International Journal of Advance Research in Science and Engineering
Volume No.06, Issue No. 11, November 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

EFFECT OF BAFFLE INSIDE THE TUBE IN SOLAR WATER HEATER ON CONVECTIVE HEAT TRANSFER COEFFICIENT AND NUSSELT NUMBER

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ABSTRACT

Experimental investigation of Nussult Number and heat transfer coefficient of thermosyphone solar water heater with flat plate solar collector fitted with full length baffle of 10cm, 5cm pitch and plain tube have been presented. The flow regime is completely laminar for this study with lower value of Reynolds number in the tubular case. The experimental data obtained were compared with plain tube data. The effects of full length baffle with 10cm and 5cm pitch inside the tube on heat transfer coefficient and Nussult number were presented. The heat transfer coefficient and Nussult number increases with lower pitch in comparison to that of plain tube and higher pitch for a given Reynolds number. The created baffle improved the performance of thermosyphone solar water heater .

Keywords: Augmentation, baffle creates, flat plate collector, Heat Transfer, Reynolds Number.

I. INTRODUCTION

The requirement for energy increases with increasing living standards each day. The important goal of the energy policy of any country should be obtaining cheap, clean, and long-lasting energy since living standards increasing, increasing world population and rapid growth in technology increases the need for energy each day, however, obtaining such energy will be tougher due to the limited energy reservoirs present around the world. The environmental pollution resulting from the excessive usage of energy is another very serious problem. Due to these difficulties related to the energy issue, the world is eyeing for alternative energy sources.

There has always been a gap between supply and demand of electricity especially during peak summer load and winter seasons. The situation further worsens during early hours of the peak winter season when excessive heating load is switched 'ON'. This has been a consistent problem. If the heating load is switched over to renewable sources of energy from conventional energy sources; the gap can be bridged considerably. Therefore, there is a requirement to take up measures to initiate steps for adoption of 'Solar Energy'.

'Solar Energy' is an unlimited source of non conventional energy. Solar Energy, if utilized, shall not only bridge the gap between demand and supply of electricity, but will also save money since running cost of equipment working on solar energy is minimum or it could be say that very negligible. Its use will also help in reducing pollution and maintenance of eco-balance. The amount of solar energy received by the earth is substantial, but is dilute and its availability varies with time. The variation in availability occurs daily because of the day –night cycle and also seasonally because of the earth's orbit around the sun. In addition, variations occur at a specific location because the local weather conditions. Consequently, the energy accumulated when the sun is shining must be stored for use during periods when it is not available. The necessity for storage also adds significantly to the cost of the system. Thus, economics is an important consideration in utilizing solar energy as an energy alternative. In 2006 Eiamsa-ard et al, cold and hot water are used as working fluids in a double pipe heat exchanger fitted with regularly spaced twisted tape elements. Results show that the heat transfer coefficient and friction factor increase with the free space ratio .In 2007Eiamsa et al, The value of heat transfer is about 15% lower with regular spacing twisted tape than the full length twisted tape inserts with 90% decreased in pressure drop is investigated by the researcher. In 2007Sivashanmugam and Nagarjan, The heat transfer coefficient can be enhanced higher, by using a circular tube fitted with right and left helical screw inserts is than that for straight helical twist inserts of equal and unequal length for a given twist ratio.In 2007 Hong et al. Experimental study on Pressure drop and compound heat transfer characteristics of a converging-diverging tube with evenly spaced twisted-tapes have been investigated . Swirl was generated through evenly spaced twisted-tape elements which vary in twist ratio and rotation angle. Space ratio considered an important effect on the characteristics. Experiments in a smooth circular tube and in a converging diverging tube without twisted-tapes were carried out for Comparison. The results with twisted tape with twist ratio y=4.72 and rotation angle 8= 1800 has the best performance among the four types of twisted-tapes presented in this paper. In 2009 Jaisankar et al, Achieved that the minimum twist ratio provides higher percentage of enhancement performance of twisted tape solar water heater collector compared to the plain one. In 2009 Rahimi et al, Experimentally and theoretically proved that the Nusselt number and performance of the jagged inserts are higher than other modified twisted tape inserts. In 2009 Murugesan et al, Find out a significant increase in heat transfer coefficient and friction factor inside tube fitted with full length trapezoidal cut twisted tape. In 2009 Sharma et al, showed convective heat transfer enhancement with AL2O3 nano fluids compared to flow with water in a circular tube fitted with twisted tape inserts considerable

II. NOMENECLATURE

T_1	Temperature of inlet of solar collector box
T_2	Temperature of outlet of solar collector box (℃)
T_3	Upper layer temperature of water tank (℃)
T_4	Lower layer temperature of water tank (℃)
T_a	Ambient Temperature (^{0}C)
T_{fluid}	Average temperature of inlet and outlet temperatures (℃)

T_p	Collector panel temperature (℃)
A_c	Solar collector area (m^2)
R_a	Rayleigh Number
F'	collector efficiency factor
C_p	Fluid's specific heat (KJ/kg℃)
$\bar{h}_{fluid}$	Fluid's average convective heat transfer coefficient (w/m^2℃)
I	Hourly solar radiation on the flat- panel solar collector (w/m^2)
L_c	Length of the collector panel channel (m)
L	Length of the circular tubes (mm)
p_x	pitch of the baffle
$\overline{Nu}$	Average Nussult number.
k_{fluid}	Conductivity of the fluid.

