Heat Transfer Improvement In Solar Air Heater Using CFD

A.Kesava Kumar[1], D. Kiran Babu.[2]
[1]dept Of Mechanical Engineering
[2]assistant Professor, Dept Of Mechanical Engineering
[1, 2] DJR College of Engineering and Technology , Vijayawada , A.P

Abstract- *The objective of the current work is to study and improve the heat transfer of the air in a solar air heater for this objective the analysis is carried out on a traditional non finned solar air heater and our design finned glass air heater the analysis is been carried out using computational fluid dynamics package Ansys Fluent to do the analysis the design a 3d model is required to perform the analysis in the Ansys fluent the simulation has been carried out with different mass flow rates to observe the behavior of the air and observe the outlet temperatures The study presents the mathematical model to observe the behavior of the solar air heater in the above conditions. The main aspect of the problem is solved using finite volume method the total process has been pre processing and post processing except the designing the total discretization and the simulation is carried out using Ansys Fluent*

Keywords- Solar air heater , Cfd , Finite Volume Method, Fluent , Heat transfer

I. INTRODUCTION

Solar air heating is a solar Heat innovation in which the energy from the sun, insolation, is caught by a retaining medium and used to heat air Solar air heating is a sustainable power source heating innovation used to heat or condition air for structures or process heat applications. It is ordinarily the most financially savvy out of all the solar innovations, particularly in business and mechanical applications, and it tends to the biggest use of building energy in heating atmospheres, which is space heating and modern process heating.

Today, the heat exchange trademark and execution of the solar collector with and without finned glass are ceaselessly examined numerically. Scientific models are being created which are determined by utilizing the energy conditions. In this investigation, the Heat conductivity of the finned glass is considered.

The primary goal of a solar collector is to accomplish most extreme measure of energy collected with insignificant cost. It is widely utilized as a part of private, modern and farming field. The heat exchange attributes of the solar authority have been generally considered. Yen and Lin hypothetically and tentatively concentrated the impacts of authority angle proportion of the gather on level plate, upward and confounded solar collectors. Ong anticipated the Heat execution of four normal sorts of single-pass solar air heaters. Fath contemplated the Heat execution of a straightforward outline solar air heater. Al-Kamil and Al-Ghareeb tentatively and hypothetically considered the impacts of the different parameters, for example, temperature, solar power and wind current rate on the execution of a level plate solar air heater. Sopian et al. tentatively concentrated on the Heat execution of the twofold pass solar authority with and without finned glass in the second channel. Naphon and Kongtragool connected the numerical models for anticipating the heat exchange qualities and execution of the different arrangement of level plate solar air heater.

As portrayed above, there are many examinations on the solar air heater. Be that as it may, the examinations on heat exchange attributes of the twofold pass level plate solar authority with finned glass are as yet restricted. The goal of this paper is to examine hypothetically on the heat exchange trademark and execution of the twofold pass level plate solar collector with and without finned glass utilizing computational liquid flow (CFD). The impacts of different applicable parameters on the model expectation are additionally explored

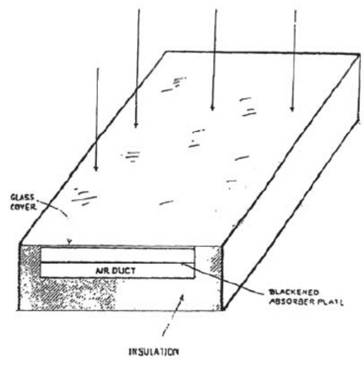


Fig. 1: Solar air heater principle

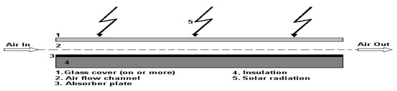


Fig 2 Schematic of single-pass solar air heater

II. LITERATURE REVIEW

1. Single Flow Single Pass Studies

Varshney et al. (1998) explored the heat exchange and liquid attributes of a solar air heater whose channel is pressed with wire work screen frameworks. The examinations were directed utilizing an extensive variety of geometrical parameters of wire work screen frameworks, for example, wire measurement, pitch and number of layers (Fig. 3.1). The solar air heater authority measurements were 2390 x 25 mm. Twofold glasses with a separation of 20 mm were utilized as coating and the wire work pressing was set between the second glass cover and the back plate. In the investigation, the heat exchange was spoken to by utilizing Colburn-j factor. Summed up relationships were created in view of the information,. It was reasoned that the heat exchange coefficient and rubbing factor were relying upon wire work geometry, for example, wire distance across, pitch and number of layers of the network.

