Computational analysis of solid tube with & without fin using Altair CFD tool Acusolve

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ABSTRACT

The study of natural convection from a heated tube having conical fin configuration using CFD tool Acusolve has been carried out and material under consideration is aluminium and the free stream fluid is air. The velocity distribution showing the convection loops formed around the heated tube surface. Velocity contours for solid tube without fin and with conical shape fin configurations has been carried out and the motion of heated fluid is shown. Increased velocity results in higher heat transfer coefficients, which may be sufficient to improve the performance. The assumptions during the analysis have been taken considering the manufacturing and practical applications and working conditions. Hence the results obtained can be referred to while solving any such kind of problems in the practical field where only natural convection is under consideration.
Keywords: Altair (Hyper works) CFD toolAcusolve.

INTRODUCTION

Fins including wavy fin and interrupted fin are widely used to improve the performance of fin-and tube heat exchangers. The wavy fin enhances heat transfer by lengthening the air flow channel and causing better mixing of air flow. The interrupted fin, including louver fin and slit fin, enhances heat transfer by renewing the boundary layer and reducing the thickness of the boundary layer. In practical application of fin-and-tube heat exchangers, condensation phenomena will occur on the fin surface when the surface temperature is below the dew. Fins are quite often found in industry, especially in heat exchanger industry as in finned tubes of double-pipe, shell-and-tube and compact heat exchangers. As an example, fins are used in air cooled finned tube heat exchangers like car radiators and heat rejection devices. Also, they are used in refrigeration systems and in condensing central heating exchangers. Moreover, fins are also utilized in cooling of large heat flux electronic devices as well as in cooling of gas turbine blades. Fins are also used in thermal storage heat exchanger systems including phase change materials. To the best knowledge of the authors, fins as passive elements for enhancing heat transfer rates are classified according to the following criteria.

(1) Geometrical design of the fin.
(2) Fins arrangements.
(3) Number of fluidic reservoirs interacting with the fin.
(4) Location of the fin base with respect to the solid boundary.
(5) Composition of the fin.

According to design aspects, fins can have simple designs, such as rectangular, triangular, parabolic, annular, and pin rod fins. On the other hand, fin design can be complicated such as spiral fins. In addition, fins can have simple network as in finned tubes heat exchangers. In contrast, they can be arranged in a complex network as can be seen in the works of. Moreover, fins can be further classified based on the fact whether they interact thermally with a single fluid reservoir or with two different fluid reservoirs. Example of works based on the last classification is the works of Khaled. In addition, fins can be attached to the surface as in the works or they may have roots in the heated/cooled walls. Finally, fins can be solid or they can be porous or permeable.

MECHANISMS OF AUGMENTATION OF HEAT TRANSFER

To the best knowledge of the authors, the mechanisms of heat transfer enhancement can be at least one of the following.
(1) Use of a secondary heat transfer surface.
(2) Disruption of the unenhanced fluid velocity.
(3) Disruption of the laminar sub layer in the turbulent boundary layer.
(4) Introducing secondary flows.
(5) Promoting boundary-layer separation.
(6) Promoting flow attachment/reattachment.
(7) Enhancing effective thermal conductivity of the fluid under static conditions.
(8) Enhancing effective thermal conductivity of the fluid under dynamic conditions.
(9) Delaying the boundary layer development.
(10) Thermal dispersion.
(11) Increasing the order of the fluid molecules.
(12) Redistribution of the flow.
(13) Modification of radiative property of the convective medium.
(14) Increasing the difference between the surface and fluid temperatures.
(15) Increasing fluid flow rate passively.
(16) Increasing the thermal conductivity of the solid phase using special nanotechnology fabrications.

OBJECTIVE OF RESEARCH

There are almost no industrial fields in which heat exchangers are not applied. The design of the heat exchangers influences greatly the design of the entire system or process in which they are applied. Many factors influence the design of a heat exchanger, but the most important one is the heat transfer rate. With an exception of a few cases usually high heat transfer rate and small pressure drop in a small volume is needed in all kind of usual processes. The intensity of heat transferred by convection is the dominant aspect in this kind of analysis as compared to that by conduction and radiation.
The exchange of heat energy is studied on a tube with circular cross-section and with specific inner and outer radius having conical shaped fins. The fins attached with the tube can be of variable shape and size. Comparison has been considered and the transfer of heat energy and velocity distribution from a tube with such fin configurations is estimated. The design calculations of the tube and the fin dimensions are done based upon equations suitable for the maximum heat transfer rate and correlation for velocity distribution at low production costs. The material used for the calculations is considered to be Aluminium. Both the tube and fins are considered to be made up of Aluminium and the fluid inside the tube is air. Altair Hyperworks version 11.0 version is used for the entire simulation processes.