III. EXPERIMENTAL SETUP

The schematic diagram of the natural circulation solar water heater is shown in Figure-1. The system consists of a solar flat plate collector, storage tank and connecting pipes. The absorber plate of the solar collector is of Aluminium, and six row of pipe length160cm and 2.54cm in diameter. Headers are in the two opposite sides of the box to maintain good contacts with the pipes. In the experiment 1600 mm long and diameter of 25.4 mm iron tubes are used. The pipes are placed parallel to each other and welded at both ends to the header. The front surface of the box is then covered with 4 mm thick clear plain glass and the overall dimension of flat-plate solar collector is 1380mmx750mmx250mm and the effective glazing area is 1537inch^2. Same dimension is selected for both the case, but in the baffled pipe 10cm of pitch is selected. The solar collector along with its water tank was installed at angle of 15° on each day of observation. The whole unit was oriented in the South .The Pyranometer measuring short wave radiation was connected at same slope to as the collector to read radiation flux(W/m^2) on the inclined surface (as shown in figure).this pyranometer output reading was converted into a heat flux using the celebration relation (1Mv= 129W/m^2) provided by the manufacturer. Readings were obtained for one inlet water temperature value (T_1) and one outlet water temperature value (T_2). In addition two readings of the temperature of water tank on top and bottom(T_3) and (T_4) of the water tank another thermocouple used to measured the absorber plate temperature (T_p). In addition, a thermocouple was also connected to measure and ambient temperature (T_{amb}).These six readings were made through the use of J-type thermocouple. The thermocouples were connected six channels of thermocouple amplifier .Once the unit was connected, it was left to run for about 2days before the recorded measurements are taken, in order to overcome the initial transient's effect and to conform reliable operation unit. Then the experiment was run for period of 5 days on Al- sheet .Experimental readings were taken in plain and baffle tube. Baffling was created to break boundary layers inside the tube and proper mixing of the fluid.

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Fig-1 Schematic diagram of experimental setup

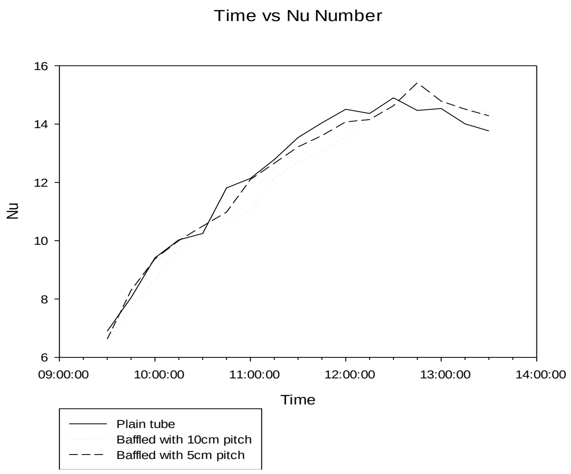
IV. DATA REDUCTION

Density difference of the fluid created by the temperature gradients causes the fluid being heated and delivered to storage tank. This type of fluid flow is usually termed as the natural or free convection. The temperature distribution, heat energy , collector efficiency and friction factor were calculated by using the equations. But in this paper our primary consideration is heat transfer coefficient and Nusselt number through which the performance of solar water heater is calculated.

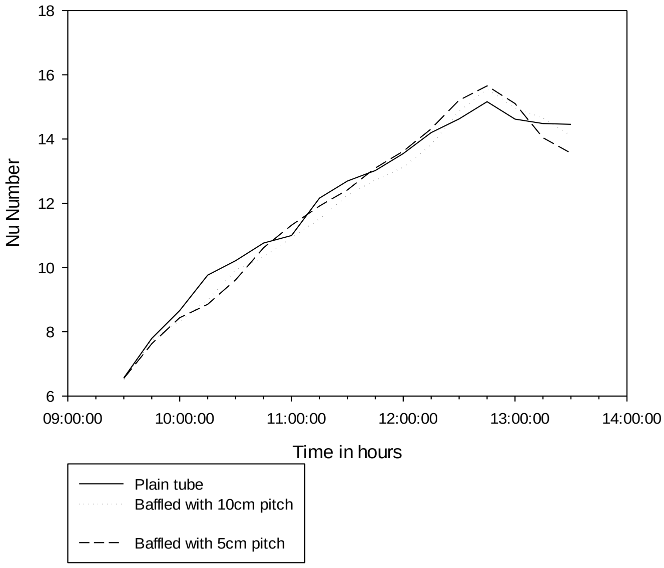
Calculation to find out Average Nusselt number and Convective heat transfer coefficient

$$\overline{h}_{\text{fluid}} = \frac{\overline{Nu}}{\text{Lc}} \times k_{\text{fluid}} \quad \text{.......... ...(1)}$$

