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# Data Retrieval on Heat Exchanger Machines

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**Abstract.** In many industrial processes, heat transfer—the movement of thermal energy from one object or medium to another—is a significant phenomena. Conduction, convection, and radiation are the three primary mechanisms via which this phenomena happens. When a temperature gradient causes heat to go from a hotter to a cooler region in a solid substance, this process is known as conduction. Heat is transferred through a moving fluid (liquid or gas) by convection, which can occur spontaneously as a result of density differences or be induced mechanically by a pump or fan. Unlike the other two methods, radiation includes the movement of energy in the form of electromagnetic waves and does not require a medium.

**Keyword:** Heat Exchanger, Conduction, Convection, Radiation

## 1. Introduction

Heat transfer or what is often called heat transfer is one of the thermal engineering disciplines which studies how to produce heat, use heat, convert heat and exchange heat between physical systems. If there is a difference in temperature in a system, or if two systems with different temperatures are brought together, energy transfer will occur which is also known as heat transfer (Wahyono, 2019). In the modern draining process, the fried Sumpia is put into a draining tube, then the motor rotates and stops according to a predetermined time. Apart from speeding up the draining process, the oil resulting from the draining process can be reused and can also be a business opportunity for people who have home industries. As a fried food, this snack has limitations, namely its consumption period is relatively short because there is still a lot of oil content in it.

A heat exchanger is a heat exchange device whose function is to transfer heat between two fluids of different temperatures and separated by a dividing partition. This heat transfer process can be regulated so that the fluid temperature is obtained according to the desired criteria so that no energy is wasted, so that the utilization of available energy sources can truly be more optimal. However, achieving the criteria as referred to above is not easy, this is due to the delay time in the process of measuring the response signal from the Heat Exchanger, therefore there is a need for a control signal that can determine plant dynamics in real time and provide appropriate control signals for any changes in the dynamics. The controller method that is suitable to use is predictive. One of these predictive methods is to use Generalized Predictive Control (GPC). By using this controller the signal measurement results with the GPC Controller can produce a stable response with a faster time and according to the desired setpoint value (Freddy Tambunan et al., 2016).

In the context of industrial environments, heat transfer has a crucial role in maintaining operational efficiency, improving product quality, and ensuring operational safety. Suboptimal heat transfer can cause economic losses, decreased equipment performance, and even the risk of accidents. For industrial purposes, the tool commonly used to transfer heat is a heat exchanger (HE).

A heat exchanger is a heat transfer device and can function as a heater or as a coolant in industrial processes. One example is the crude preheat train which is a heat exchanger network that functions to recover heat from the process fluid for raw material fluid. The type of heat exchanger that is widely used in industrial processes is the shell and tube heat exchanger. To obtain the optimal heat exchanger performance value, it can be determined by increasing the overall heat transfer coefficient value. One way to improve overall heat transfer is to use different types of tubes.

One type of tube used is low-finned tube. Low-finned tube is a type of tube where there are fins which function as a more effective heat exchanger. The low-finned tube variables for each heat exchanger used are fin height, fin thickness and number of fins. From the results of the optimization that has been carried out, the overall heat transfer coefficient has increased by an average 15,67 (W/m$^2$.K) - and tube pressure drop decreases by an average of 7,43 kPa (Zainul, 2018).

**2. Methodology**

The research method used this time is experimental, where the data obtained is based on three ways of heat propagation, namely by conduction, convection and radiation. The conduction heat transfer process is a process by which heat flows from an area of higher temperature to an area of lower temperature in one medium (solid, liquid or gas) or between different media that are in direct contact. In conduction heat flow, energy transfer occurs due to the kinetic theory circuit, the temperature of an element of a substance is proportional to the average kinetic energy of the molecules that make up that element. The basic relationship for heat transfer by conduction was proposed by French scientists. Conduction is the only mechanism by which heat can flow in impermeable solids (Harahap, 2021). The following is the equation formula for conduction:

$$Q = -kA\frac{\Delta T}{\Delta X} \tag{1}$$

Where:

$Q$ = The rate of heat transfer by conduction (watt)
$k$ = Thermal conductivity of materials (W/mK)
$A$ = Surface area (m$^2$)
$\Delta T$ = Temperature changes (k)
$\Delta X$ = The distance perpendicular to the surface (m)

Convection is a heat transfer mechanism that occurs from one object to another through the object itself. Convection heat transfer consists of two mechanisms, namely energy transfer as a result of random molecular movements and energy transferred by microscopic movements of the fluid. Convection heat transfer that occurs between a moving fluid and a surface boundary, when both are at different temperatures. Pay attention to the flow of fluid over a heated surface (Walujodjati, 2006). The following is the convection equation formula:

$$q = h\,A_s\,(T_s - T_\infty) \tag{2}$$

Where:

$q$ = The rate of heat transfer by convection (watt)
$h$ = Convection heat transfer coefficient (m$^2$.°C)
$As$ = Heat transfer area (m$^2$)
$Ts$ = Surface temperature of a solid object (°C)
$T_\infty$ = The temperature of the flowing fluid (°C)

And the last one is radiation, radiation can be interpreted as a process of heat transfer from one object to another band without going through an intermediary or medium. In radiation theory, electromagnetic waves play an important role in the process of heat transfer from one object to another.

