Experimental Study of the Effect of Reactor Temperature Reconstruction on Fuel Consumption and Distillate Quantity

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Abstract: Temperature is a measure or degree of hotness or coldness of an object or system, temperature is defined as a physical quantity that is shared between two or more objects that are in thermal equilibrium. The second law of thermodynamics is based on the fact that there is no reversible process in which heat flows naturally from a high-temperature object to a low-temperature object, and not vice versa. Heat is energy that is transferred due to a temperature difference. The concept of this law of 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 a temperature and naturally that temperature can flow from a high temperature to a lower temperature until the concept of thermal equilibrium is formed. Heat treatment through certain media can increase the temperature or the temperature of the existing fluid. In the distillation column the high temperature distillate fluid will tend to be at the top and the bottom will tend to be cooler even though heat treatment is carried out at the bottom. Equilibrium temperature will be achieved in a relatively long time because the system used for distillation is open. Temperature reconstruction by providing additional tools aims to achieve thermal equilibrium more quickly. The process is carried out for 60 minutes using 25 liters of raw materials of the same quality and the temperature is set at 90 degrees Celsius. The results obtained are the average temperature difference in the reactor is 86.11%, the decrease in fuel consumption is 30.3%, and the distillation quantity increases by 16.67% between the reactor without a pump compared to the reactor with a pump.

1 INTRODUCTION

Distillation is a process of separating two or more components of a liquid based on the boiling point. In simple terms, distillation is done by heating/evaporating the liquid and then the steam is cooled back to become liquid with the help of a condenser. The reactor is tightly closed so that no steam comes out of the lid gap or connection pipe. The temperature increases gradually until the maximum can evaporate water and other dissolved materials which then flow through the connecting pipe and undergo a process of condensation/phase change from vapor to liquid.

Temperature is a measure or degree of hotness or coldness of an object or system, temperature is defined as a physical quantity that is shared between two or more objects that are in thermal equilibrium (Putra, 2007). If heat is transferred at the temperature of the object, then the temperature of the object will decrease if the object in question loses heat. The relationship between the heat unit and the temperature unit is not a constant, because the magnitude of the increase in temperature due to receiving a certain amount of heat will be influenced by the heat capacity of the receiving object (Lakitan, 2002). Heat is energy that is transferred due to a temperature difference. Another definition of heat / heat is something that moves between the system and its environment due to changes in temperature (Zemansky, 1986). The second law of thermodynamics is based on that there is no reversible process. This law is a statement about the processes that occur in nature. One of the statements expressed by R.J.E Clausius is that heat flows naturally from objects at high temperature to objects at low temperature, not the other way around.

The development of the second law of thermodynamics is based on the study of heat engines, namely devices that can convert thermal energy into mechanical work, such as steam engines (Giancoli, 2005). Heat is energy that is transferred due to a temperature difference. Another definition of heat / heat is something that moves between the system and its environment due to changes in

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temperature (Zemansky, 1986). This concept of the law of thermodynamics will always occur and the process will stop until the concept of thermal equilibrium occurs (Ninik, 2019). It can be concluded that an object or fluid will have a temperature and naturally that temperature can flow from a high temperature to a lower temperature until the concept of thermal equilibrium is formed. This flow of temperature is often referred to as heat transfer.

Heat transfer is the science of predicting the transfer of energy that occurs due to temperature differences between objects or materials. Where the energy transferred is called heat. Heat is known to be able to move from a higher place to a lower temperature (Evalina, 2019). Heat transfer is the process of transferring energy from one place to another due to differences in temperature in these place, heat transfer can also take place in several ways by convection, conduction and radiation (Indriatma, 2016). Conduction is the transfer of energy from a particle with a high concentration of an adjacent substance to a particle with a lower concentration as a result of the interaction between the particles. Convection is a model of energy transfer between a solid surface and an adjacent gas or liquid motion, and it involves a combination of the effects of conduction and fluid motion. Radiation is the emission of energy from matter in the form of electromagnetic waves (photons) as a result of changes in the electronic form of molecules or atoms (J.P Holman, 6th Edition). Theoretically, the heat transfer can occur through solid, liquid or gas due to the treatment.