Pakdaman et al. (2011) assessed the execution of a characteristic convection solar air heater with a rectangular finned safeguard plate. It expected to accomplish an observational model which predicts different huge parameters for characteristic convection solar air heaters. The Nusselt number relationships for such finned gadgets were additionally gotten in the investigation. The exergy investigation and the conditions that give the most extreme effectiveness for the framework were additionally decided. The authority outline measurements were 2000 x 1000 x 150 mm (Figure 3.2). A dark painted electrifies press plate was utilized as a safeguard plate with a thickness of 1 mm. An aggregate of 46 rectangular balances were joined to the safeguard plate which was 20 mm separated from each other. The appended blades were 2000x10mm with a thickness of 1 mm. A single glass cover with a thickness of 4 mm was utilized as coating. It was reasoned that a longitudinal rectangular blade course of action improved the heat exchange of solar air heaters. In this investigation the heat exchange region was expanded by 66% though heat exchange was expanded by 20% roughly.

Karmare et al. (2009) tentatively examined the impact of unpleasantness of rib corn meal on the thermohydraulic execution of solar air heaters. The metal rib corn meal were set on the safeguard plate with a 60° approach to the wind stream bearing. On the premise of thermohydraulic contemplations, the ideal outline and working conditions were resolved and a trial setup was built (Fig. 3.3). The setup comprised of two indistinguishable Collector, each with measurements of 1500 x 250 x 25 mm. Three diverse safeguard plates with various unpleasantness parameters and a smooth safeguard plate were tried (Table 1). The trial information acquired from these four safeguard plates under ideal working conditions were looked at. It was presumed that the Heat effectiveness could be expanded between a scope of 10– 35% by utilizing metal rib unpleasantness on the safeguard plate set up of a smooth safeguard plate. As the Heat productivity was upgraded the power required for the blower expanded because of increment in the erosion factor. It was likewise discovered that the Reynolds number range must be indicated to acquire better thermohydraulic execution and this relied on the protection. To accomplish ideal execution for a solar air heater, an experimental connection was produced which incorporated the framework and working parameters.

Moheseni-Languri et al. (2009) researched the energy and exergy investigation of a solar air heater. A solar air heater was planned, produced and associated with a space to explore the relevance and plausibility of such a framework (Fig. 3.4). The safeguard plate was made of carbon steel and painted dark with measurements of 1800 x 1000 x 4 mm. Single coating was utilized with a thickness of 3 mm. A little fan with the energy of 40 W was utilized to circle the air through the authority and room. To shield the authority from the shadow of neighboring structures, it was introduced 2500 mm vertically over the ground. Two aluminum channels with a protection of 20 mm thick glass fleece were utilized to interface the gatherer delta and exit to the testing room. The testing room's measurements were 4 x 3 x 3 m. Keeping in mind the end goal to locate the ideal mass stream rate which delivers the most extreme energy, the test information got by the estimations amid winter were examined utilizing energy and exergy investigation. This examination presumed that the ideal mass stream rate which prompts the most elevated second law proficiency was 0.0011 kg/s.

