OPTIMIZATION OF CONDENSER PROCESS PARAMETERS OF SOLID WASTE PLASTIC PYROLYSIS PROCESS

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Abstract : Plastic waste being a non-biodegradable material has deleterious effect on environment. Numerous efforts are being made to reduce the plastic waste or to effectively manage the waste, but any of such efforts have failed provide a strong and a reliable solution. Out of the various technologies developed to manage the over 300 million tonnes of plastic waste generated globally on daily basis, Pyrolysis of waste plastic is the most efficient one. This method of pyrolysis of waste plastic into fuel is the best way to manage the huge amounts of plastic waste and to produce the valuable petroleum products. Our project deals with cooling down of the reactor gas in order to produce the two by-products namely, Gasoline and Diesel. In today's world which is booming with technological advancements, transportation and logistics forms the base of industrial advancement. The conventional resources such as petrol, diesel are used on a very large scale, with this frequency of usage we will surely fall short of these conventional fuels in a near future. Through pyrolysis of waste plastic, we can produce these conventional fuels which will help us carter the ever-increasing demand of these fuels. On the other hand, we can also efficiently manage to effectively use these huge amounts of plastic waste by preserving the environment. Hence, this process of pyrolysis proves to be a reliable solution which encompasses the solution for the two major problems, depletion of conventional fuels and the harmful effects of plastic waste on environment.

IndexTerms **-Solid waste management,Optimization of condenser, Plastic Pyrolysis.**

I. INTRODUCTION

Plastics are the most commonly used material now-a-days as it offers a massive contribution to the society. They are used on a large scale because of its innumerable advantages over other products. These plastics are light weight and reusable. They are formed by the process of polymerization as also different shapes can be given by moulding and extrusion processes.

Today we are recycling more plastics than ever before, as recycling can turn these valuable resources into new products. But some plastics cannot be recycled economically. One promising alternative other than burying the waste plastics into landfills is 'pyrolysis'. Pyrolysis is a process in which it converts the non-recycled used plastics into oils and other petroleum-based products. The products obtained from pyrolysis process can be used as fuels for power cars, buses, ships and planes, and as also fuel oils to produce electricity.

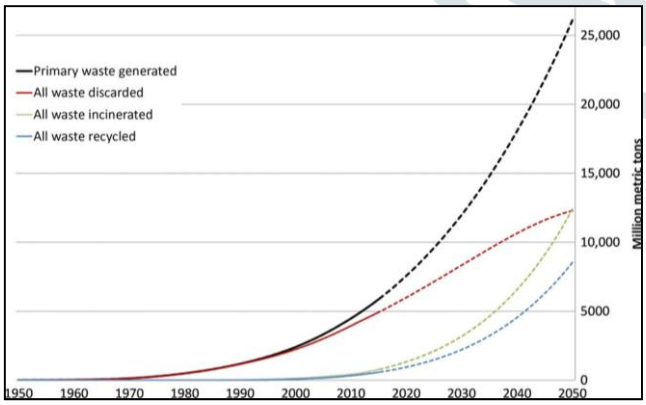

Fig. 1. cumulative plastic waste generation and disposal

II. OBJECTIVE

The primary objective of our project is to design and fabricate such a condenser system which would cool down the plastic pyrolyzed gasses by the use of water with minimum involvement of man power and optimum use of resources thereby reducing the operation cost and providing output that is economically feasible to the customer. The secondary objective our project aims to reuse the uncondensed gasses to heat the gasses in the reactor.

III. LITERATURE REVIEW

A] Reference:

"Waste Plastic to Diesel Conversion", Akash Gupta, Vikas Jha, Nurai Salam Khan, Vinay Bhatkar.

Overview:

For the increasing population and their needs, it has become very difficult to satisfy their needs with the conventional available sources of fuel. Also find solution to meet up the increasing demand of landfills for waste disposal is the matter of concern. The pyrolysis of waste plastic into diesel figure outs both these problems. In this paper the different mechanism for conversion of waste plastic into diesel such as catalytic cracking, hydrogenation and gasification of granulated waste plastic has been inculcated. The efficiency of the process is enhanced using catalyst ZSM-5. For the pyrolysis purpose LDPE plastic is selected with its catalytic cracking into smaller chains. Hence conversion of plastic into diesel will cater the needs of human beings of waste disposal as well as the increasing human needs of fuel energy. [1]

Conclusion:

The paper highlighted the basics related to plastic pyrolysis, its need and importance in the current scenario. Also, the paper gave a methodology to the previous model present.