REVIEW OF PAPERS

The subject of heat transfer enhancement is of serious interest in the design of compact heat exchangers. The emphasis is given on minimizing the space occupied by the equipment for the desired rate of heat transfer. A large number of augmentation techniques have been developed in the last few decades and these are applicable to diverse areas such as, single phase flows, two phase flows and convective mass transfer. A number of review articles and handbooks by Bergles., 1978, 1983 and 1985, deals with the enhancement of heat transfer for different applications.
A paper by D. Thornhill et al., 2006, works on proposing a variant for his formula to rectify this mistake, considering more fin geometries. Considering the heat transfer distribution around the circumference of the cylinder, for any particular fin geometry and flow condition, values are determined that are considered constant along the fin’s length at any particular angular position around the cylinder surface, ignoring only the circumferential heat transfer by conduction around the cylinder and through the fins.
Another basic flaw in the fundamental equations derived by Gibson and Thornhill was that they had a zero-heat transfer at zero velocities, which is false. An attempt to correct this was made by Masao Yoshida and his group.
A detailed account of the various techniques of heat transfer augmentation is given by Bergeles., 1985, and Webb., 1987, Augmentation techniques can be classified either as passive methods, which require no direct application of external power, or as active methods, which require the external power. The effectiveness of both active and passive types

depends strongly on the mode of heat transfer, which might range from single-phase free convection to dispersed-flow film boiling.
Biswas and Chattopadhyay., 1992, further extended this numerical model by including a hole under the delta wing for forced convection heat transfer.

MATHEMATICAL FORMULATION

At x = 0.15 at just Outer body of the Solid Tube.
$U = 5.17\times \nu[Pr \times \frac{20}{21}]$^-0.5 $\times[\frac{g\beta(Ts-T_\infty)}{\nu^2}]$^0.5 × x^0.5
by D. Thornhill
h = 2.11 * u^0.71 * s^0.44 * L^0.14
s = fin separation at middle fin length (mm)
h = 2.11 * u^0.71 * s^0.44 * L^0.14
so from above correlations we can find the velocity speed over the fins surface.

RESULTS AND DISCUSSIONS

Presents the velocity distribution along the length of the solid tube with conical fin and without fin. A higher magnitudeis observed at the tipas comparison to solid tube. In fig. 1 Maximum velocity is 0.854 m/s and in fig, 2 velocity vector is 0.8491 m/s.In fig. 3 Maximum velocity is 1.240 m/s and in fig, 2 velocity vector is 1.240 m/s which is the case for solid tube with conical fin.Table1.below shows the variation of velocity difference which depicts that increased velocity results in higher heat transfer coefficients, which may be sufficient to improve the performance.

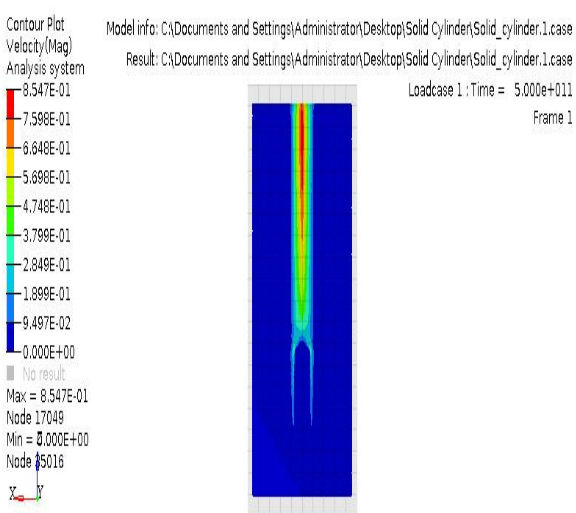

Figure.1 Nature of velocity across the solid tube.

