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Simulate the Rheological Behaviour of the Solar Collector by Using Computational Fluid Dynamic Approach

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ABSTRACT

In the present study, the computational fluid dynamics (CFD) method was utilized to explore the rheological behavior of the flat solar collector. ANSYS 16.1 has been used to do an analysis on the drafted three-dimensional model. In order to investigate the heat transmission from the solar panel to the fluid, a CFD tool has been used. The effectiveness of the heat transfer across the entire system has been evaluated with the help of Nano fluid. Both 0.3 and 0.5 meters per second might be considered the speed of the water. These results have been compared to others and validated in accordance with those standards. The most recent findings from this line of investigation have shown that include a greater number of specifics in the working fluid of the system can contribute to an increase in the temperature at which the solar plate discharges its heat. In addition to this, it is possible to get the highest possible temperature by bringing the velocity value down to its lowest possible range.

1. Introduction

Nanomaterials are one of the most intriguing developing technologies for heat transfer fluids that can be used for commercial reasons. Loni *et al.,* [1] conducted research to investigate the efficacy of heat transfer fluid Nano fluids, which were either dependent on water or diathermy oil. Rebhi *et al.,* [2] conducted research on the feasibility of utilizing Al2O3-fluid as a cooling method for a windmill. Nano fluids are utilized extensively in satellites for a variety of applications, and research into their use in space has been conducted by Flórez [3]. They utilized a water-Cu Nano fluid combination in conjunction with a straightforward parabolic concentrator and an evacuated tubular heat exchanger (ETEC). Evaporating co-Cu tube with a caveated interior: For Cu-O Nano fluids with masses between 0.8% and 1.5%, the parameters for the spiral-coil evaporator were determined by Popovici *et al.,* [4]. The results were compared to those that had been produced by using water by itself and found to have high heat transfer coefficients that conducted by Shan *et al.,* [5]. The mass fraction of the solid

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phase had an important influence in the process of heat transfer, specifically for heat transfer coefficients ranging from 0.8% to 3.2% [6].

An analysis of the impact of the tilt and the tracker was performed. Water and Nano fluid with a 50° tilt yield the best performance. Aside from solar heat-pipe enhancement, solar collector performance is also improved." Comparisons of heat-pipe collectors concerning heat efficiency and low-fluctuation variation have been studied. The findings revealed that water-CNT fluid mixes had greater up to 10% overall efficiency compared to the mix of water and CNTs [7]. The latest deployment of Nano fluids in solar thermal systems, as a fluid for heat transfer, holds great promise

On the other hand, however, issues were discovered in conventional solar panels, because of nanoparticles settling in the fluid, as presented in this experiment were resolved by Ma *et al.,* [8].

There are three methods of applying the solar thermal collector principle in the real world today: The fluid model, the discrete fluid model, and the numerical model [9]. It was found that a lumped model incorporating the collector heat transfer temperature variance could be used to simulate the heat transfer from the fluid to the steam properly Unsteady state balance of energy per unit of discretized location [10]. Rather than using the Thermal Conduction Capacitance model, it is considered instead of the thermal capacity of the fluid in a 3-node model: the absorber, the cover, and the heat transfer fluid [11]. If we think of the thermal collector as having a capacitance, it is a 4n-node type. Discretization of the model yields an ordinary Runge-Kutta-Felder (RK) representation. They increased performance by a factor of 28.3%, compared to using water, and the surfactant improved by a factor of 15.63%. The subject of sedimentation, which was discussed by Peng *et al.,* [12] to maintain a constant flow, suggested a modified flat-plate solar collector. This paper concentrates on studying the temperature simulation of a flat-plate solar thermal collector made by Aggarwal and Tiwari [13].

In this study, the finite element method (FEM) of a flat plate solar collector is modelled using DesignModeler19, and the computational fluid dynamics (CFD) method is used for the numerical investigation of the model. The inquiry has been carried out numerically in terms of the velocity of Nano fluid with a variety of temperature ranges. In addition to this, we will explore how it affects the flow of heat across the solar system.

