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Thermal Stress Analysis of Fin and Tube type solar water heater

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Abstract- This paper studied experimentally and theoretically the effect of heat transfer on fin and tube type solar water heater for different mass flow rate of fluid. The thermal stresses induced on fin and tube is also studied by ansys software at steady state condition and static structural. Comparison will do experimentally for obtaining results. It is observed that as the temperature increases on fin and tube model increases thermal stresses on fin and tube model. Likewise inlet temperature of fin and tube model is minimum as compared to outlet temperature of fin and tube model.

Index terms: Copper Fin, Copper Tube, Experimentation instruments, Mass flow rate, Steady State thermal Stress.

I. INTRODUCTION

A fin and tube type solar water heater is a part of equipment built for efficient heat transfer from surface of fin to water flowing through tube solder centrally in fin. One of the important processes in engineering is the heat transfer from hot surface to cold surface.

This work uses ANSYS to predict the intensity of thermal stresses induced during heat transfer in the fin and tube type solar water heater and to find optimum thickness of fin and tube of solar water heater wall without affecting heat transfer rate.

In this work set up for fin and tube heat exchanger in solar water heater model is fabricated for finding temperature distribution along tube and fin also for finding thermal stresses, which uses fin and tube model, temperature indicator, thermocouples, water tank, pipes. cold water flows through pipe to the copper tube which is then heated by heat transfer takes place between surface of fin and cold water flowing through tube. This experiment also involves the determination of overall heat transfer rates of water in tube and solar radiation over the fins.

Modelling of fin and tube model is done on CATIA software and then stresses are calculated using ansys software.

Analytical stresses are observed in ansys software in two cases first is in steady state thermal and second is in static structural case.

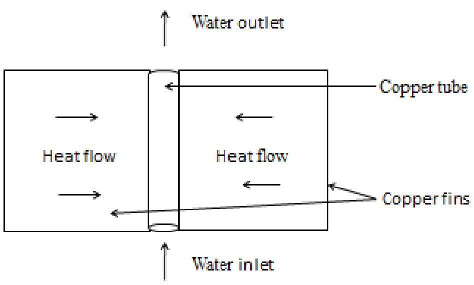

Figure1. Structure and heat flow mechanism

II. EXPERIMENTAL SET UP

The schematic of the experimental set-up used for present investigation is shown in fig.2. The set-up consists of following components.

1. Copper Tube
2. Copper Fins
3. Water Tank
4. Temperature Indicator
5. Measuring Flask
6. Stop Watch

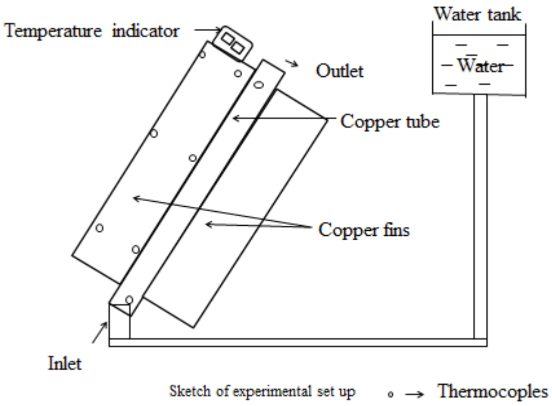

Figure 2. Line diagram of fin and tube type solar water heater

During performing this experimentation mass flow, temperatures are observed which later used for comparing the calculated and the observed temperatures along the model.

Quantities measured during the observation were-

1) Mass flow rate
2) Temperature
3) Heat transfer rate

Fig.3 shows detail description of the experimental model.

L = Length of fin
W = Width of fin
T = Thickness of fin
L = Length of tube
Do = Outer Diameter of tube
Di = Inner Diameter of tube
mh = Mass flow rate of water
Th_1 = Inlet temperature of hot fluid (water)
Th_2 = Outlet temperature of hot fluid (water)
Q = Rate of heat transfer
E = Young's Modulus
α = Co-efficient of expansion
ΔT = Temperature difference

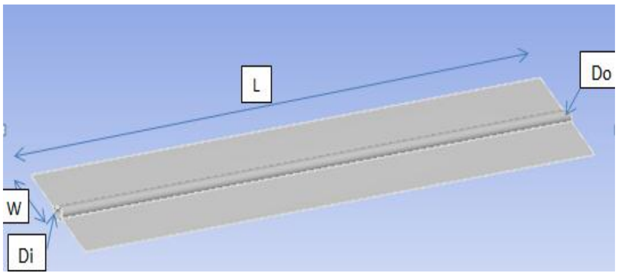

Figure 3. Geometry of fin and tube model

Data consider for this experimentation are,
Length of fin = 100 mm
Length of tube =100mm
Width of fin = 50 mm
Thickness of fin = 0.15 mm
Outer Diameter of tube = 14 mm
Inner Diameter of tube = 13 mm

