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EXPERIMENTAL STUDY OF THE EFFECT OF REACTOR TEMPERATURE RECONSTRUCTION ON FUEL CONSUMPTION AND DISTILLATE QUANTITY

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Abstract. Temperature is a physical quantity as a measure the degree of hotness or coldness an object or system that is in thermal equilibrium. Heat flows naturally from high temperature objects to low temperature (reversible process). Heat is an energy that transferred between of two difference temperature. This heat transfer will occur and the process will be stops until thermal equilibrium occurs. The high temperature fluid in the distillation reactor will tend to be at the top, even though the heat treatment is carried out at the bottom side. The open model distillation reactor makes equilibrium to be reached in relatively long time. Time will affect to energy consumption. The pump aims to reconstruct of the temperature, so that can be reaches the thermal equilibrium more quickly. The process is carried out for 60 minutes using 25 liters of raw materials with the same quality and the temperature is set at 90^0 C. The average temperature difference in the reactor is 86.11%, the decrease in fuel consumption is 30.3%, and the increase in distillation quantity between the reactor without a pump compared to with a pump is 16.67 %.

Keywords : temperature, energy, reactor.

1. INTRODUCTION

Distillation is a process to separating of two or more liquids based on their boiling points. Based on this theory, the process is most often carried out of heating. The result of the heat process will produce steam, the vapor is converted into a liquid phase again in the condenser. There are two main components in distillation apparatus, namely reactor and condenser. Steam is generated in the reactor components, so this device is closed to reduce steam leakage. The reactor is heated using a burner which is controlled by temperature sensor so that the heat can be adjusted as needed.

Temperature is a physical quantity as a measure the degree of hotness or coldness an object or system that in thermal equilibrium [1-3]. Heat is energy that is transferred between of two temperature difference in the system or its environment. The relationship between heat and temperature is not constant, the amount of temperature increase due of receiving a certain amount of heat will be influenced by the heat capacity of the object receiving [4-7]. Heat is known be able to move from a higher temperature to a lower temperature [8-10]. The statement expressed by R.J.E Clausius is the heat flows naturally from high temperature to low temperature objects (reversible process). The concept of second law thermodynamics will always occur and the process will stop until the concept of thermal equilibrium occurs. It can be concluded that an object or fluid will have heat and naturally heat can flow from a high temperature to a lower temperature until the concept of thermal equilibrium is formed.

Heat transfer is a science to studies the transfer of energy or heat that occurs due of two temperature differences between objects or materials. Heat transfer can take place in several ways, namely by convection, conduction and radiation [11-14]. The transfer of heat from a high concentration of adjacent substances to heat of a lower concentration as a result of interactions between particles is called conduction. Convection is a model

of heat transfer between adjacent surfaces of a gas or liquid and involves fluid motion. Radiation is the emission of energy from matter in the form of electromagnetic waves as a result of changes in the shape of molecules or atoms [15][16]. Heat transfer can occur through solid, liquid or gas because of the treatment.

Distillation reactor as one of the important tools in the separation [17-20]. Heat treatment through certain media can increase the temperature of the existing fluid. The second law of thermodynamics states that heat will tend move to a place of lower temperature until thermal equilibrium is reached. The high temperature fluid in distillation reactor will tend to be at top even though heat treatment is carried out at the bottom side. The open model distillation reactor makes equilibrium to be reached in a relatively long time. Time will affect energy consumption.

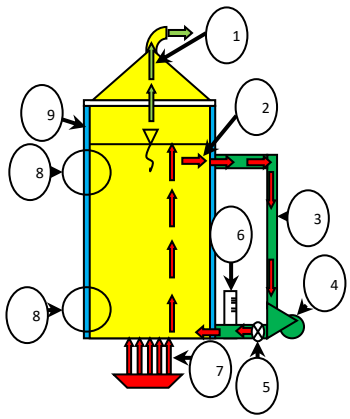
The treatment will be carried out on the reactor by adding a device whose purpose to achieve thermal equilibrium more quickly. It is hoped this equilibrium will affect energy consumption in production process. The fixed variables are temperature and fluid flow rate, while the independent variables are energy consumption and the amount of distillate.

The problem is how to design a distillation reactor with the addition of temperature reconstruction tool and whether temperature treatment can affect energy consumption and the quantity of distillate produced. Application of science to design appropriate technological tools that can speed up production time to reduce costs. The design of the distillation reactor uses 1.5 mm thick stainless steel plate with a base dimension is 40 cm and a height is 60 cm which is wrapped with a heat cover (glass wool and burlap sack). The heater uses an LPG stove with a control to regulate the temperature requirement of the reactor. Steam is conveyed using stainless steel pipes. Temperature data is recorded every 15 minutes. LPG weight is measured every 15 minutes to get the amount of energy use. The distillate quantity will be measured after the distillation process is stop.

2. METHODS

2.1. Research Design

Traditional distillers make alcoholic beverages with raw materials from coconut tree sap or palm sap. The raw materials required are at least 16 liters of palm sap, the time required to heat the raw materials into steam is about 3 to 4 hours, while the results obtained are about 1 liter of alcohol.



1 Steam flow
2 Hot fluid flow
3 Hot pipe
4 Pump
5 Ceck valve
6 Flow meter
7 Burner LPG
8 Temperature measurement point
9 Heat cover

Figure 1 Distillation reactor design with temperature reconstruction

The addition of a heat cover to prevent heat loss which causes relatively high energy requirements has been carried out in previous studies. The spread of heat in the reactor tube still adheres to the natural law where the highest heat will be on the surface of the fluid.