2. Methodology

2.1 Primary Condition

The solar collector is made up of a copper unit, which is supported by two large headers and nine risers. For the top and the top tube, 20 mm ID and 1 mm ID tubing have been considered, whereas a 10 mm ID and 1.2 mm thick model have been used for the riser tubing. 1100 × 110 -mm copper plate has the tubes welded on, then painted with black paint. A constant velocity-maintaining internal feature is placed in the top and the bottom header to keep the sedimentation at bay. A steel frame is lined with polycarbonate plastic and foam closed with 10 cm thick glass wool and encased in galvanized steel. The heat transfer fluid is a bi-distilled water solution that is varied in its concentration of Al2O3 nanoparticles, which are designed to have a nominal diameter of 10 mm as shown in Figure 1.

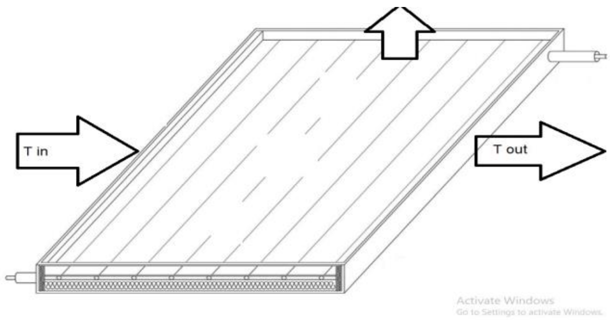

Fig. 1. Model of the heat transfer system

2.2 Fluid Properties

The viscosity of Nano fluids decreases as the temperature rises and the Nano concentration diminishes Increase in solid Nano particulate concentrations increased the viscosity. the increase in temperature causes a drop in the viscosity of fluids for the viscosity of Nano fluid.

2.3 Geometry and Meshing

In the current study, the Box Dimensions are is 1110mm X 1100 X 110 mm. While the tube length that has been used on the side of the box is 9910 mm with a 25 mm Diameter. The tubes offset was 110 mm with 1.3 mm as a thickness. the sidle wall thickness of the whole box is 1 mm as well. As well as absorber has been employed with a thickness of 1.1mm.

ANSYS is a program known as Design Modular Pre-Processor (DM), which prioritizes the investigation and creates and optimizes the design mesh on geometric representations of the problem. Both chemical and mechanical processes are involved in the production of ANS gears. Because of its mixed Tri and Quad model, the mesh uses varied parts [14]. Amorphous meshes allow for a diverse number of solutions and this can be handled by both polishing or roughening the mesh grid constraints. Once the grid had been entered into the database ANSYS as shown in Figure 2

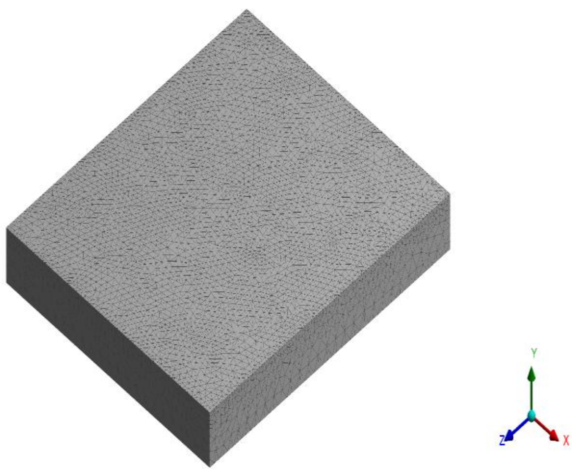

Fig. 2. The meshed model

2.4 Software Setup

ANSYS 19 is used to simulate the physical model (See Figure 2) the machine that concentrates sunlight to be used for electricity It's done in Iraq, in weather conditions more than almost anything else. As the analyst began to act on the issue, it was discovered that gravity had a significant impact on the solution. The models for Viscosity ($K - \varepsilon$), were used.

3. Results

In this research, the effect of temperature and velocity will be investigated and discussed accordingly. To perform the numerical results grid, an independent study will be carried out accordingly.

3.1 Validation Process

As can be seen in the picture, the appropriateness of the current numerical results has been confirmed by applying the Nusselt number to the velocity for the experimental inquiry. This was done in order to validate the results. This was done to ensure that the results were accurate and reliable. The range of possible numbers for the outcome, which has been taken into account, is from ten to one hundred. The range of the data that was collected allowed for the representation of the following speeds: 0.1, 0.2, 0.3, 0.4, and 0.5 metres per second (see Figure 3). At this stage, we can say with 91 percent certainty that there is a correlation between the numerical results and the experimental ones [1].

