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Modeling of Pyrolysis Equipment for Plastic Wastes Conversion into Liquid Hydrocarbon Fuel

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ABSTRACT: *Waste plastics posess a very serious environment challenge because of their disposal problems all over the world. Plastics have now become essential materials in the modern world and the applications of plastics in the industrial field is continually increasing, but it affects the human health, creates environmental pollutions and global warming. Because of the above reasons waste plastic recycling is required. Various recycle technologies like carbon sink, Incineration, pyrolysis, gasification are exists for reducing the plastic wastes. As per the literature pyrolysis process is the best method. For the conversion it needs special equipments. In this present work an attempt is made to model a waste plastic oil converter in CATIA modelling software. In further work fabrication of this equipment has been done in finding environment-friendly means of waste recycling. Pyrolysis process was the basis in the model of the equipment. The main components of the model are reactor assembly, condensing chamber, vapour line assembly, and the oil collecting unit. All the components are modelled in the modelling software and finally assembled.*

KEYWORDS: *Waste plastic oil converter, LDPE plastic, reactor assembly, CATIA soft ware.*

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I. INTRODUCTION

1.1 Waste plastic recycling management

By discharging of waste plastic into the land, it pollutes the land. Incineration involves burning of plastic waste; this gives very negative impact on the environment. Burning of 1 kg of plastic liberates 3 litres of carbon dioxide into the atmosphere. Recycling involves melting the plastics and making new products from it. Gasification involves burning of waste plastic and these combusted gasses are further collected and these are made to produce "syngas" and obtaining energy by it. Gasification is an appreciable process but it is very expensive. 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 thermo sets. Thermoplastics are composed of polyolefin's such as polyethylene, polypropylene, polystyrene and polyvinyl chloride and can be recycled. On the other hand thermo sets mainly include epoxy resins and polyurethanes and cannot be recycled. Therefore, recycling method was used in this study. Recycling has many types of techniques including **pyrolysis, gasification, hydrolysis** etc. Among these, the most attractive technique of recycling is PYROLYSIS or THERMAL CRACKING.

1.2 Literature review

K.G. Burra et al.[1] He investigated on isothermal gasification of different compositions of 100% pine wood pellets in the presence of three different types of plastics were poly propylene (PP), black polycarbonate (BPC), polyethylene terephthalate (PET). All of these plastics were post-consumer recycled with PP and BPC being pellet extrudes while PET being small size flakes. **Shafferina Dayana Anuar Sharuddin et al.[2]** In his study on the non-recycled plastics (NRP) data were used as feedstock ratio in pyrolysis process to observe the production of liquid yield as well as the by-products. The NRP data of global and three different countries which were Malaysia, US and UK were selected to be studied. Besides, the effect of polystyrene (PS) addition into the feedstock ratio was also studied to investigate the product improvement. **H. Hassan et al.[3]** He carried out experiments mainly focused on co-pyrolysis, catalytic co-pyrolysis, and their benefits on the enhancement of bio-oil derived from biomass. Catalytic co-pyrolysis has opened a new area for future explorations because of its superior performance in upgrading bio-oil.

R. Miandad et al. [4] He concluded that the produced liquid oil and gases from pyrolysis have high HHV and maintain the potential to be used as an alternative source of energy. To overcome some issues, catalytic pyrolysis of plastic wastes has been introduced. Use of different catalysts makes the process more efficient by improving the liquid oil and gases quality with a decrease in both process temperature and time. ZSM-5, HZSM-5, FCC, Al2O3, Red Mud, and NZ are the most important and significant catalysts used by different researchers. The use of Natural Zeolite (NZ) is as a catalyst in the pyrolysis process is becoming more prominent due to both its easy availability and economical factors. **Jon Alvarez et al.[5]** He carried out experiments on the co-pyrolysis/gasification of biomass and plastics has been studied with the aim of exploring the synergetic effects between these two materials in order to increase hydrogen concentration and production in the gaseous fraction. Therefore in his experiments deals with the influence of plastic content and plastic type in the feed and the presence of a Ni/Al2O3 catalyst on the yield and composition of the final products. **A. Lopez et al.[6]** The objective of this work is the study of the influence of temperature and time in the products obtained in the pyrolysis of plastic wastes. He conducted experiments on pyrolysis of complex plastic mixture which includes both PVC and PET in similar proportion to real plastic waste is presented. **W. Kaminsky et al.[7]** In this study that to use steam as a fluidizing gas enables one to shift the product spectra of the pyrolysis to higher yields of olefins. The pyrolysis of mixed plastic waste is not so advantageous, especially for the simultaneous pyrolysis of polystyrene and polyolefin's. To gain higher yields of monomers it would be better to pyrolyze these materials at different temperatures. So it is possible to recycle polystyrene at low temperatures (500-550°C) and polyolefin's could be cracked to olefins at temperatures of 700 to 750°C.**Elizabeth A et al. [8]** He was examined that Six thermoplastics, which represent more than two-thirds of all polymer production in western Europe, and further experiments carried out on the issue of paralyzing both single and mixed plastic wastes for further utilisation.