B] Reference:

"Distillation Column Selection and Sizing", Mr. Chew Yin Hoon, Mr. Ai Li Ling, Mr. Aprilia Jaya, Mr. Mochamad Adha Firdaus

Overview:

This paper covered the basic elements in designing a typical condenser system. A condenser column is sized by determining the diameter of the tower. An initial estimation of the tower diameter can be done based on the vapor and liquid loadings in the column. This paper covered the basics of distillation process too which included types of distillation process, mode of operation of each process and the general design considerations.

Conclusion:

After studying about different condensers, a suitable condenser (Shell and Tube type) was selected which was as per the requirements and easy to manufacture.

C] ***Reference:***

*"*Shell and Tube Heat Exchangers Basic Calculations", Mr. Jurandir Primo

Overview:

In intercoolers, boilers, pre-heaters and condensers inside power plants as well as other engineering processes, heat exchangers are utilized for controlling heat energy. Heat exchangers are devices that regulate efficient heat transfer from one fluid to another. There are two main types of heat exchangers.

- The first type of a heat exchanger is called the recuperative type, in which heat are exchanged on either side of a dividing wall by fluids;
- The second type is regenerative type, in which hot and cold fluids are in the same space which contain a matrix of materials which work alternately as source for heat flow.

The optimum thermal design of a shell and tube heat exchanger involves the consideration of many interacting design parameters. [3]

Conclusion:

The calculations of a shell and tube condenser depend upon the various thermodynamic characteristics like pressure, temperature and energy. The other factors to be considered were the orientation of the condenser, type of cooling medium, etc.

IV. METHODOLOGY

The project is based on the optimization and upgradation of previous existing condensing unit of plastic pyrolysis plant.

- The designing starts with the calculation based on the reactor gas temperature and required product temperature for 1Kg pilot plant.
- By the calculations mentioned above, we concluded to have 1 reflux chamber and 2 condensing towers.
- The reactor gas enters the reflux chamber at 450°C and leaves at 350°C simultaneously separating heavy oils at the base of chamber.
- Then the reactor gas enters the 1st condensing tower at 350 ˚C and leaves the condenser at 180°C in the form of gas + liquid diesel.
- The gas leaving 1st tower enters the 2nd tower at 180 ˚C due to suction induced at the end of 2nd tower and leaves at 80 ˚C.
- The gas which liquifies as petrol gets collected at bottom of the tower and gas leaves the tower with certain content of methane at 80 ˚C.
- The gas will be stored using a suction pump and will be used for regeneration.
- The cooling medium used in the tower is water and the rate of flow of water will be 100 litres/hour.

The cooling medium is kept in closed loop. Hence at the end of process the reactor gas will be converted into heavy oils, liquid diesel and petrol in their purest form and flammable/ regenerative gas.

V. DESIGN & IMPLEMENTATION

As mentioned in the previous chapters, the objective of this project is to commercialize plastic pyrolysis process by obtaining fuel-oils which do not require further processing and by improving the process efficiency thus, reducing the overall process operating costs. Pyrolysis is parameter-oriented process. The parameters that affect the quality of fuel obtained and the efficiency of the process are mentioned below.

- Type of plastic used
- Cooling Medium
- Temperature
- Use of the syngas produced
- Cooling Medium

The entire condensation process is divided into three stages namely, reflux chamber, first stage condensation and second stage condensation.

1. *Reflux Chamber*

The function of the reflux chamber is to separate out the heavy oils ranging C18-C24 before the reactor gas passes through the condensers. The chamber is placed right after the reactor outlet. It has a different design as compared to the Diesel and Gasoline Condenser. Reflux Chamber has a wide diameter pipe and that pipe is concentrically inside another pipe. The outer pipe holds water whereas the inner pipe provides the passage to the gases. A dome shaped structure is provided inside the inner pipe which will spread out the gases and helps in lowering the temperature. The gas temperature will be lowered from 450°C to 350°C. The heavy oil is collected in a single container with the help of slant base. The collected heavy oil is then transferred back to the reactor in the second batch for thermal cracking.

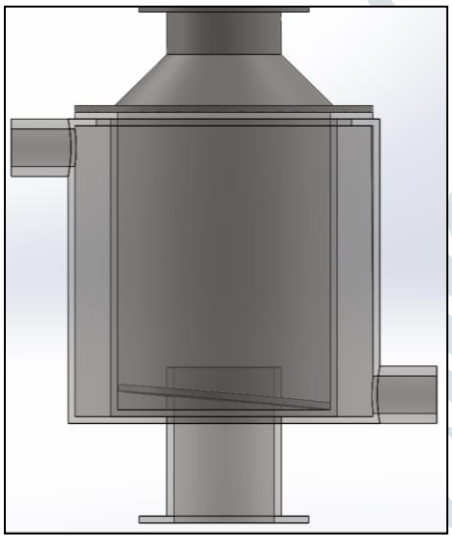

Fig. 2.CADD model of reflux chamber

2. *First Stage Condenser*

The first stage condenser deals with obtaining diesel as a by-product. The gas that originate from the reactor after passing through reflux chamber enters the first stage condenser. The cooling medium arrives from the second stage condenser as a single cooling medium source is used. The gasses pass through two copper tubes in the shell of 0.5m height. The water in the surrounding decreases the temperature of the gas up to 180 ºC and diesel as a by-product is obtained.

