IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Numerical Study on Solar Water Heater using CFD Analysis

S.Eswaran[*1],M.Chandru[2],M.Vairavel[3], R.Girimurugan[4]
[*1]Assistant professor, Department of Mechanical Engineering,Nandha Engineering College, Erode, India
[2,3,4]Department of Mechanical Engineering, Nandha Engineering College, Anna University, India
eswaranlecturer @gmail.com

Abstract

Solar water heater plays an important role in energy conservation. Because of its efficiency is comparatively more than the electrical energy conversion. It has become the well proven and established appliance for providing hot water requirements in lacks of families in India. Solar water heater is a very simple device and efficient way to absorb energy from the sun rays and use it. Therefore improvement in their operating condition & geometrical would definitely result in saving conventional fuel and cost. The objective of this study is to validate the mass flow rate of water inside the collector tube in an ado-ekidi natural circulation solar water heater system. The existing solar water heating systems the optimum mass flow rate is 0.1 kg / m2 .The numerical analysis is carried out with CFD software and the results shows maximum mass flow rate inside the collector
tube is 0.6 kg / m2 ,dynamic pressure of 4.30×105 Pa , flow velocity of 5.91×105 l/m2 & relative temperature of 360° K.

Keywords - Ado-Ekidi, CFD, mass flow rate, solar water heater, uniform flow.

Introduction

According to [1] a solar water heater (SWH) is an environmentally friendly device which absorbs free and renewable solar energy to reduce hot water, economically, reducing the use of conventional energy such as electricity by up to 80%. The solar hot water system produces hot water of 50°C to 70°C depending upon the season, location, solar intensity and number of solar collector panels. According to [2] 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. According to[2] Solar water heating system with capacity of 50 to 100 liters per day has been installed in more than 30,000 homes throughout India the requirement of hot water per day for
industrial and commercial sector is around 2, 40,000 liters. According to [2] 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°C.In this study the already existing solar water heater panel model has reengineered and the new model has been created by using solid works software. Finally the whole assembly is imported to ANSYS FLUENT software and the mass flow rate inside the collector tube is calculated numerically by using it.

Methodology

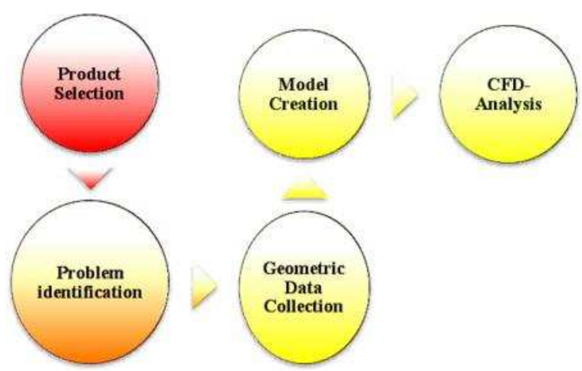

Fig.1 Methodology of this study

Methodologies of this study starts with the product selection (ado-ekidi solar water heater) and continue with problem identification it refers to the problem in mass flow rate inside the collector tube then collection of geometric data from an already existing solar water heater systems (ado-ekidi) and goes to creation of model using solid works software finally it ends with the CFD analysis to optimize the mass flow rate.

ISSN: 2277-9655
Impact Factor: 1.852

Existing Models

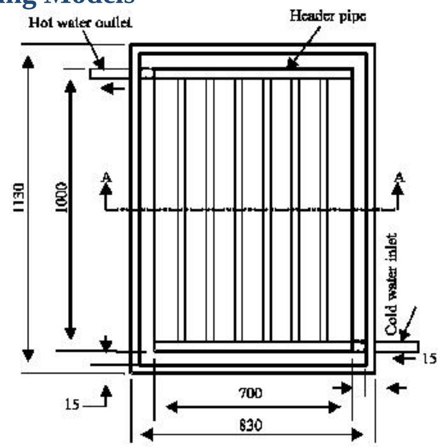

Fig.2 Flat –plate solar collector with water pipes obtained from [3]

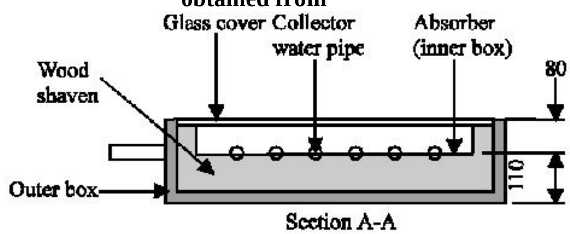

Fig.3 Section at A-A obtained from [3]