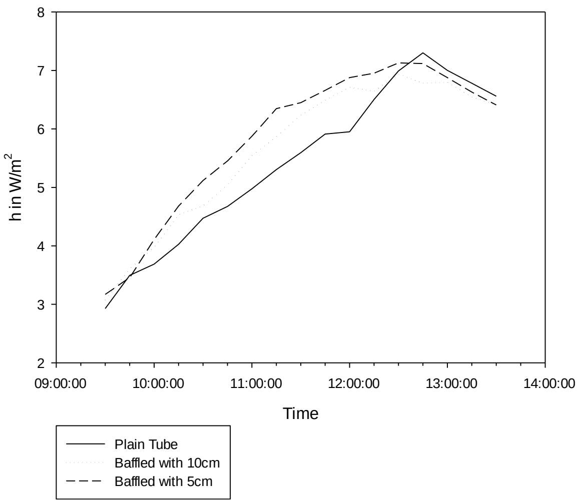
$$\overline{Nu} = 0.645[\text{Ra}\,(\frac{S}{\text{Lc}})\,]^{0.25} \quad \text{........ (2)}$$



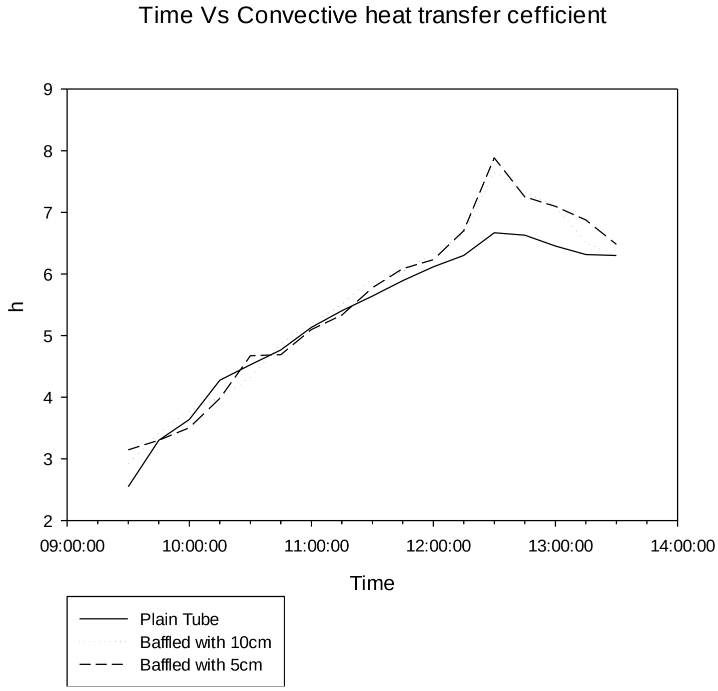
Time Vs Nu



Time Vs h



Graph No-1(Day 1) Graph No - 2 (Average)



Graph No - 4(Average)

Graph No- 3(Day 1)

V. RESULTS AND DISCUSSIONS

The Natural circulation solar water heater was examined in the month of December-January, 2012-13 at intervals of quarter an hour between 9.30 hours and 13.30 hours. The incident solar radiation intensity was measured using pyranometer. The water inlet and outlet temperatures for the collector as well as ambient air were measured by thermocouple. The mass flow rate of the system was measured by rota meter. The performance of solar water heater is measured through Nu number and convective heat transfer coefficient i.e. h. The quarterly variation of the Nu number and CHTC are shown in Graphs 1, 2, 3 and 4. The solar intensity was measured quarterly from 9.30am to 1.30pm, and observed that the intensity was increasing from 9.30 hours to 12.45 hours, reaching a maximum value at 12.45 hour and after that it was declining in all the three cases. In the first graph the value of Nu number for plain tube is 14.47, 15.416 for 5cm pitch tube and 15.164 for 10cm pitch tube. In the average value it is also shown that the value of Nusselt number is higher for 5cm pitch tube in comparison to two other tube. The CHTC Value for plain tube was found 7.11, for 10cm pitch tube 7.33 and for 5cm pitch tube it was 7.25. But in the average case it was found that the value of CHTC is higher for 5cm pitch tube in comparison to the other two.

VI. CONCLUSION

I.The Nu number value and convective heat transfer coefficient was increasing for some time and after which decreases, the maximum value is obtained at 12.45hours in all the three cases.

II.from the graph it could be say that the Nusselt number and CHTC for baffled tube with 5cm pitch tube is higher in comparison to other tubes.

III.With increasing temperature the turbulence of the fluid increases that's why CHTC and Nu number increases.

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