Heat transfer analysis on the tool of heat exchanger of plate type

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Abstract. North Sulawesi has a geothermal energy source which is renewable energy and can be used as a geothermal power plant or Geothermal power company(PLTP). The Geothermal Power Company(PLTP) is located in Lahendong and is a power plant that is friendly to the surrounding environment because it uses geothermal energy as its resource. In Lahendong Geothermal Power Company(PLTP) unit 2, there are important components used to convert steam into electricity, one of which is a heat exchanger. The research aims to find out the heat transfer coefficient and the effectiveness of the heat exchanger during commissioning with real time, based on operational data and installation data on heat exchangers in the Geothermal Power Company(PLTP) Lahendong Unit 2. From this study the results obtained were the highest heat exchange coefficient at commissioning was 107.47 kW / m²K and the lowest at real time II was 66.93 kW / m²K. Furthermore, the effectiveness of the highest heat exchanger occurred at commissioning of 51.96% and the lowest at real time II was 37.19%. From the results obtained, the heat exchanger has decreased both in the heat exchange coefficient and the effectiveness of the heat exchanger. The Increase of the effectiveness of the tool of heat exchanger will affect the increase in the heat transfer coefficient on the tool of heat exchanger.

1. Introduction
Geothermal Power Company(PLTP) Lahendong utilize geothermal energy as a resource that is friendly to the environment because of it the emission produced are very low and are not environmentally damaging.

There are two important components that are used to convert steam into electricity. These components include demisters, turbines, condenser, generator, injection hole and heat exchanger. Heat exchanger is a device that can used to transfer heat between fluids [1,2]. On the tool of heat exchanger of plate type is a tool that is shaped like a frame and then separated using a plate [3,4]. This study was made to analyze heat transfer coefficient and effectiveness of tool performance of plate type on commissioning time and real time in Lahendong Geothermal Power Company(PLTP) unit 2 [5]. In the second law of thermodynamics heat will move from high temperature object to a lower temperature object, and will not move in the opposite direction [6]. Heat exchanger is the tool that used in the process of transferring heat from a fluid to another fluid without any moving mass and can be used s cooler or heater [7]. Plate type heat exchangers are usually composed of an upright plate or a corrugated plate [8]. The tool of heat exchanger of plate is a tool used in the process of exchanging heat energy from one medium to another continuously [9]. The tool of heat exchanger of plate type provide relatively compact and light weight heat transfer on the surface [10].
2. Methods

Effectiveness of heat exchanger is a comparison between actual heat transfer and maximum heat transfer that occurs in a heat exchanger [11]. Effective of plate can be calculated.

\[ \varepsilon = \frac{q_{act}}{q_{max}} \times 100\% \]

Information:

\( E \) = Effectiveness
\( Q_{max} \) = maximal transfer rate (W)
\( Q_{act} \) = Rate of actual heat transfer

This study aims to analyze heat transfer coefficients and effectiveness of tool performance on the tool of heat exchanger of plate type. on the commissioning time and real time in Lahendong Geothermal Power Company (PLTP) unit 2.

Equipment used in this study namely: 1. Laptop 2. GPS 3. Stationary 4. Camera.

The material used in this study is Operation data and installation on the tool of heat exchanger that is in (Geothermal Power Company (PLTP) Lahendong unit 2.

The parameters measured are actual, cross sectional area and LMDT temperature changes that occur in plate type exchanger. The stages of research to be carried out begin with conducting an existing literature study. The researcher conducting a field study to find out the state of the heat exchanger which would later be examined. Data processing in this study using Microsoft Excel.

3. Results and discussion

See table 1-3 and figure 1-3 below.

**Table 1.** Data of operation when Commissioning with real time.

|                  | Commissioning (02 0ct 2007) | Real Time I (02 0ct 2012) | Real Time II (02 0ct 2018) |
|------------------|-----------------------------|---------------------------|---------------------------|
| \( T_{c1} \)     | 25,29 °C                    | 30,45 °C                  | 32,66 °C                  |
| \( T_{c2} \)     | 28,75 °C                    | 34 °C                     | 35,66 °C                  |
| \( T_{h1} \)     | 33 °C                       | 39,72 °C                  | 40 °C                     |
| \( T_{h2} \)     | 29,41 °C                    | 35,15 °C                  | 38 °C                     |