The existence of a distillation column as one of the vital tools in the separation place, is an almost always part of the complete process design. A special understanding of this tool is considered very important (Komariah, 2009), so in planning a distillation reactor, it is very important to pay attention to the manufacture of the reactor. Heat treatment through certain media can increase the temperature or the temperature of the existing fluid. Looking at the second law of thermodynamics, the heat that occurs will tend to move or flow to a place that has a lower temperature. This process will occur continuously until thermal equilibrium is established. In the distillation column (reactor) the high temperature distillate fluid will tend to be at the top and the bottom will tend to be cooler even though heat treatment is carried out at the bottom. Equilibrium temperature will be achieved in a relatively long time because the system used for distillation is open. This time will greatly affect energy consumption which in turn will increase the cost of distillate production.

This research will be carried out on the treatment of the temperature that occurs in the reactor tube. Temperature reconstruction by providing additional tools with the aim of thermal equilibrium can be achieved more quickly. The hope is that as soon as this equilibrium is reached, it will affect the energy consumption in the production process. The fixed variables in this study are temperature and fluid flow rate, while the independent variables are energy consumption and distillate quantity.

Based on the background of the problem, the problem is how to design a distillation reactor with the addition of a temperature reconstruction tool and whether the temperature reconstruction treatment can affect energy consumption and the quantity of distillate produced.

The problem will be limited by applying existing applied science to design an appropriate technological tool that can speed up production time to reduce production costs that affect energy consumption. The problem discussed in this study is the design of a distillation reactor using a 1.5 mm thick stainless steel plate with dimensions of 40 cm base and 60 cm height wrapped with heat cover (glass wool and burlap sacks). The heater uses an LPG stove with a temperature setting to adjust the flame to suit the needs of the reactor tube temperature. Steam outlet using stainless steel pipe. Temperature data is recorded between 15 menit. LPG weight is measured in a certain time to get the amount of energy use. The distillate quantity will be measured after the distillation process runs at a predetermined time.

2 RESEARCH METHODS

2.1 Research Design

The application of traditional distillation equipment is to make alcoholic beverages with coconut tree sap or palm tree sap as raw materials. To obtain 1 liter of alcoholic beverage it takes at least 16 liters of palm juice, while the time required to heat the raw materials to become steam is about 3 to 4 hours, this takes a relatively long time to reach equilibrium.

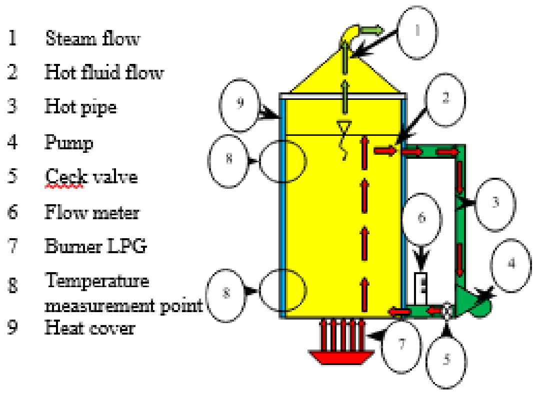

Figure 1: Distillation reactor design with temperature reconstruction.

The addition of a pump in a device designed to flow hot fluid that tends to be on the surface back to the bottom of the reactor. The hope is that with this circulation, the heat balance will occur more quickly. The faster the increase in temperature is achieved, the faster the evaporation of alcohol that occurs and thus the energy consumption will decrease.

Previous research has been carried out with the addition of heat cover to prevent heat losses causing energy requirements to be relatively high. The spread of heat in the reactor tube still adopts the natural law where the highest heat will be on the surface of the fluid.

The addition of a fluid pump in this study is to obtain thermal equilibrium so that the evaporation process will be faster and affect energy consumption.

2.2 Research Instruments

The instrument used in the research with the title of experimental study is the effect of temperature reconstruction on fuel consumption and distillate quantity. Collecting data in the test using a thermocouple by measuring the temperature at several locations on the distillation tube as shown in Figure 2.

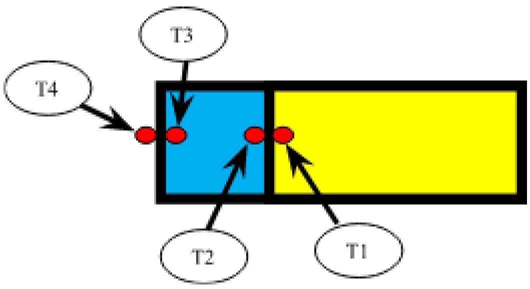

Figure 2: Location of data retrieval.

The test is carried out 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. The test will be limited to only 5 trials and then find the average.