Moummi et al. (2004) hypothetically and tentatively examined the energy of a solar air authority with columns of rectangular plate balances embedded opposite to the stream. The point of the examination was to enhance the Heat execution of the solar air gatherer by creating turbulent stream between the safeguard and the back wooden plate through deterrents. Keeping in mind the end goal to accomplish this objective, a solar gatherer 1.6 m long and 0.8m in width was developed (Fig 3.5). The straightforward cover was alveolar polycarbonate sheets with 10 mm thickness and the hole between the cover and the safeguard plate was 25 mm. Two sorts of safeguard plates were utilized as a part of the authority; dark painted aluminum sheets (nonselective safeguard plate) and coopersun plates (particular safeguard plate). The outcomes accomplished were contrasted and trial aftereffects of a solar air gatherer without balances. It was inferred that the rectangular blades expanded the temperature of the safeguard plate and upgraded the heat exchange.

III. METHODOLOGY

The Designing of the solar air heater is done in the solid works below is the figure of the total design there after the design is converted in to the step to import in to the Ansys where the model is prepared to perform the analysis

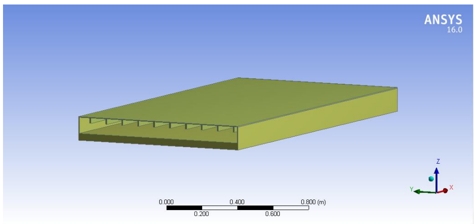


Figure 3 Imported geometry from solid works

The Volume generation is the key aspect in the performing cfd analysis.

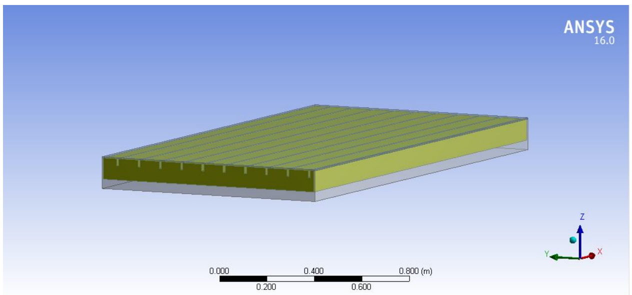


Fig 4 Volume generation in Ansys Design Modeler

Computational fluid dynamics, CFD, is a computational technology that enables the study of dynamics of things that flow. Using CFD, a computational model can be built according to the desired requirement. Flow physics can be applied to the model and an output prediction of the fluid dynamics and related physical phenomena can be obtained. It is also a sophisticated computational-based design and analysis technique.

CFD has the power to simulate flows of gases and fluids, heat and mass transfer, fluid structure interaction and acoustic through computer modeling. By using CFD, we can create a virtual prototype which we want to analyze and apply the required physical characteristic or any real world physics which in turn will predict the outcome and performance of the desired model.

In this study, we will be using the software from ANSYS© for CFD. With this software, we will have to build a virtual model of the double pass solar collector with and without porous media. From there, we are able to determine the output prediction of the air flow and heat transfer in this solar collector. By using the virtual model, we are able to manipulate the values and characteristic of the solar collector to achieve the optimum heat transfer and air flow. All this values obtained from the CFD software are theoretical,

For top glass cover

$$I \cdot \alpha_p = h_a (T_c - T_a) + h_{f1c} (T_c - T_{f1}) + h_{r,cp} (T_c - T_p) + h_{r,ac}(T_c - T_a) \quad (1)$$

Where I is the solar intensity, α_c is the absorptivity of the glass cover, h_a is the heat transfer coefficient between the ambient and the glass, T_c is the glass cover temperature, T_p is the absorber plate temperature, T_a is the ambient temperature, T_{f1} is the fluid temperature in the top channel, and $h_{r,cp}$ and $h_{r,ac}$ are the radiative heat transfer coefficients between the glass cover and the absorber plate, the glass cover and ambient, respectively, as follows (Fig. 1):

$$h_{r,cp} = \frac{\sigma(T_c^2 - T_p^2)(T_c - T_p)}{(1/\varepsilon_c + 1/\varepsilon_p - 1)} \quad (2)$$

$$h_{r,ac} = \frac{\sigma(T_c^2 - T_a^2)(T_c - T_a)}{(1/\varepsilon_c - 1)} \quad (3)$$

For first-pass air stream

$$m \cdot C_p \frac{dT_{f1}}{dx} = h_{f1c} (T_c - T_{f1}) + h_{f1p} (T_p - T_{f1}) \quad (4)$$

where m is the mass flow rate of fluid per unit width, C_p is the specific heat of working fluid, h_{fc1} is the heat transfer coefficient between the glass cover and working fluid, and h_{f1p} is the heat transfer coefficient between the absorber plate and working fluid.