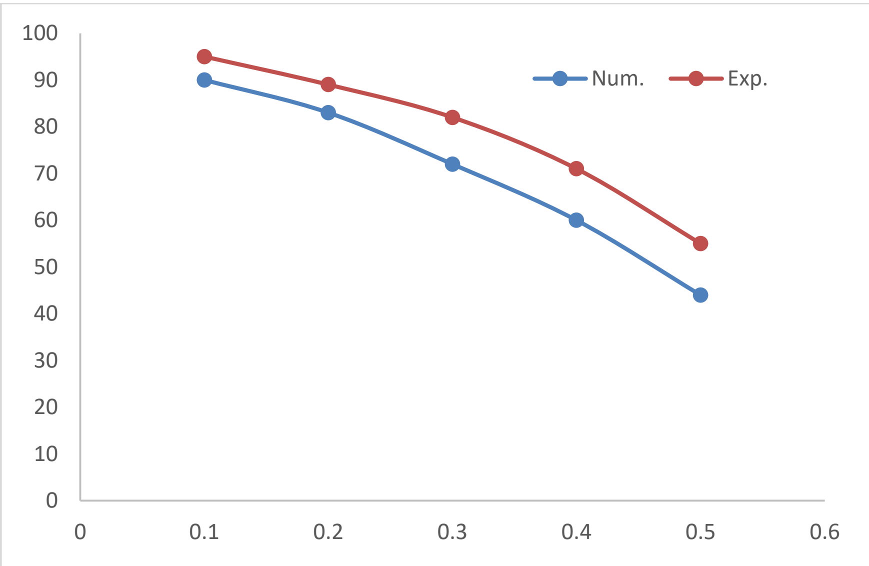

Fig. 3. Validation process

3.2 Grid Independent Study

It can be seen that the Nu is proportionate to the number of elements, and the Nu was 70 when the number of elements was 2517. This will be done as a grid-independent test to validate the results of the simulation. For the outcomes, it can be shown that the Nu is proportionate to the number of elements. In addition, when the temperature is held constant at 70 degrees Celsius, there is no change in Nu even though the number of components has increased from 2718 to 2828. As a result, the number 2718 has been decided upon as the optimal selection, as depicted in Figure 4.

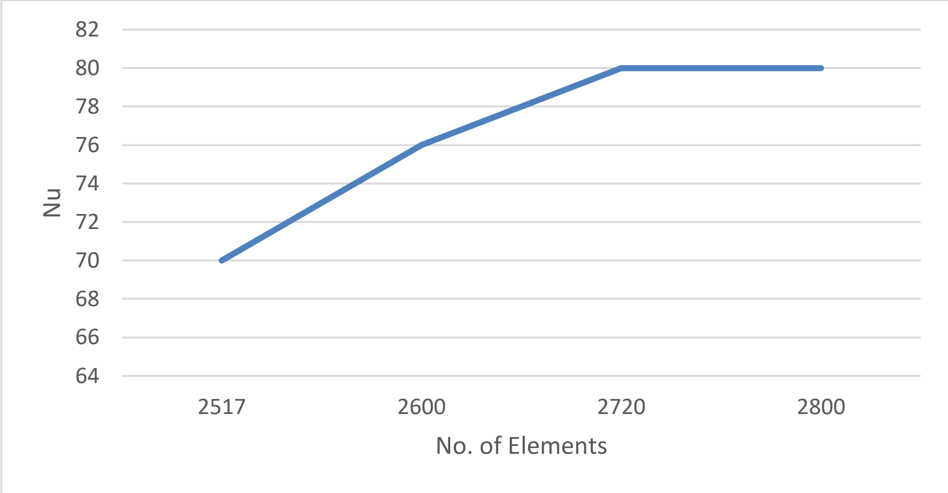

Fig. 4. Grid independent test

3.3 Effect of Velocity

As can be seen in Figure 5, the computational fluid dynamics (CFD) software in ANSYS was used to perform the numerical study of the effect of the velocity. A representation of the range of nanofluid's velocity can be seen as a gradation along the line. The point at which the red indicator displays the highest possible velocity over the whole solar system.

