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Investigation of Heat Transfer Rate and Temperature Distribution of Different Fin Geometry Using Experimental and Simulation Method.

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***Abstract*-- Convective heat dissipation from the standard surface can be significantly increased by the use of fins. Calculation of heat released from the fin involves a complex conjugate system of conduction and convection. The performance analysis is carried out using simulation and experimental method. Experiment carried out by using different geometry at different heat inputs. In this study, the enhancement of natural convection heat transfer from a horizontal rectangular fin embedded with rectangular perforations of aspect ratio of two has been examined using finite element technique. A fin experimental value set up is for designed developed and working procedure of the apparatus is simple. The results show that the rate of heat transfer is high for with insulated triangular fin, followed by without insulated triangular fin the results show that the rate of heat transfer is high for tapered pin fin, followed by pin fin.**

I. INTRODUCTION

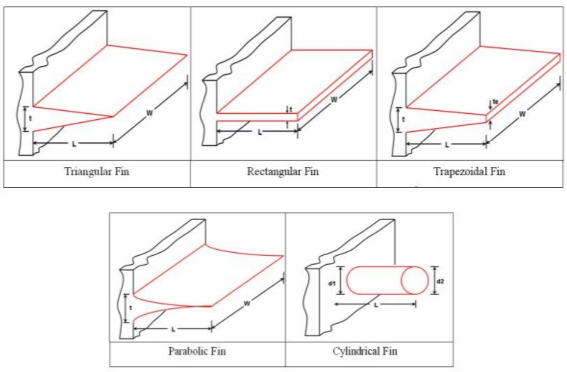
1.1 FINS

In many engineering application large quantities heat has to be dissipated from small area. Heat transfer by convection between a surface and the fluid surrounding it can be increased by attaching to the surface thin strip of metal called Fins.

1.2 Different Configuration Of FIN

- Longitudinal fins
- Pin Fins or Spines
- Circumferential fins.
- Fins may be uniform or variable cross section.

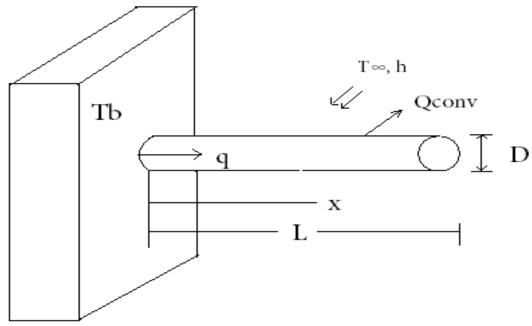
1.3 Types Of FIN Geomentry



1.4 General FIN Equations

Consider a volume element of a fin at location x having a length of Ax, cross sectional area of A_c and a perimeter of p, under steady state conditions, the energy balance on this volume element can be expressed as

Analysis Of FINS



In this experiment the fin is assumed to be infinitely long (i.e., the tip of the fin is at the same temperature as the adjacent fluid).

The analysis is simplified by the following assumption

- One dimensional conduction in the X-direction
- Steady state conditions
- Constant thermal conductivity
- No heat generation

1.5 To Improve The Fin Efficiency

- Increase the fin thickness
- Increase the thermal conductivity of the fins

Comparison Of Analytical And Experimental Result With The Simulation Result

For a Pin Fin Aluminum material (K=180 W/mk)

ELMER RESULT FOR FIN IN (2d):

Al – MATERIAL.

