Experimental investigation of vacuum tube collectors with heat pipe and their comparison with simulation using Trnsys software in Kerman

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ABSTRACT

The heat pipe solar collector who studied in the laboratory results with the results of the modeling done by software Trnsys also compared these results with the results of the use of the Flat plate with the same area and the same conditions were compared and validated with experimental data. software outputs showed that the efficiency of flat plate collectors in the summer better than heat pipe collector and more efficient of flat plate collector with heat pipe vacuum tube collector. Results Software Trnsys at the time referred to thermal vacuum tube collector with pipe in good agreement with experimental results showing the two collector performance chart for Kerman location, has been created so that may be needed for different temperatures due to more efficient choose this chart collector.

Regarding the comparison of these two collectors throughout the year, it was observed that the flat plate collector in cold weather due to low ambient temperature is much more efficient than the heat pipe solar collector, and in the warm seasons of the year when the outside air temperature in Kerman is high The heat pipe solar collector has a higher efficiency than flat plate collectors.

KEYWORDS

Solar energy, Vacuum tube collector, Heat pipe, Trnsys modeling, Flat plate collector

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1. Introduction

Shadfar et al., In 1396, numerically, the effect of the length and angle of the vacuum tube on the thermal performance of the solar collector showed that the increase in the length of the pipeline increases the average temperature of the reservoir. Among the angles studied, the angle of ° 45 is also the best option.[1]

Tang et al., In 2011, investigated the thermal performance of solar water heaters with void collectors that had a different slope. Their results showed that increasing the collector angle gradient does not have any positive effect on the heat transfer from the tube to the reservoir and the flow of the thermosyphon from the water inside the tube, while the slope of the collector has a significant effect on the radiation collected and the solar heating throughout the day by the collector.[2]

In this research, the heat pipe vacuum tube collector and flat plate collector was used in laboratory environment and by validating the data obtained from the Trnsys software under the same conditions as the test conditions. Comparison between these two models of solar collector in Kerman and the results will be presented. One of the most important goals of this research is to compare the experimental performance of heat pipe collector and flat plate collector and comparing the experimental performance of the heat pipe collector with the simulated data.

2. Laboratory system and its components

In this research, two flat plate collector, a heat pipe collector uses with a 45-degree angle to the horizon and in geographical coordinates (length: 30.281729, width: 57.018899), with a storage tank and a circular pump was used for testing. The method of connecting these components is shown in Fig. 1.

To measure the amount of solar radiation in this study, a solar radiation detector mounted at an angle of installation of collectors near them was used. This device measures and records the instantaneous radiation every 5 minutes, by using digital thermometers, the temperature of the three point of system is recorded every 5 minutes, which is respectively:

1. Outdoor temperature $T_1$
2. Inlet collector fluid temperature $T_2$
3. Outlet collector fluid temperature $T_3$

In this study, a flow meter with a precision of 0.1 shows the measure of flow rate which is constant throughout the system during a test, that is expressed in Kg / hour. The system uses water as an operating fluid, and then by logging the three temperatures and using into the equations below the required values obtained.

$$Q_{\text{useful}} = \sum w itc (T_3 - T_2) \Delta t \quad (1)$$

$$n = \frac{Q_{\text{useful}}}{A T_1} \quad (2)$$

3. Simulation using TRNSYS

In this study, the modeling of both collector panels has been done. The simulated flat panel collector model in Fig. 2 and the simulated model of vacuum tube collector are presented in Fig. 3.

![Figure 2: Circle designed in the TRNSYS Software to Simulate Flat Panel Collector](image-url)
follows has been extracted from Each of these models in TRNSYS:

- Useful energy gain
- The input and output temperature of collector (T_in-T_out)
- The average amount of heat absorbed in one day
- Comparison of the amount of heat reached to the collector and the amount of heat up to the fluid

4. The results of the experiments

In order to compare the performance of two collectors in cold months, the mean values are shown in Table 1, the comparison between the average values measured between the two test specimens in the two days (November 30 and November 22). According to Table 1, it was found that flat panel collectors at lower ambient temperatures have higher efficiency than heat pipe collectors.

Table 1: Average quantities of collectors obtained from the test

<table>
<thead>
<tr>
<th>Collector properties</th>
<th>Heat pipe</th>
<th>Flat plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorber area</td>
<td>3.6 m²</td>
<td>3.42 m²</td>
</tr>
<tr>
<td>Radiation</td>
<td>572.9 W/m²</td>
<td>611.6 W/m²</td>
</tr>
<tr>
<td>Air temp.</td>
<td>16.9°C</td>
<td>19.5°C</td>
</tr>
<tr>
<td>Inlet temp.</td>
<td>23.1°C</td>
<td>27.1°C</td>
</tr>
<tr>
<td>Outlet temp.</td>
<td>20%</td>
<td>4%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>68%</td>
<td>66%</td>
</tr>
</tbody>
</table>

By the TRNSYS, 3 days, 10-12 July, modeling for two heat pipe collectors and flat plate was performed and the results are plotted in Figure 4.

Table 2: Average modeled quantities of collectors in the summer

<table>
<thead>
<tr>
<th>Collector properties</th>
<th>Heat pipe</th>
<th>Flat plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorber area</td>
<td>3.6 m²</td>
<td>3.6 m²</td>
</tr>
<tr>
<td>Air temp.</td>
<td>29°C</td>
<td>29°C</td>
</tr>
<tr>
<td>Inlet temp.</td>
<td>27.4°C</td>
<td>27.4°C</td>
</tr>
<tr>
<td>Outlet temp.</td>
<td>30.2°C</td>
<td>29.6°C</td>
</tr>
<tr>
<td>Efficiency</td>
<td>68%</td>
<td>66%</td>
</tr>
</tbody>
</table>

5. Results of simulation with TRNSYS

The average amount of the modeled data for the three summer days are given in Table 2. Table 2 data shows that the efficiency of the heat pipe collector in summer when the air temperature and the inlet fluid temperature are higher than that of the flat panel collector, but the difference is much less than that of a flat plate collector in cold seasons.

6. Conclusions and suggestions

In the climate of Kerman for home use, which has an average temperature range of 30-50 degrees Celsius, this collector does not have the necessary equipment and it is better to use a flat plate collector, but at high temperatures (50-90 degrees Celsius) the heat pipe collector’s efficiency is better than the flat plate, and it’s best to use the heat pipe vacuum tube collector.

Due to the good efficiency of the heat pipe collector at high operating temperatures, this collector can be used for use in solar water heaters.

In the home-heating system (floor heating), a heat pipe collector can be used along with a gas aid system.

The heat pipe vacuum tube collector can be compared with the normal vacuum tube collector through testing and with laboratory data.
7. References
