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CFD Analysis of Thermo Hydraulic Performance of Solar Air Heater Having Roughness of Triangular Cross Section Continuous Ribs on Absorber Plate: A Critical Review

S.R.Bhoyar[1], Prof. P.P.Patil[2], Prof. R.Y.patil[3]
[1]Lecturer, Mechanical Engineering Department, GHR Poly Jalgaon, INDIA
[2]Assistant Professor, Mechanical Engineering Department, SGDCOE Jalgaon, INDIA
[3]Professor, Mechanical Engineering Department, SGDCOE Jalgaon, INDIA

ABSTRACT

In Present work solar air heaters are studied with their applications computational fluid dynamics, Trails have been conducted on the heat transfer and friction factor for a solar air heater duct with triangular cross-sectional ribs without symmetric gaps. In the CFD investigation, it will assure that the height is 2mm, the pitch (p) of the ribs is 20, the relative roughness pitch (p/e) is 10mm and the angle of attack taken is 60^0 . This investigation will carry out on a Reynolds Number (Re) ranging within 4000-18000. Results of this analysis will compare with experimental results of Rajesh maithani and j.s. saini for solar air heater with absorber plate having triangular cross section ribs and absorber plate having v-shaped circular cross section ribs with symmetrical gaps at optimum designed value of ribs.

Keywords-- CFD analysis, Reynold numbers, Solar Duct, Friction factor

I. INTODUCTION

In the recent years demand of energy is increase continuously, to meet the current demand of energy conventional sources of energy is not sufficient also the stock of conventional sources of energy is limited in future we needs alternate sources of energy, one of the most promising sources of energy which never end found by the energy researcher is non-conventional source of energy. Some of the non-conventional source of energy are solar energy, wind energy, ocean thermal energy, tidal energy, this are also called as natural sources of energy. Out of this solar energy is called as primary source of energy because the other energy like wind energy, ocean thermal energy are derived from the solar energy.

A solar air consists of an absorber plate with a parallel plate formed a small passage called as duct.in the duct air is forcefully passed absorbed the heat from the absorber plate, except absorber plate all the wall of duct are thermally insulate. Absorber plate consists of transverse cover plate through which solar radiation enter and this radiation is absorbed by absorber plate and become heated and the heat of the absorber is taken by the flowing fluid.

II. TYPES OF SOLAR AIR HEATER

(a) Single pass solar air heater\
(b) Two pass solar air heater
(c) Matrix type solar air heater
(d) Unglazed transpired solar air heater

(a) Single pass solar air heater:

This is conventional type solar air heater which is most basic in design, in this type of solar air heater air is heated in single pass when it flow through the underneath of absorber plate a show in figure

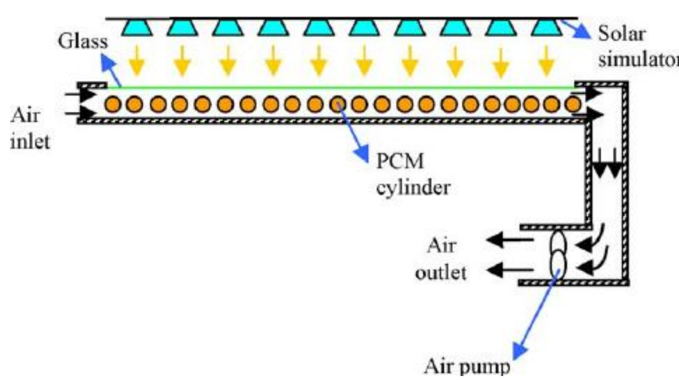

Figure 1 Single pass solar air heater

(b)Two pass solar air heater:

This is the second type of solar air heater in which air is in two pass while flowing through the duct.in one pass air is flow underneath of absorber plate while in second pass it flow above the absorber plate as show in figure .this heater is more efficient in heating the air but at the same time it requires more pumping power.
This solar heater again classify in two category
(1).Two pass solar air heater with recycle
(2) Two pass solar air heater with porous medium

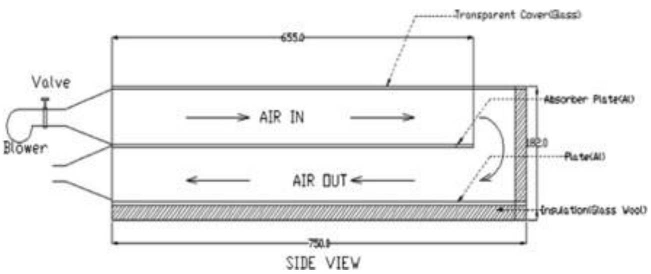

Figure 2 Double pass solar air heater

Two pass solar air heater with recycle:- -if the outlet temperature of air from the solar air heater is too high than our requirements than some heat of the outlet air is given to the inlet air of heater through heater exchanger this process is similar to the regernative heating .

Two pass solar air heater with porous medium: -in this type of solar air heater air in first pass flow over the absorber plate while in the second pass it flow through the porous medium which is kept below the absorber plate this type of solar air heater is highly efficient in term of heat transfer to air but consume very much pumping power for pumping the air through the duct.

(c) Matrix type solar air heater

This type of solar air quite different from conventional solar air heater in this absorber plate is in the form matrix formed by the fined meshed copper wire screen. Sun radiation directly incident on it and penetrate it and stored in the form of thermal energy air with the help blower pass through the matrix and absorbed the stored thermal energy as show in figure.

