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Full Length Article

Design and Analysis of Fins with Various Configuration

M.V.Shanmugam[1], M.Vignesh[2] , G.Umanath[2], S.Shyamsundar[2] , M.Vijay[2]

Assistant Professor, Department of Mechanical Engineering, KSR Institute for Engineering and Technology, Tiruchengode,

[2]UG Scholar, Department of Mechanical Engineering, KSR Institute for Engineering and Technology, Tiruchengode,

***Corresponding Author**
vikky1065 @gmail.com
(M.Vignesh)
Tel.: +91 8428850880

ABSTRACT: Convective heat transfer between a surface and the surrounding has been a major issue and a topic of study for a long time. In this project, the heat transfer performance of fin is analysed by ANSYS workbench for the design of fin with various design configuration such as cylindrical configuration, square configuration and rectangular configuration. The heat transfer performance of fin with same base temperature having various geometry is compared. In this thermal analysis, Aluminium was used as the base metal for the fin material and for various configurations. Fin of various configuration are design with the help of CATIA software Analysis of fin performance done through the software ANSYS workbench

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Keywords: Heat transfer, Fin and Convection.

1 Introduction

Heat exchangers are widely used in various, transportation, industrial, or domestic applications such as thermal power plants, means of heating, transporting and air conditioning systems, electronic equipment and space vehicles. In all these applications improvement in the efficiency of the heat exchangers can lead to substantial cost, space and material savings. Hence considerable research work has been done in the past to seek effective ways to improve the efficiency of heat exchangers. The basis of any heat transfer enhancement technique lies in the utilization of some external power in order to permit the mixing of working fluids, the rotation of heat transfer surfaces, the vibration of heat transfer surfaces or of the working fluids also the generation of electrostatic fields. The major heat transfer enhancement techniques that have found widely spread commercial application are those which possess heat transfer enhancement elements. All passive techniques aim for the same, namely to achieve higher values of product of the heat transfer coefficient and heat transfer surface area. A distinguish between the way how the heat transfer enhancement is achieved, is common in the heat transfer community. Here in the present work, a terminology similar to the literature is followed although for practical applications are irrelevant how the heat transfer enhancement is achieved.The most effective heat transfer enhancement can be achieved by using fins as elements for the heat transfer surface area extension. In the past a large variety of fins have been applied for these purposes, leading a very compact heat exchangers with only gas or gas and liquid as the working media. Plate fin rotary regenerators and tube fin are widely encountered compact heat exchangers across the industry. Here the area of interest is the tube fin configuration. These are built as a combination of tubes with various cross sections with fins present both outside and inside the tubes. The common form of the tube cross-section is round or rectangular, but elliptical cross-sections are also encountered. Fins are generally attached by means of tight mechanical fit, adhesive bonding, soldering, brazing, and welding or by extrusion. Depending upon the form and direction of the fins, the tubes may be classified as individual tube with normal fins, individual tubes with longitudinal fins or tube arrays with plain, wavy or interrupted external of internal fins.

Based on Newton's law of cooling, convective heat transfer can be calculated as the product of heat transfer coefficient, heat transfer surface area and the temperature difference between the wall of the tube and the fluid flowing inside the walls. The wall to fluid temperature difference is usually adjusted oneself based on the operating conditions and therefore it cannot be used to enhance the heat transfer rate. One can increase the heat transfer surface area or the heat transfer coefficient, or both of them simultaneously. But as the heat transfer coefficient for a specific material at temperature is constant, hence the only way of changing the heat transfer rate is to vary the heat transfer surface area. Interrupted fins in the form of strips or louvered fins provide both a heat transfer surface area increase and also increase in the Effective heat transfer coefficient. Therefore these are particularly effective in obtaining high heat transfer rates. The mechanism which leads to high heat transfer coefficients of such fins is the periodic interruption of boundary layer around the fins and in this way also achieving better mixing with different temperature fluid streams.

The design calculations of the tube and the fin dimensions are done based upon equations suitable for the maximum heat transfer rate 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 Water.