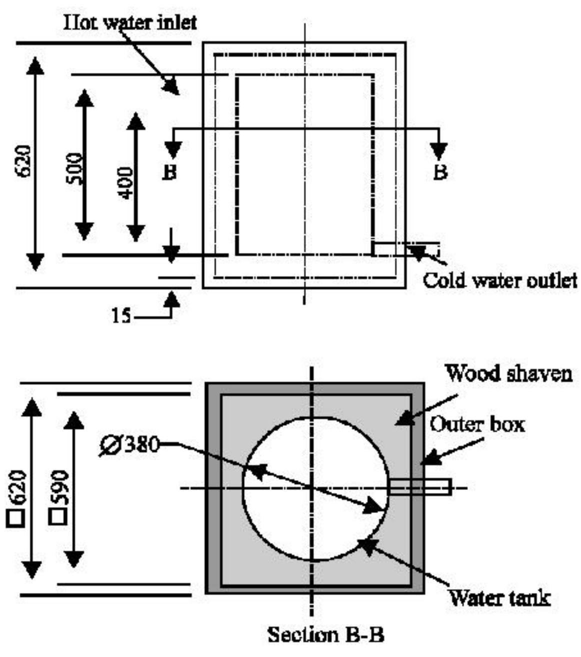

Fig.4 Storage tank obtained from [3]

The above geometric models are obtained from [3] and the help of these geometric models the following models has been created by using solid works software to get the maximum mass flow rate inside the collector tube.

Three Dimensional Model

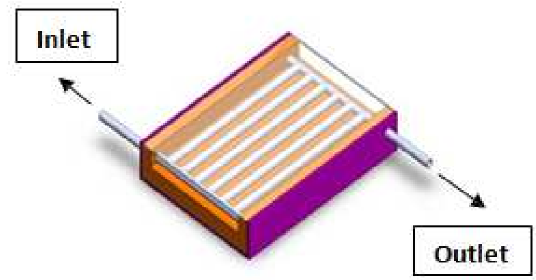

Fig.5 3D Model

The above three dimensional model of solar water heater panel was created by solid works software. Over all dimensions of this panel is same as obtained from [3]

Problem Identification

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.

Optimization of Mass Flow Rate

In this paper mass flow rate of water is optimized with respect to the total relative temperature at constant level (360 K) by using ANSYS 14.5/CFD.Turbulance flow is selected for this optimization and K-ϵ solving equation is governed with the help of first order equation.

CFD Analysis

CFD analysis is carried out to optimize the mass flow rate of water inside the collector tube by means of the following steps.

1) Model creation

We have already discussed about the three dimensional model creations. Created model is imported to ANSYS.

2) Mesh generation

After importing the three dimensional model, the imported model is meshed with help of mesh options. Meshed model is shown in Fig.5

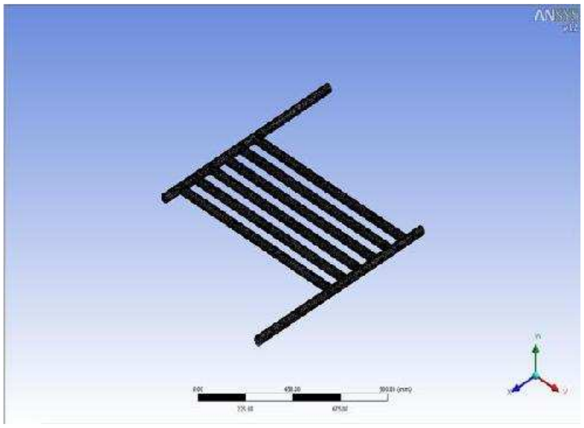

Fig.5 Mesh model

3) Applying boundary condition

After mesh generation boundary conditions are given to this system. In this solar water heater there are two boundary conditions well defined. (Inlet & Outlet).

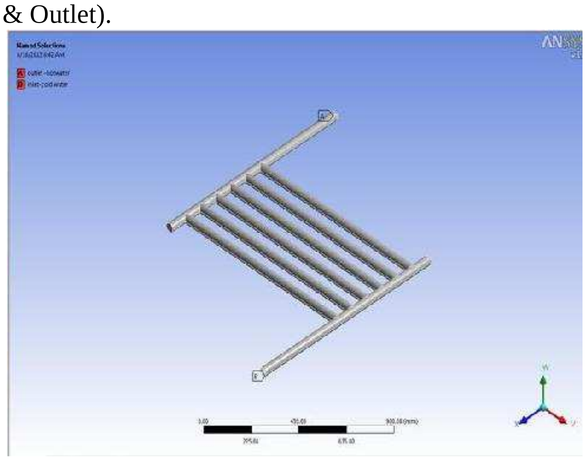

Fig. 6 Boundary conditions

4) Initialization

The solver functioning areas its initialization values in constant mass flow rate 300 k ,pressure distribution analysis insert 1bar ,velocity magnitude 0.6m/s its initialized it.