So in this process the heat transferred does not require any intermediary or medium at all. Even in a vacuum, the heat transfer process will still take place through electromagnetic wave radiation. The sun's heat reaching the earth is a clear example of a form of radiation heat transfer. The distance between the earth and the sun is very far. There is a vacuum that separates the earth and the sun. However, the sun's heat can still be felt and reaches the earth through radiation (Nurhayati et al., 2021). The following is the radiation equation formula :

$$Q = \varepsilon \sigma A_s T_s^4 \quad (3)$$

Where:

$Q$ = Radiation transfer rate (Watt)
$\varepsilon$ = Emissivity
$\sigma$ = Stefan-Boltzmann constant (5,67 x 10-8 W/m$^2$K$^4$)
$A_s$ = Surface area (m$^2$)9
$T_s^4$ = The absolute temperature of the surface of an object emitting radiant heat ($^0$K)

Especially for perfectly black objects according to law Steven Boltzman:

$$Q = \sigma A_s T_s^4 \quad (4)$$

Where:

σ = 5,67 x 10-8 W/m$^2$K$^4$ is the Stefan-Boltzmann constant.

The scheme for obtaining experimental data this time is explained as follows, set temperature, set the hot water temperature in the head tank with TEMP.SET on the control unit, wait until the hot water thermometer reading reaches stable. Set laminar and turbulent flow, adjust the flow speed by opening the valve by 30$^o$ for high temperature and low temperature slowly to get the desired water flow. Measurement, measure value T1, T2, t1, t2, W and w and write the data in the data collection sheet provided. Calculation, calculate value ΔTm, calculate value (T1+T2) / 2 then determine the kinematic viscosity value vh in the water property table, calculate the value qw and Qw, calculate value (t1+t2) / 2 then determine the kinematic viscosity value vl in the water property table, calculate the Re value for hot and cold flow, and finally calculate the efficiency value.

### 3. Result and Discussion

Based on the practicum that has been carried out, data is obtained as in the table below:

Table 1. 1 Test data 1

| MEASUREMENTS | | | | | | |
|---|---|---|---|---|---|---|
| Data | HIGH TEMP (HOT WATER) | | | LOW TEMP | | |
| | THERMOMETER | | FLOW RATE | THERMOMETER | | FLOW RATE |
| | INLET | OUTLET | | INLET | OUTLET | |
| | T1 | T2 | W(kg/h) | t1 | t2 | W(kg/h) |
| Test 1 | 74.7 | 70.2 | 1296 | 30.7 | 32.6 | 1296 |
| Test 2 | 74.4 | 69.8 | 1296 | 30.8 | 31.9 | 1296 |
| Test 3 | 75.1 | 69.2 | 1296 | 30.7 | 31.6 | 1296 |
| average | 74.73333 | 69.73333 | 1296 | 30.73333 | 32.03333 | 1296 |

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Table 1.1 is a table of observation results obtained by the group C produces an average value at high inlet temperature of 74,73$^0$C, The average value at low inlet temperature is 30,73$^0$C, The average value at low temperature outlet is 32,03$^0$C.

Table 1. 2 Test Data 2

| TABLE | | | | |
|---|---|---|---|---|
| Data | HIGH TEMP (HOT WATER | | LOW TEMP (COOL WATER) | |
| | KINEMATIC VISCOSITY | | | |
| | (T1+T2)/2 | Vh | (t1+t2)/2 | Vi |
| Test 1 | 72.4 | 4.00E-07 | 31.6 | 7.746E-07 |
| Test 2 | 72.1 | 4.021E-07 | 31.3 | 7.794E-07 |
| Test 3 | 72.1 | 4.021E-07 | 31.1 | 7.826E-07 |
| Average | 72.2 | 4.021E-07 | 31.3 | 7.794E-07 |

Table 1.2 is data processing of kinematic viscosity obtained by group C to produce an average value at high temperatures of 4.021E-07 $m^2/s$, while kinematic viscosity at low temperatures produces an average value of 7.794E-07 $m^2/s$.