2. Material Description

Phase at STP	solid
Melting point	933.47 K (660.32 °C, 1220.58 °F)
Boiling point	2743 K (2470 °C, 4478 °F)
Density (near r.t.)	2.70 g/cm^3
when liquid (at m.p.)	2.375 g/cm^3

Table 1 Physical properties

Natural occurrence	primordial
Crystal structure	face-centered cubic (fcc)
Speed of sound	(rolled) 5000 m/s (at r.t.)
Thermal expansion	23.1 µm/(m·K) (at 25 °C)
Thermal conductivity	237 W/(m·K)
Young's modulus	70 GPa
Shear modulus	26 GPa
Bulk modulus	76 GPa
Poisson ratio	0.35
Mohs hardness	2.75
Vickers hardness	160–350 MPa
Brinell hardness	160–550 MPa
CAS Number	7429-90-5

Table 2 Other properties

3. Modelling

Computer-aided design (CAD) is a computer technology that designs a product and documents the design's process. CAD may facilitate the manufacturing process by transferring detailed diagrams of a product's materials, processes, tolerances and dimensions with specific conventions for the product in question. It can be used to produce either two-dimensional or three-dimensional diagrams, which can then when rotated to be viewed from any angle, even from the inside looking out. A special printer or plotter is usually required for printing professional design renderings.

CAD is used as follows:

1. To produce detailed engineering designs through 3-D and 2-D drawings of the physical components of manufactured products.
2. To create conceptual design, product layout, strength and dynamic analysis of assembly and the manufacturing processes themselves.
3. To prepare environmental impact reports, in which computer-aided designs are used in photographs to produce a rendering of the appearance when the new structures are built.

The CAD software used here is CATIA (Computer Aided Three-dimensional Interactive Application) for designing the models for the fins configurations. The design is based on a heat exchanger tube with extended surface.

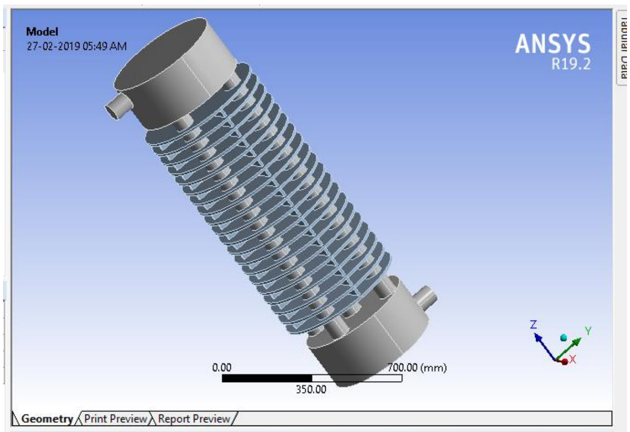

Fig 1. Cylindrical configuration

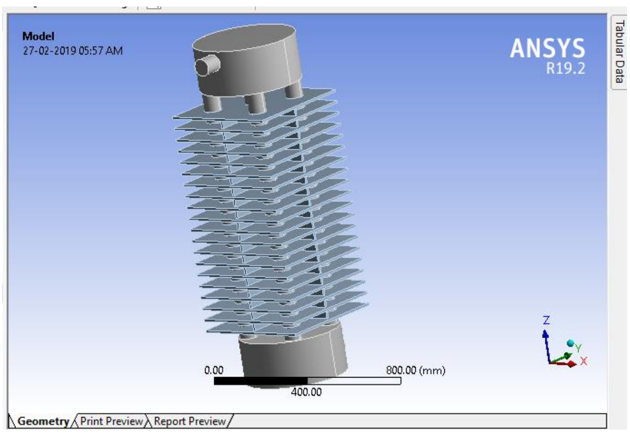

Fig 2. Square configuration

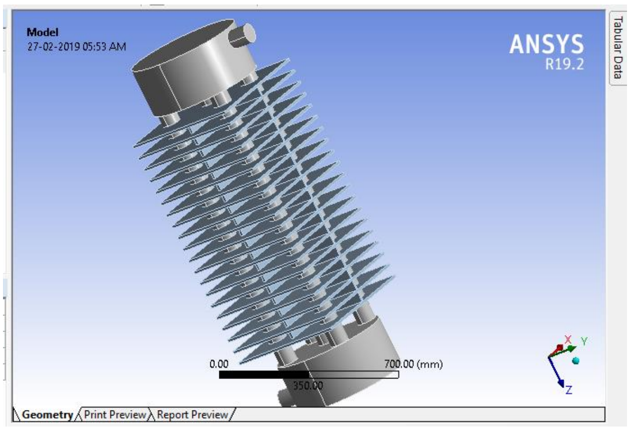

Fig 3. Rectangular configuration

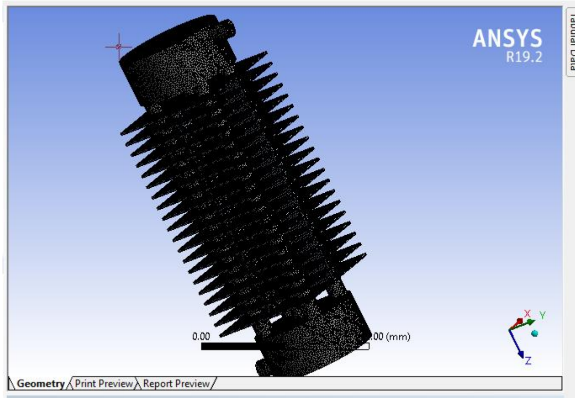

Fig 4. Meshing

4. Analysis

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses variation methods (the calculus of variations) to minimize an error function and produce a stable solution. FEM encompasses all the methods for connecting many simple element equations over many small sub domains, named finite elements, to approximate a more complex equation over a larger domain.