II. DESIGN AND FABRICATION OF PYROLYSIS REACTOR

2.1 REACTOR SHELL

Reactor shell is made of mild steel having inner diameter (I.D) of 205 mm, outer diameter of 215mm, height of 300mm, and thickness of 5 mm. whose allowable pressure is 70 bar (71.38 Kg /cm^2). By this arrangement high pressure and high temperature cracking can be achieved.

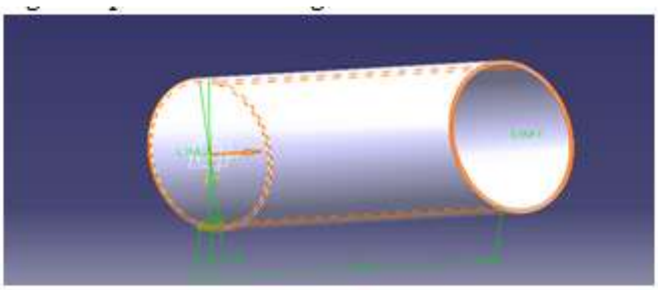

Fig.1. Reactor shell

2.2. BOTTOM ENCLOSURE

A flat plate bottom enclosure is made up of mild steel material having thickness of 3mm and diameter of 300mm. it is welded to the reactor at bottom side by the application of arc welding with leek proof.

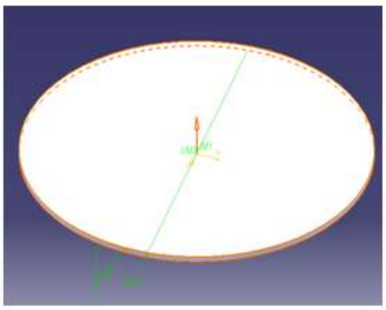

Fig.2. Design of bottom enclosure

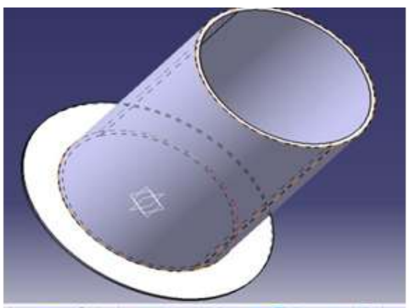

Fig.3.attached bottom enclosure to reactor

2.3. DESIGN OF TOP ENCLOSURE

A flat plate top enclosure is made up of mild steel material having thickness of 3mm and diameter of 300mm.The flat plate is then formed into the required shape as shown in figure by the application of gas cutting. Number of Bolt estimation: -Number of bolts is estimated to be 8, which are provided on the top enclosure by drilling machine. Finally the fabricated plate is welded to the reactor at top side by arc welding machine.

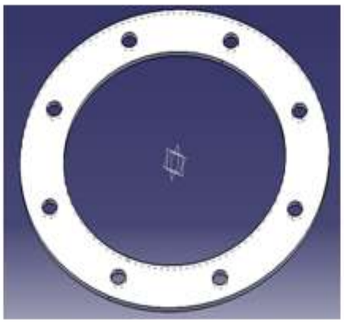

Fig.4.Top enclosure

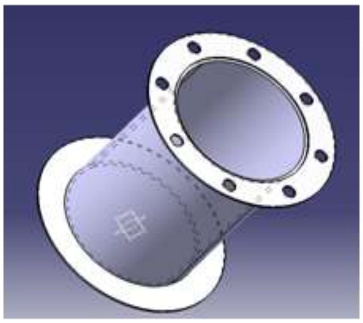

Fig.5. Attached the top enclosure to reactor shell

2.4. DESIGN OF TOP PLATE TO CLOSE THE REACTOR

A mild steel flat plate is used to close the reactor by using mechanical fastening process as nut and bolt. A small hole is provided at the centre of the plate with a dimension of 0.75 inches.

