

# Thermal Analysis of a Solar Air Heater

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**Abstract-** Solar air heater is a solar warm innovation in which the vitality from the sun, segregation is caught by an engrossing medium and used to warm air. Solar air warming is a sustainable power source warming innovation used to warmth or condition air for building or process warm applications. Its regularly the most savvy out of all the solar innovation particularly in business and mechanical application

In this examination, enthusiastic productivity of a solar air heater with aluminum level plate safeguard was inspected tentatively for wind current speed of 0.5 m/s. An exploratory setup was developed and tests were contrasted and the aftereffects of the examination performed by utilizing computational liquid progression (CFD) programming. Results were additionally assessed in view of thermo realistic camera pictures.

**Index Terms-** Solar air heater, energy efficiency, absorber plate.

## I. INTRODUCTION

A solar air heater is a straightforward gadget to warm air by using solar vitality, which has numerous applications in drying horticultural items, for example, seeds, leafy foods. Likewise, solar air heaters are used for warming structures with helper heaters to spare vitality in winter-time. Traditional solar air heaters mostly comprise of coating with a safeguard plate or coating with a pipe of two parallel plates shaping a section for wind stream with top plate going about as a safeguard. This game plan is protected thermally from the back and the sides. To upgrade the execution of solar air heaters, endeavors have been made to lessen top warmth misfortunes from safeguard, increment warm exchange coefficient and increment contact region between the safeguard plate and the air stream. Diverse adjustments, for example, multi-pass air section, longitudinal balances in the wind stream entry,

roughened surface of safeguard plate, V-molded creased safeguard plate and deterrents on safeguard plate, have been recommended to accomplish this.

Garg et al. reasoned that the various pass air heater performs well for low stream rates and substantial plate lengths. Satcunanathan and Deonarine recommended utilization of two goes in the regular solar air heater in which arrangement was made for the air to go between the glass sheets before going under the darkened metal gatherer. It brought about increment of proficiency from 10% to 15% than of an ordinary heater. Wijey sundera et al. directed examinations to build up that the activity of a customary solar air heater with two covers in a two-pass mode (gulf wind currents first over the safeguard plate and after that under it) offers an economical technique for enhancing the gatherer productivity by around 10– 15% in contrast with single pass framework. Ezeike composed a triple pass level plate air authority with the normal proficiency of 73– 81%. Outlet temperature ran from 90 to 101 °C on crisp mornings and with air speeds up to 3.5 m/s. Yeh et al and Sebail et al composed twofold stream solar air heater with blades appended over and under the retaining plate. This brought about impressive change in gatherer effectiveness of twofold stream solar air heaters with blades contrast with single stream working at a similar stream rate. Alta et al. compared three unique kinds of level plate solar air heaters; two having blades and the other without balances, one of the heater with a balance had single glass cover and the others had twofold glass covers. The vitality and vitality yield rates of the solar air heaters were assessed. In light of the vitality and vitality yield rates for different wind stream rates, tilt edge and temperature conditions versus time, heater with twofold glass covers and balances was more viable and the distinction between

the info and yield air temperature was higher than of the other solar air heaters. Pakdaman et al. tentatively explored the distinctive warm qualities of a characteristic convection level plate solar air-heater with longitudinal rectangular blades cluster. Connection for Nusselt number was created and exergy examination has been completed to decide the ideal conditions in which the framework has the most astounding execution. Yeh and Ho et al. enhanced the gatherer proficiency of solar air heater by making air turbulence and broadening the warmth exchange territory by appending the confounds to balances in the authority. Sahu and Bhagoria utilized 90° broken transverse ribs on safeguard plate of a solar air heater to expand warm exchange coefficient. Karmare and Tikekar examined the liquid stream and warmth move in a solar air heater with metal ribs of roundabout, square and triangular cross-area at bring down side of gatherer plate. The rate improvement in the warmth exchange for square plate over smooth surface was 30%.

