International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 6, Nov-Dec-2021, ISSN (Online): 2395-566X

Investigation Of Solar Water Heater Designed Model Using CFD Fluent

KonarkTripathi, Asst.Prof. Deepak Solanki
Astral Institute Of Technology and Research,
Indore, MP,India

Abstract- Non-renewable energy sources are useful in a crisis situation, when there are problems with energy consumption and the environment. At first, the usage of solar energy was restricted, as was the choice to use it. And this is meant to be a breakthrough in the way that technology interacts with nature, as well as a fresh way to use renewable energy and to make it the main energy source in the future. This project's goal is to use computational fluid dynamics (CFD) models of various tubes to compare heating methods for solar water heaters. There are three kinds of design for tube form water heaters such straight, 'S' pattern, and 'U' pattern; the first one has water flow in a straight line, the second has the water moving in a 'S' shape, and the third has water moving in a 'U' shape. When testing the design, we gathered information on how well it would work. the findings were compared to the CFD results.

Keywords- Solarwater heater, solar energy, CFD, solar radiation, renewable energy.

I.INTRODUCTION

Solar energy is the most capable alternative energy source. With the rising cost of fossil fuels such as gas and oil, as well as increasing demand for energy, solar power is regarded as a viable alternative for heating water in both homes and businesses. Water heating accounts for about 20% of a normal family's total energy use. Because solar water heating systems are the cheapest and most accessible alternative for hot water, many households are using renewable energy by installing them. A solar heater is a device that uses solar energy to warm water for use in residential and commercial water heating. Solar energy is the infinite radiation emitted by the sun, which is converted to heat when it strikes a certain surface. This kind of thermal collector loses heat due to convection and radiation. As the working fluid heats up, the amount of fluid lost increases considerably. Thermal efficiency, which is influenced by transmittance, absorption, conduction, and working fluid conductivity, is often used to evaluate solar water heaters. The absorber plate is critical to the operation of a solar water heater.

1. Computational Fluid Dynamics And Software

The Ansys programme is used to model and design the solar water heater, and to conduct the thermal analysis of the system. The corporation has offices in Canonsburg, Pennsylvania, and is traded publicly. Engineering simulation software is its business: it creates and markets it. A wide range of simulations is run using Ansys software, including tests of product strength, temperature distributions, fluid flows, and electromagnetic characteristics. Computational fluid dynamics was created in order to estimate the performance and flow system parameters. The ultimate achievement is getting a handle on a system and deducing how to analyse its elements; the details of what are called "cells" and how they make up the whole have to be figured out in order to really have a full understanding of what's going on. Mesh creation describes the process of breaking down the system domain into volumes or regions. To increase the complexity of a system, one may increase the number of cells in a mesh, but the exact amount depends on the levels of precision, as well as how complicated the design is. Equations help with pressure, heat fluxes, and temperatures, as well as flow velocities and energy.

II.MODELLING

The gadget is simple, but it is also effective. One should not build a gadget that just has basic mechanics. Easy designs work well, too. The solar boiler, like the solar cooker, has merely a physical similarity and not a functional one. It is made out of a curved, polished half-shell. The tubes are designed to concentrate the light in a tiny region on the tube's concave surface, and thus quickens the temperature rise. To raise the radiation levels, clear glass is put over the casing, to keep out any other elements while protecting against convection. The metallic casing is completely covered in black powder, which soaks up the heat.

Table 1: Dimensions and material of Solar water heater models

Sizes of Tubes	Sizes of Heater Body	Detail	Tube Pattern Characteristics
Outside Diameter = 30 mm	L = 900 mm	side Frame = Wooden	Straight
Inside dia = 26 mm	W= 300 mm	base platter (Absorbent Plate) = Aluminium	'U'
	H= 50 mm	top surface = Glass	'S'
Water flow = 0.05 Kg/S			

1. Tubular Heat Exchangers

The shape of the exchangers varies, but they tend to be made up of circular tubes, which are found in a variety of shapes such as elliptical, rectangular, or flat/twisted tubes. Because the structure's core shape can be adjusted by altering the tube diameter, length, and placement, there is a lot of design leeway. For very high-pressure applications, special tubing may be used to construct the exchanger. In liquid-to-liquid and liquid-to-phase change (condensing or evaporating) heat transfer applications, tubular exchangers are widely utilised. They are used for transferring heat between gases in situations where the working temperature and/or pressure is extremely high, and when the fluid with the fouling issue has to be sent through several steps. Exchangers such as shell and tube, double-pipe, and spiral tube exchangers may be grouped together. They're all main exchangers, save for surface exchangers with or without internal/external tubes.

