Vol.2 Issue.1, January 2014. Pgs: 147-152

ISSN (ONLINE): 2321-3051

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

UNIFORM VELOCITY SOLAR HEATER

Mubeen. N , Prawinn Kumar. R , Ranjith. R , Sanjay Kumar. V

Mechanical engineering, Bannari Amman Institute of Technology, sathyamangalam,Erode dist-638401,TN,India. *mubeen.manil@gmail.com , r.prawinnkumar@gmail.com , ranjithr312@gmail.com , skp.sanjayyadav@gmail.com*

Abstract

Solar water heater plays a vital role in energy conservation. Because of its efficiency is more than the electric conversion. It has become the well proven and established appliance for providing hot water requirements in thousands of families in India. Solar water heating is a very simple and efficient way to grab energy from the sun and use it. In spite of its low efficiency it occupies a respectful place among the energy users. Therefore any improvement in the construction and operation of solar water heating system would definitely result in saving conventional fuel and cost. The objective of this project is to create uniform velocity in solar water system by using variable header. The solar water heater is designed with a larger diameter of the header is 5.08 cm and smaller diameter of 2.54 cm with the length of 100 cm. The existing solar water heating systems the overall thermal performance reduces due to non-uniform flow in riser tubes. The overall thermal performance and efficiency is higher in variable header system due to uniform velocity. The experimental results are analyzed with CFD analysis software and the results are compared with the existing solar water heating system.

***Keywords*:** Variable header; Solar water heating; riser tubes; CFD.

1. INTRODUCTION

Solar water heater is a devise which is used to heat the water. Solar water heater plays a role in energy conservation. Solar water heaters are characterized by its thermal performance that depends on the transmittance, absorption and conduction of solar energy and the conductivity of the working fluid. Because its efficiency is more than the electric conversion. In conventional solar water heating system, the water flows in laminar regime. a Solar radiation is the heat input to the collector; water is used as the working fluid. The overall thermal performance and efficiency is higher in variable header due to uniform velocity one of the biggest uses of electricity, gas and oil is the heating of water home, and in offices, schools and hospitals etc. Solar water heating is a very simple and efficient way to grab energy from the sun and use it. Solar water heaters concentrate diffused solar radiation into thermal energy [1] .

Hot water plays a vital role in human society. It is used for various applications in the day-to-day human life. The utility of hot water in India covers various applications which can be categorized under three main sectors, viz., and domestic, commercial and industrial. It is used for many applications like bathing, washing and drinking in flats, bungalows and apartments under the domestic sector. Solar water heating system with capacity of 50 to 100 liters per day has been installed in more than 30,000 homes throughout India[2].Larger

solar water heating systems are used in restaurants, canteens, guest houses, hotels, hospitals, hotels and dormitories under commercial sector. Similarly, water heating systems are used in process, dyeing, food industries and in thermal power plants for pre-heating the boiler feed water. The requirement of hot water per day for industrial and commercial sector is around 2, 40,000 liters. The overall installed capacity of thermal collectors in India is capable of producing around 25 million
liters of hot water per day at 60-70^{0}c [3].

Fig.1 shows the installed capacity of solar collectors till 2007. This figure clearly shows the ever increasing demand for hot water in India. The installed area of solar collectors in India is around 2.15 million square meters as on December 2007. The Government of India promotes the commercialization of solar collectors every year and they have approved 47 manufactures to produce these collectors based on the norms of the Bureau of Indian Standards [4].

