Enhancement of the Efficiency of Solar Air Heater by Using Artificial Roughness of Spiral Tubes Contained Hot Oil Flowing Inside the Tubes

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ABSTRACT
Generally heat transfer from fluid flowing to the stationary plate due to conduction process. After conduction further heat transfer will takes place that is due to convection process. Heat transfer will be reducing due to low thermal conductivity and due to relatively low air velocity. To overcome such type of a problem it is necessary to use artificial roughness to break laminar sub layer in order to reduce the thermal resistance and to increase the turbulence of flowing fluid result increase in heat transfer rate. In order to increase the heat transfer in solar air heater artificial roughness in spiral-pipe form are used. Inside the spiral pipes hot oil enforced to flow so it will create a further enhancement of heat transfer to the flowing air across the tubes. High frictional losses occur due to artificial roughness result high power required for the fluid flow. Turbulence results Due to artificial roughness which ultimately break the viscous laminar sub layer.
Keywords: Solar air heater, Heat transfer, Friction factor, Spiral tubes.

I INTRODUCTION

Sun is the ultimate source of energy for all form of energy. Sun which is over a hundred times larger than the earth is located at a distance of 150 million kilometer from the earth. A sun ray emitted from the sun takes about 9 minute to reach the earth. Sun is a fusion reactor emitting 3,800 million, million, million watts of energy each second and the earth receives only 1/2,00,000,000,000 portion of this amount equal to 1.3×10^{17} w/h which is 20,000 times the energy requirement of the world. The temperature of the sun at the center is 15 million $^{\circ}$ C and at the surface it is about 6000°K.About 50% of the energy received outside Earth's atmosphere actually reach the earth and is about 1 cal/sq.cm min at sea level. In these tropical and subtropical countries, the isolation is considerably high, and therefore, solar energy has been traditionally used in drying and preservation of agriculture crops .In the current scenario when the petroleum prices is increases sharply it is essential that we can switch over to non conventional energy sources to avoid such type of energy crisis. The thermal efficiency of a solar air heater with smooth duct plate is always low as compare to a solar water heater due to greater heat loss and low value of heat transfer coefficient .Solar energy is very abundant in nature that provide a clean and pollution free atmosphere. the solar air heater are modeled as a rectangular channel having one rough wall and two smooth walls. This make the fluid flow and heat transfer characteristics distinctly different from those found in the case of channel with two opposite roughened wall rough annular and circular tubes. Further the range of reynolds number application in solar air heater are of lower range in comparison of the studies discussed above. This can be done by keeping the height of the roughness element small in comparison with the duct dimension. Several parameter that characterize the arrangement and shape of the roughness, the relative roughness pitch (p/e) and pitch (p) are the most important parameter. These parameters, namely, relative roughness height (e/D) and the roughness element height(e). Here chamfered , circular, semi- circular and grooved sections have been investigated in order to get most beneficial arrangement from thermo hydraulic consideration.

These investigations studied the effect of geometric parameters of roughness element, on heat transfer and friction factor in gas turbine cooling and heat exchanger applications. Keeping this in view several investigators investigation various geometries of artificial roughness in solar air heater ducts. Correlation for heat transfer and friction factor were develop based on the experimental study carried out by the various investigators. Different geometries of roughness element studies by the investigators of roughness element studies by the investigators are discussed later.

II SETUP USED FOR ARTIFICIAL ROUGHNESS

In this type of set a extra concept is used for increasing the heat transfer rate to the air flowing inside the solar air heater . A oil sump is provided here in which when solar radiation is falling on it get heater and lot of energy has been stored in the form of heat. That heat will be used to increase the performance rate of solar air heater. Spiral pipes are used to flow the oil inside the tube that will create the artificial turbulence to the flowing oil result of increasing the heat transfer rate. The inlet and outlet condition of flowing oil through the spiral pipes is show in the given figure-02