Jaurker et al. examined the warmth exchange and grinding attributes of rib-scored game plan and rectangular transverse ribs of comparable rib tallness and rib separating under comparable stream condition. Warmth exchange coefficient for rib-furrowed plan was higher than that for the transverse ribs while grinding factor was marginally higher for rib scored course of action. At low stream rates the solar air heater with harshness components had a superior execution, though at higher stream rates, the smooth pipe air heater would do well to viable effectiveness. Kumar et al. tentatively concentrated the warmth exchange and erosion qualities in solar air heater conduit roughened with discrete W-formed harshness and created relationships for warm exchange and grating as an element of unpleasantness and stream parameters. Karim and Hawlader directed examinations to consider the execution of three sorts of solar air heater, in particular level plate, finned and V-ridged solar air heaters. The V-layered gatherer was observed to be most productive while the level plate authority was the slightest effective. Lin et al. what's more, Gao et al. utilized the cross-folded retaining plate and base plate to improve the turbulence and the warmth exchange rate inside the wind current channel and tried its warm execution. The outcomes demonstrated that cross-ridged solar air heater had a huge predominant warm execution in

contrast with that of the level plate solar air heater. Akpinar and Kocyigit tentatively researched the execution of level plate solar air heater having three distinct hindrances of triangular, leaf and rectangular shape and without obstructions. The efficiencies, the warmth pick up components and warmth misfortune coefficients are resolved for the authorities and examinations were made among them.

The first and second law efficiencies changed in the vicinity of 20% and 82% and 8.32– 44.00% separately. Pressed bed safeguards have likewise been utilized to build the warmth exchange coefficient. Safeguards having a bed pressed of opening and extended aluminum thwart network permeable lattice, wire screen grid/wire work, empty circles, press turning, farming rings, pulverized glass frameworks, semi-straightforward material like glass globules or glass tubes, Limestone and rock and recyclable aluminum jars have been accounted for. Further to decrease top warmth misfortune from grid stuffed bed solar air heater, Laluda and Buchberg cured the pressed bed with honeycomb. To increment convective warmth exchange coefficient from base of safeguard plate Choudhury and Garg researched the impact of stream plate which was presented between the safeguard and the base plate. The expansion in proficiency was ascertained to be 26.5% for a mass stream rate of 50 kg/h-m<sup>2</sup>. Gawlik et al. built up an unglazed, happened plate solar air heaters for warming air straightforwardly from surrounding on an once through premise.

The authority temperature was low, with respect to frameworks that recycle the air, and the primary law productivity of the framework could be more than 80%. Mass motions of the air going through the authority commonly extended from 0.01 to 0.05 kg/s-m<sup>2</sup>. In all above adjusted plans primary point was to expand proficiency however for vast scale utilization of solar air heaters in drying of items, it is wanted that the cost of solar air heaters be low i.e. the cost of material utilized as a part of creation of a solar air heater is low. There have been endeavors by different scientists to diminish the cost of solar air heater by utilizing minimal effort materials like plastic.

Bansal and Uhlemann created two minimal effort air heaters, one with a dark permeable material safeguard and the other with dark PVC thwart non-permeable safeguard, by utilizing plastic movies for coating with sensible execution and worthy life time.

The permeable gatherer is like the authority of the present investigation. Its effectiveness for 10 °C air temperature rise is around 18%. Ahmad constructed a basic solar air heater from shoddy plastic wrapping film with air rises, for use in drying activities on a ranch. For air temperature ascent of 10 °C, the air heater effectiveness was observed to be around 12.5%. In both these minimal effort solar air heater, level safeguard loses warm from the two sides through coating bringing about lower safeguard temperature and lower proficiency. The above discourse shows that the higher productivity solar air heaters have higher cost and the endeavors to diminish the cost prompted diminish in effectiveness. In the present examination, minimal effort solar air heater with enhanced effectiveness has been produced. This minimal effort solar air heater has level plate safeguard of fiber-glass that is protected on one side by ease protection (thermocole) and has UV settled plastic sheet as coating on the opposite side simply like traditional level plate gatherer. The thermocole protection on bring down side of safeguard accomplishes higher safeguard temperature and subsequently higher warm productivity. This protection likewise goes about as a supporting structure which diminishes the general cost of solar air heater. The minimal effort solar air heater was tried utilizing single and twofold coating in summer and winter seasons. The warm productivity, warm evacuation factor contingent upon air outlet temperature, warm expulsion factor contingent upon air gulf temperature and authority effectiveness factor were resolved for single and twofold coated minimal effort solar air heaters alongside pressed bed solar air heater.