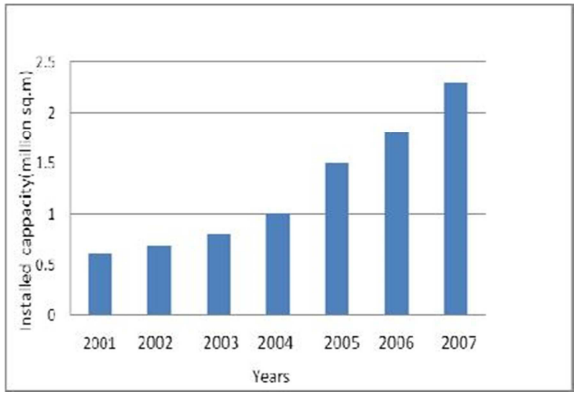

Fig.1 Installed capacity of solar collectors in India

II. LITERATURE REVIEW

Solar water heaters are characterized by its thermal performance that depends on the transmittance, absorption and conduction of solar energy and the conductivity of the working fluid. The absorber plate in a solar water heater plays a major role in the performance of solar water heaters. Plate efficiency factor (F') and heat removal factor (Fr) are the important design parameters in the fabrication of solar collector systems. It has been analyzed by Hottle and Woertz [5] and later redefined by Whiller [6] and then by Hottle and Whiller [7] which significantly reduced the empiricism associated in the design of solar collectors. Further, Bliss [8] proposed the mathematical derivations for several efficiency factors for various types of collectors, together with graphical data. Similarly, the collector efficiency and loss factors in solar air heaters have been analyzed mathematically by Parker [9] and the equations developed. These equations enable the designers to predict the collector performance for a selected flow rate and environmental conditions. Thermal performance of collector is also dependent upon the optical efficiency of glass cover, design and thermal properties of the absorber plate. The maximum energy conversion of absorber plate by the use of selective coatings that reduces the radiative losses has been analyzed by many researchers [10-12]. Further, the effect of thermal conductivity of the absorber plate has been studied through the transient simulation system (TRNSYS) by Shariah et al. [13] and they confirmed that the characteristic factors like fin efficiency factor, collector efficiency factor and heat removal factor are strongly dependent on the thermal conductivity of absorber plate.

Cost accounted for fabrication of solar water heater is one the major factor in economic analysis. Charisa [14] carried out experiments to design and develop a low cost solar water heating system using cement concrete. The temperature of hot water obtained in this study varied from 36 degree C to 58 degree C. This type of collectors are very useful for low temperature house hold applications. This can be used by architects for designing the roof of the building which may serve as a low cost solar collector to provide hot water at moderate temperature in buildings for meeting various purposes during daytime. Variable header is used as

Vol.2 Issue.1,
January 2014.
Pgs: 147-152

one of the passive techniques to augment heat transfer. It is widely used in heat exchangers but their applications in solar water heaters are limited. In conventional thermosyphon solar water heating system uniform header used in which the velocity is unequal ie.non uniform flow. Here the overall thermal performance is reduced.

III. EXPERIMENTAL SETUP

The uniform and variable header system as shown in Fig.2 and Fig.3.The cross sectional variation for the bottom header is from 2inchs to 1inchs. The decreasing cross sectional area increase velocity and hence is expected to compensate the effect of variation in mass flow rate at the inlet of different risers. The top header is fabricated in the reverse 1inch to 2inch at the exit, and the overall length of collector remains the same 1metre. Top and bottom headers are fabricated using copper as material of construction.