Table 1. 3 Data for all groups

| *Instru. (Equation)* | | *Calculation* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Logarithmic Mean-Temp Difference* | | | *High Temp* | | *Low Temp* | | *Efficiency of Heat Exchanger* | *Coefficient of Everall Heat Trans* | |
| | | **T_1-t_2** | **T_2-t_1** | **dTm** | **Qw** | ***Reynolds Number*** | **qw** | ***Reynolds Number*** | ***Cross Flow*** | **q** | ***Cross Flow*** |
| | | *Counter Flow* | | | | | | | | | |
| | | ΔT_1 | ΔT_2 | | | | | | **nh** | | **U** |
| *Cross Flow* | **A** | 54,43 | 40,83 | 13,60 | 36738 | 111473,543 | 2721,6 | 29274,81287 | 96,29 | 19729,8 | 2213642,302 |
| | **C** | 42,70 | 39,00 | 3,70 | 6480 | 56715,714 | 1684,8 | 29237,44789 | 97,05 | 4082,4 | 530810,822 |
| | **E** | 43,70 | 41,66 | 2,04 | 8915,4 | 104811,2288 | 4141,8 | 52891,09801 | 96,11 | 6528,6 | 812077,4567 |
| | **G** | 53,70 | 36,77 | 16,93 | 37936,8 | 91562,59052 | 2890,08 | 29309,59455 | 96,01 | 20413,44 | 2423867,401 |
| | **I** | 49,86 | 38,00 | 11,86 | 16848 | 58716,41992 | 2257,2 | 44497,93798 | 97,76 | 9552,6 | 1161283,9 |

Table 1.4 above is the average of data that has been obtained in this practicum, the data above is the average of data that has been obtained by five groups which will later be used as a comparison between other groups. This data collection was carried out according to the procedures that have been implemented, the results are as follows. Group A with a pump Tc value of 1296 kg/h (30°) and Th pump of 2340 kg/h (90°), for group C it has a pump Tc value of 1296 kg/h (30°) and pump Th of 1296 kg/h (30°), for the next group, namely group E, has a pump Tc value of  2340 kg/h (90°) and pump Th of 2340 kg/h (90°), Next, group G has a pump Tc value of 1296 kg/h (30°) and pump Th of 1980 kg/h (45°), and the last one is group I which has a pump Tc value of 1980 kg/h (45°) and for pumps Th has a value of 1296 kg/h (30°). From this data it can be concluded why the five groups got different practical data results.
From the data that has been obtained, calculations can be made as follows:

a. ΔTm = Average temperature difference (°C)

$$[(T_1 - t_2) - (T_2 - t_1)] \; / \; [ln\,(T_1 - t_2) - (T_2 - t_1)]$$

$$[(74{,}7 - 32{,}6) - (70{,}2 - 30{,}7)] \; / \; [ln(74{,}7 - 32{,}6) - (70{,}2 - 30{,}7)]$$

= 43,204°$C$

b. High Temp Kinematic Viscosity

$(T_1 + T_2) / 2 = (74{,}7 + 70{,}2) / 2 = 72{,}45$ °C

c. Qw (heat released) & qw (heat received)

- $Qw = W.Cp.(T_1 - T_2)$

  Qw = 1296 kg/jam. 1 (kcal/kg°C) . (74,7 – 70,2)°C
  = 5832 (kcal/jam)
- $qw = W.Cp.(t_2 - t_1)$

  qw = 1296 kg/jam. 1 (kcal/kg°C) . (32,6 – 30,7) °C
  = 2468 (kcal/jam)

d. Low Temp Kinematic Viscosity

$(t_1 + t_2) / 2 = (30{,}7 + 32{,}6) / 2 = 31{,}65$ °C

e. High Temp and Low Temp flow speeds

- High Temp

  Rew = D . (W / Vh)
  = 0,006 m . (1296 (kg/h) / 0,0000004021)
  = 1933847,3
- Low Temp

  Rew = D . (W / Vi)
  = 0,006 m . (1296 (kg/h) / 0,0000007794)
  = 9976905,3

f. ηh = [(W . Cp . (T1 – t2)) / (W . Cp . (T1 – t1))]

ηh = [(1296 kg/jam. 1 (kcal/kg°C) . (74,7 – 32,7) °C / 1296 kg/jam. 1 (kcal/kg°C). (74,7 – 30,7) °C]
= 97 %

g. Heat transmission coefficient

U = q / (A . ΔTm)
= 8203 / (0,00072 . 40,822)
= 279.10 kcal/$m^2$ jam °C

**4. Conclusion**

From the results of practical work on heat exchangers, the following can be concluded, the heat exchanger itself is a heat exchange device which functions to transfer heat between two fluids of different temperatures and separated by a dividing partition. This heat transfer process can be regulated so that the fluid temperature is obtained according to the desired criteria so that no energy is wasted, so that the utilization of available energy sources can truly be more optimal. There are several types and types of flow in a heat exchanger such as shell and tube, shell side type, baffels type, tube bundle type, and the last one is finned tube. However, what is most often used is shell and tube. There are several types of flow in a heat exchanger, namely parallel flow, cross flow, counter flow.

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