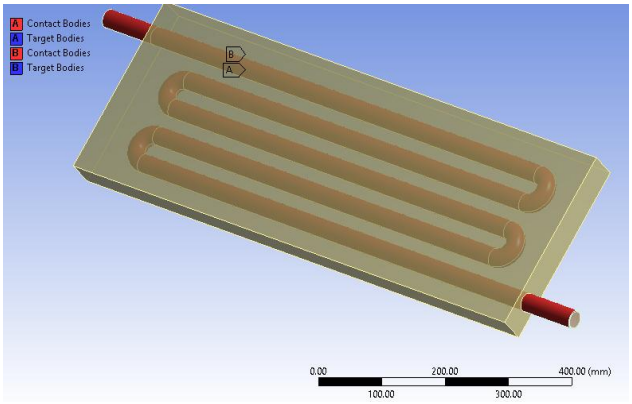

Figure 1:Solar Heat Exchanger.

Shell-and-Tube Units This exchanger consists of many rounds of cylindrical tubing, all of which are aligned along the shell. Inside the tubes, one liquid is travelling. Outside the tubes, another liquid moves in various directions. Tube bundles, shell, frontend head, rear-end head, buffers, and tube sheets are a few of the important parts that are detailed further in this chapter.

2. Design Of Solar Water Heater In Ansys

A structural evaluation using ANSYS Workbench V.14.0 was completed to carry out finite element analysis of the solar water models, since solar water arrangements provide an improved temperature and heat transmission to the water through tubes. At this stage, a steady state thermal study is conducted on the solar water heater models. To modify the material composition of the solar water models, layering aluminium material. The ANSYS Workbench design programme was used to construct the design of the solar water models.

Table 1: Dimensions and material of Solar water heater models

Dimensions of Tubes	Dimensions of Heater Body	Materials Detail	Types of Tube Pattern
Outer Diameter = 30mm	Length = 900mm	Heater side Body = Wooden	Straight Tube
Inner diameter = 26mm	Width = 300mm	Heater base plate (Absorbent Plate) = Aluminium	'U' pattern Tube
	Height = 50mm	Heater top Face = Glass	'S' Pattern Tube
Fluid used = water			
Inlet Temperature of water = 27°C			
Mass flow rate = 0.05 Kg/Sec at Inlet			

Experimental tests of solar water heater models are performed through ANSYS, a software partner to engineering simulation, supplying an entire organisation of engineering simulation solutions. The software provides physics-based engineering simulation techniques and is equipped to be used in various areas of thermal engineering. It is fully able to help a design method achieve an engineering simulation objective. The software programme provide utilises its hardware to place a digital product through a testing method, such as going over various temperature level circumstances to examine several solar water heater styles before turning into a comprehensive product.

III.RESULTS AND DISCUSSIONS

Using the ANSYS 14.0, Workbench structural modeller to create solar water heater geometry as well as to aid in future investigations. Geometry offers a module to help with planar symmetry. The tube side of this solar water heater is split into one input and one output, providing three kinds of designs for solar water heater tubes. Run a thermal simulation after designing the model. The effects that were overcome were all carefully examined under normal conditions. Three different tube designs are shown here in the image of a solar water heater in Ansys CFDs.