3 RESULT

The test was carried out 5 times with raw materials of the same quality for each treatment. The volume of raw materials is 25 liters. Preheating is done to reach a temperature of 90 degrees Celsius according to the temperature setting. Data collection on the internal temperature and weight of the fuel begins when the distillation reactor temperature has reached 90 degrees Celsius and the circulation pump is started. Data were taken every 15 minutes for 60 minutes of heating. The distillate quantity and final fuel weight were measured after 60 minutes of processing. The data is displayed according to graph 1.

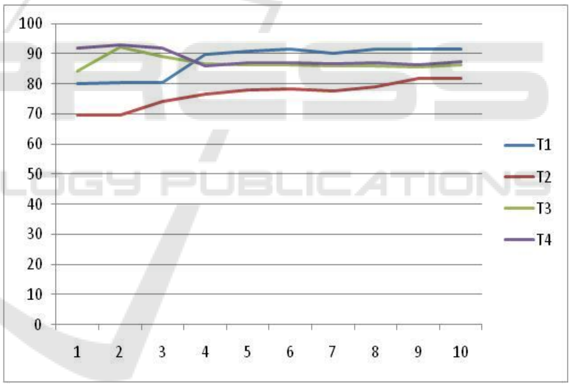

Figure 3: Test result data.

Figure 1 shows a very significant difference between a reactor using a pump and a reactor without a pump. T1 and T2 are the temperatures in the reactor without a pump. T3 and T4 are the temperatures in the reactor using a circulation pump. Understanding the pump in general is a tool used to move fluid from one place to another (Hirt, 1986). 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 reactor are use a centifugal pump. They use a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are commonly used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits into the downstream piping system. Centrifugal pumps are used for large discharge through smaller heads. The principle work of the pump is driven by a motor. Power from the motor is given to the pump shaft to rotate the impeller attached to the shaft. The liquid in the impeller will also rotate due to the impetus of the blades. Because the centrifugal force arises, the liquid flows from the center of the impeller out through the channel 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 whose cross section is getting bigger (volute/diffuse) so that there is 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 draining the fluid on the surface to the bottom. The hot fluid on the surface is returned to the bottom of the reactor. Pumps used with a capacity of 10 liters per minute.

The temperature of the reactor without a pump (T1 and T2) shows a very significant difference where there is an average temperature difference of

11.09 degrees Celsius. 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 in weight of 0.395 kg. That's an average of 5 times off/on burner with a very short time span from off burner into 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 process.

The reactor temperature with the pump (T3 and T4) looks almost the same where there is only an average temperature difference of 1.54 degrees Celsius. This almost small difference indicates that the temperature in 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 average 2 times off/on burner with a long time span from off to on. The quantity of distillation results during the process obtained an average of 1,500 ml after one hour of process.

4 CONCLUSIONS

The conclusions of this study are:

1. The difference in temperature is 86.11% between the reactor without a pump compared to the reactor with a pump.
2. Decrease in fuel consumption by 30.3% between reactors without pumps compared to reactors with pumps.
3. An increase in the quantity of distillation results by 16.67% between reactors without pumps compared to reactors with pumps.

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REFERENCES

Intang, A., & Darmansyah, D. (2018). Analisa termodinamika laju perpindahan panas dan pengeringan pada mesin pengering berbahan bakar gas dengan variabel temperatur lingkungan. *FLYWHEEL: Jurnal Teknik Mesin Untirta*, *1*(1), 34- 38.

Chen, Y., & Athienitis, A. K. (1998). A three-dimensional numerical investigation of the effect of cover materials on heat transfer in floor heating systems. *Ashrae Transactions*, *104*, 1350.

Krasnoshlykov, A. S. (2016). Analysis of Influence of Heat Transfer Conditions on the Upper Cover to Heat Transfer in Thermosyphon. In *MATEC Web of Conferences. Vol. 72: Heat and Mass Transfer in the System of Thermal Modes of Energy–Technical and Technological Equipment (HMTTSC-2016).— Les Ulis, 2016.* (Vol. 722016, p. 1052). [sn].

Budiman, A. (2009). Penghematan energi pada menara distilasi. *Reaktor*, *12*(3), 146-153.

Budiyanto, A., Fadiawati, N., Tania, L., & Syamsuri, M.
M. F. (2015). Alat Distilasi Sederhana Berbasis Barang Bekas. *Jurnal Pendidikan dan Pembelajaran Kimia*, *4*(3), 1137-1150.

Bergman, T. L., Bergman, T. L., Incropera, F. P., Dewitt,
D. P., & Lavine, A. S. (2011). *Fundamentals of heat and mass transfer*. John Wiley & Sons.