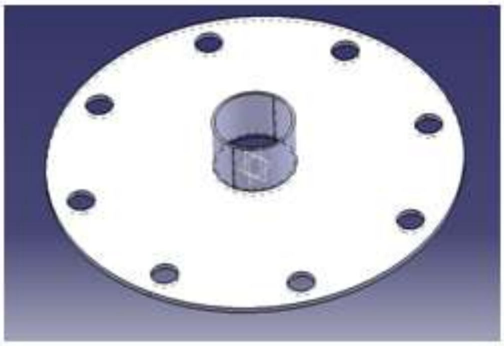

Fig.6. Design of top plate

III. COMPONENTS ARE USED FOR FABRICATION OF PYROLYSIS MACHINE

3.1 HEAT SOURCE

Electric ceramic band heater is used to heat the plastic to break down into fuel rang hydrocarbons. Capacity of heater is 3KW and 230 V is clamped on the reactor and temperature of above 550^{0}C can be attained.

Fig.7. Ceramic band heater

3.2 CONDENSER

Condenser is used to condense the vapours produced in the reactor due to the application of heat. For this process copper tubes are used to circulate the vapours and it is made to contact with the water. Due to this heat transfer takes place so that the vapours are converted into liquid form.

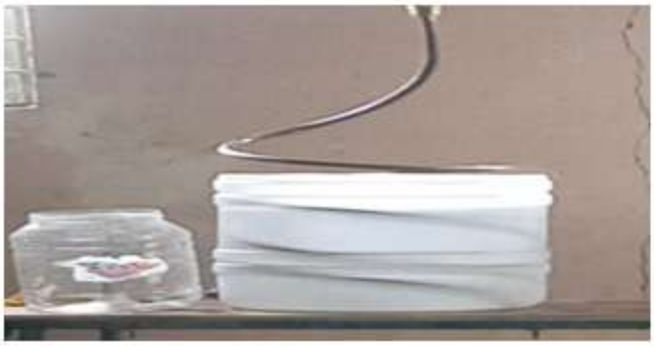

Fig.8. Condenser

3.3 TEMPERATURE MEASURING SEPUP

In order to measure the vapour temperature inside the reactor we need to use this temperature setup. From the literatures we know that the estimated vapour temperature would be in the range of 300^0 C to 450^0C. So we choose K type thermocouple sensor which is coupled to a K type controller. This device not only indicates temperature but also we can set the required temperature.

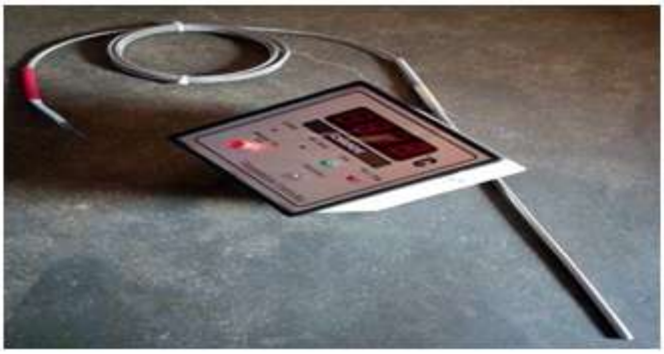

Fig.9. K Type Thermocouple and temperature indicator

IV. EXPRIMENTAL SETUP

Fig.10.pyrolysis equipment

V. CONCLUSION

The increasing quantities of plastics and their disposal has been becoming a major problem in public concern. The plastics take millions of years for complete degradation and littering, clogging results health issues for human and animals. Recycling of plastic wastes by pyrolysis, gives fuel range hydrocarbons for automobiles, generators and industries.

For doing pyrolysis process we have to made one pyrolysis machine based on our required size. Before doing the actual pyrolysis operation we should have to design the pyrolysis machine. The entire body of pyrolysis machine have designed by using CATIA software based on our required dimensions.

So the present work is planned accordingly, to model the components needed for the pyrolysis equipment using known software. Further we have to fabricate and assemble all components of pyrolysis machine.

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