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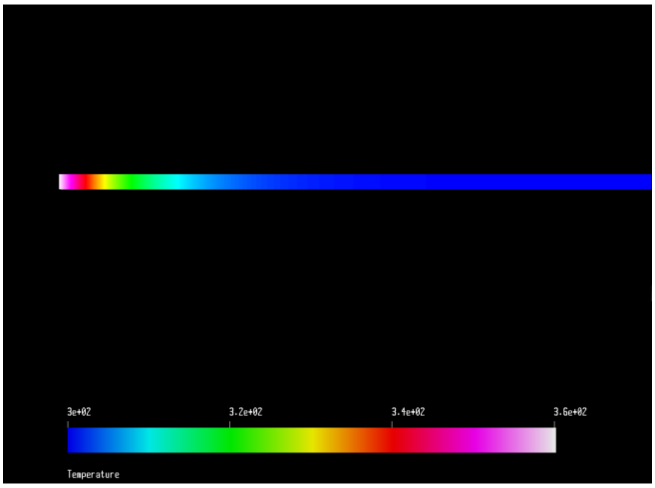
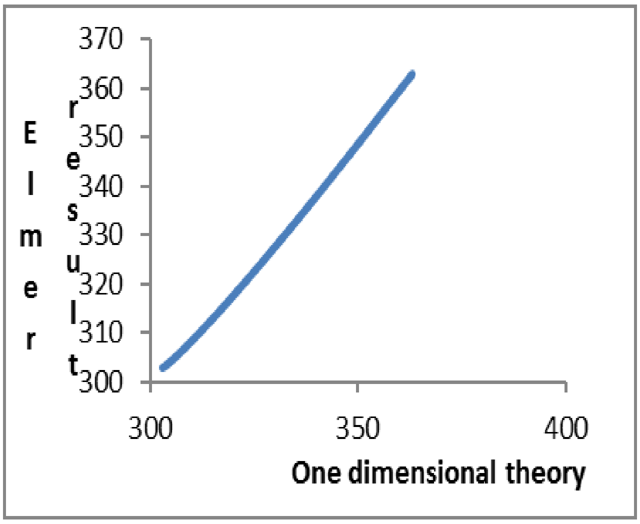


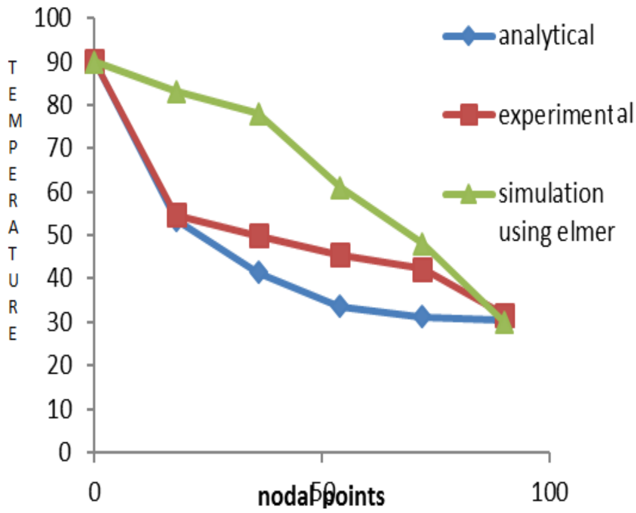
The Temperature distribution along the pin fin was analyzed for the base temperature at 90^0C. For all these conditions, the temperature of the tip of fin was the same as that of air.

Elmer Analysis Graph



The above graph is drawn between the one dimensional theory ant the Elmer result case file.

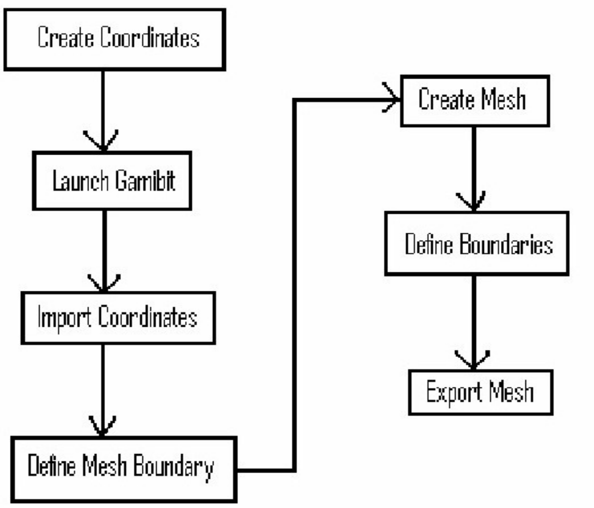
Comparison Graph



The measured temperature distribution for the three different power inputs (45V, 80V) are presented in the above tables and the graphs are plotted for the different power supply for different fin materials are plotted in the above fig.

GAMBIT

Gambit is modeling software that is capable of creating meshed geometries that can be read into FLUENT and other analysis software. An outline for the Gambit geometry creation process can be seen in figure.



Gambit Schematic Diagram

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FLUENT

Introduction About FLUENT:

FLUENT is the CFD solver of choice for complex flows ranging from incompressible to mildly compressible to highly compressible flows. Providing multiple choices of solver options, combined with a convergence-enhancing multigrid method, FLUENT delivers optimum solution efficiency and accuracy for a wide range of speed regimes.

General Modeling Capabilities

- 2D planar, 2D axisymmetric, 2D axisymmetric with swirl, and 3D flows
- Unstructured mesh (triangle and quadrilateral elements for 2D)
- Prism and pyramid elements for 3D)
- Steady-state or transient flows
- All speed regimes (low subsonic, transonic, supersonic, and hypersonic flows)

II. Modelling And Simulation

In CFD calculations, there are three main steps.

