

# Design and Optimization of Solar Water Heater Using CFD Analysis

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**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 and geometrical would definitely result in saving conventional fuel and cost. In this project design improvement of solar water heating temperature up to bathing in home and nursing home applications above home temperature and analysis of normal water heater materials stainless steel and solar water heater material such as copper those material strength can be analysis using Coupled-Field Analysis of computational fluid dynamics (CFD) – static structural. Now solar water heater model was created of CATIA V5 and then it was export from CATIA V5 to ANSYS workbench 13.0. The solution of general problem by finite element method always follows an orderly step-by-step process. Finally compared analysis results with electric water heater materials and solar water heater materials.

**Index Terms-** ANSYS 13.0, solar water heater, CFD – static structural, stainless steel, Copper.

## 1. INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more Fluids, between a solid surface and a Fluid, or between solid particulates and a Fluid, at different temperatures and in thermal contact. Typical applications involve transferring of heat from one Fluid at higher temperature to another Fluid at lower temperature. In many heat exchangers, the Fluids are separated by a heat transfer surface, and ideally they do not mix or leak. Such exchangers are referred to as direct transfer type, or simply recuperate. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold Fluids via thermal energy storage and release through the exchanger surface are referred to as indirect transfer type, or simply regenerators.

## 2. LITERATURE REVIEW

Literature papers are reviewed to see the effect of Different environment, operating, design and Material properties on solar water heaters.

[1] This solar heating experimental apparatus was designing to meet several requirements: 1) the system was to operate using the thermo siphon concept, in which flow through the system was created by density differences in the fluid; 2) to increase the solar energy absorbed by the water and improve the educational value of the project, the solar collector must have the ability to rotate in order to maintain a position

perpendicular to the sun's rays; and 3) the experimental apparatus must be mobile. A prototype of a solar water heating system was constructing and testing. The solar collector rotated as the sun position angle was changing, indicating the functionality of the control system that was design to achieve this task. Experimental measurements indicate that the water in the tank was heated by the solar energy being absorbing by the solar collector. Moreover, the water temperature measurements at different heights in the storage tank show the thermo siphon effect has been attained. Solar water heating utilizing thermo siphon is attractive because it eliminates the need for a circulating pump.

[2] Solar water heater plays an important role in energy conservation. Because of its efficiency was 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 was 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 / m<sup>2</sup>. 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 / m<sup>2</sup>, dynamic

pressure of  $4.30 \times 10^5$  Pa , flow velocity of  $5.91 \times 10^5$  l/m<sup>2</sup> & relative temperature of 360° K

### 3. SPECIFICATION OF THE PROBLEM

The existing solar water heating systems the 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. There are material based get more thermal conductivity.

### 3. SOLAR WATER HEATER

A Solar Water Heater is a device which provides hot water for bathing, Washing, cleaning, etc. using solar energy. It is generally installed at the terrace or where sunlight is available and heats water during day time which is stored in an insulated storage tank for use when required including mornings. A Solar Water Heater comprises of a or an array of solar collectors to collect solar energy and an insulated tank to store hot water. Both are connected to each other. During the day time, water in solar collectors gets heated which is either pumped or flown automatically on thermosyphon principle to the storage tank. Hot water then stored in the tank can be used for various applications.

In this paper of helical tubular water heater based systems. Now design following ideas.

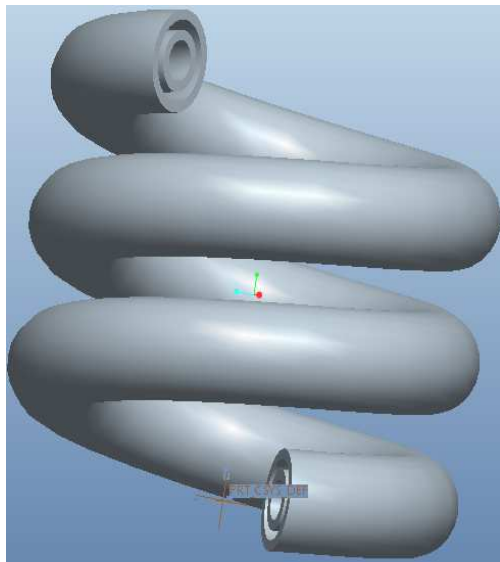


Figure 1: Helical tubular water heaters.