For absorber plate

$$I \cdot \alpha_p \tau_c = h_{f1p} (T_p - T_{f1}) + h_{f2p} (T_p - T_{f2}) + h_{r,cp} (T_p - T_c) + h_{r,pb}(T_p - T_b) \quad (5)$$

where α_p is the absorptivity of the absorber plate, τ_c is the transmitivity of the glass cover, and T_{f2} is the fluid temperature in the bottom channel.

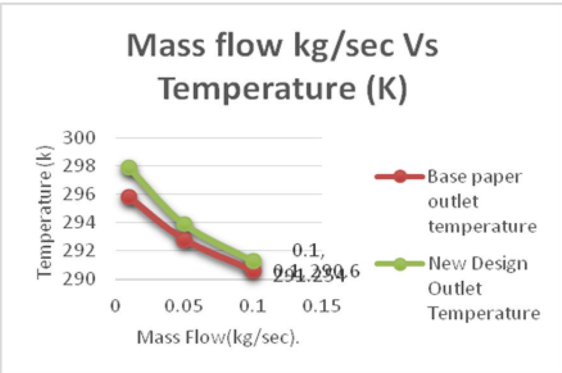
For bottom plate

$$0 = h_{f2b}\left(T_b - T_{f2}\right) + h_{r,pb}\left(T_b - T_p\right) + U_a\left(T_b - T_a\right) \quad (6)$$

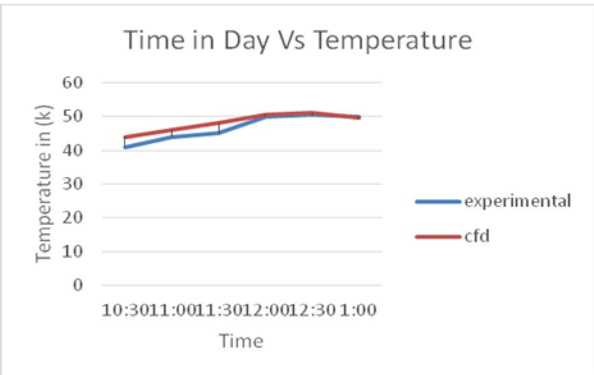
where U_a is the overall heat transfer coefficient, T_b is the bottom plate temperature, and k_p is the thermal conductivity of the finned