IV. Theoretical Procedure For Heat Transfer

Theoretical stresses are carried out by using the equation,
Thermal stress (σ} = Eα ΔT (1)

General formula for heat traansfer from fin is given as,

$Q = k A_c m (t - t_a)$ (2)

Heat transfer from the hot surface to the cold fluid is given by,

$Q = h a (\Delta T)$ (3)

V. Modelling And Analysis Of Fin And Tube Modeling In Catia Software

The model of fin and tube is generated in CATIA modeling software. The various steps followed to generate the model of fin and tube is given.

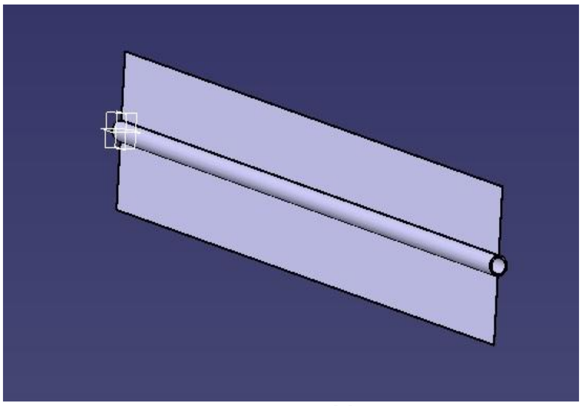

Figure 4. Model in Catia

A. Procedure For Ansys Analysis

A static analysis can be either linear or nonlinear. In our present work we are going to consider linear statistical analysis.

The procedure for static analysis consists of these main steps:

1) Building the model
2) Material properties.
3) Obtaining the solution.
4) Reviewing the results.

B. Stress In Fin And Tube Model

The finite element analysis of fin and tube model at static structural conditions reveledthe thermal stress distribution in the form of stress counter.The representive von mises thermal stress contours are shown in fig.5.

In this fig. 5 stresses are generated maximum at outlet surface of tube because hot water flows through it and minimum at inlet surface of tube because cold water enter through it .stresses are increases from inlet to outlet of tube in fin and tube model.

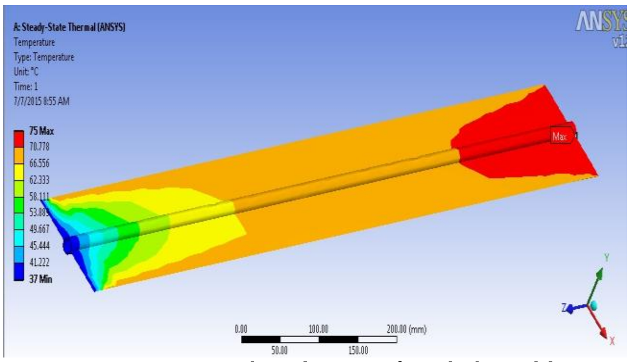

Figure 5. Von mises thermal stress on fin and tube model.

C. Temperature Distribution On Fin And Tube Model

The finite element analysis of fin and tube model at steady state thermal condition showing temperature distribution along the model. Temperature is highest at outlet of fin and tube model and temperature is lowest at inlet of fin and tube model in figure 6.

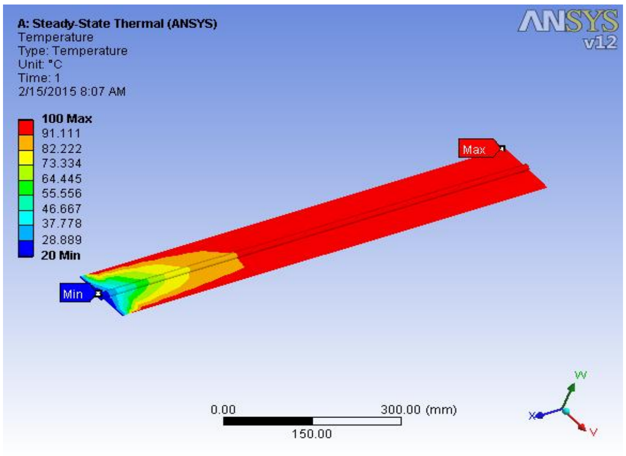

Figure 6. Temperature distribution along the tube and fin model

VI. Result And Conclusion

Comparison between theoretical and experimental result is shown in table 1. After comparison result that calculated values give nearly same value of outlet temperatures, rate of heat transfer.