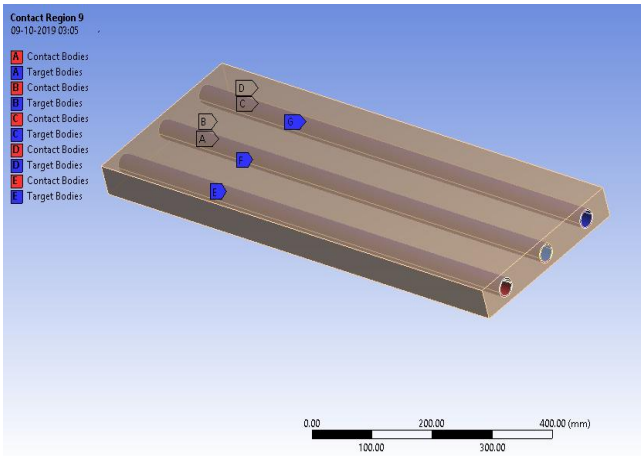

Figure 2: Solar water heater with straight tubes

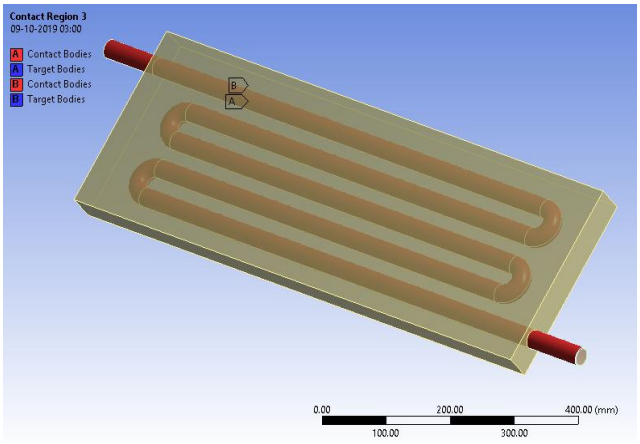

Figure 3: S Pattern pipe flow in solar water heater

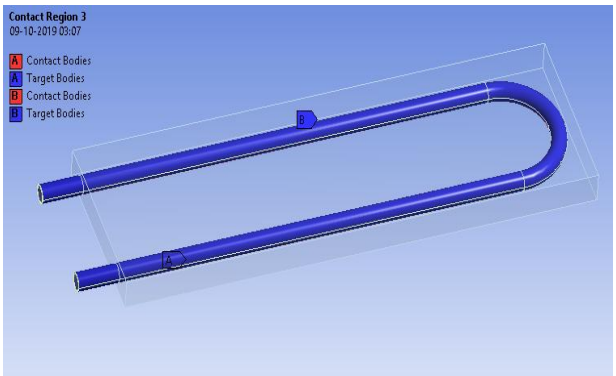

Figure 4: helical pipe flow tube solar water heater

As per CFD analysis of All three models of solar water heater with the variations in tubes we found the inlet outlet temperatures.