1. Pre-Processing
2. Solver Execution
3. Post-Processing

2.1 Procedure To Analyze The FIN

The thermal conductivity of the fin material can be specified. In this exercise, the default thermal conductivity represents Aluminum.

2.2 Modeling Details

The computational domain is represented in two dimensions.

The procedure for solving the problem is:

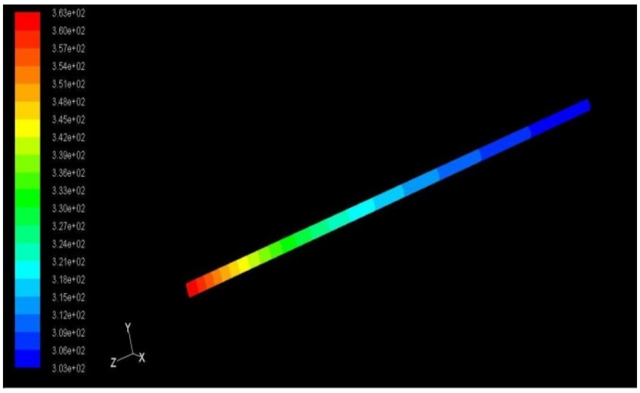
- Create the geometry.
- Set the material properties and boundary conditions.
- Mesh the domain.

Flow Lab creates the geometry and mesh, and exports the mesh to FLUENT. The boundary conditions, material properties, and surrounding properties are set through parameterized case files.

Solution

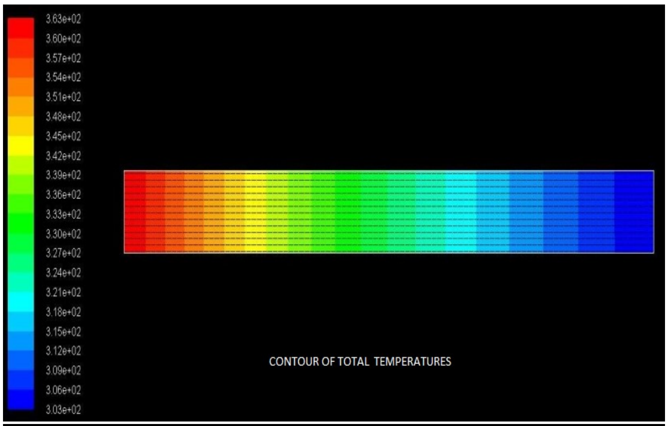
The mesh is exported to FLUENT along with the physical properties and the specified initial conditions. The material properties and the initial conditions are read through the case file, and the journal file provides instructions for the solver to start the solution.

2.3 Contour DIA For PIN FIN IN 3d: (Al material)



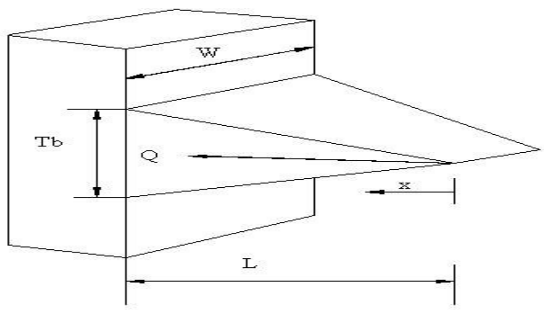
The Temperature distribution along the pin fin was analyzed for the base temperature at 90^0C. For all these conditions, the temperature of the tip of fin was the same as that of air.

2.4 Contour DIA For PIN FIN : (Copper material)



The Temperature distribution along the pin fin was analyzed for the base temperature at 90^0C. For all these conditions, the temperature of the tip of fin was the same as that of air. It was found that the temperature profile of the pin fin made up of aluminum whose thermal conductivity is 180W/mk.

