Transient Thermal Analysis in Vertical Cylinder With Duct or Without Duct For Natural Convection

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Abstract
The investigation of maximum heat transfer rate in with duct and without duct condition for vertical cylinder in natural convection when heat is transfer into the surrounding, using ANSYS (Transient Thermal) 14.0 is presented. Present study determine if temperature increases heat transfer rate decreases for with duct condition and for without duct condition heat transfer rate increase when temperature increases. Specimen is made by stainless steel tube with diameter 40mm and length 400mm nichrome wire type heater along its length. For visual display of test section enclosure with acrylic door.

Keywords
Natural Convection, Heat Transfer Rate, Heat Transfer Coefficient, Vertical Cylinder With Duct And Without Duct

I. Introduction
The convection is mode of heat transfer in which the energy is transported by moving fluid particles. The convection heat transfer comprises of two mechanisms. First is transfer of energy due to random molecular motion (diffusion) and second is the energy transfer by bulk or macroscopic motion of the fluid (advection). The molecules of fluid are moving collectively or as aggregates thus carry energy from high temperature region to low temperature region. Thus the faster the fluid motion, the greater the convection heat transfers.

In absence of any bulk fluid motion, the heat transfer occurs by pure conduction. Hence heat transfer rate increases in presence of temperature gradient. The convection heat transfer is due to superposition of energy transfer by random motion of the molecules and by bulk motion of the fluid.

Many studies for natural convection heat transfer from a vertical cylinder and horizontal cylinder have been carried out.

Sparrow and Gregg [4] obtained a numerical solution of the laminar boundary layer equations for natural convection from the outer surface of a vertical cylinder with a uniform temperature and established and quantitative criterion for determining the conditions under which the heat transfer from a cylinder agreed with the flat plate results within 5 % error.

Leferve and Ede [6] executed the integral method to the laminar boundary layer equations in cylindrical coordinates. The numerical results were almost in agreement with those by sparrow and Gregg.

Fuji and Uehara [2] presented the correlation for the local natural convection heat transfer from a vertical cylinder with the uniform surface temperature and the uniform heat flux. This correlation based on the boundary layer approximation was expressed in comparison with the theoretical solutions for a vertical plate.

Masters [1] studies natural convection heat transfer from arrays of vertically arranged heated copper cylinders in air were the number of cylinders in the arrays, the dissipated heat, and the spacing between the cylinders were varied. Marsters reported that for closely spaced cylinders, the Nusselt numbers for the cylinder in the array were reduced with up to 50% compared to the single cylinder. However, for large spacing's the Nusselt numbers were increased with up to 30%.

Khanorkar and Thombre [3] studies CFD analysis in vertical tube a vertical copper tube having constant cross section area is used for representing the medium through which natural convection of water takes place. In this present work study and analysis of natural convection flow of water through vertical pipe is done. In this study includes what is the effect of the physical parameters of tube like diameter, length and heat flux on the outlet flow parameters like velocity and temperature.

Jensen [5] presents an experimental investigation conducted on two evenly heated vertically arranged horizontal cylinders with a diameter of 54mm in water. The change in nusselt number on the upper cylinder compared to a single cylinder is presented for seven Rayleigh numbers ranging from 1.82E7 to 2.55E8 for vertical separation distances S = 1.5D, 2D, 3D, 4D and 5D.

Zhang ning and Jin tao [9] presents the numerical model are built to analyze the natural convection around cylinder heat sinks with longitudinal fins. The computational results show that the edge of thermal boundary layer can be expressed as a sinusoidal function in 2D polar coordinate system and they compared present result with the previous results, the correlation is simpler in form but more accurate with 93% data.

II. Results and Discussion
In this section, temperature, and total heat flux for stainless steel tube fitted in a rectangular duct or without duct at different points are described. The graphs of temperature which have been plotted using ANSYS Transient Thermal 14.0 are shown. Lastly, comparison between both results has been done for determining maximum heat transfer rate. The contours of temperature, and total heat flux for a tube are shown for with duct and without duct.

