Design of a Parabolic Collector for Solar Adsorption Refrigerator

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Abstract. This study aims to design a parabolic type collector used in solar adsorption refrigerator. The solar collector is a device designed to collect heat by absorbing sunlight, which is then utilized as useful thermal energy, one of which is in the adsorption cycle refrigerator. The material used for solar collector is aluminum. In the design of a parabolic type, solar collectors must pay attention to the design of the collector design, how the solar collector works, and the materials and materials used to improve the collector's performance. The influence of the heat intensity of solar radiation and the collector insulation box is very influential on the collector's performance. From the results of the design of this tool, it can be seen that the type of parabolic collectors lifts the heat of solar radiation more focused and more efficiently. Overall, a parabolic type collector design with a cross-sectional area of 0.5 m² results in a thermal collector efficiency of 64.60%.

1. Introduction
The increase in Indonesia energy consumption has increased historically in line with technological developments. In line with the increased energy consumption, the supply of primary and final energy follows the increase [1,2]. However, increasing energy supply relies heavily on building energy infrastructure such as power plants, oil refineries, ports, which require substantial funding; this is often a significant obstacle. It is essential to develop renewable energy as an alternative and environmentally friendly. Some renewable energy that can be applied is biodiesel, bioethanol, geothermal energy, wind energy, micro-hydro, and solar energy. One solution that has been developed today is the use of solar energy. Indonesia is one of the countries in the equatorial region, so that it has a high enough level of solar radiation. The average intensity of sunlight falling on the surface of Indonesia's earth is 4.8 kWh/m²/day [3-5]. Given the geographical condition of Indonesia which consists of small islands and many remote areas, it is difficult to reach a centralized electricity supply. Then solar energy can be used to provide electricity to accelerate the electrification ratio.

Because the energy conversion efficiency is still better, the current research focuses on the use of thermal energy from solar energy, namely cooling machines, especially cooling machines that are powered by solar power [6,7]. One of the tools used to utilize solar thermal energy is solar collectors. Solar collectors have functions to absorb heat energy sources and also sunlight radiation. To the solar collector of parabolic type is able to collect greater sunlight because it is focused on one particular point line [8,9]. There are several factors that affect solar collector's working capability among others: solar radiation energy, required energy requirements, ambient temperature, carbon type absorbent and
material characteristics of collectors [10,11]. The use of solar energy as a heat source is the basis for understanding the solar collector as a substitute for the adsorption refrigeration system generator.

2. Methodology

2.1 Place
The design of this type of concentrator collector was carried out on the 4th floor of the Mechanical Engineering building, Faculty of Engineering, Universitas Sumatera Utara.

2.2 Design method
In the implementation of this research, activities include the following stages:

![Design flowchart](image-url)

*Figure 1. Design flowchart*
2.3 Building Design Method

Collector Design

The solar collector is a device designed to collect heat by absorbing sunlight. The design of the adsorption cooling machine has been carried out with various types of collectors to get maximum results. So the design of the solar collector is based on the results of various previous designs.

The following is the calculation of the dimensions of the collector in the design:

Collector cross-sectional area.

\[ A_{\text{collector}} = 2 \ (p.l + p.t + l.t) = 2 \ (1000 \text{ mm} \times 500 \text{ mm} + 1000 \text{ mm} \times 70 \text{ mm} + 500 \text{ mm} \times 70 \text{ mm}) = 1.21 \text{ m}^2 \]

Collector volume

\[ V_{\text{collector}} = p.l.t = 1000 \text{ mm} \times 500 \text{ mm} \times 70 \text{ mm} = 0.025 \text{ m}^3 \]

\[ V = p.l.t = 500 \text{ mm} \times 50 \text{ mm} \times 50 \text{ mm} = 0.00125 \text{ m}^3 \]

So the total activated carbon that can be contained in the collector:

\[ V = 10 \times 0.00125 \text{ m}^3 = 0.0125 \text{ m}^3 = 12.5 \text{ kg} \]

Figure 2. Inner space collector
Caption:

- Material: Aluminum
- Outer dimensions: 780 mm × 650 mm × 70 mm
- Plate thickness: 3 mm
- Dimensions of collector fins: 774 mm × 50 mm × 2 mm
- Fin thickness: 2 mm
- Distance between fins: 70 mm
- Number of fins: 9 pieces
- Collector pipe diameter: 19 mm
- Wire screen width: 0.037 mm
- Thickness of wire mesh support: 3 mm

In the design of 9 fins containing 10 containers of activated carbon each container contains 1 kg of activated carbon so that there is no build-up and the distribution is more evenly distributed.

**Collector Insulation Boxes**
Collector insulation box is a layer arranged in series from several insulating materials such as black foam, ordinary foam, rock wool, Styrofoam and wood which form in accordance with the shape of the collector so that the heat absorbed by the collector is not much wasted.

![Figure 3. Collector insulation box](image)

**Glass cover collector**
Glass (cover) collector cover has a function to continue solar radiation and provide a greenhouse effect on the collector so that solar radiation is trapped longer in the collector. The collector cover glass is designed to open and close with the aim that when opened it can ease the temperature drop or release heat into the environment for a decrease in collector pressure.
3. Test Results

3.1 The Intensity of solar radiation
The maximum radiation intensity on these measurements occurs at 12.05 PM-01.35 PM (GMT+7), and the maximum air temperature occurs at 12.15 PM-02.25 PM (GMT+7). The graph of the solar radiation intensity during the test time is shown in the Figure 5.

3.2 Collector Temperature
From the three days of testing the temperature of the collector was obtained as shown in Figure 6.
3.3 Thermal Efficiency of Solar Collectors

The thermal efficiency of the solar collector can be determined by using the following equation:

\[ \eta = \frac{Q_b}{Q_{rad}} \times 100\% \]  
(1)

Where:

- \( Q_b \) = radiant heat energy used by the collector (J)
- \( Q_{rad} \) = radiation energy received by the collector (J)

Calculation of the thermal efficiency of solar collectors:

\[ Q_b = 232,576.74 \text{ J} \]
\[ Q_{rad} = 360 \text{ J} \]

\[ \eta = \frac{232,576.74}{360} \times 100\% \]
\[ = 64.60\% \]

4. Conclusions

A solar parabolic collector type been designed as a component of a solar adsorption refrigerator. The designed collector is made of aluminum plate material with a 0.5 m collector cross-sectional area and an absorber using 10 kg of powdered activated carbon. The design of a parabolic type collector can absorb the intensity of solar radiation by 312,177 J and heat loss of 53,754 J. The parabolic type collector has a thermal efficiency of 64.60%.

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