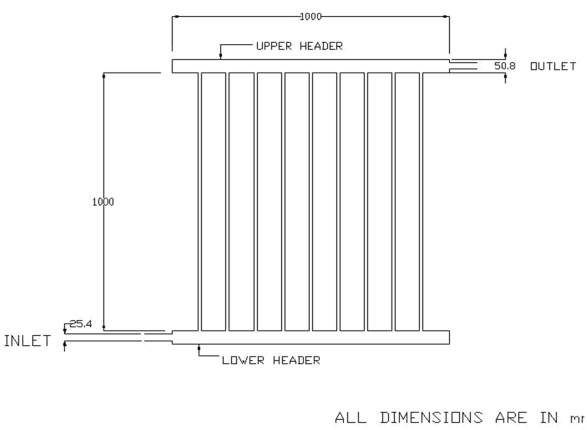

Fig.2 Uniform header system

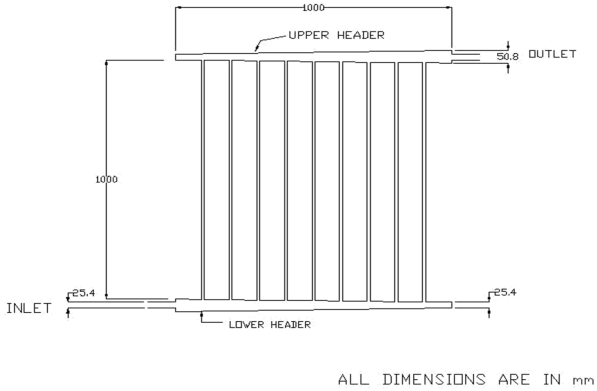

Fig.3 Variable header solar water heating system

IV. EXPERIMENTATION

The transparent model as given in Fig.2and Fig.3. It's are tilted at an angle of 10 with horizontal. The syringe with dye (blue color ink) and attached with needle is fixed at the center of each riser . The flow rate of water is fixed at 10.5cc/s. After the flow is stabilized, the dye is injection ink the first riser gently. The flow path of a single stream of dye is followed for a distance of 20cm. This is repeated many times to get the concordant values and this is averaged to get the maximum velocity at the center. Similar way the velocities at the other risers are also found. The experiment is repeated for the other flow rates of water such as 14, 18, 29.2 and 39cc/s. Table gives the experimental data and mass fraction at individual risers. The tilt angle of the model is varied from 22 to 15 with horizontal and the experiments are carried out at the water flow rates of 10.2, 14, 18, 29.3 and 39.3cc/s .

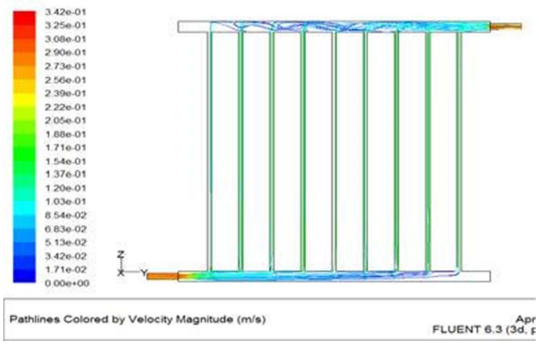

Fig.4 Uniform header system Simulation

Vol.2 Issue.1,
January 2014.
Pgs: 147-152

V. SIMULATION ANALYSIS

The above observations are transferred in CFD simulation with the following parameters Analyze the velocity of the both normal and variable header systems

Justify the uniform velocity of riser tubes in solar water heater.
Analysis of both normal and variable header through CFD software.

Both normal and variable header solar water heaters are can be analyzed to know about the thermal performance of them. Also the velocities of both normal and variable header are to be
compared in CFD software, through this analysis we can justify the overall thermal performance of the variable header solar water heating systems.

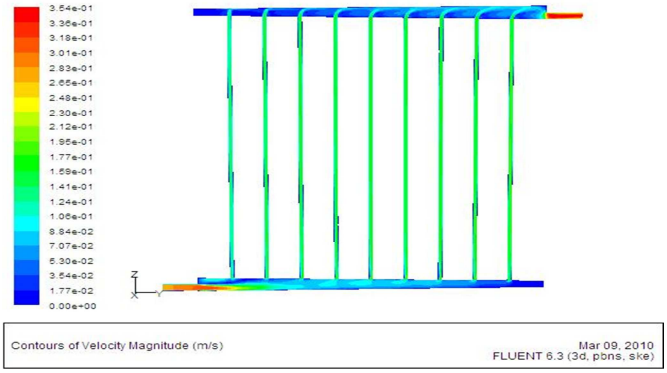

Fig.5 Variable header system

VI. RESULTS AND DISCUSSION

Fig.4 and Fig.5 shows the velocity distribution for uniform and variable header collector. From the above Figs in variable header the fluid velocity is at most uniform in all riser tubes.

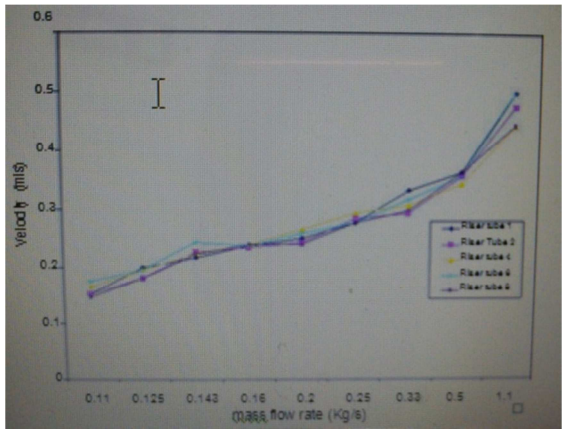

Fig.6 Fluid velocity various riser tubes (Experimental)

It is clear in Fig.6 explains that the velocity of all riser tubes are equal. Hence the flow distribution is even.