5) Solution converged plot

In solver stage optimum results computed with the solution converged plot. Fig.7 shows the solution converged plot which is taken from ANSYS/CFD. If optimum result reached at that time the above mentioned solution converged plot is appeared.

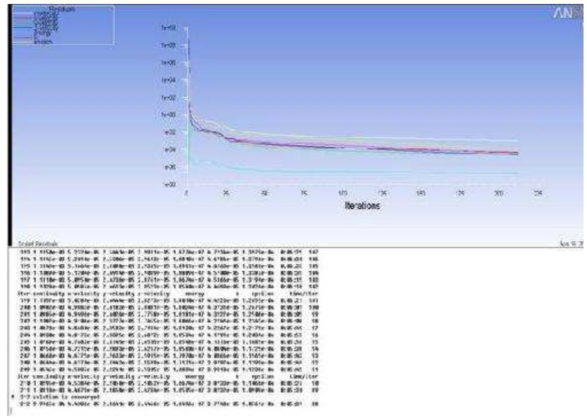

Fig.7 Solution converged plot

Results

In table 1 computed result are tabulated at different mass flow rate. These values are obtained from ANSYS/CFD. Mass flow rate is optimized keep with the total temperature is constant

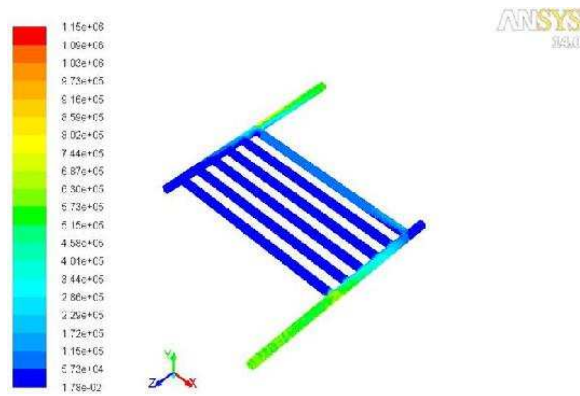

Fig.8 Contour plot of dynamic pressure

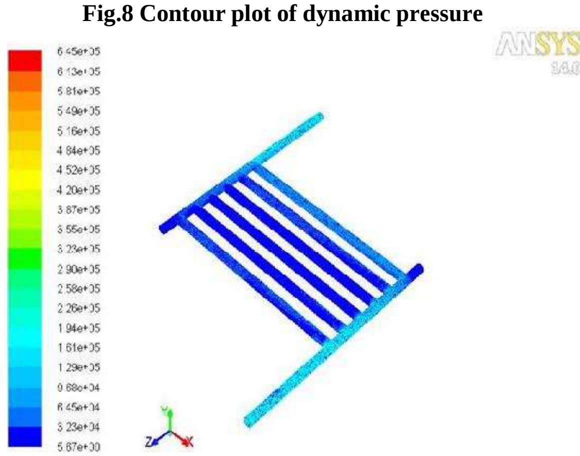

Fig.8 Contour plot of flow velocity

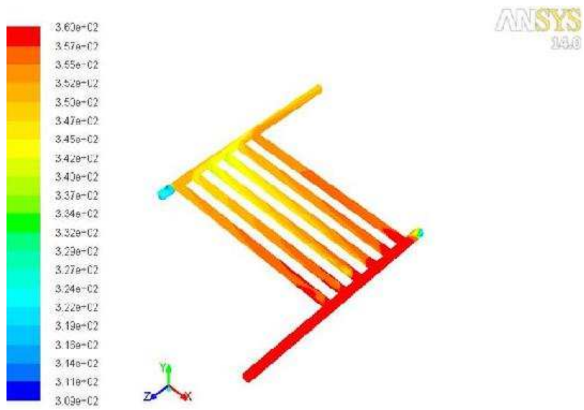

Fig.9 Contour plot of total temperature

Table 1 Effect of mass flow rate at different pressure and velocity

Mass flow rate (kg / m^2)	Dynamic Pressure (Pascal)	Flow Velocity (1 / m^2)	Total relative temperature (K)
0.3	1.15×10^5	6.45×10^5	360
0.4	2.04×10^5	1.83×10^3	360
0.5	2.99×10^5	2.28×10^3	360
0.6	4.30×10^5	5.91×10^5	360
0.7	6.28×10^5	3.20×10^5	360