TABLE I

COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL RESULT

Theoretical Results	Experimental Results
t_1 =34	t_1 =32
t_2 =66	t_2 =64
m =5.11×10^{-4} kg/s	m =6.15×10^{-4} kg/s
Q =68.67 w (68%)	Q =82.65 w (82%)

Difference in results are 13.98%

Calculated heat transfer rates are shown in graphical forms. Both heat transfer variation through fin as well as through tube are shown.

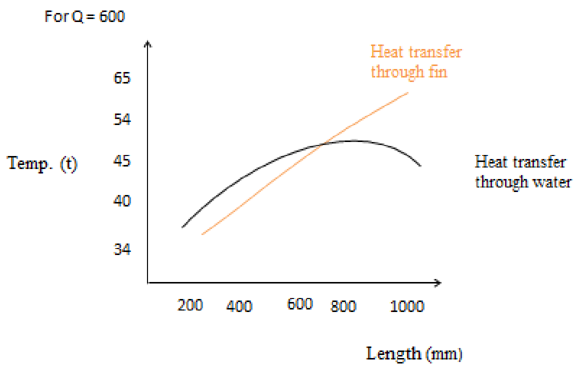

Figure 7. Variation of heat transfer through fin and water for Q = 600w

It is observe that after performing experimentation thermal stresses arises at outlet of fin and tube model. it is also observed that analytical results also gives the maximum thermal stress is on fin and tube model outlet surface. Tube has maximum thermal stress because tube outlet having maximum temperature so tube outlet surface persist more stress than fin.

The final conclusion can be made that the experimental model of specified dimension is a safe design and also gives appropriate results of heat transfer which is our prime importance.

References

[1] Mr. Rupesh Telrandhe, R. E. Thombre "*CFD Analysis Of Natural Convection Flow Through Inclined Pipe*", 'International Journal of Engineering science and innovation technology, Vol 2, Issue 2, March 2013.

[2] MS. N. B. Rairekar, Prof. A.V. Karmankar, Prof. R. E. Thombre, "*Thermal Analysis of Fin and Tube Heat Exchanger*" International Journal of Engineering Research and application, VolumeNo.4, 2014.

[3] Dr.M.Thirumarimurugan, Dr. T. Kannadasan, Prof. S. Gopalakrishnan, "*Performance analysis of Cross Flow Plate Fin Heat Exchanger for Immiscible system Using Ann*", International Journal of Chemical and Environmental Engineering, July 2010.

[4] Ahmed F. Khudheyer and Mahmoud Sh. Mahmoud, "*Numerical Analysis Of Fin tube Plate Heat Exchanger By Using CFD Technique*", ARPN Journal of Engineering and Applied Sciences, Vol. 6, No. 7, July 2011.

[5] Stewart, S.W. Shelton, S.V. and Aspelund, K. A. ,"*Finned Tube Heat Exchanger Optimization*", 2nd International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics. U.S., 2003.

[6] Praful Date and V. W. Khond**,** "*Heat Transfer Enhancement In Fin And Tube Heat Exchanger*"**,** ARPN Journal of Engineering and Applied Sciences, VOL. 8, NO. 3, march 2013.

[7] J. A. Livingston1, P. Selvakumar "*Effective Heat Transfer Enhancement In Finned Tube Heat Exchanger With Different Fin Profiles*" International Journal of Engineering Research, Volume 2, Issue 2, Pg : 83-87, 2013.

[8] N. Nagrani, professor, K. Mayilsamy, "*Experimental Heat Transfer Analysis on Annular Circular and Elliptical Fins*", International Journal of Engineering Science and Technology Vol.2 (7), 2839-2845, 2010.

[9] Manish Mishra, Prasanta Kumar Das "*Optimum Design Of Crossflow Platefin Heat Exchangers Through Genetic Algorithm*", International Journal Of Heat Exchangers, Vol 5, Iss. 2, Pg. 379-401, 2004.

[10] N. Nagarani, Professor, "*Experimental Heat Transfer Analysis Onannular Circular And Elliptical Fins*", International Journal of Engineering Science and Technology Vol. 2(7), Pg. 2839-2845, 2010.

[11] Ricardo Romero-Mendez, MihirSen, K.T. Yang, Rondey McClain, "*Effect Of Fin Spacing On Convection In Aplate Fin And Tube Heat Exchanger*", International Journal Of Heat and mass transfer, Vol 43, 39-51, 2000.

[12] A. V. Z. Domkudwarand, Dr. V. M. Domkundwar *"Heat And Mass Transfer data book"*, 6th edition, Danapat Rai & Co. publication, 2012.

[13] Dr. D. S. Kumar "*A Text Book Of Heat And Mass Transfer*" 7th revised edition, SK Kataria & Sons publishers, 2010.