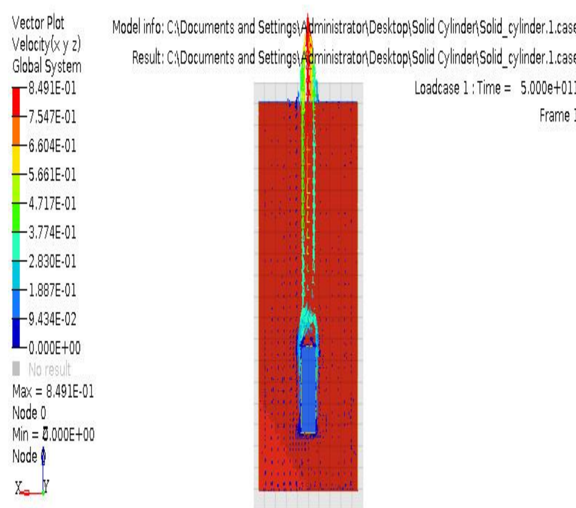

Figure.2 Nature of velocity vector across the solid tube

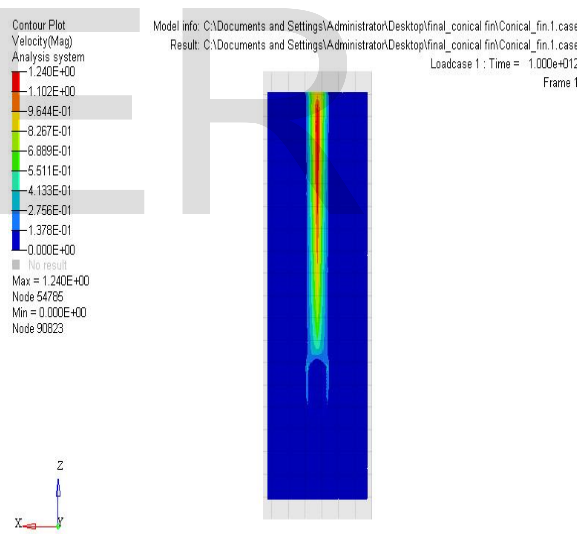

Figure.3 Nature of velocity across the solid tube with conical fins.

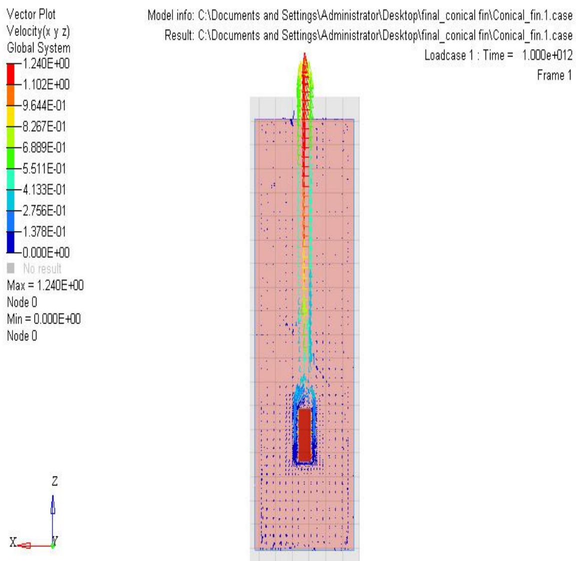

Figure.4 Nature of velocity vector across the solid tube with conical fins

Table 1. Comparative results of velocity distribution between Solid tube with conical fin & without conical fin.

S.NO	**Solid tube without fin**	**Solid tube with conical fin**
01	0.854	1.240
02	0.759	1.102
03	0.664	0.964
04	0.569	0.826
05	0.474	0.688
06	0.379	0.551
07	0.284	0.413
08	0.189	0.275
09	0.094	0.137
10	0.000	0.000

CONCLUSION

In this computational analysis, natural convection heat transfer and velocity distribution on vertical heated solid tube without fin and solid tube with conical fin through CFD (Acusolve) is shown Increased velocity results in higher heat transfer coefficients, which may be sufficient to improve performance. Velocity contours motion of heated fluid is shown successfully.

REFERENCES

1) A. Franco, Luigi Martorano ; University of Pisa; "A Basic Method for the Two-Stroke Engine Air Cooling System Design and Optimization"; (1997) SAE Technical Paper, 970802

2) Bergles, A. E., 1978. Enhancement of Heat Transfer. In: Proceedings of the Sixth International Heat Transfer Conference 6, 89-108, Toronto, Canada, 7-11 August.

3) Bergles, A. E., Webb, R. L., Junkhan, G.H. and Jension, M. K., 1980. Bibliography on Augmentation of Convective Heat and Mass Transfer. Heat Transfer Laboratory, Department of Mechanical Engineering, Iowa State University, Ames, IA.

4) Bergles, A.E., 1983. Augmentation of Heat Transfer. Heat Exchanger Design Handbook. Hemisphere Publishing Co., Washington DC.

5) Bergles, A. E. and Joshi, S. D., 1983. Augmentation Techniques for Low Reynolds Number In-Tube Flow, Low Reynolds Number Flow in Heat Exchangers. Hemisphere Publishing Corporation, Washington.

6) Bergles, A.E., 1985.Techniques to Augment Heat Transfer. Handbook of Heat Transfer Applications, McGraw Hill, New York.

7)Bergles, A.E., A.R. Blumenkrantz, and J. Taborek, “Performance Evaluation Criteria for Enhanced surfaces.

8) Biswas, G., Mitra, N. K. and Fiebig, M., 1989. Computation of Laminar Mixed Convection Flow in a Channel with Wing Type Built-in Obstacles. J. Thermo physics 3, 447-453.

9) D. Thornhill, A. Stewart and G. Cunningham (The Queen’s University of Belfast), P. Troxler, R. Meyer, B. Price (Harley-Davidson Motor Co.); "Experimental Investigation into the Temperature and Heat Transfer Distribution around Air-Cooled Cylinders"; (2006) SAE Technical Paper, SAE 2006-32-0039, JSAE 200665539