Design of a Reactor Tube on a Non-Isothermal Pyrolysis Reactor Prototype for High-Density Polyethylene Plastic Waste as a Practicum Learning Module

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ABSTRACT
The design of the pyrolysis reactor tube was carried out as part of the initial process of making the practicum module. This tool is used to carry out the pyrolysis process of plastic waste, especially High-Density Polyethylene (HDPE) plastic waste. In the process carried out to design a pyrolysis reactor tube for HDPE plastic waste that is efficient in the use of materials and can function as a support for learning. The design of HDPE plastic waste pyrolysis reactor tubes has several stages. The sequence of steps carried out to design a pyrolysis reactor tube is making a sketch of the tube, determining the size of each part of the tube, making working drawings for the manufacture of the reactor tube and determining the materials used in the reactor tube. The material used for the manufacture of the pyrolysis reactor tube will be St37 steel plate with a thickness of 5 mm which will be formed according to the design that has been made. The additional components or tools used in the reactor tube are U channel steel profiles, copper pipes, valves, pressure gauges, thermocouples, PT100 sensor cables, digital temperature LCDs, gas stoves, bolts and nuts, and finally RTV silicone. Additional tools and components in the pyrolysis reactor tube are needed so that the work of the pyrolysis reactor tube can function optimally and then proceed to the next stage so that a practicum module is realized which is ready for use by students.

Keywords: *HDPE, Pyrolysis, Reactor, Plastic Waste.*

1. INTRODUCTION

Plastic waste is very difficult to decompose naturally in the environment, that is what causes various problems in the environment because it will accumulate more and more over time. Plastic waste has a chemical structure as an organic compound made from polymers and is composed of very strong carbon chains. The carbon bonds contained in plastic cannot be broken by microorganisms in the environment, so it takes a very long time to decompose them. The time needed for plastic waste to decompose naturally is around eighty years for the plastic waste to be completely degraded. In addition, plastic can also release harmful chemicals into the surrounding soil, then these chemicals can seep into the soil, water or water sources around it and can also damage ecosystems. These factors can threaten the life of living things that drink the water.

Most of the 50% plastic production makes this type of single-use plastic which makes more and more plastic waste and damages the environment [1]. Based on data [2] Indonesia produces 187.2 million tons of plastic waste annually. Synthetic polymers or petroleum are the raw materials for making plastics that are used today. Based on data, as many as 500 trillion types of single-use plastic bags are used by Indonesians every year and one million plastic bottles are traded every minute.

Therefore, to reduce damage and avoid pollution caused by plastic waste, recycling and recovery processes are needed. One of the chemical recycling technologies is pyrolysis, as an acceptable method for processing plastic waste from an environmental and

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economical perspective [3-4]. Plastics can be defined as polymeric materials that can be shaped at will, melt when heated to a certain temperature and harden after being cooled or the solvent is evaporated.

2. HIGH DENSITY POLYETHYLENE PLASTIC

Plastic type of High Density Polyethylene (HDPE) is a type of plastic that is commonly used by humans and is usually used as a raw material for making detergent bottles, shampoo bottles, plastic chairs, gallons, and others. This type of plastic material is classified as safe for human use, because the ability possessed by this plastic material is to prevent a chemical reaction from occurring between the packaging and the packaged material including food and beverages.

This type of HDPE plastic also has the properties of a material that is stronger, harder, and capable of resistant to high temperatures. The characteristics of this type of High-Density Polyethylene plastic are that at the bottom of the plastic bottle there is the word HDPE under the recycling triangle logo which has the number two in the middle.

3. PYROLYSIS

Pyrolysis can occur in biomass and plastics when burned or through natural heating with thermal conditions [7]. The use of plastic raw materials in the pyrolysis process has advantages over biomass, namely the hydrogen content in oil products is more than that in the pyrolysis process of biomass. These results indicate that if the pyrolysis feedstock is different, it will produce a different oil content [8].

3.1 Pyrolysis Reactor

Pyrolysis is a process of heating a material in the absence of oxygen or heating in a closed room, resulting in the decomposition of the compounds making up the material into liquids or into gases at a certain hot temperature. This gives an understanding that if HDPE type plastic waste is given heat energy in a closed room without air and then given a high enough temperature, then there is a possibility that a reaction will occur that decomposes plastic waste from its constituent compounds and will produce a product in three variant forms. namely solid, liquid, and gas.

A pyrolysis reactor is defined as a device that is capable of decomposing organic compounds in the pyrolysis raw materials by heating the reactor, without the presence of air in the reactor which is in direct contact with the outside, given a temperature of 300-600°C, using a gas stove as fuel or hot oil stove (Hadi., 2014). In the pyrolysis process for HDPE plastic waste, a reactor is needed to process the decomposition of compounds in plastic waste into liquids and gases.