## II. MATERIALS AND TECHNIQUES

Depiction of single coated, twofold coated and pressed bed solar air heaters

### SINGLE GLAZED SOLAR AIR HEATER

The points of interest of single coated solar air heater, having general measurements of 2060 × 720 × 150 mm, is appeared in Fig. 1. It is of parallel plate write with wind current in the middle of the safeguard plate and best coating. It has a gap region of 1.2 m<sup>2</sup>. To diminish the cost, a large portion of the structure is manufactured with thermocole. The thermocole utilized as a part of manufacture of solar air heater

fills the need of protection, supporting structure and vapor hindrance for solar air heater in this way hindering the need to utilize G.I. sheet for supporting structure and vapor hindrance. UV balanced out plastic sheet is utilized as a coating at the best rather than glass as in traditional solar air heater. Fiber glass sheet utilized as a safeguard plate is settled at a separation of 30 mm beneath coating to retain solar radiation.

To avert shrinkage of thermocole underneath the fiber-glass because of warming, 18 mm space for dormant layer of air is made in the middle of thermocole and fiber glass sheet with the assistance of spacers as appeared in Fig. 1. The layer of stale air diminishes warm exchange from fiber-glass to thermocole. The cross-area of the air pipe is 30 mm × 620 mm. For air channel and outlet, two openings of 25 mm width, one close to the best and other close to the base, have been given on the contrary side of solar air heater. Headers are accommodated even dissemination of the air in the pipe of solar air heater. To keep up the uniform separating between fiber-glass and coating, little spacers made of thermocole are settled on the fiber-glass (safeguard) as appeared in Fig. 1. The tallness of the spacers is same as the profundity of the air channel. These spacers additionally go about as diverters in the channel, which helps in breaking of the limit layer. The heaviness of single coated solar air heater is 7.5 kg.

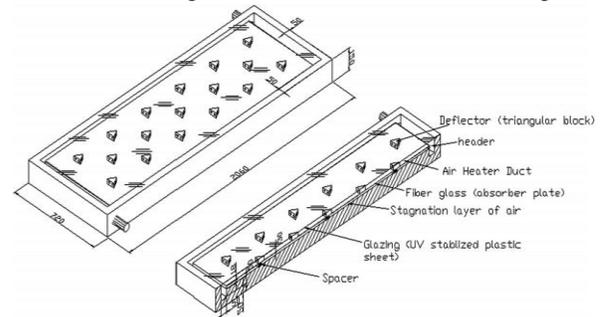


Fig 1 single layer air heater

### Twofold glazed solar air heater

The subtle elements of twofold coated solar air heater, having general measurements of 2160 × 820 × 175 mm and gap territory of 1.2 m<sup>2</sup>, is appeared in Fig. 2. The plan of single coated and twofold coated solar air heaters is same aside from that twofold coated solar air heater has two glazings rather than one to keep up dormant air over the pipe to decrease

top warmth misfortunes however there is hindrance of lessening in radiation falling on safeguard because of additional retention in second coating. The space between two glazings is 25 mm. Its weight is 8.7 kg.

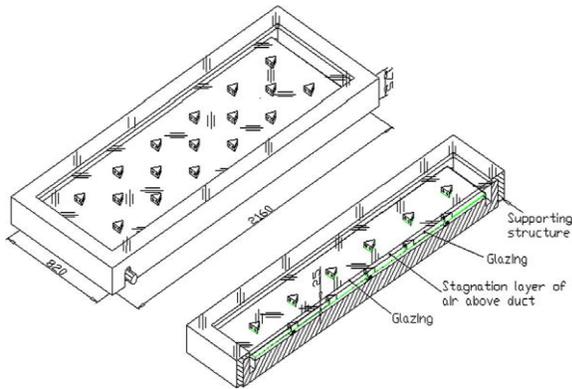


Fig 2 Double glazed solar air heater

**PRESSED BED SOLAR AIR HEATER**

The points of interest of the pressed bed solar air heater is appeared in Fig. 3. Its opening region is 1.3 m<sup>2</sup>. It comprises of two plate made of 24 check G.I. sheet. The inward plate (littler size) is kept in the external plate (bigger plate) with the goal that it is encompassed by external plate on every one of the sides. Inward plate has a melancholy along its broadness at the lower end with a pipe associated with it. Pipe is associated with blower for suction of air from the solar air heater and gloom permits uniform suction of air. A space of 75 mm is made between these plate with the assistance of rectangular wooden backings. This space is loaded with glasswool for protection purposes.

