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Investigating the direct absorption planar collector with a central absorber tube for simultaneous surface and volume absorption and the effect of carbon nanofluid in improving thermal performance

Ali Asghar Amraee[1], Mohammad Eftekhari Yazdi[2,*], Arash Mirabdolah Lavasani[3]

[1] Ph.D. student, Mechanical Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[2] Assist. Prof. , Department of Mechanical Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[3] Assoc. prof. , Department of Mechanical Engineering, Central Tehran Branch, Islamic Azad University, Tehran, Iran

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Abstract

The purpose of this work is to investigate a different geometry in the parabolic collector in order to increase the thermal efficiency through simultaneous surface and volume absorption in a combined condition. Recently, it has been observed that if the inlet temperature is above 250 °C, Direct absorption collectors can increase efficiency up to 10% Considering that there is a direct relationship between the concentration of nanofluid and the diameter of the transparent tube carrying the fluid with the absorption coefficient, On the other hand, as the concentration of nanofluid increases, fluid sedimentation and system maintenance problems occur. In this research, the amount of nanocarbon used as a suspension of 0.02 gr/l in oil base fluid is considered. According to experimental data, this amount of nano carbon concentration completely absorbs light rays at a depth of 24 (mm) and this absorption coefficient has been used for this specific geometry of the collector. The results show that the rest of the radiation is absorbed on the surface using the central tube, so that the thermal efficiency is up to 6% compared to the usual copper absorption collector, which is about 19 degrees Kelvin.

Keywords: Parabolic collector, Nanofluid, Adsorption, Thermal performance

1. Introduction

A solar concentrating system is an effective technology to generate thermal and electric energies by reducing pollution intricacies and is a suitable alternative for fossil fuels in future years. Solar absorbers are among the main components of solar concentrating systems. In this regard, numerous studies have recently addressed solar absorbers.

In direct absorption collectors, the absorption process of radiation is not on the surface and is done by the absorbent fluid in the total volume of the fluid. For this reason, compared to surface absorption collectors, the temperature of the outer surface decreases and reduces radiation and convection losses. The use of direct absorption of radiation with the base fluid and the addition of nano particles to the oil base fluid and its use instead of conventional oils is a novel design that increases the thermal performance and thermodynamic capabilities of the system, as well as increasing the heat capacity in the nanofluid, the overall efficiency of the system increase [1].

Therefore, in this research, the aim is to use the working fluid as a major part of the adsorbent with a different geometry. And at the end, the effect of using nanofluid on the thermal and hydrodynamic performance of the collector compared to the thermal oil base fluid should be investigated and studied.

2. Theoretical model and governing equations

Firstly, the Monte Carlo tracking method is used for calculating the solar radiation received by the circular section of the tube for a concentrating collector [2], considering Table 1 (geometrical parameters of the problem).

The dimensions of the used collector are sampled from the dimensions of the lS-3 commercial model in source [3]. This collector includes a parabolic mirror with dimensions of 5.76 meters wide and 5 meters long, which has a transparent glass tube with a transmission coefficient of 0.94. Other geometric parameters of the problem are given in Table 1.[3]

Table 1. Geometric parameters of direct absorption collector used in numerical calculations

Diameter of inner glass tube D 0.07 m	Concentrator's aperture width W 5.76 m
Thickness of the glass D2 0.003 m	Optical efficiency factor F 0.73
Collector tube length L 5 m	Transmittance of glass T_gla 0.94

In this research, the amount of nanocarbon used in the form of a suspension of 0.02 gr/l in the oil base fluid is considered, which according to the experimental data, this amount of nanocarbon concentration completely absorbs light rays at a depth of 24mm, and from this absorption coefficient for This particular geometry is used in the collector[4].

It should be mentioned that in this research, which was conducted numerically, Ansys software was used to check the data and functions and record the results, and also to simulate the radiation model, according to the boundary conditions of the research geometry, from the direction ordinate model (DO) Used .

3. Results and Discussion

The results show that most of the radiation is absorbed by volume and by the working fluid itself, and the rest of the radiation is absorbed by the surface using the central tube, so that the thermal efficiency is increased by 6% compared to the usual direct absorption collector.

According to Figure 1. In the temperature contours, the central absorbent tube absorbs part of the incoming radiation and due to the hollowness of the absorbent tube and the relative vacuum, it again transfers the absorbed heat to the fluid around it. And this geometry minimizes heat loss with the increase in outlet temperature for the same mass flow rate is 0.1 kg/s for the operating fluid. The role of the hollow copper central tube in surface absorption of radiation can be seen in the contours of fluid outlet temperature (Figure 1).

Among the absorbent tubes, three diameters (D=1,2,3 cm) were examined. According to the diagram in Figure 1. It can be seen that the absorber with a diameter of (D=2cm) has the highest fluid outlet temperature at inlet temperatures from 450 to 550 degrees Kelvin. As shown in the diagram of Figure 1, this advantage can be seen with a greater difference in the inlet temperature of 550 K, and this point was taken into consideration to choose the desired geometry for a higher outlet temperature and, consequently, a higher efficiency.

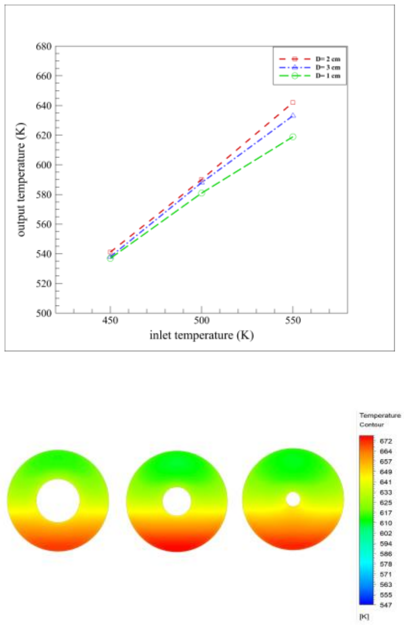

Figure 1.The effect of changing the diameter of the central pipe on the temperature and contour of the fluid outlet

2. References

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