Table 1: Heat Transfer Rate and Heat Transfer Coefficient – With Duct

Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Heat Transfer Coefficient (W/m^{2-K})	Heat Transfer Rate (Watt)
-119.53	166.37	25.58	1.825
-110.63	161.37	17.21	2.914
-70.97	149.02	25.59	21.892
-5.82	118.3	30.45	57.397
-3.6258	116.34	30.45	52.571
-1.0847	115.08	25.61	45.414
7.343	112.39	26.13	25.069
10.174	111.91	31.07	60.968
11.265	111.71	31.42	62.360

Table 2: Heat Transfer Rate and Heat Transfer Coefficient – Without Duct

Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Heat Transfer Coefficient (W/m^{2-K})	Heat Transfer Rate (Watt)
-200.92	342.47	47.48	138.82
-133.21	257.58	48.05	141.37
-46.047	179.54	46.71	105.01
2.4951	125.98	46.23	981.22
4.2747	122.78	46.23	964.75
5.7936	120.93	46.23	961.10
10.79	117.21	46.23	980.57
11.945	117.27	56.42	120.75
12.452	117.08	56.41	121.23

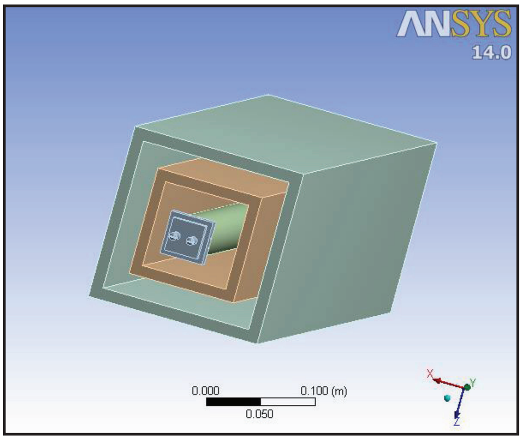

Fig. 1: Model of a Tube With Rectangular Duct

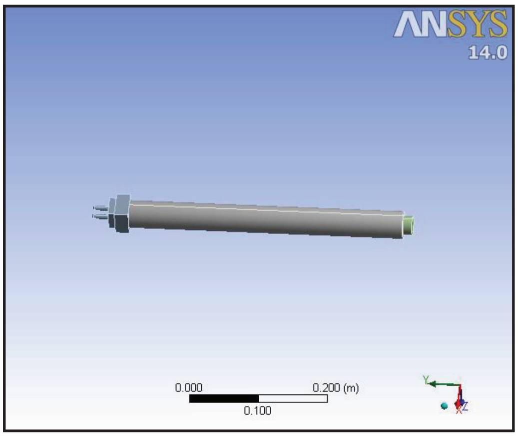

Fig. 2: Model of a Tube Without Duct

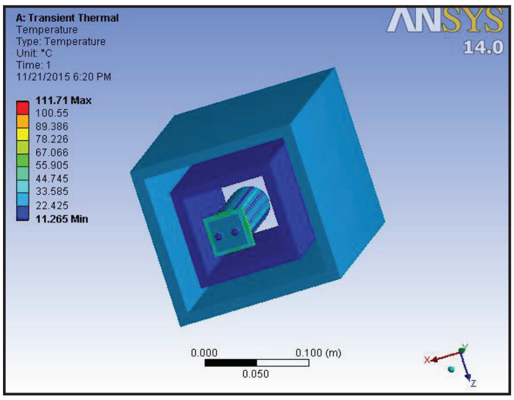

Fig. 3: Contour of Temperature in Tube With Duct