Undereath the discouragement, this space is 25 mm and loaded with glasswool. Internal plate (barring the sadness part) is loaded with darkened iron chips. Press chips are misuse of the turning procedure performed on gentle steel. The iron chips go about as a safeguard of solar radiations. These weigh 175 kg for 1 m<sup>3</sup> volume. Weight of iron chips stacked in solar air heater of 1 m<sup>2</sup> is around 6 kg. The heaviness of pressed bed solar air heater is 37 kg. In this solar air heater, the retention of solar radiation is volumetric ingestion in bed of chips. Air goes through this layer of iron chips which is 25 mm thick. The void portion and pressing thickness of iron chips is 72.7% and 212 kg/m<sup>3</sup> separately. Glass cover is set on the iron chips. Edge press has been utilized to help this glass cover.

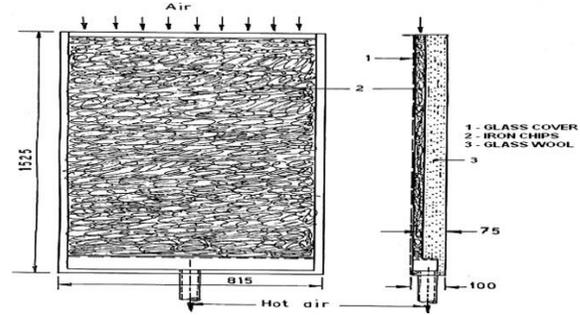


Fig 3 : Detailed top and side views of packed bed solar air heater.

**III FINITE ELEMENT ANALYSIS (FEA)**

The genuine idea in FEA is that the body or structure might be withdrawn into more unassuming parts of confined estimations called "Compelled Elements". The essential body or the structure is then considered as a variety of these segments related at a destined number of joints called "center core interests". Arrange purposes of control are approximated the evacuations over each obliged part. Such perceived cutoff focuses are called "shape limits". This will recommend the change inside the bits like the development at the focal points of the parts.

The Finite Element procedure is a smart contraction for settling standard and for the most part differential examination in light of reality it is a numerical mechanical get together, it can deal with the cerebrum boggling issue that can be inferred in differential consistent verbalization from. The utilization of FEM is boundless as regards the system of adjusted outline issues. In this manner of surprising expense of dealing with constrain of years went by, FEM has an establishment set apart by being used to oversee complex and cost basic troubles.

