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THERMAL PERFORMANCES OF WATER HEATER ANALYZED BY CFD SIMULATION BY VARYING HEATER TEMPERATURE

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ABSTRACT

A simulation study was done in a water heater by varying the position of the heating coil inside the chamber and initial temperature by electric energy to validate the thermal performances and time-consuming. Numerical reading was compared with experimental work. Position of the heater, placed in two different locations. Horizontally placed in the a) ground surface, b) the middle-point of the chamber. The investigation focused on the analysis of the temperature distribution in the chamber by the heater and higher temperatures attained by varying initial electric energy within a short duration. The result reveals that the heating rod at the midpoint of the chamber has produced symmetrical heat distribution throughout the chamber and experimental results of electric energy 3 KW were compared with simulation and yield higher temperature in rapid duration.

KEYWORDS:

Solar air heater;
PCM;
Circular rib absorber plate;
Thermal efficiency.

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1. INTRODUCTION

A water heater is abundantly using in a cold region and during the winter season in worldwide. The electric energy to heat the water is most expensive for a large capacity of heater and challenging to control the heat loss. Another significant perplexing is the location of the heating rod inside the water chamber. Many domestic and large scale water heater are consume high electric energy to produce a higher temperature in the range of 60^{o} C to 70^{o} C. and time duration to attain that temperature takes more than 20 minutes for a 20-liter capacity water heater.Another alternative solution is consuming solar energy for heating the water. Many researchers did an experimental investigation to prove the thermal enhancement by integrating solar plates or tubes with the water heater to produce heat energy by active or passive methods. Ghezelbash et.al (1) done an experimental investigation in shell and tube heat exchanger to modified the throttle valve to the inlet to divide the inlet stream and water into a separate channel for attaining higher temperature in steam and liquid. The author reveals that by this method 88% of the energy consumed for increasing the temperature of water and steam. Mohammadzadeh et.al (2) conducted research using solar collectors integrated with a pump to supply hot water for daily uses by adapting the axillary heating system. Arabkohsar et al.(3), done experimental work by a combination of energy storage systems as hybrid technology. Researchers reveal that its most economic technics to save 17.2% of energy for producing high temperature. Farzaneh-Gord et al (4), studied part of heat demand in Off sun radiation. It was most suitable for receiving hot liquid during night time by consuming heat energy from the sun during day time. The result reveals that the payback ratio is for 6.9 years and the Net Present Value gives net benefit after 11 years. Ghezlbash R. et al. (5) conducted an experiment investigated on vertical coupled heat pump integrated with natural gas The result reveals that the analysis has the potential to save as annual energy saving nearly 45.8% and the discounted payback time was extended 6 years. Saadat-Targhi (6) reported that a renewable-based NG pressure reduction station system can be found like solar energy, geothermal, and fuel cell which were reported, and finally it found to be infeasible since energy is cheap in Iran. - Smart heating system. Olfati et al (7) researched energy and exergy loss in heaters in different seasons. Energy consumption during summer was 1.60KW and winter 15.33KW for 20,000 liters. By adapting the second law of thermodynamics in heater for the whole year the performances were improved. The result reveals that exergy efficiency of 77%, for winter and 69% for summer has shown significant performances than normal condition.

Based on a detailed survey, integrating renewable energy with normal setup performed better and found improvement, but no researcher conducted by varying heater coil position inside the chamber and conducted varying input energy as numerical investigation. In this concept duration of charging heat energy is to longer than normal and instant heating not possible. The present research focused to optimize the consumption of electric energy for heating the same capacity of water by varying the

position of heater and attain the required temperature rapidly. The performances of investigation compared with experimental reading to validate the enhancement of thermal efficiency in the water heater and rapid charging. Extension of the present work, the solar energy can be integrated with proposed geometry to validate the performance of thermal energy for better attainment.

2. NUMERICAL PROCEDURE:

The cylindrical shape of the water heater was taken to investigate the temperature distribution by varying the initial temperature in the heating rod. Heating rod placed horizontally in a) ground surface b) middle-point of the chamber and performances of thermal efficiency were described.