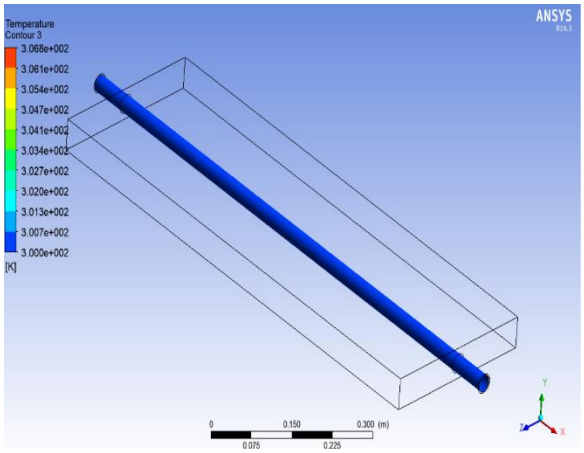

Figure 5: Parallel pipe flow temperature

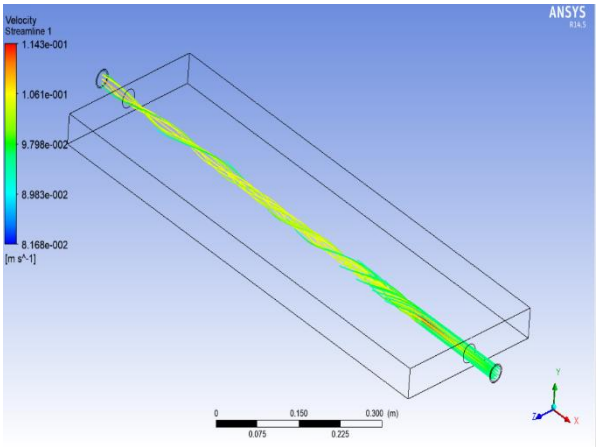

Figure 6: velocity in parallel pipe flow

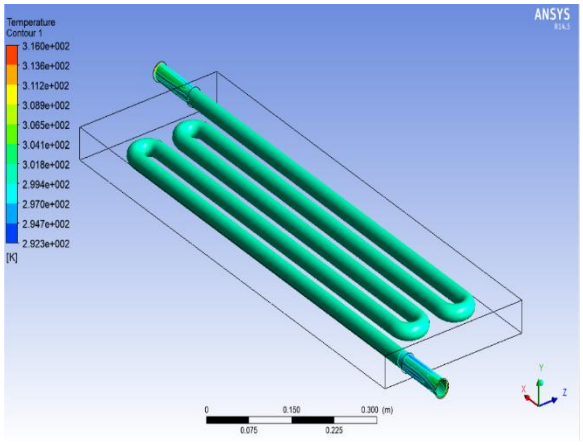

Figure 8:velocity inS Pattern pipe flow

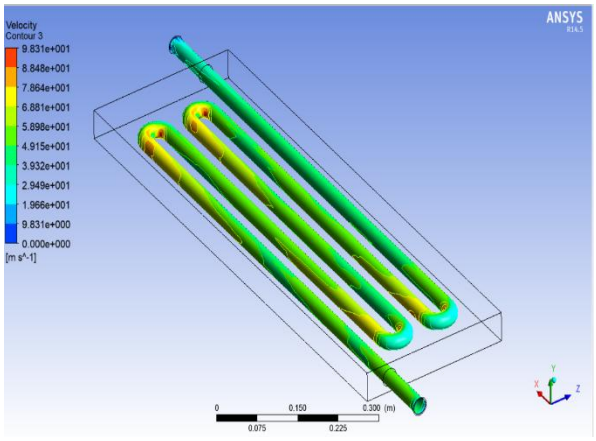

Figure 7: S Pattern pipe flow temperature

In this study of solar water heater designs are taken into consideration case 1 solar water heater designed with straight tube. In case 2 solar water heater designed with 'S' Pattern type flow tube. In case 3 solar water heater designed with 'U' pattern. For solar water heater at inlet temperature of water is 27°C and 'S' pattern type tubes pass in the box. Water flow through the tube and water outlet temperaturesmeasured.