III EXPERIMENTAL DATA COLLECTION

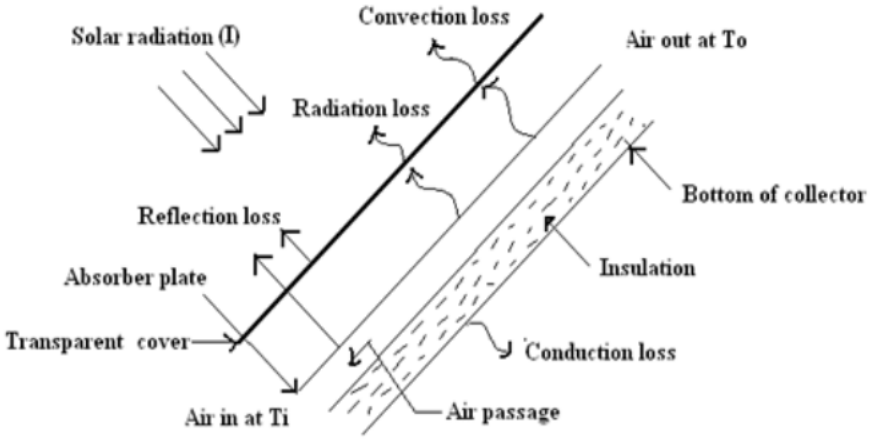
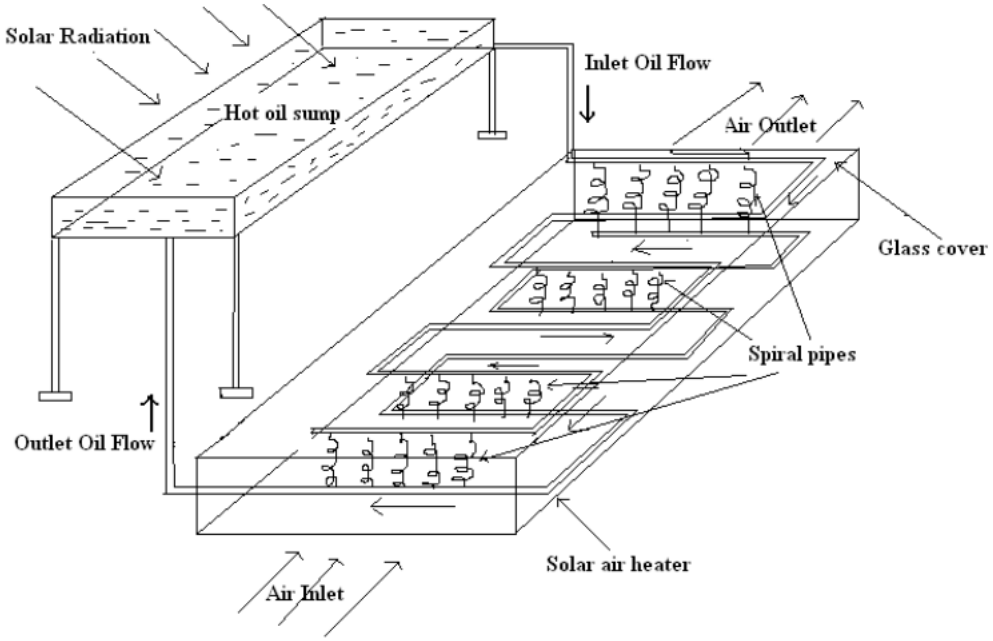


Fig-01

Conventional solar air heater



A Solar Air Heater in which Hot Oil Flowing Inside the Spiral Pipes

Fig-02

OBSERVATION TABLE

FLOW OF AIR THROUGH THE SPIRAL PIPES

S.NO	TIME	Ti	To
1	8 A.M	27	45
2	9. A.M	30	58
3	10 A.M	33	71
4	11 A.M	35	79
5	12 A.M	37	82
6	13 P.M	38	81
7	14 P.M	38	78
8	15 P.M	38	71
9	16 P.M	36	58