The above geometric models are obtained from thesis and the help of these geometric models the following models has been created by using Pro-E software.

### DESIGN PARAMETERS:

| Description             | Values |
|-------------------------|--------|
| Outer diameter of coils | 20 mm  |
| Inner diameter of coils | 10 mm  |
| Pitch radius            | 35 mm  |
| Height of coil          | 100    |

### 4. CFD

Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat transfer, mass transfer, chemical reactions, and related phenomena by solving the mathematical equations which govern these processes using a numerical process. Computational Fluid Dynamics (CFD), sometimes referred to as flow simulation, is a computer simulation technique that allows the fluid flow around or through any product to be analyzed in great detail. By using this technique, designers can verify that their products will conform to a client's specifications early in the design cycle, greatly accelerating the product development process. CFD can be used to calculate design mass-flow rates, pressure drops, heat transfer rates, and fluid dynamic forces such as lift, drag and pitching moments.

### 4. RESULTS AND DISCUSSION

In this paper are having so many advantages based are:

1. Water heater materials such as normal water heater like nursing home applications using stainless steel it is have corroded.
2. Solar water heater materials copper alloy it more thermal conductivity and less corrode

### Meshing:

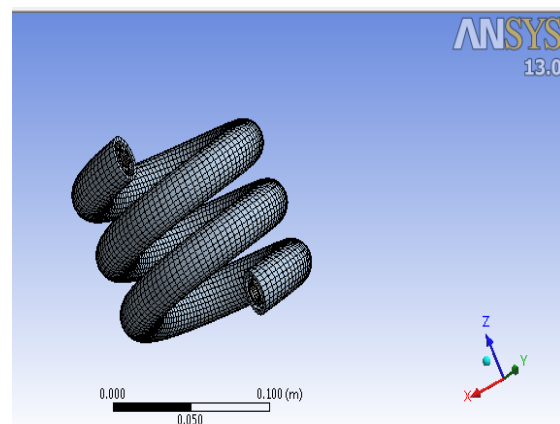


Figure 2: Meshing of heating coil

Number of Element: 34750

Number of nodes : 54764

### Boundary conditions:

#### Part .1

Inlet tube of hot air = 400 K

Outlet tube of hot air = 300 K

#### Part .2

Water liquid

Analysis of Water Heater of Stainless Steel using CFD analysis:

Now in these iterations is maximum ten it use to find the velocity about X, Y, Z, energy and K epsilon.