2.1 Geometry:

A proposed geometry as 300mm diameter and 300 mm height contains 20 liters of water were heater by electric heater rod placed in two different locations inside the cylinder. An electric rod has 50mm diameter and 250mm long to produce heat energy at 60 $^{\circ}$ C to 100 $^{\circ}$ C. An electric heater rod employed ground surface of the cylinder in to produce thermal energy from the ground surface to top surface and another type located in the middle of the cylinder at 150mm height were shown in Fig.1

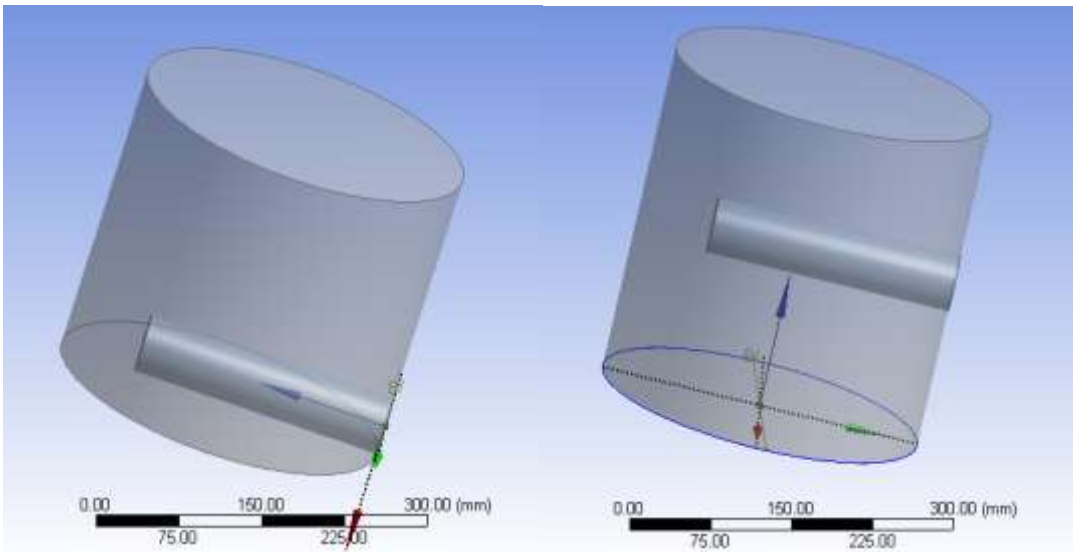


Fig.1 a) Heater in ground surface b) Heater in the middle point of the cylinder

2.2 Meshing:

A proposed geometry has transferred to the meshing portion to split the size of the element in-cylinder into fine particles for attaining a better heat transfer rate from the heating rod. Quadra shape

was selected with an element size of 0.001mm. Boundary conditions are named individually to separate the wall from liquid and labeled the portion for applying calculated values for thermal performances. The schematic diagram of the meshed cylinder as shown in Fig.2.

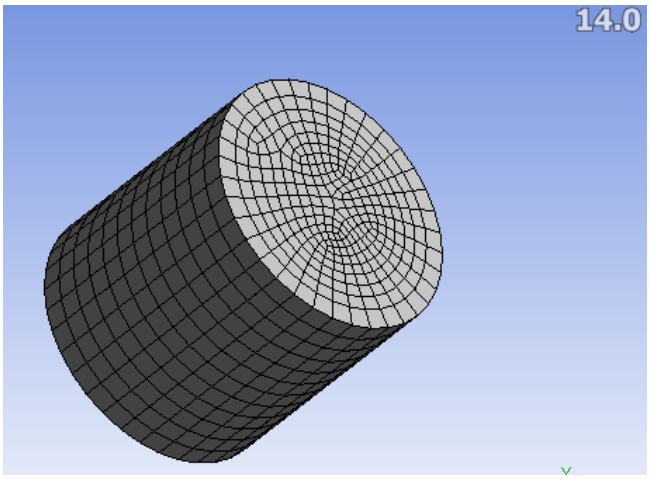


Fig.2. Fine meshed sized of a cylinder.

2.3 Solver solution:

In solver used to converge the meshed cylinder to validate the proposed geometry with experimental values. In the solution part, initial checking is done to verify the labeled part and selected the models to analyze the performances. Mixed flow selected with volume fraction 2 to simulate the heater capacity at 20 liters. Later energy equation switched on for applying temperature at the heater surface. Further viscosity, the k-e model selected with wall enhancement for augmenting thermal effect in-wall region and fluid particles.

In boundary condition, heating rod temperature varied from atmospheric condition to maximum evaporation temperature between 0^{o} C to 100 $^{\circ}$ C. The fluid particles are assumed as water- vapor particle for convectional heat transfer and material of cylinder selected as steel with insulated. Later, water particles are regulated boundary region to separate wall surface from a fluid. A SIMPLE method selected to converge the geometry as finite volume methods and solution iterated with 375K. In the calculation part, the time interval set as 20 sections in volume fraction. Later 2000iteration set to validate the performances.