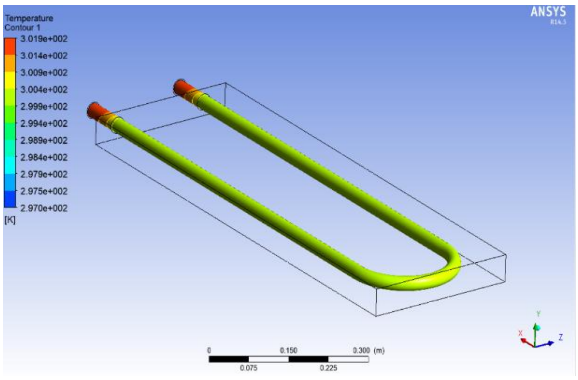

Figure 9: U pattern Pipe flow temperature

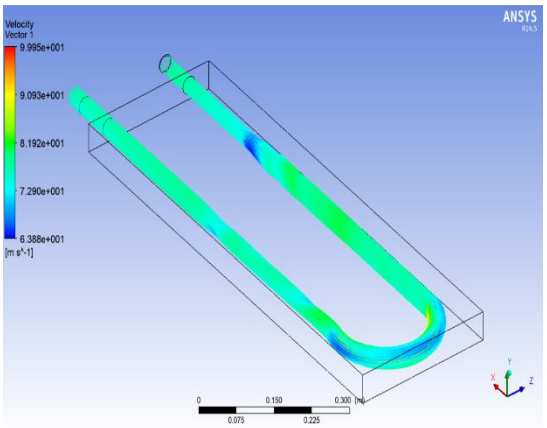

Figure 10: velocity in U pattern Pipe flow

As per study figure shows the variations of temperature difference. In above study three types of solar water heater designed by using ANSYS. Different types of tube used in solar water heater i.e. straight tubes, 'S' pattern tubes, and 'U' pattern tubes. After designing water inlet temperature given 27°C and water temperature given at outlet is 35.5°C in 'S' pattern tubes. as per CFD analysis heat absorb by solar water heater from sun radiation and results optimized.

Table 1: water temperatures at inlet and outlet

Pattern of Tubes	Water inlet Temp. (°C)	Water outlet Temp. (°C)
Straight tubes	27	33
'S' pattern tubes	27	35.5
'U' pattern tubes	27	29.22

Table 2: Pressure and velocity at outlets

Results	Max Pressure (Pa)	Max Velocity (m/s)
Straight tubes	13.24	0.114
S Pattern tubes	59.62	1.42
U Pattern Tubes	22.25	0.127