1) Mass flow rate Vs Dynamic pressure

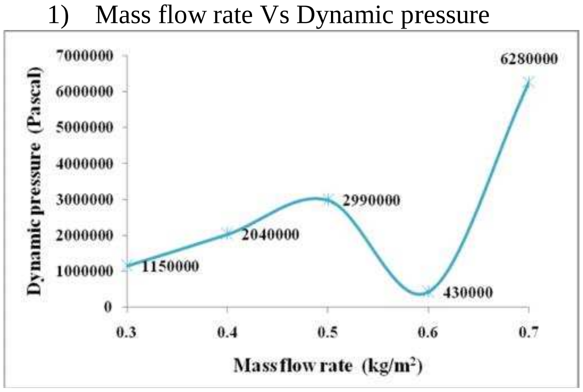

Fig.10 Effect of mass flow rate at different dynamic pressure condition

2) Mass flow rate Vs Flow velocity

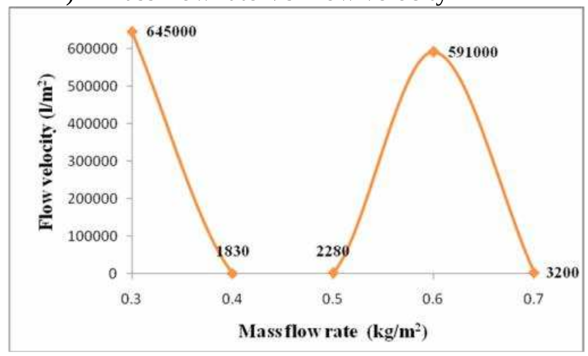

Fig.11 Effect of mass flow rate at different velocity level

3) Mass flow rate Vs Total temperature

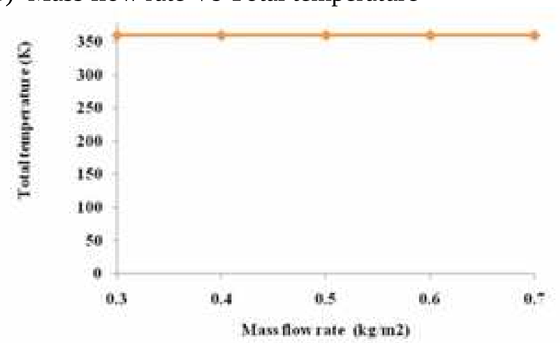

Fig.12 Effect of mass flow rate at total temperature

Discussion

1) Mass flow rate Vs Dynamic pressure

Fig.8 shows clearly increasing mass flow rate causes the increased value of dynamic pressure. Maximum dynamic pressure of 4.30×10^5 Pa has been obtained at the mass flow rate of 0.6 kg / m^2.

2) Mass flow rate Vs Flow velocity

Fig.9 shows the effect of velocity of water flow at different mass flow rates. At the mass flow rate value of 0.3 kg / m^2 initial flow velocity of water is high then its velocity suddenly gets the drastic changes at mass flow rate of 0.4 &

0.5 kg / m^2 again the flow velocity suddenly increased at the mass flow rate of 0.6 kg / m^2.Finally the maximum velocity can be obtained at the mass flow rate of 0.6 kg / m^2.

Summary

In this study numerical analysis is carried out in reengineered Ado-Ekidi solar water heater by using CFD software. Results show that maximum mass flow rate is achieved more than experimental values. At the mass flow rate of 0.6

ISSN: 2277-9655
Impact Factor: 1.852

kg / m^2 maximum velocity has been obtained 5.91 $\times 10^5$ l / m^2.The simulated velocity at the different mass flow rate compared and the results are discussed in detailed manner. Results proved that the maximum mass flow rate of these systems can be obtained up to 0.6 kg / m^2.

References

[1] *G.N. Okonkwo and A.O.C. Nwokoye, Experimental Investigation and Performance Analysis of Thermosyphon Solar Water, Advances in Natural and Applied Sciences, 6 (2), 2012, 128- 137.*

[2] *Jaisankar Subramanian, Senthilkumar Tamilkozhndu, and Thulasi Selvam, Experimental Studies on Variable Header Solar Water Heating System: Proc. 2nd International Conference on Mechanical, Production and Automobile Engineering , Singapore, April 28-29, 2012,258- 261.*

[3] *Bucola.O.Bolaji, Flow design & collector performance of natural circulation solar water heater, Journal of Engineering & applied Sciences 1(1), 2006, 7-13.*