Someway the temperature of the heating rod surface was varied from 60 to 100 depend on electric energy 3KW. Simulation reading is tabulated in tables. 1 and temperature distribution for both cases are discussed briefly in the next part.

Table.1 Component and parameter of the water heater.

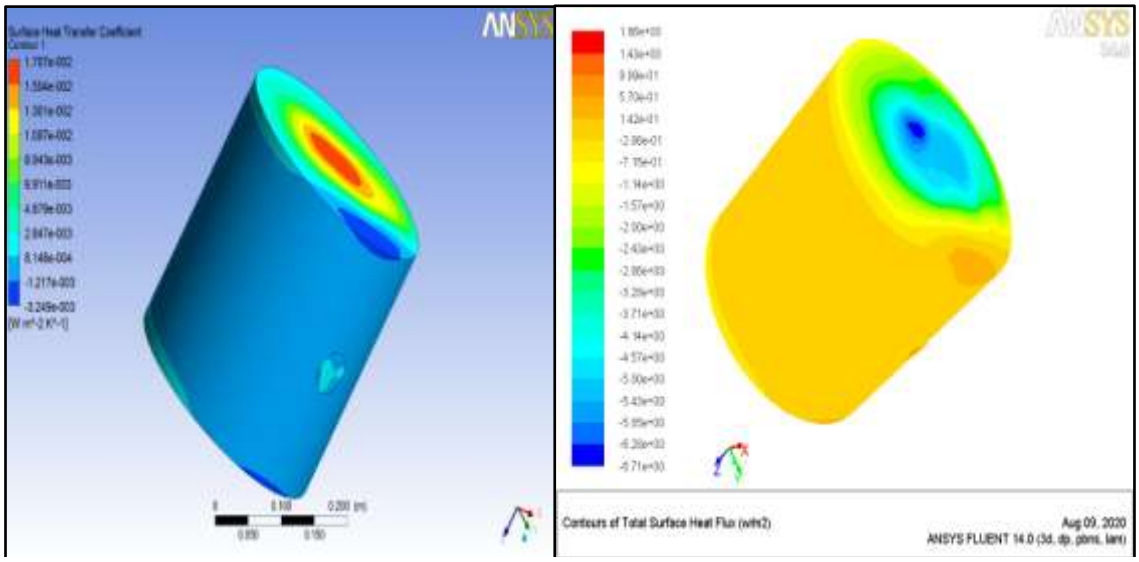
S.No	Components	Dimention	Material
1	Cylinder	Height - 300mm	Steel
2		Diameter – 300mm	
3		Thickness -10mm	
4	Heating coil	Diameter – 50mm	Steel
5		Length – 250 mm	

3. WORKING PRINCIPLE:

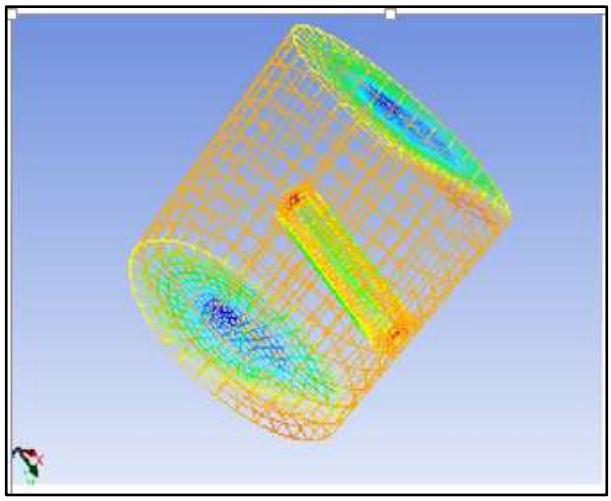
A steel body water heater contains 20 liters of liquid that were heated by electric energy using a steel coil placing in two different locations in inside the cylinder to analyze the temperature distribution between the surface of the liquid. Initially, the electric coil placed ground surface later it lifted upward above 150mm from the ground. The investigation focused on evaluating thermal performances based on the position of the heating coil and various temperatures applied on the surface of the coil as an energy input. Detailed reports are compared with experimental values and presented in result & discussion.

4. RESULT AND DISCUSSION:

Thermal performance of water heater analyzed by varying position of the electric coil and inlet temperature. Fig.3 [a-c] shows the temperature distribution in the water heater with a mesh cell by varying inlet temperature in the middle-point electric coil. It illustrates that at 60^{o}C in 20 liter capacity of water has a gradual distribution from the coil to the wall surface on both ends. Further varying initial temperature, maximum distribution accrued on both sides of walls, to the end surface of the cylinder. It shows that applying maximum energy of 3KW as input energy performed better than varying energy where this 3KW taken from experimental performances. . In the middle point, the electric coil has a maximum possible to distribute the heat on both sides of the coil where a chance to distribute the heat within a short duration. It expires that, maximum temperature attained within a short duration than normal design.