2.5 Analysis of Triangular FIN



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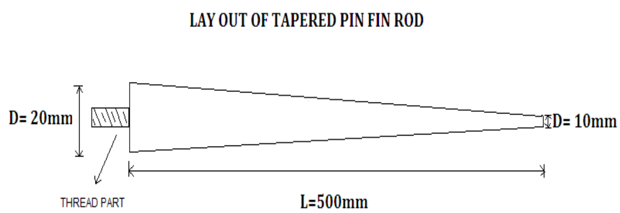
Assumptions

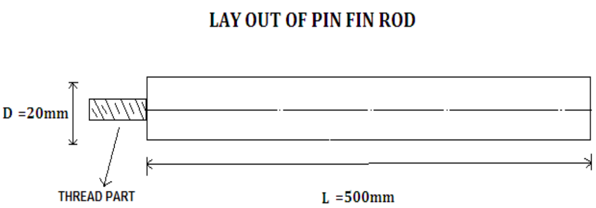
- Heat transfer is steady
- There is no heat generation in the fin
- Assuming heat transfer to be into the medium all sides

2.6 Expermental Setup For A Brass Rod For DIA 10mm:

The Temperature distribution along the Triangular fin was analyzed for the base temperature at 90^0C. For all these conditions, the temperature of the tip of fin was the same as that of air. It was found that the temperature profile of the triangular fin made up of aluminum whose thermal conductivity is 180W/mk.

2.7 Lay Out Of Experimental FIN Rods





2.8 Analysis Of The Tapered PIN FIN

In this experiment the fin is assumed to be infinitely long (i.e., the tip of the fin is at the same temperature as the adjacent fluid).

The analysis is simplified by the following assumption

- One dimensional conduction in the X-direction
- Steady state conditions
- Constant thermal conductivity
- No heat generation

Thermocouple

A thermocouple is a junction between two different metals that produces a voltage related to a temperature difference. Thermocouples are a widely used type of temperature sensor for measurement and control and can also be used to convert heat into electric power.

III. Experimental Setup

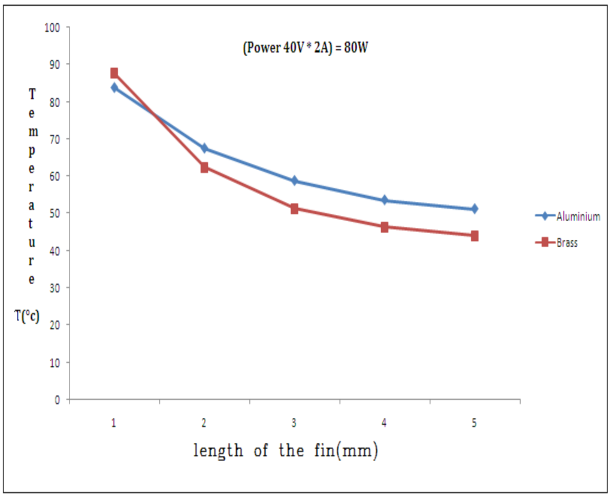
A circular tapered test rod of 20mm to 10 mm and length of the rod is 500mm is employed as a fin. The tip of the fin is at the same temperature as the adjacent fluid. Five iron constant an thermocouple is inserted at equal intervals into the rod to measure the axial temperature distributions. The intervals at which the thermocouples are inserted are based on length of the rod.

3.1 Experimental Procedure

- The Experimental procedure is very simple, quick, and straight forward to carry out.
- First turn on the energy source and adjust the electrical energy input to the desired heating level using the variable voltage transformer.
- Second when the system reaches steady state conditions measure the axial temperature distribution(x), of the rod. In addition, measure the surrounding air temperature T∞ using digital temperature indicator.

3.2 Temperature distribution of different fin in different fin materials in Tapered rod

(Power 40V * 2A) = 80W



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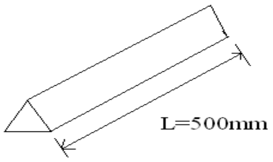
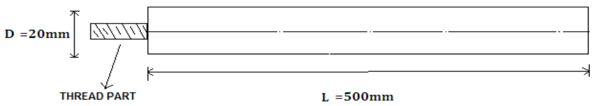
Lay Out Of Experimental FIN *Rods*

LAY OUT OF THE TRIANGULAR SHAPE ROD



LAY OUT OF THE SQUARE SHAPE ROD

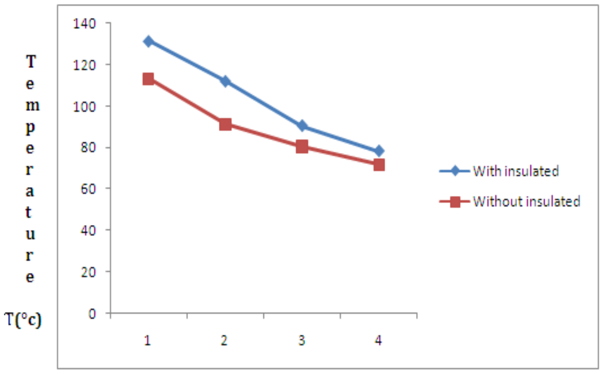


3.3 Temperature Distribution Of Different In Different FIN Materials In Triangular Shape Rod

(Power 40V * 2A) = 80W

For Brass material

Power=80W



Length of the fin mm

The measured temperature distribution for the three different power inputs (45V, 80V) are presented in the above tables and the graphs are plotted for the different power supply for different fin materials are plotted in the above fig.