3. *Second Stage Condenser*

The second stage condenser deals with obtaining gasoline as a by-product. The gas that originate from the reactor after passing through the reflux chamber and then through the first stage condenser finally enters the second stage condenser. The cooling medium that comes from tap enters into the second stage condenser and then into the first stage condenser as a single cooling medium source is used. Four copper tubes of 0.5m each are incorporated; through them the pyrolyzed gas passes through. The temperature of the gas leaving the condenser would be around 80 ºC and gasoline as a by-product is obtained.

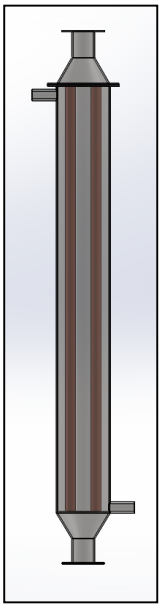

Fig. 3. CADD model of first stage condenser

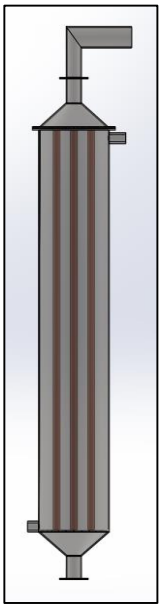

Fig. 4. CADD model of second stage condenser

4. Final Design

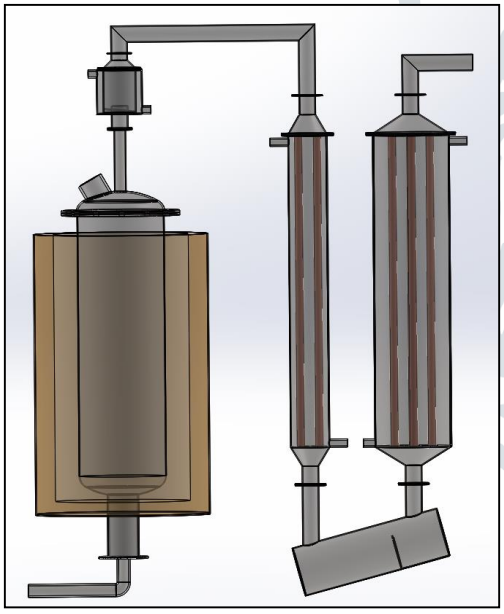

Fig. 5.CADD model assembly of the entire pyrolysis setup

VI. Expected Outcome

- Optimum cooling of the reactor gas from 450˚C to 80˚C.
- Two cooling towers and a reflux chamber is incorporated so as to obtain two liquid products i.e. Diesel & Gasoline and separate out the heavy oils in reflux chamber.
- At the end of condensation process the flammable gas is obtained at 80˚C for the regeneration process.
- With proper condensation rate, two by-products are expected in their purest form.
- Explore our understanding of the contradictions between models, observation and actual unit; the sources and reason.
- Outline the possible research agenda that would explicitly address the problems that will be faced in scaling up the unit.
- Prioritize the research frontiers which offer the greatest return for investment when the plant is scaled up.
- Assess the possibility of making up the condensation unit fully automated for the scaled-up plant.

VII. Conclusion

We human beings are at such stage presently that a day without the use of plastic seems to be very obnoxious and irresistible. As a result, eliminating plastics from the daily use is very difficult but utilizing the waste plastics to obtain is what everyone is looking for. As per the current situation and environmental problems across the globe it seems no country as an individual wants to completely cease the use of plastics. This plant has far reaching effects in terms of its utilization of daily waste plastics which would reduce and eliminate the hazardous effects in the environment and offer fuels which tend to be eco-friendly due to less contaminants being present and good performance characteristics. Recently this issue has taken a huge campaign because in a country like India where fuel costs are at peak and where annually at least 8million tonnes of plastics end up in the oceans which is equivalent to a truck full of garbage every minute. The plant and the process of plastic pyrolysis would be a boon to the society to solve the two major problems and by further modifications as per different regions and atmosphere would result into massive help to mankind.

VIII. Acknowledgment

We express gratitude to our mentor Prof. Jayant Patil for guiding us in the project and giving us the opportunity to work freely on the entire project.

References

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