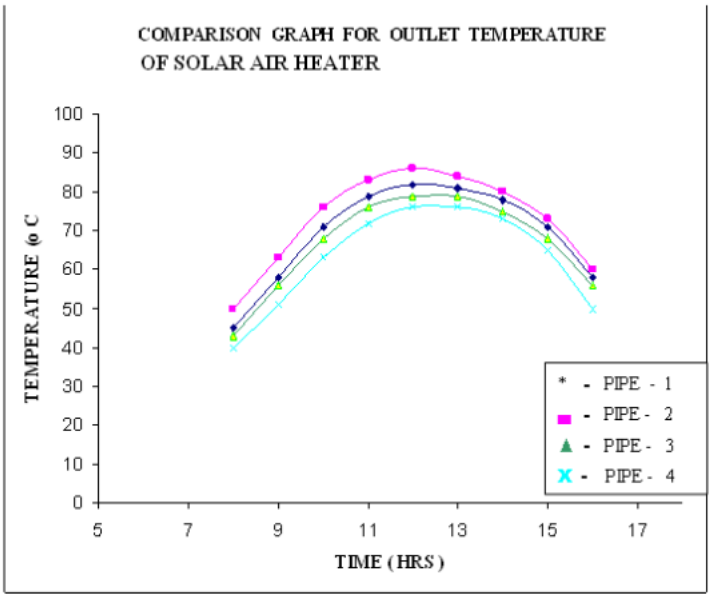


Fig-03

IV FORMULATION

Following equations have been used for the evaluation of relevant parameters

$Q = m \times c_p \times (t_o - t_i)$

$H = q / [A_c \times (t_p - t_f)]$

$Nu_r = (h \times D_h) / h$

$f_r = D_h \times \Delta p / (2 \times L \times V^2 \times \rho)$

V CONCLUSION

In this type of artificial roughened solar air heater more heat transfer has been observed due to hot oil flow through spiral pipe. As compare to another type of roughness geometries it is much more effective because of turbulence create by the spiral pipe to the flowing fluid also, this give an extra benefit for increasing heat transfer rate.

REFERENCES

[1] Varun, R.P.Saini, S.K.Singal, Feb-(2007). A review on roughness geometry used in solar air heaters.

[2] Arvind Kumar, J.L. Bhagoria, R.M. Sarviya May-(2009). Heat transfer and friction correlation for artificially roughened solar air heater duct with discrete W-shaped ribs;

[3] Brij Bhushan, Ranjit Singh, Oct-(2009). A review on methodology of artificial roughness used in duct of solar air heaters.

[4] Rajendra Karwa, Kalpana Chauhan, Nov-(2009).Performance evaluation of solar air heater having V-down discrete rib roughness on the absorber plate.

[5] V.S.Hans, R.P.Saini, J.S.Saini, March–(2010). Heat transfer and friction factor correlation for a solar air heater duct roughened artificially with multiple V-ribs.

[6] A. Lanjewar, J.L.Bhagoria, R.M. Sarviya, Feb-(2011). Experimental study of augmented heat transfer and friction in solar air heater with different orientations of W-Rib roughness.

[7] Atul Lanjewar, J.L.Bhagoria, R.M. Sarviya, May-(2011). Heat transfer and friction in solar air heater duct with W-shaped rib roughness on absorber plate.

[8] Sukhmeet Singh, Subhash Chander, J.S.Saini, July - (2011). Heat transfer and friction factor correlations of solar air heater ducts artificially roughned with discrete V-down ribs.

[9] Sukhmeet Singh, Subhash Chander, J.S.Saini, Nov-(2011). Exergy based analysis of solar air heater having discrete V-down rib roughness on absorber plate.

[10] Sukhmeet Singh, Subhash Chander, J.S.Saini, Jan-(2012). Investigation on thermo-hydraulic performance due to flow-attack-angle in V-down rib with gap in a rectangular duct of solar air heater;

[11] Anil Kumar, R.P. Saini, J.S.Saini, Heat and fluid flow characteristics of roughened solar air heater ducts; May-2012.

[12] Anil Kumar, R.P. WSaini, J.S. Saini, Development of correlation for Nusselt number and friction factor for solar air heater with roughened duct having multi n-shaped with gap rib as artificial roughness; 12April-2013.

[13] Rajendra Karwa, Girish Chitoshiya 29April-(2013). Development of correlations for Nusselt number and friction factor for solar air heater with roughened duct having multi v-shaped with gap rib as artificial roughness.

[14] Dhiman P., Thakur N.S., Kumar A. and Singh S., (2011). An analytical model to predict the thermal performance of a novel parallel flow packed bed solar air heater, *Applied Energy.,* 88: 2157–2167.

[15] El-Sebaii A.A, Aboul-Enein S, Ramadan MRI, Shalaby SM and Moharram BM, (2011). Thermal performance investigation of double pass-finned plate solar air heater. *Applied Energy*. 88: 1727–1739.\

[16] Velmurugan P. and Ramesh P., (2011). Evaluation of thermal performance of wire mesh solar air heater, Indian Institute of Science & Technology., *4(1),* 12-14.