The fluid pump in this study was added to speed up the thermal equilibrium process so that the evaporation process would be faster. Understanding the pump in general is a tool used to move fluid from one place to another [21][22]. In principle, the pump converts the mechanical energy of the motor into fluid flow energy, the energy received by the fluid will be used to increase the pressure and overcome the losses that occur in the line. In this study, a centrifugal pump was used. This pump uses a rotating impeller to increase the fluid pressure. Centrifugal pumps are usually used to move fluids through piping systems. The fluid enters the pump impeller along or near the rotating axis and is accelerated by the impeller, flowing radial outward into the diffuser or volute (casing) chamber, from where it exits to the downstream piping system. Centrifugal pumps are used for large discharges through smaller heads. The working principle of the pump is driven by a motor. Power from the motor is supplied to the pump shaft to rotate the impeller mounted on the shaft. The fluid in the impeller will also rotate due to the thrust of the blades. Due to the presence of centrifugal force, the liquid flows from the center of the impeller out through the channels between the blades and leaves the impeller at high speed. The liquid that comes out of the impeller at high speed will then come out through a channel with a larger cross-section (volute/diffuse) resulting in a change from the velocity head to the pressure head. Suction occurs because after the liquid is thrown by the impeller, the space between the blades becomes lower in pressure so

that the liquid will be sucked in. The pump in the reactor is useful for flowing liquid from the surface to the bottom. The hot fluid at the surface is returned to the bottom of the reactor.

This type of pump is installed with a capacity of 10 liters per minute. The pump will be turned on during the process. The fluid in the tube is made to always circulate from the top side of the tube to the bottom side of the tube. The hot fluid on the top side will be forced to the bottom side of the tube to accelerate the equilibrium condition.

2.2. Research Instruments

The instruments used in this research are fuel consumption and distillate quantity. Retrieval data using a thermocouple to measure the temperature in distillation tube as shown in figure 2.

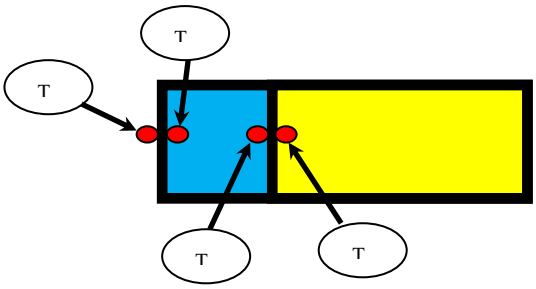


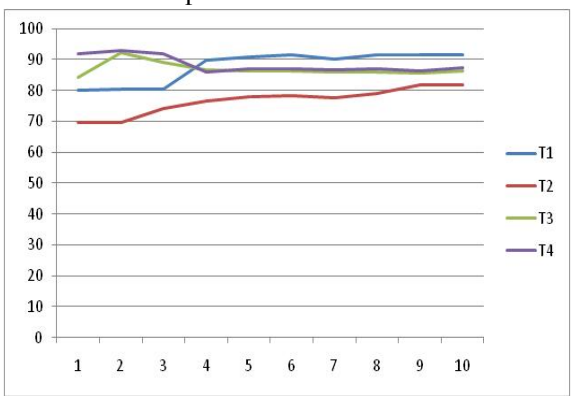
Figure 2 Location of data retrieval

Processing is done based on the data that has been taken and the variables that have been set. Fixed variables are heating temperature and fluid flow rate. The independent variables are fuel consumption and distillate quantity.

3. RESULTS AND DISCUSSION

The test was carried out for 5 times with the same quality raw materials for each treatment. The volume of raw materials is 25 liters. Preheating was done to reach a temperature to 90^0 C. Data retrieval of temperature and weight of fuel when the reactor temperature has reached 90^0 C and the circulation pump is turned on. Data were collected every 15 minutes for 60 minutes process. The quantity of distillate and final fuel weight were measured after 60 minutes of processing is done. The data is displayed according to graph 1.

Graph 1 Test result data



The difference is very significant between a reactor using a pump and without a pump as shown in graph 1. T1 and T2 are the temperature in the reactor without a pump. T3 and T4 are the temperatures in the reactor using a circulating pump.

The temperature of the reactor without a pump (T1 and T2) showed a very significant difference is 11.09^0 C based on top side and bottom side of the reactor. This temperature difference affects the fuel consumption used. The initial fuel weight is on average 6.980 kg and after the process becomes an average of 6.585 kg, there is a decrease 0.395 kg of weight. That's an average of 5 times off/on burner with a very short time span from off burner to on burner to maintain a stable temperature. The quantity of distillation during the process obtained an average of 1,250 ml after one hour of processing.

The reactor temperature with the pump (T3 and T4) looks almost the same where there is only an average temperature difference of 1.54^0 C based on top side and bottom side of the reactor. This almost small difference indicates that the temperature inside the reactor becomes more even with the addition of a pump for fluid circulation. This affects the fuel consumption used only 0.275 kg from an average initial weight of 6.950 kg to an average of 6.675 kg. That's an average of 2 burner off/on times with a long time span from off to on. The quantity of the distillate during the process obtained an average of 1,500 ml after one hour of processing.

There is a difference between a reactor without a pump and a reactor with a pump. The difference of temperature distribution between the top side and the bottom side in the tube is 86.11 %, that's indicates the heat balance can be achieved. This equilibrium condition affects the energy consumption. The decrease consumption of LPG is 30.38 % . The quantity of the distillation product also increases due the increasing heat balance in the reactor tube. The increase of distillate was 16.67 % from the reactor without a pump compared to the reactor with an added pump.

4. CONCLUSION

The conclusions of this study are:

1. The difference of temperature is 86.11% between the reactors without a pump compared to with a pump.
2. Decrease of fuel consumption is 30.3% between reactors without pumps compared with pumps.
3. Increase of distillate quantity is 16.67% between reactors without pumps compared with pumps.

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