyrolysis Unit:-

EXPERIMENTAL PROCEDURE:-

A grounded waste plastics mixture was transfer into reactor chamber. A waste plastic to fuel production process thermal degradation process was applied and temperature range was 25 C to 390 C During fuel production process vacuum system did not apply and catalyst or extra chemical did not added. Condensation unit was setup with reactor and no water circulation system was added. Reactor temperature capability range from 25 C to 500 C and experimental temperature controller was water flow system. Experiment was batch process under Labconco fume hood and experiment was fully closed system setup. LDPE waste plastic melting point temperature is 120 C, PP waste plastic melting point temperature is 160 C and PS waste plastic melting point temperature is 240 C. Based on three types of waste plastics melting point temperature experimental temperature profile was setup. Initial raw sample was start heat from 25 C and temperature increased gradually up to 390 C for fuel production. Waste plastics starts to melt when temperature is increased and turn into liquid slurry after that liquid slurry turn into vapour, volatile vapour passed through condenser unit, at the end collection liquid hydrocarbon fuel. Waste plastics sample melting point temperatures are different range temperature for that reason was used temperature from 25 C to 390 C. Temperature when goes up from150 C to 260 C was notice that fuel was coming droopily and when temperature goes up to 300 C fuel production rate was increased and until finished experiment was monitored step by step. During production period vacuum system was not apply to take out moisture for that reason carbon and water is creating carbon dioxide and its come out with light gas and passed through alkali cleaning system. Also production period are creating some alcoholic group compounds. Ones start experiment heat moisture is come out with some light gas which is present methane, ethane, propane and butane mixture. These types of light gas is not condensing due to negative boiling point are present in this light gas compounds. These light gases pass through collection tank to alkali cleaning process then transfer into storage system for future use or identification by using small pump. Whole production process finished time was 5-5.30 hours. Raw materials were used 3 types of waste plastics (LDPE/PP/PS) to fuel production process equal ratio wise. After finished experiment process produced fuel was cleaned by using RCI technology provided RCI fuel purification system with 35 psi force and micron filter to remove all kind of fuel sediment. At the end liquid fuel was collected as fuel and fuel density is 0.80 g/ml. The pyrolysis by direct heating was adopted to produce the paraffin and crude oil from the plastic wastes in the 1990s. The small-scaled process is featured by facilitation, convenience and low equipment investment However, the temperature caused by pyrolysis is higher and all the reactive time is longer than the other methods. The octane number of gasoline gained is relatively low and the pour point of diesel oil is high. More paraffin is produced in the process of pyrolysis. Although this process is simple and convenient, the converting rate and yield is still lower. The total yield of fuel oil is 50-65%. The other problem for this process is the pyrolysis equipment corrosion incurred by PVC in mixed plastic wastes. Therefore, it is strongly recommended to establish a reasonable sorting system and apply an efficient technique to eliminate the toxic emissions and highly corrosive hydrochloric acid that is formed. Since the total yield of fuel oil with pyrolysis is still lower and the quality of oil is not satisfied as gasoline and diesel oil, the upgrade by catalytic cracking for the crude products gained with pyrolysis can be used. Having improved the quality of finished oil, this process has been widely used in many factories. The system consists of the knapper, extrusion machine, pyrolysis reactor, catalytic cracking reactor, fractionating tower, heating and temperature controller, separator of oil and water, and oilcan. An improved apparatus apart from the pyrolysis reactor, consists of a cylindrical rectangular vessel heated by electrical heating coils or any other form of energy, the said vessel is made of stainless or mild steel surrounded by heat rector and insulator to avoid heat loss. It is provided at its side an outlet vent which connects with the condensing section which is made up of stainless or mild steel provided with an outer jacket for circulating cold water or any coolant, the condenser is connected to the receiving section and to a gasometer.

Flow chart of conversion of plastic waste into liquid fuel:-

Collection and washing of household waste plastic

Feeding into reactor

Heating of plastic waste in presence of catalyst

Movement of liquid-vapour into condenser/condensing

Collection of liquid fuel

Purification of liquid fuel

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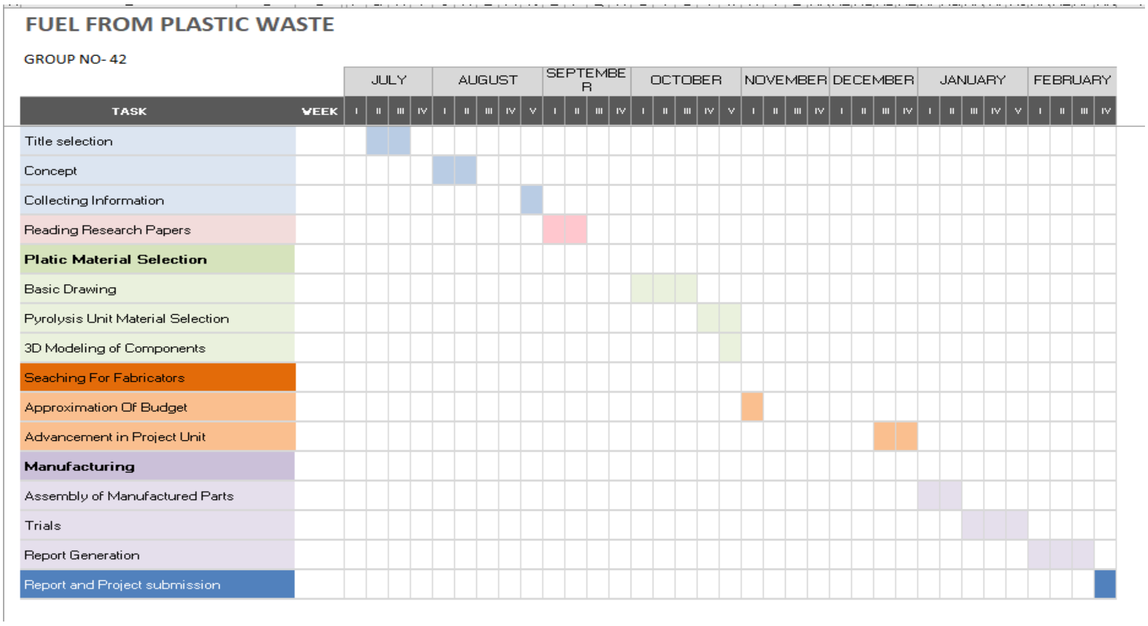
Fig.8

SCHEDULE:-



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