VII. CONCLUSION

The solar water heating system is analyzed in both simulation and experimentation carried out in identical conditions for both uniform header and variable header systems. Data recorded continuously. The velocity difference and efficiency of variable header solar water heater system is than conventional one.

The experimental velocity and simulated velocity of variable header systems compared and the results are discussed in detailed manner. Results proved that the overall velocity is uniform in Variable header systems

VIII. REFERENCES

[1] OPET-TERI, HECOPET, Status of Solar Thermal Technologies and Markets in India and Europe,Department for the Promotion of Energy Technologies, Greece, 2001,pp 1-21

[2] P.Meisen, E.Queneudec,Overview of Renewable Energy Potential of India, 2006,pp 1-20 A. Chandra, A.K.Raghav, S.P.Raghuvanshi, Carbon dioxide emissions from coal based power generation in India, energy. Converse. Manage. 2006, pp. 427-441.

[3] http://www.indianmba.com,2008.

[4] H.C. Hottel, B.B. Woertz, the performance of flat-plate solar heat collectors, Trans. Am. Soc. Mech. Engrs. 1942, pp. 91-104.

[5] A. Whiller, Solar energy collection and its utilization for house heating, Sc.D. Thesis, Dept. of Mechanical engineering, Massachusetts Institute of Technology, 1953.

[6] H.C. Hottle, A. Whiller, Evaluation of flat-plate solar collector performance, Trans.of conference on the use of Solar Energy, University of Arizona, 1958, pp. 74-104.

[7] W.R. Bliss, The derivations of several plate-efficiency factors useful in the design of flat-plate solar heat collectors, sol. Energy,1959, pp. 55-64.

[8] B.F. Parker, Derivation of efficiency and loss factors for solar air heaters, Sol. Energy,1981, pp. 27-32.

[9] M.G. Hutchins, Spectrally selective solar absorber coatings, Apply. Energy. 1979, pp. 251-326.

[10] C.M. Lambert, coatings for enhanced photo thermal energy collections, 2nd non-selective and energy control films, Sol. Energy. Mat. Sol. C.I 1979.

[11] J.L. Cost worth, K. Raghunathan, development of selective surfaces, USA Department of energy Contract no. DE-AC04-78CS-34293, technical progress report, 1980.

[12] A.M. Sharma, A. Rousan, KHz. K. Rousan, A.A. Ahmed, effect of thermal conductivity of absorber plate on the performance of a solar water heater, Apply. Thermo. Eng. 1999, pp. 733-741.

[13] P.B.L.Chaurasia, solar water heaters based on concrete collectors, Energy J. 2000, pp. 703-716.

IX. A BRIEF AUTHOR BIOGRAPHY

Mubeen. N - The author is currently pursuing his Final Year B.E. Mechanical Engineering in Bannari Amman Institute of Technology and is currently doing his Intern in FORD, Chennai. His passion towards Mechanical Engineering is shown by the numerous projects, that he has done. His main projects include " Retractable Impact Absorbing Steering" & "Mulberry Stick Cutter" fetching him several awards including Ist Prize in the "CII Innovators Award 2013".The author has also published many journals and is currently preparing for his Higher Studies Abroad.

Prawinn Kumar. R - The author is currently doing his third year B.E. Mechanical Engineering in Bannari Amman Institute of Technology. Owing to his passion towards to Mechanical Engineering and Automobile

field, the author has done many projects in the same field, listing a few- "Safety Ignition System for Automotives" & "Eco Friendly Delta shaped three wheeler powered by BLDC Motor". The author has also won Numerous awards, listing a few - "Special Jury Award" in the CII Innovators Award 2013 and a finalist in the Next Big Idea 2013, held at IIM, Bangalore and in "Indian Innovation Initiative", held at IIT, Chennai . The author has also published many journals, listing a few - "Conversion of Scrap Tires into Carbon Black" & "Design, Analysis and Manufacturing of Tadpole Shaped Hybrid Three Wheeler". The Author, in the pursuit of doing his Higher Studies abroad, can speak, learn and write English, Hindi and German.

Ranjith. R - The author is currently pursuing his final year of Mechanical Engineering in Bannari Amman Institute of Technology, Sathyamangalam.

Sanjay Kumar. V - The author is currently pursuing his final year of Mechanical Engineering in Bannari Amman Institute of Technology, Sathyamangalam.