Figure 3 Matrix type solar air heaters

(d) Unglazed transpired solar air heater:-

This type of solar heater particularly used for space heating in this type heater absorber plate is perforate dark color metal sheet, this sheet is molded in the form of duct, air is flow in this become hot after taking thermal energy from the absorber plate, absorber plate which is also act as duct kept in vertical direction adjacent to wall a blower at the top the duct is used for pumping the air inside the duct. This of solar air heater generally used for space heating, drying crops in cold country

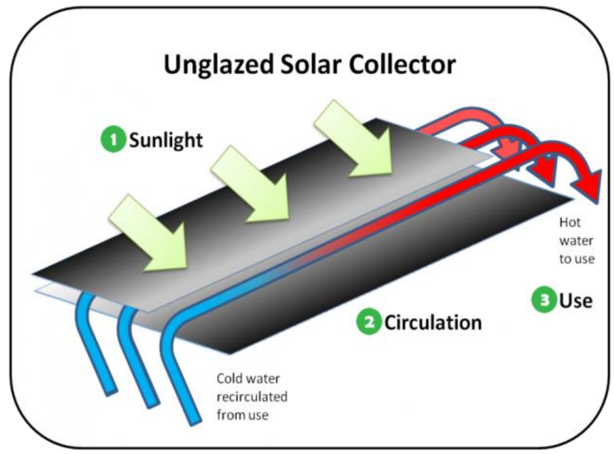

Figure 4 unglazed transpired solar air heaters

Out of the four types solar air heater single pass solar air heater is more in use and the efficiency of heat transfer to working fluid in this type of heater is mainly depend upon the geometry of absorber plate, in order to understand the effect of roughness in a absorber plate we study the research of various researcher based on the roughness of absorber plate some of this research are as follow.

III. REVIEWS

K.R. Aharwal,B.K. Gandhi,J.S. Saini, [1] researched in the year 2008, they used square inclined ribs with gaps in it, and found friction factor and Nusslet number increases in air by an amount as compare to flow of air in smooth duct for Reynolds number ranging from $3X10^3$ to $18X10^3$ with rib geometry having 60^0 angle of inclination .

S.V. Karmare A.N. Tikekar [2] researched in the year 2009, for the thermal efficiency and effective efficiency in a solar duct by using cylindrical metal grits roughness in the absorber and concluded that gain in thermal energy increases with increasing in the Reynolds numbers but it is not same in the case net gain thermal energy because increase in Reynolds number increases pumping power for the flow of air as compared to gain in thermal energy , this analysis also concluded that at high value of isolation the optimum condition for net gain in thermal energy shift towards high value of Reynolds number .

Arvind kumar, J.L balgoria, R.M.sarviya [3] research in the year 2009 on the solar air by taking absorber plate having discrete W-ribs and concluded the following points in his experimental study.
(a) Keeping the relative roughness height constant i.e. ratio of rib height to the hydraulic diameter of the duct , Nusslet number vary with the variations in Reynolds number and the value of Nusslet number for each Reynolds number at this geometry of ribs is higher than the Nusslet number of smooth duct
(b) Keeping the relative roughness height constant friction factor decreases for each increase in Reynolds number but the value of friction factor at this geometry of ribs is higher than the friction factor of smooth duct
(c) At higher value of relative roughness at this geometry the net heat transfer in air is less with the increase in Reynolds number
(d) Keeping the roughness height constant maximum value of Nusslet number and friction is obtained at an angle of attack of 60^0

Rajesh Maithani, J.S.saini [4] researched in the year 2016 on the solar duct by taking absorber plate which has v-shaped circular cross section ribs with symmetrical gap in their study they concluded the flowing point. (a) Keeping all the roughness parameters constant except no of gaps Nusslet number first increase with increase in Reynolds number but further increase in Reynolds number results in reduction of Nusslet number ,at gap 3 Nusslet number attain maximum value in his experiments (b) friction factor also attain maximum value at 3no gap for 4000 Reynolds number (c) At3 no of gap Nusslet number attain its maximum value when relative gap width g/e (ratio of gap distance /height of rib) is 4 (d) At 3 no of gap Friction factor also attain its maximum value at g/e=4 (e) At 3 no of gap Nusslet number attain maximum value at P/e i.e. relative pitch ratio is 10 (ratio of pitch to height of rib) (f) At 3no of gap friction factor attain maximum value when P/e=10 for 4000 Reynolds number (g) At 3 no of gap Nusslet number and friction factor attain maximum value when angle of attack is 60^0

IV. CONCLUSION

Based on the review of literature on solar air heater, it has been found that, it is widely investigated both analytically and experimentally. A number of studies have been carried out in order to investigate the effect of various parameters on the performance of the heat transfer and friction factor for a solar air heater duct with triangular cross-sectional ribs without symmetric gaps. In the CFD investigation, it will assure that the height is 2mm, the pitch (p) of the ribs is 20, the relative roughness pitch (p/e) is 10mm and the angle of attack taken was 60^0. This investigation will carried out on a Reynolds Number (Re) ranging within 4000-18000. Then the observations will compare between smooth Absorber plates, Author's circular ribs with symmetrical gaps, And Absorber plate with triangular cross-section and we expect that: - The smooth ribs couldn't transfer the desired heat. The rough ribs having symmetrical gaps were efficient enough to transfer heat but it is not economical and has a huge complexity in design, whereas the triangular ribs without symmetric gaps will overcame this problem. The result of triangular ribs will investigate by comparing Nusselt number and Friction factor with circular ribs having symmetric gaps

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