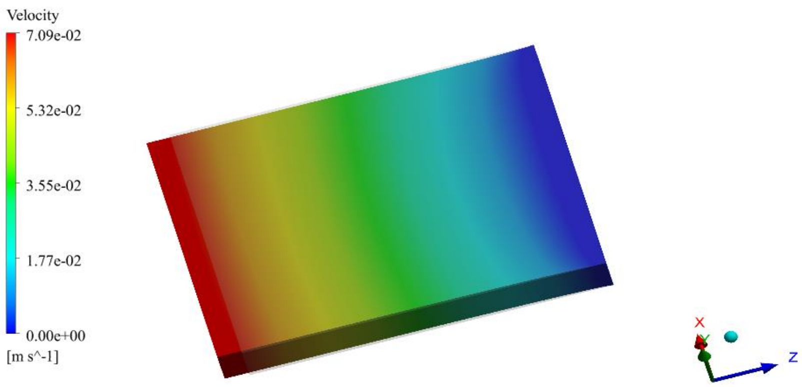

Fig. 5. The effect of velocity on the heat transfer

The findings have demonstrated that velocity has a significant impact on the manner in which heat is distributed, with the greatest amount of heat transfer occurring at the lowest possible velocity value. In this investigation, the velocities of 0.1, 0.2, 0.3, 0.4, and 0.5 metres per second were selected. Figure 6 illustrates that the largest amount of heat transmission occurs at 0.1 metres per second. In light of the fact that nu has been utilised as the primary indicator for the heat transfer on the solar collector.

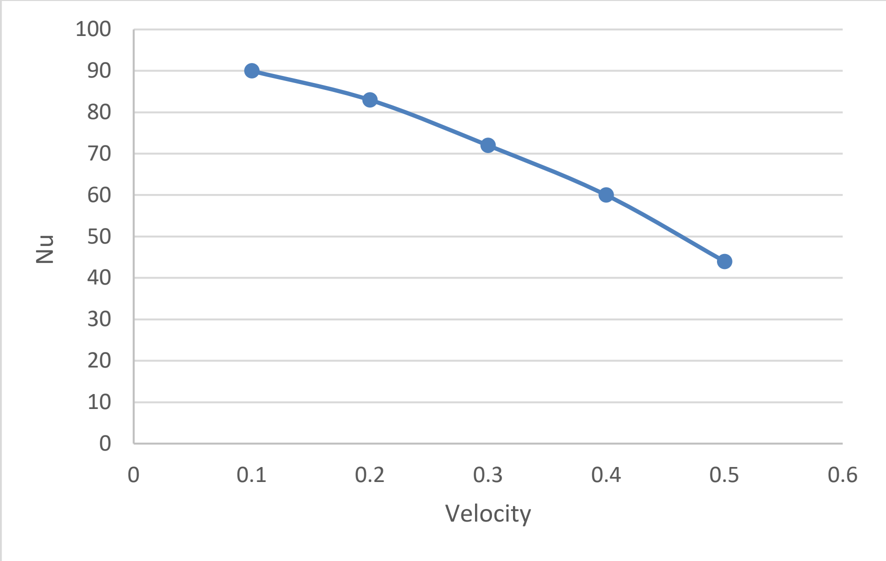

Fig. 6. Relationship between velocity and Nu

3.4 Effect of Temperature

The computational fluid dynamics (CFD) method was also used to obtain the numerical results. As can be seen in Figure 7, the model attempts to replicate the effects that temperature has on the systems. The progression along the line depicts the range of temperatures experienced by the nanofluid in conjunction with the system. The point at which the red indicator displays the highest temperature that can be found anywhere in the solar system.