3.4 Procedure To Analyze The FINS In Fluent

Heat transfer through various fin geometries is modeled. Geometry configurations such as rectangular, trapezoidal, triangular, cylindrical, and parabolic profiles are available.

Modeling Details

The computational domain is represented in two dimensions.

The procedure for solving the problem is:

- Create the geometry.
- Set the material properties and boundary conditions.
- Mesh the domain.

3.4 The Meshing Scheme Applied Ia Based Upon The Following Logic

a. For the trapezoidal and cylindrical fins, the shortest edge is identified and the edge element size is calculated by dividing the shortest edge into 8, 6 or 4 elements for fine, medium and coarse mesh types, respectively.

Material Properties

The thermal conductivity of the fin material can be specified. In this exercise, the default thermal conductivity represents Aluminum.

Boundary Conditions

The following thermal boundary conditions may be specified at the base of the fin:

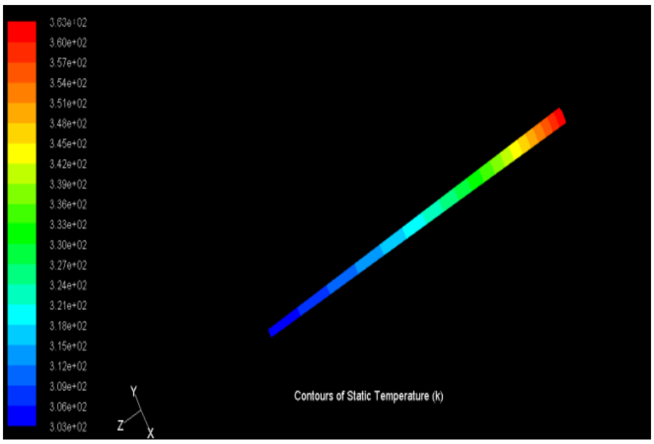
- Temperature
- Heat Flux

IV. Solution

The mesh is exported to FLUENT along with the physical properties and the specified initial conditions. The material properties and the initial conditions are read through the case file, and the journal file provides instructions for the solver to start the solution.

4.1 Simulation Results For PIN FIN In 10mm DIA:

Contour Dia For Taper PIN FIN: (BRASS material)



The Temperature distribution along the pin fin was analyzed for the base temperature at 90^0C. For all these conditions, the temperature of the tip of fin was the same as that of air.

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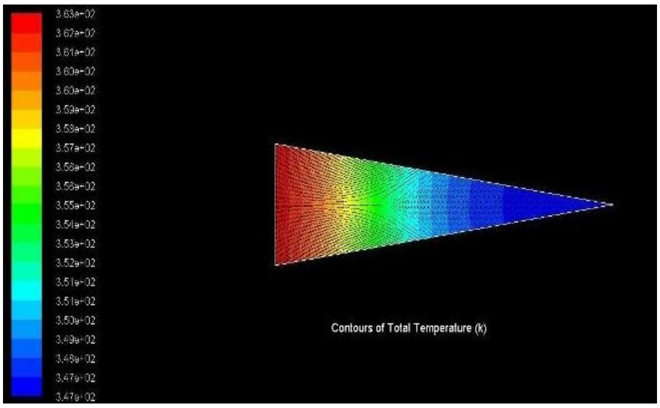
Simulation Results For PIN FIN In 10mm DIA:

Traingular FIN: (Al material)



The Temperature distribution along the pin fin was analyzed for the base temperature at 140^0C. For all these conditions, the temperature of the tip of fin was the same as that of air.

V. CONCLUSION

Temperature distribution and heat transfer rates are calculated using simulation method for the aluminum material and compared with the experimental result. The measured and predicted values have good agreement.

For all the conditions the temperature at the tip of the fin has to be the same as that of air. But reality the tip temperature of the fin is not the same as that of ambient temperature this shows that heat transfer is enhanced.

Simulated valves are calculated for temperature distribution and heat transfer for the pin fin and triangular fin for different materials at the base temperature 90°c.

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