4. HEAT TRANSFER

Heat transfer is a science that examines the rate of heat transfer in materials or objects due to temperature differences. Heat transfer that occurs because there is a temperature difference in a material or object. Heat transfer will occur, namely flowing from a high temperature to a place with a lower temperature [9]. Heat transfer can be interpreted as the transfer of energy from one area to another as a result of the temperature difference between these areas [10-15]. In the process of heat transfer in the combustion of pyrolysis reactor tubes, heat transfer occurs by conduction heat transfer mechanism.

5. DESIGN OF PLASTIC WASTE PYROLYSIS REACTOR TUBES OF HIGH-DENSITY POLYETHYLENE TYPE

The first step in designing the reactor tube is to make a sketch or basic drawing that defines the shape and size of the reactor tube. Making sketches also aims to find out the budget spent on making reactor tubes, so that we can calculate the costs that will be spent on purchasing the basic materials for the reactor. Making this sketch is done with a simple description of the reactor tube as a reference in terms of shape and size.

At the stage of making the sketch of the reactor tube it has been completed, meaning that it has found a definite picture and basis for this tool. In the design of this reactor tube using a fixed or moving bed type pyrolysis reactor design that is adjusted to the specified needs and budget, then proceed with the process of determining the size and making working drawings in two dimensions (2D) and three dimensions (3D).

After carrying out the initial stages of making a sketch for the reactor tube, the next step is to determine the size of the reactor tube that suits your needs. The size given is very influential on the design budget and can determine the effectiveness of the pyrolysis process, therefore it must be ensured that the size and dimensions given are in accordance with the requirements and conditions.

The process of making new working drawings can be done after the sketching stage and determining the size have been done in the previous stage. Where are the working drawings of the High-Density Polyethylene

(HDPE) plastic waste pyrolysis reactor tube must have the desired shape and size. In the process of making working drawings that must be considered in accordance with the rules of technical drawings in general, namely determining the shape of the object, the dimensions of the object, and the view of the object drawing, all must be carried out with the applicable provisions. Making 2D and 3D working drawings of pyrolysis reactor tubes using SolidWorks software. The following Figure 1 shows the design of a pyrolysis reactor for HDPE plastic waste and Appendix 1 shows working drawings of a pyrolysis reactor. Later working drawings of the pyrolysis reactor parts will also be placed in the attachment section.

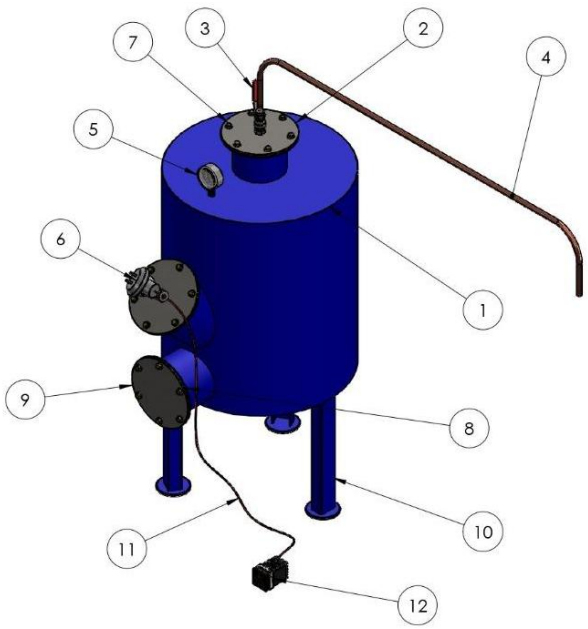

Figure 1. Pyrolysis Reactor Design.

Determining the material is the final stage carried out in a design process where this resistance is the selection of materials used according to the wishes and needs. Therefore, in the stage of determining the material must be effective in order to function optimally and efficiently. This stage of determining materials also serves to calculate the amount of budget needed to make a high-density polyethylene (HDPE) plastic waste pyrolysis reactor tube.

6. CONCLUSION

Determining the material is the final stage carried out in a design process where this resistance is the selection of materials used according to the wishes and needs. Therefore, in the stage of determining the material must be effective in order to function optimally and efficiently. This stage of determining materials also serves to calculate the amount of budget needed to make a high-density polyethylene (HDPE) plastic waste pyrolysis reactor tube.

AUTHORS' CONTRIBUTIONS

The authors contribute to this paper according to their capability and specialization.

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