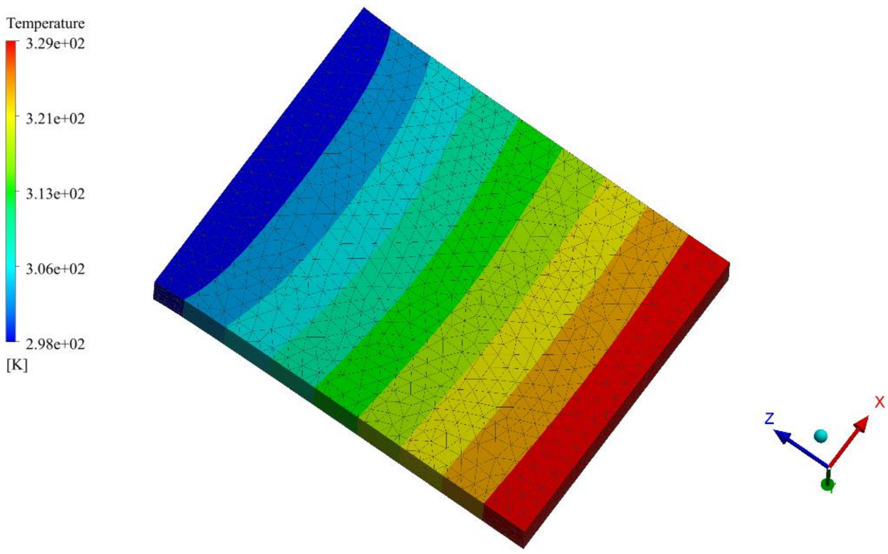

Fig. 7. The effect of temperature on the heat transfer

According to the findings, there is a connection between the numeric constant Nu and the temperature. An increase in temperature resulted in a rise in the Nusselt number, which is denoted by Nu. Only temperatures of 70, 75, 80, and 90 degrees Celsius were employed for this study. As seen in Figure 8, the value of Nu is at its highest when the temperature is 90 degrees. At the same time, the value of the Nu reached its lowest point when it was 70. In addition, the temperature shifts as a result of the impacts that are caused by the solid and liquid portions. It has been demonstrated that the temperature of the riser fluid remains constant at 90 degrees Celsius, and it has also been demonstrated that the inlet gradually heats up as it comes into touch with the heated plate and the solid boundary components. Final temperature readings for the water-like fluid produced were 70, 75, 80, and 90 degrees Celsius.

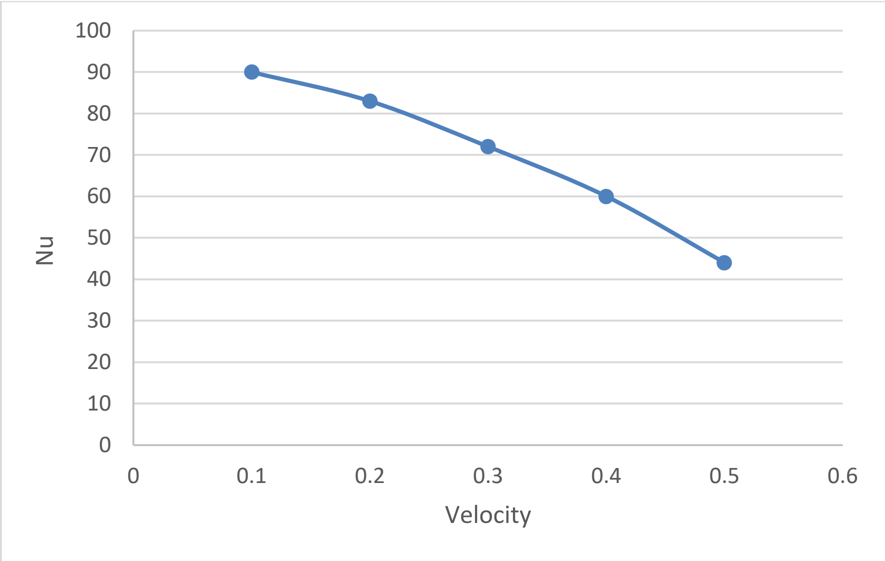

Fig. 8. Relationship between temperature and Nu

4. Conclusions

In this, the computational fluid dynamic CFD approach has been carried out to investigate the rheological behaviour of the flat solar collector. 3 Dimension model has been drawn and analysed by ANSYS 16.1. the numerical results have been investigated and discussed in terms of the effect of temperature and the effect of a variety in velocity ranges on the heat transfer of the system. CFD tool has been employed to investigate the heat transfer from the solar plate to the fluid. Nano fluid has been used to assess the efficiency of the heat transfer of the whole system. The velocity of water was 0.3, and 0.5 m/sec respectively. the present results have been benchmarked and validated accordingly. The concluded result of the current research has indicated that, the addition of the Nano particular to the working fluid in the system helps to enhance the temperature outlet of the solar plate. As well as the maximum value of temperatures can be reached by decreasing the velocity value to the lowest range

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