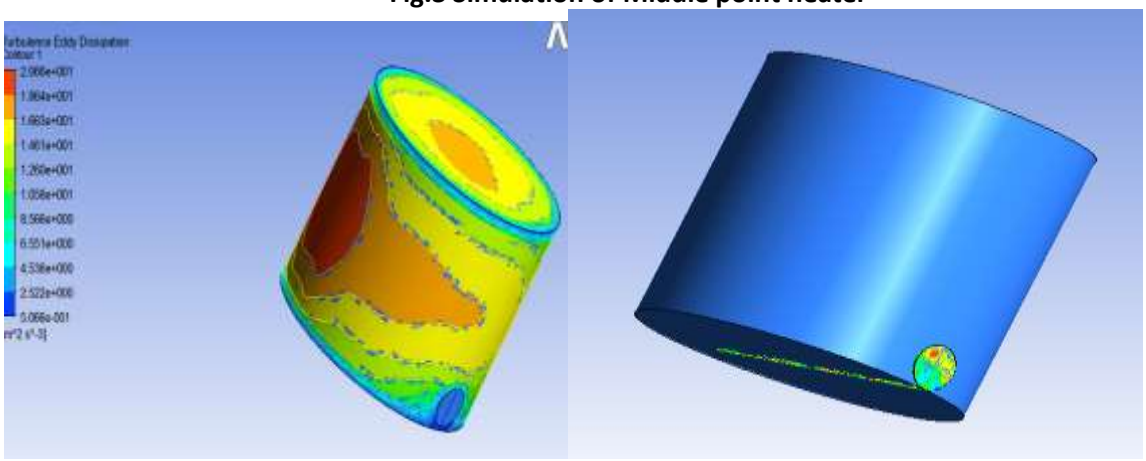


a) Surface wall flux b) Temperature distribution

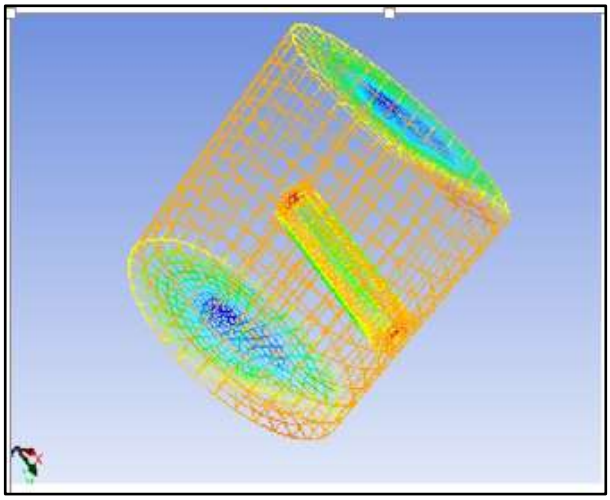


C)Meshing contour plot

Fig.3 Simulation of Middle point heater



a) Surface wall flux b) Temperature distribution



C) Meshing contour plot

Fig.4 Simulation of a ground surface heater

Extension of the work, the heating coil placed the ground surface of the cylinder to validate the performances of changing positions. In fig.4 [a-c] shows the temperature distribution along with mesh cell performances. It illustrates that temperature distribution has occurred in one direction and has taken more duration to attain the maximum temperature of 100°C consuming 3KW as input energy. It expresses that the bottom surface has changed to heat the surface more than normal and damage the material causes minimum durability. And consumers more electric energy to attain maximum temperature for a long duration. The Performance of contour plot diagram illustrates wall surface has uneven temperature distribution cause high heat losses than normal design.

5. CONCLUSION:

Thermal performances of water heater analyzed by CFD simulation by varying location of the heating coil and initial temperature. The performances of numerical values are compared with experimental values and found the following findings.

a. By varying location, it found maximum temperature may be attained within a short duration in 20 liters of water.
b. In the middle point, the electric coil has possible to distribute the heat on both sides of the coil and extend symmetrically to the wall region.
c. Input temperature 3KW was assumed in numerical analysis by validating experimental performances and the same energy applied on both types to coils.
d. It found maximum temperature attained with a short duration by placing the middle of the cylinder and constant supply of input energy to the coil.

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