Adams, E. E., & Sato, A. (1993). Model for effective thermal conductivity of a dry snow cover composed of uniform ice spheres. *Annals of Glaciology*, *18*, 300-304.

Ferahta, F. Z., Bougoul, S., Médale, M., & Abid, C. (2012). Influence of the air gap layer thickness on heat transfer between the glass cover and the absorber of a solar collector. *Fluid Dynamics & Materials Processing*, *8*(3), 339-351.

Kros, S. J. (1986). Elemen Mesin, edisi kedua. *Erlangga, Jakarta*.
Holman, J. P. (1986). Heat transfer, 1986. *Mc Gran–Hill Book Company, Soythern Methodist University*.
Supu, S. I., Usman, U. B., & Basri, B. S. (2016). Sunarmi,". *Pengaruh Suhu Terhadap Perpindahan Panas Pada Material Yang Berbeda" Pogram Studi Fisika, Fakultas Sains Universitas Cokroaminoto Palopo*.
Indriatma. (2016). "Heat Analisis at Rotary Kiln Unit Iii Pt. Antam, Tbk (Persero)," *Ubpn Sultra, Enthalpy Jurnal Mechanical Enginering.* e-ISSN:2502-8944, Vol. 2, No.2.
Syaichurrozi, I., Karina, A. M., & Imanuddin, A. (2014). Study of Plate and Frame Heat Exchanger Performance: The Effects of Mass Flow Rate, Inlet Temperature and Type of Flow Againts The Overall Heat Transfer Coefficient. *Eksergi*, *11*(2), 11-18.
Mursito, J. A., Sukadana, I. G. K., & Tenaya, I. G. N. P. (2017). Perancangan Dan Pengujian Alat Distilasi Minyak Dari Limbah Sampah Plastik. *Jurnal Ilmiah Teknik Desain Mekanika*, *6*(4), 311-17.
Walangare, K. B. A. (2016). Design of a Seawater Conversion Tool into Drinking Water Using a Distillation Process. *Journal of Electrical and Computer Engineering, Department of Electrical Engineering-Ft. Unsrat Manado.*
Lakitan, B. (2002). Dasar-dasar klimatologi. *PT. Raja Grafindo Persada. Jakarta*.
Komariah, L. N., Ramdja, A. F., & Leonard, N. (2009). Tinjauan Teoritis Perancangan Kolom Distilasi untuk Pra-Rencana Pabrik Skala Industri. *Jurnal Teknik Kimia*, *16*(4).
Noufal, M., Kusuma, I. G. B. W., & Suarnadwipa, I. N. (2017). Analisa Perpindahan Panas Pada Heater Tank FASSIP-01. *Jurnal Mettek: Jurnal Ilmiah Nasional dalam Bidang Ilmu Teknik Mesin*, *3*(1), 1- 10.
Evalina, N., Riza, M. K., Arfis, A., & Rimbawaty, R. (2019, May). Pemanfaatkan Bahan Bakar Sampah Plastik Dengan Menggunakan Pembangkit Listrik Hot Air Stirling Engine. In *Seminar Nasional Teknik (SEMNASTEK) UISU* (Vol. 2, No. 1, pp. 71-76).
Akhyar, O., & Mashuri, M. T. (2016). Perancangan Dan Uji Kualitas Alat Destilasi Sederhana Sebagai Langkah Kreatif Mewujudkan Kemandirian Laboratorium. *AL ULUM JURNAL SAINS DAN TEKNOLOGI*, *1*(2).
Putra, S., & Kelana, M. (2007). Rancangan Bangunan dan Analisa Perpindahan Panas pada Ketel Uap Bertenaga Listrik. *Medan: USU*.
Khurmi, R. S., & Gupta, J. K.(2008). Text Book of Machine Design Eurasia. *Ram Nagar ltd, New Dehli*, 68.
Zemansky, M. F. (1986). Social Support and Burden In Adult Child Caregivers of Physically Ill Elderly.
Giancoli, D. C. (2005). *Physics: Principles with applications* (Vol. 1). Pearson Educación.
Ninik, T. S., Zaenal, A., Dyah, I., & Nurhidayat, N. (2019). Sensitive and stable ethanol biosensor development based on Acetobacter aceti biofilm for halal detection of food and beverages.
Hirt, P. I. E. R. R. E., Hiller, G., & Wittek, R. (1986). Localization and fine structure of a vaccinia virus gene encoding an envelope antigen. *Journal of Virology*, *58*(3), 757-764.