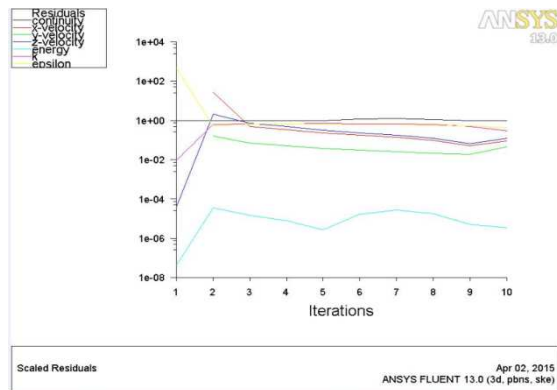


Figure.3: Scaled Residuals

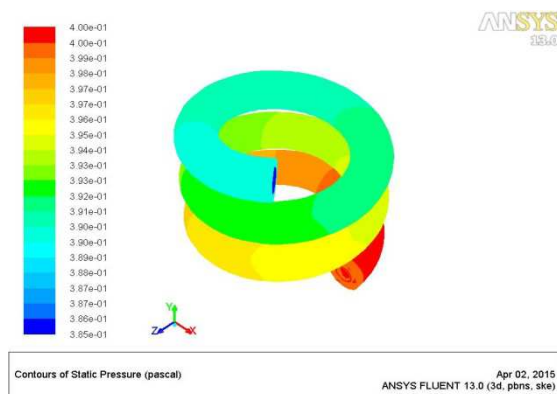


Figure.4: Scaled Residuals contours of Static pressure in Pa

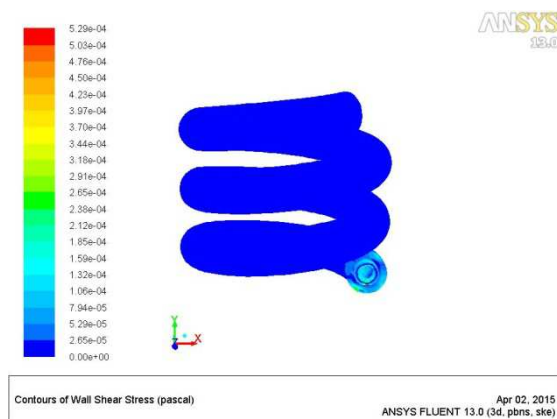


Figure.5 contours of Wall shear stress in Pa

Analysis of Water Heater of Stainless Steel using CFD with static structural analysis:

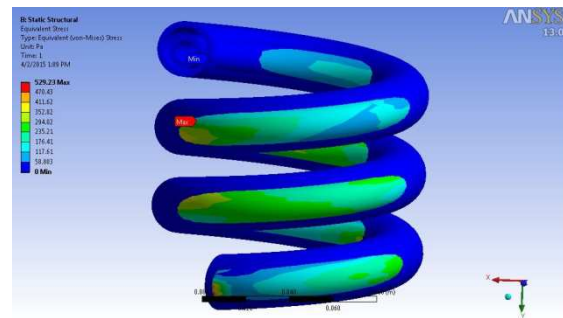


Figure.6 von-mises stress Stainless Steel in Pa

Analysis of Water Heater of copper using CFD with static structural analysis:

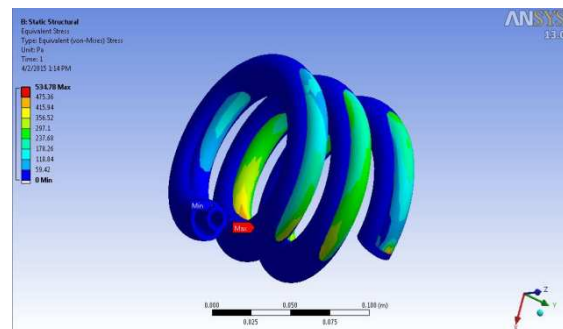
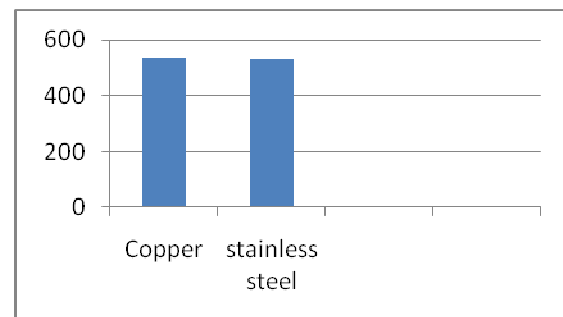


Figure.6 Von- mises stress of copper in Pa

### Graph:



### 5. CONCLUSION

In this project now study and design of solar water heater for providing hot water requirements home and nursing home now solar water heater model

was created of Pro-E and then it was export from Pro-E to ANSYS 13.0 workbench. Results are Stainless Steel and copper material of solar water heater is more stress comparatively. But more thermal conductivity of copper materials with continues heat flows. Cost, maintenance, corrosion is low copper materials. So I conclude suitable for solar copper water heater in nursing home.

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