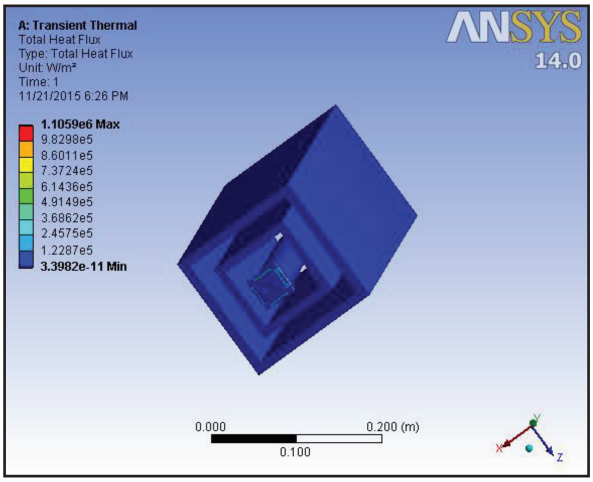

Fig. 4: Contour of Total Heat Flux in Tube With Duct

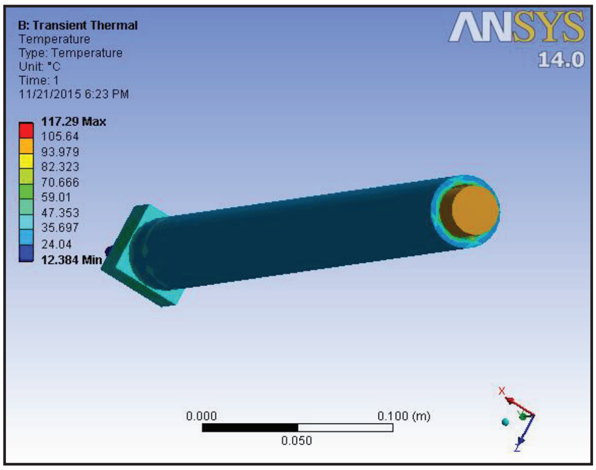

Fig. 5: Contour of Temperature in Tube Without Duct

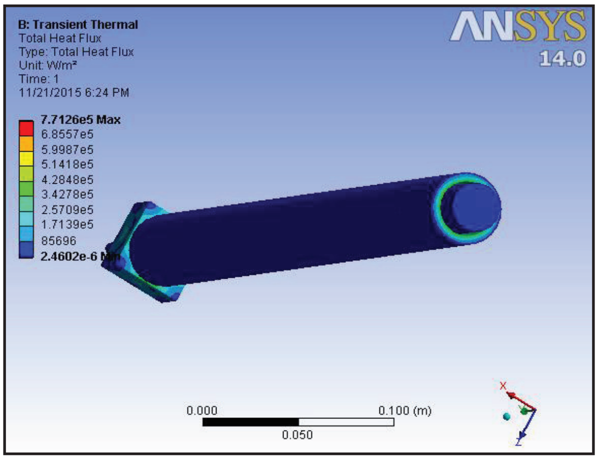

Fig. 6: Contour of Total Heat Flux in Tube

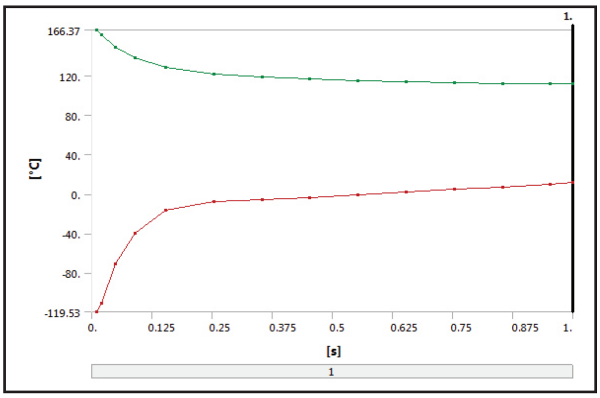

Fig. 7: Temperature Vs. Time Plot

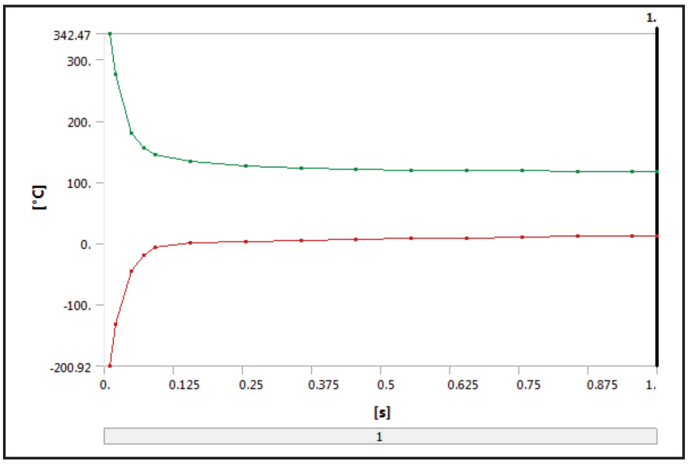

Fig. 8: Temperature Vs. Time Plot

III. Conclusion

In the present work, the heat transfer coefficient and heat transfer rate in with duct and without duct for vertical cylinder in natural convection is determined using ANSYS (Transient Thermal) 14.0.

The temperature of tube is found in with duct and without duct condition. The graph is plotted between temperature and time for the above mentioned conditions. The heat transfer rate and heat transfer coefficient are calculated using above results. It is concluded from the results that the heat transfer rate in case of without duct condition is higher as compared to with duct condition.

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