**Table 2.** Data of installation on the tool of heat exchanger of the plate type.

| Parameter                  | Results            |
|----------------------------|--------------------|
|                            | Hot fluid          | Cold fluid          |
| Mass flow rate             | 0.861 kg/s         | 0.9978 kg/s         |
| Heat capacity rate         | 3598,98 kW/k       | 4167,46 kW/K        |
| Water heat (panas jenis air)| 4.180 kJ/kg.K      |                    |
| Cross-sectional area       | 32,06 m²           |
Table 3. Analysis of data on the tool of heat exchanger of plate type when commissioning real time I with real time II.

| No. | Parameter                          | Commissioning          | Real Time I     | Real Time II    |
|-----|-----------------------------------|------------------------|-----------------|-----------------|
| 1   | Actual heat transfer rate         | 14419.4 kW             | 14794.5 kW      | 12502.4 kW      |
| 2   | Maximal heat transfer rate        | 27748.1 kW             | 33362.5 kW      | 33614.5 kW      |
| 3   | Effectivity                       | 51.96 %                | 44.34 %         | 37.19 %         |
| 4   | $\Delta T_{\text{in,}}$          | 4.18 K                 | 5.17 K          | 58.2 K          |
| 5   | Heat transfer coefficient         | 107.47 kW/m².K         | 89.13 kW/m².K   | 66.93 kW/m².K   |

Based on Table 1 can be known the temperature of the fluid of water and cold water entering and exit from the tool of heat exchanger of Plate type [12].

Figure 1. Analysis of the heat transfer on the tool of heat exchanger of plate type.

Based on figure 1. shows the effect of time on the heat transfer coefficient coefficient is directly proportional to the amount of actual heat transfer and is inversely proportional to the amount of actual heat transfer and is inversely proportional to the cross sectional area and $\Delta T_{\text{in,}}$ on the tool of heat exchanger of plate type. Analysis of heat transfer (U) on commissioning data has a value of the coefficient heat exchanger $U = 107.47$ kW/m².k has a value of the coefficient heat exchanger $U = 107.47$ kW/m².k. The value of the heat exchanger coefficient the time and the cooling process [13].

Figure 2. The analysis of effectiveness on the tool of heat exchanger of is exchanged.
The magnitude of the tool effectiveness of heat exchanger on geothermal power plant is influenced by magnitude of the value of the actual heat transfer rate and maximum heat transfer rate. In Table 2, it can be known the installation data from the tool of heat exchanger of plate type. The conductivity of the heat exchanger increases as the temperature of the fluid increases [12,14]. In Table 3.3, it can be known the data of calculation result on the tool of heat exchanger of plate type. On the real time data 1 the displacement coefficient (U) on the tool of heat exchanger decreased by 89,13 KW/w/m².k. When on the time of real time 2 the heat transfer coefficient (U) on the tool of heat exchanger is getting by decrease in heat of U = 66,93 kw/m.k from this data it can be known that the longer the tool of heat exchanger works, the less of heat coefficient is exchanged [15]. The effectiveness of heat exchangers on commissioning data on heat exchangers is 51,96 %/ [15]. On the data of real time 1, effectiveness of the tool of heat exchanger.

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Figure 3. Effectiveness compared on the tool of heat exchanger of plate type.
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The magnitude of the tool effectiveness of heat exchanger on geothermal power plant is influenced by magnitude of the value of the actual heat transfer rate and maximum heat transfer rate. The heat transfer potential of the fluid can increase the heat transfer rate of the heat exchanger [16]. The effectiveness of heat exchangers on commissioning data on heat exchanger is 51,96 %, the data of 1 real time, effectiveness of the tool of heat exchanger has decreased by 44,34 % and on real time 2 the effectiveness of the tool of heat exchanger more decreased by 37,19%. From this data it can be known that the longer of the tool of heat exchanger works the less effective the tool performance of the plate type from this data it can be seen that the longer the plate type heat exchanger works, the less effectiveness of the plate type heat exchanger performances. The conductivity of the heat exchanger can have decreased its effectiveness due to the age factor of the heat exchanger [17]. The effectiveness of the performances of the heat exchanger is directly proportional to the coefficient of increasing heat transfer in the heat exchanger. The increase in the effectiveness coefficient on the heat exchanger [18]

4. Conclusion

- The value of heat transfer coefficient (u) in the Commissioning data has a heat exchanger coefficient value (U=107,47 kw/M² in real time data 1 heat transfer coefficient (U) in the heat exchanger has decreased by U=66,93 km/m²K.
- The effectiveness of the heat exchanger at the time of commissioning was 51,96% the real time 1 the effectiveness of the heat exchanger decreased by 37,19%.
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