IV. RESULTS

Validation of base paper and experimental results



Plot 1 Validation of the Base paper results



Plot 2 Validation of the experimental results

Case 1 Mass flow rate 0.05kg/s

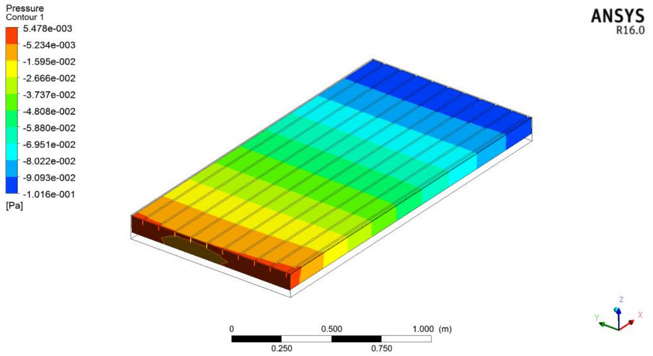


Fig 5 Pressure Distribution of solar air heater with extended Fins

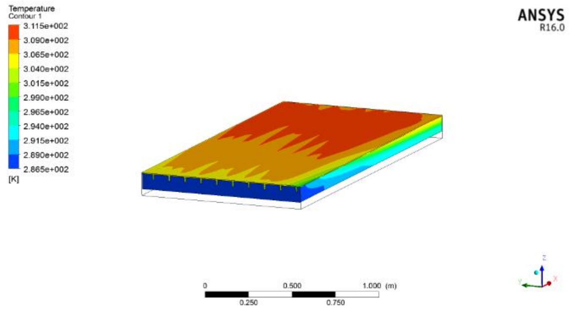


Figure 6 Temperature Distribution of solar air heater with extended Fins

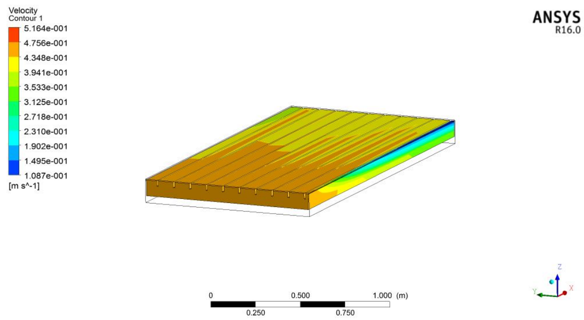


Fig 7 Velocity Distribution of solar air heater with extended Fins

Case 2 mass Flow 0.1 kg/sec

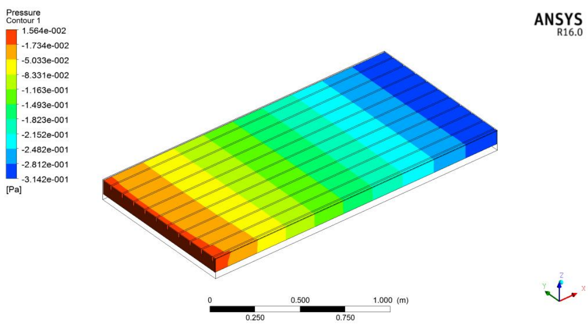


Fig 8 Pressure Distribution of solar air heater with extended Fins

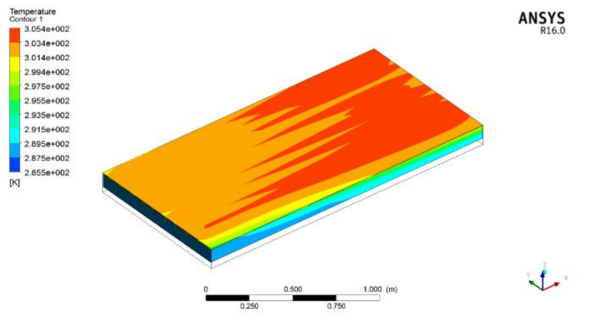


Figure 9 Temperature Distribution of solar air heater with extended Fins

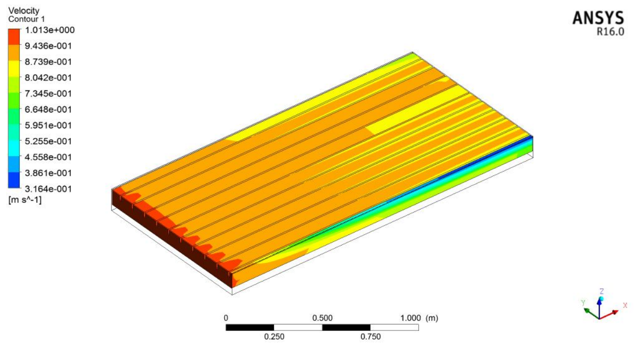


Fig 10 Velocity Distribution of solar air heater with extended Fins

V. CONCLUSION

The present study shows mathematical modeling for predicting the heat transfer characteristics and the performance of solar air heater with and without Extended glass Fins . The solar air heater with Extended glass Fins gives higher thermal performance than without Extended Glass Fins Numerical results and CFD analysis has predicted that the effect of depth on outlet temperature for both Models of solar air heater and illustrates that with increase of depth the outlet temperature decreases. This is due to the low convective heat transfer coefficient between the absorber plate and air. It is observed that the performance of the extended Fin solar air heater is good when compared with non finned model and also concluded that in both the cases mass flow increases outlet temperature decreases.

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