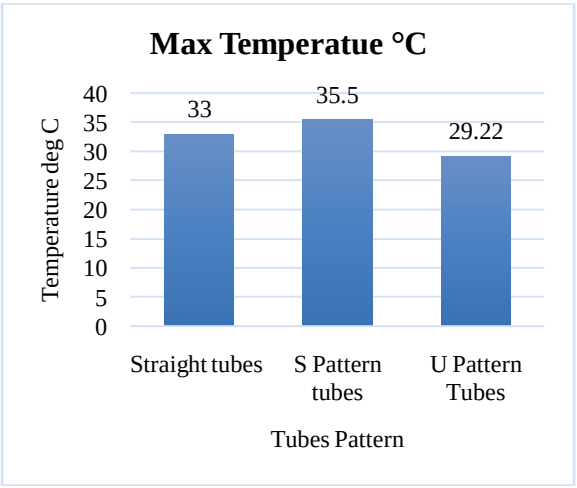

Figure 11 Temperature Variations in solar water heaer

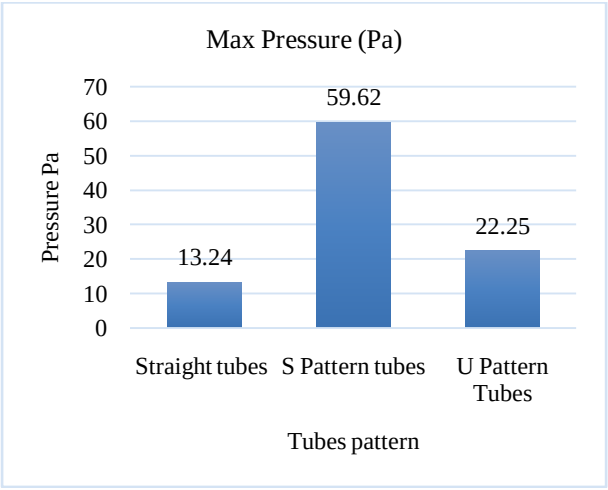

Figure 12: Pressure Variations in solar water heater

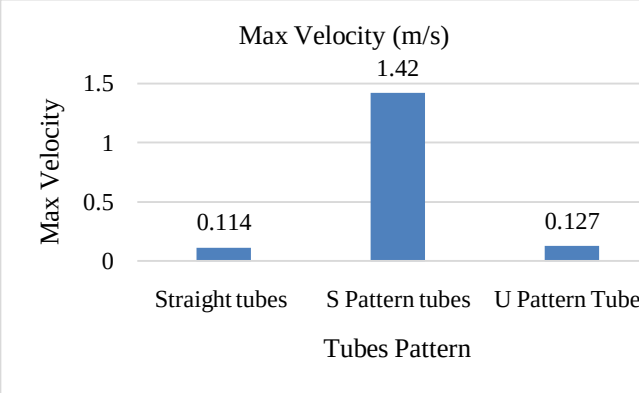

Figure 13: Velocity Variations in solar water heater

VI.CONCLUSION

After conducting a research and consulting Ansys software, we found that the optimum values of temperature variation across the various materials were aluminium for the tubes and glass for the surface. in order to ascertain that there is no heat transmission between the shell and the surroundings Resulted revealed that "S" shape tube results in superior heat transmission compared to other designs. The temperature at the outflow increased by two degrees, going from 27°C to 33°C. The U-tube configuration offers a flow temperature of 29.22°C, whereas the S-tube configuration provides a flow temperature of 35.5°C. We discovered that 'S' and 'U' patterns were both faster than the straight pattern, as shown by this graph. 'S' pattern had a maximum pressure of 1.42 m/s, whereas the speed on a straight tube was 0.114 m/s. So, after looking at these findings, we discovered that the 'S' shaped design of a solar water heater yields more hot water compared to the others. The 'S' pattern is ideal for achieving maximum heat transfer from the water to the air in a solar water heater during the sun's radiation.

REFERENCES

1. Hussein A. Kazem, "Evaluation and analysis of water-based photovoltaic/thermal (PV/T) system", Case Studies in Thermal Engineering, Elsevier, 2019.
2. AbdellahShafieian, Mehdi Khiadani, AtaollahNosrati, "Thermal performance of an evacuated tube heat pipe solar water heatingsystem in cold season", Applied Thermal Engineering, 2019.
3. Aidah M J Mahdi, Khaleel I Abass, Raid S Jawad, "The performance of an effective solar water heater enhancement based on experimental study", World Wide Journal of Multidisciplinary Research and Development, 2018, pp 50-54.
4. RuchiShukla, K.Sumathy, "Recent advances in the solar water heating systems",Renewable and Sustainable Energy Review, 2013.
5. Mohamed Abu Waseem, "Numerical analysis of absorber tube of solar parabolic trough collector with and without insertion by using Ansys Fluent", Journal of Engineering Research and Application, Vol. 8, Issue 12, Dec 2018, pp 01-04.
6. D Prakash, "Thermal analysis of building roof assisted with water heater and insulation material", Indian Academy of Sciences, 2018.
7. S. Sadhishkumar, "Thermal performance of water-in-glass evacuated tube solar Collector with and without phase change material", Indian Journal Sciences, 20(2), 193-201, 2018.
8. Ankit S. Gujrathi, Sachin P. Ingale, Sudhir U. Patil, "Analysis of Parabolic Trough Collector using Ansys Fluent Software", Volume 5, Issue 4 December 2017.
9. Arun K. Raj, K. Dileep, S. Jayaraj, "Solar ETC Type Water Heaters an Analysis Based on CFD Packages", Indian Journal of Science and Technology, Vol 10(15), April 2017.
10. Ganesh K. Badgujar, Sachin Nimbulkar, Rajesh Dahibhate, "Experimental Investigations on Solar Flat Plate Collector by changing Geometry of Fin", Journal of Mechanical Engineering, Vol 2, 2017, Pages 52-62.
11. K. VasudevaKaranth, "CFD Analysis of a Flat Plate Solar Collector for Improvement in Thermal Performance with Geometric Treatment of Absorber Tube", International Journal of Applied Engineering Research, Volume 12, Number 14, 2017, pp. 4415-4421.
12. Mohammed Abdul Junaid, Mohammed Nazimuddin, MohdArifuddin, "Thermal Analysis of Solar Flat Plate Collector Using CFD", International Journal of Engineering Research & Technology, Vol. 6 Issue 04, April-2017.
13. Y. Chaudhary, Bharat Kalamkar, Prashant Patel, "CFD Analysis of Evacuated Tube Heat Pipe Solar Water Heater", International Journal of Latest Technology in Engineering, Management & Applied Science, Volume VI, Issue VS, May 2017.
14. KumavatMukeshManilal, "Design, CFD Analysis and Fabrication of Solar Flat Plate Collector", International Research Journal of Engineering and Technology (IRJET), Volume: 03, Issue: 01, Jan-2016.