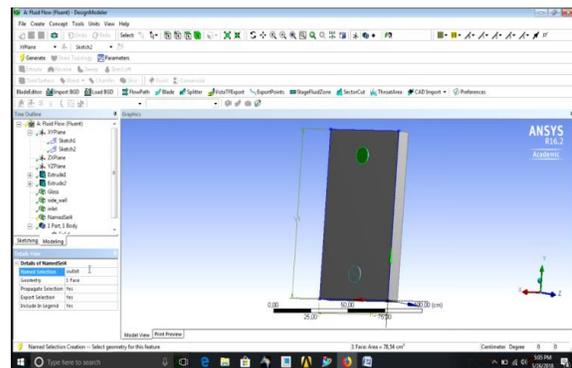


Fig 4: Geometry in ansys

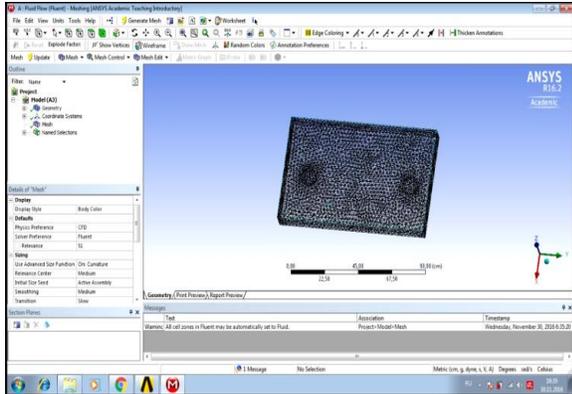


fig 5 Mesh model in ansys

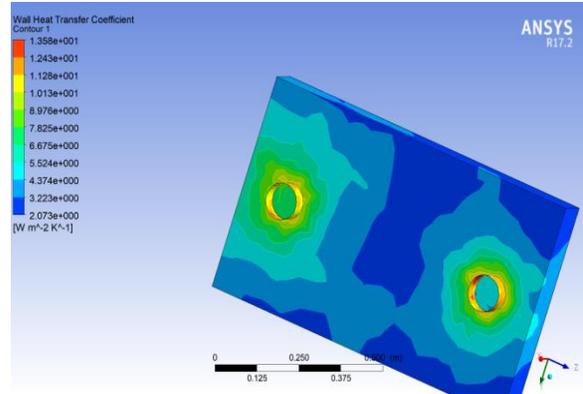


Fig 9 wall heat transfer coefficient

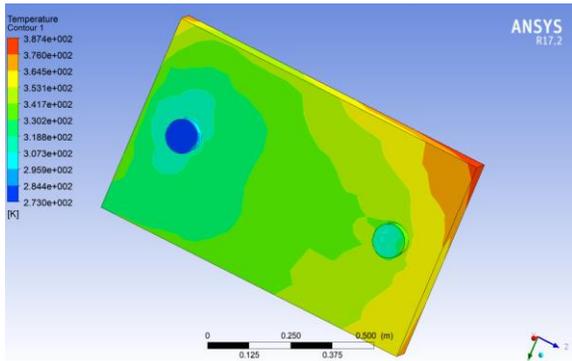


Fig 6 : Temperature contour

IV. RESULT AND DISCUSSION

Contour value	Temperature (k)	Pressure (Pa)	Boundry heatflux (Wm <sup>-2</sup> )
maximum	3.874e+002	4.297e-001	4.303e+003
minimum	2.73e+002	1.145e-001	1.574e+004

V. CONCLUSION

In this present examination, a numerical expectation has been directed to think about warmth exchange and stream grinding practices of a solar air heater having blade on the safeguard plate surface. The accompanying conclusions have been drawn from the present work:

1. There is a decent understanding outcomes reference for outlet air temperatures. In spite of the fact that there are some little errors because of some test imperfectness matters, regardless we have a decent trust in the CFD reproduction program that can be utilized as a part without bounds for more solar air heater issue.
2. Impact of various warmth motion an incentive on solar air heater demonstrated that expansion the estimation of warmth transition increment the warm effectiveness of solar air heater.
3. As of late CFD has been connected in the plan of solar air heater. The investigations detailed that the nature of the arrangements acquired from CFD reenactments are to a great extent inside the worthy range demonstrating that cfd is a viable apparatus for foreseeing the conduct and execution of a solar air heater.

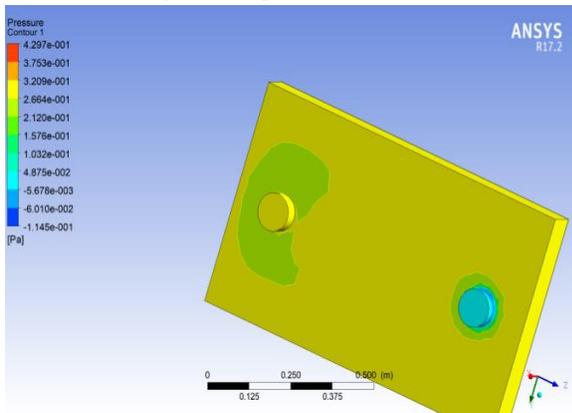


Fig 7: Pressure contour

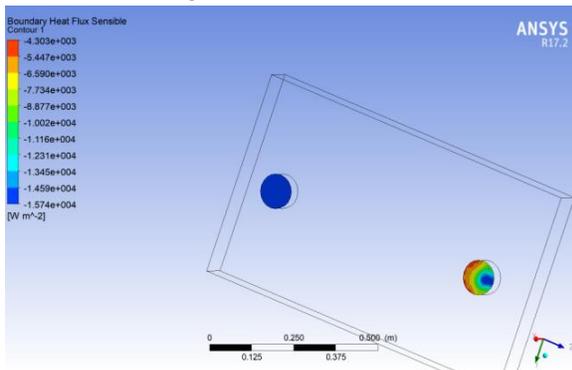


Fig 8: Boundary heat flux

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