The subdivision of a whole domain into simpler parts has several advantages:

- Accurate representation of complex geometry
- Inclusion of dissimilar material properties
- Easy representation of the total solution
- Capture of local effects.

Meshing is done using triangular element. Meshing is the process of dividing a component or a product design into finite elements for the mathematical calculations. It can be minimum or maximum based upon the requirements of the result accuracy or the type of result.

5. Results

The use of fin (extended surface), provide efficient heat transfer. Heat transfer through fin of rectangular configuration is higher than that of other fin configurations. Temperature at the end of fin with rectangular configuration is minimum, as compare to fin with other types of configurations. The effectiveness of fin with rectangular configuration is greater than other configurations. Choosing the optimum size fin of rectangular configuration will reduce the cost for heat transfer process and also increase the rate of heat transfer.

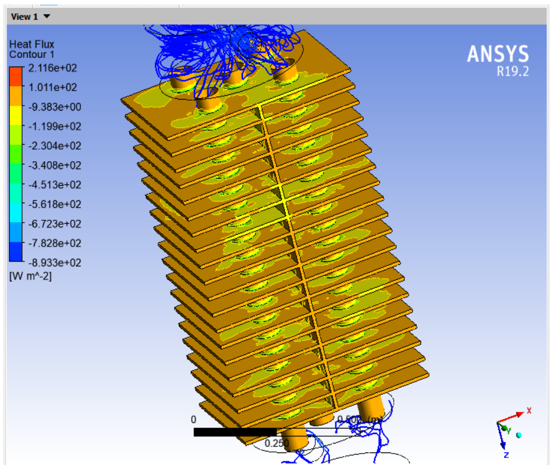

Fig 5. Heat flux contour of Rectangular configuration

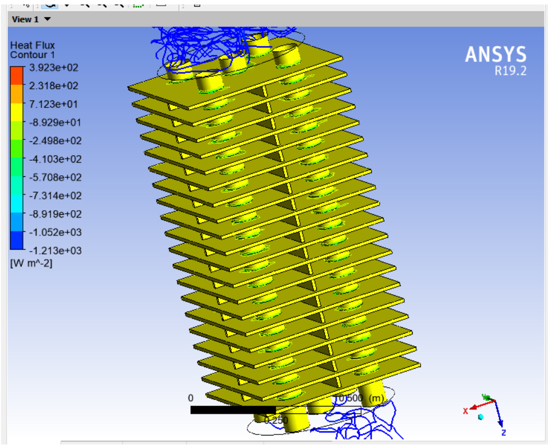

Fig6. Heat flux contour of Square configuration

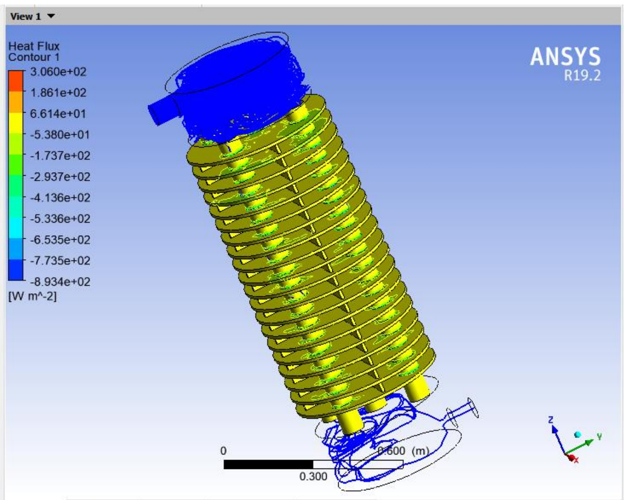

Fig 7. Heat flux contour of cylindrical configuration

Table 3 Comparison of Heat Transfer Rate of Different Configuration

CONFIGURATION	HEAT FLUX w/m²
Cylindrical	53.8
Rectangular	101.1
Square	65.3

6. Conclusion

The Heat Transfer through fins have been found to be high than that without fins. In future it may be improved by providing extensions on the fin which may provide increase in heat transfer rate. In other hand the fins may provide with notch which also results in improvement of heat flux through the fins.

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