Study of Heat Transfer rate using V-pin fins by using CFD analysis.

Abhijit Rajole[1], Kailas Pardeshi[2], Firoj Pathan[3], Navnath Khokale[4], Manoj Ganage[5], Shashikant Dughad[6]

[1,2,3,4] BE student Mechanical, SND COE & RC, YEOLA, Maharashtra, India
[5] Asst. Prof. Mechanical, SND COE & RC, YEOLA, Maharashtra, India
[6] Prof. Mechanical, SND COE & RC, YEOLA, Maharashtra, India

---***---

Abstract – *In most of the cases, the heat transfer takes place by conduction & convection. Heat is conducted in solid material up to its surface & finally the heat is rejected by convection from its surface to surrounding. Thus aim is to increase the heat transfer rates from the surface so that the temperature of solid surface is maintained within desired limit to avoid damage to the surface. In design consideration temperatures are fixed. Therefore there are two ways to increase heat transfer rate; either by increasing heat transfer coefficient (h) or by increasing the surface area. Increasing 'h' may require the installation of pump or fan. But approach may or may not be practical. The alternative is to increase the surface area by attaching extended surface called as fins. Fins are made highly conductive materials such as aluminum.*

Fins enhance heat transfer from a surface by exposing a layer surface area to convection & radiation. The fins like rectangular, trapezoidal, V-fins are used to increase the heat transfer rates. The steady-state natural convection heat transfer from fins extending perpendicularly from vertical rectangular base here investigated analytically. The effects of geometric parameters on the heat transfer performance of fin arrays were observed and the maximum heat transfer rates were determined by CFD analysis.

Key words: Heat Transfer, Conduction, Convection, Radiation, Heat Transfer Rate, CFD, V-pin fins.

1.1INTRODUCTION

1.1.1. NEED OF STUDY

The development of high performance thermal system has stimulated interests in the methods to enhance the heat transfer. But the enhancement techniques are frequently accompanied by increase in cost, weight and complicated manufacturing techniques and material. Hence the designer should also evaluate the performance of the enhancement technique in terms of applicable design constrains. The Objectives of our study are:

- To test the various V-fins array models, with variations in the included angle with the help of computational fluid dynamics and find the angle giving maximum heat transfer coefficient among the models chosen.
- To validate the results obtained for the optimum angle by the application of computational fluid dynamics with standard paper.

PROBLEM DEFINITION:

As the continuous increasing of globalization the heat produced by various application such as engine, electronics equipment etc. are transfer rapidly.

For this heat transfer from the appliances the extended surface called as fins are used. Fins are in the form of arrays which is arranged on the circumference of the heated surface.

1.1.2. STUDY OF ENHANCEMENT TECHNIQUES

Enhancement techniques are classified in two groups – Active Techniques and passive techniques. Passive techniques employ special surface geometries or fluid additives for enhancement i.e. no direct application of external power. While active techniques require external power such as electric or acoustic fields and surface vibrations. Passive techniques consist treated surfaces, rough surfaces, displaced enhancement devices, swirl flow devices, extended surfaces, and additives for liquids and for gases surface tension devices. Active techniques include mechanical aids, surface vibrations, fluid vibrations, electro of magnetic fields, and injection on suction and jet impingements.

The majority of commercially interesting enhancement techniques are passive. The active technique have not found commercial interest because of the capital and operating cost of the enhancement devices sand problems associated with vibration or acoustic noise. We shall study the extended surface passive technique of enhancement.

Applications of Finned surface in various fields.

1. Tubes of various heat exchangers, for example, radiator of cooling system, condenser tubes of domestic refrigerators, and intercoolers of air compressors are having finned surfaces exposed to ambient air.
2. The head and Cylinder of air cooled engines and compressors are provided with fins.
3. Outside surfaces of the cooling and dehumidifying coils in the air conditioning systems are provided with fins.

4. Electronic components such as diodes, transistors etc. are provided with finned surfaces which are known as heat sinks.
5. Direct energy conversion devices.
6. Nuclear fuel modules.
7. Process heat dissipaters and waste heat boilers.
8. Conventional furnaces and gas turbines.

1.2 WHAT IS CFD?

CFD: A methodology for obtaining a discrete solution of real world fluid flow problems. – Discrete Solution: Solution is obtained at a finite collection of space points and at discrete time levels

1.2.1. The Benefits of CFD:-

1. Insight: Difficult to prototype or test through experimentation.
2. Foresight: Better prediction in a short time.
3. Efficiency:
    a. Design better and faster, economical, meet environmental regulations and ensure industry compliance.
    b. CFD analysis requires to shorter design cycles and production to market faster.
    c. In addition, equipment improvements are built and installed with minimum downtime.
    d. CFD is a tool for compressing the design and development cycle allowing for rapid prototyping.

STEPS OF CFD ANALYSIS FLOW DIAGRAM

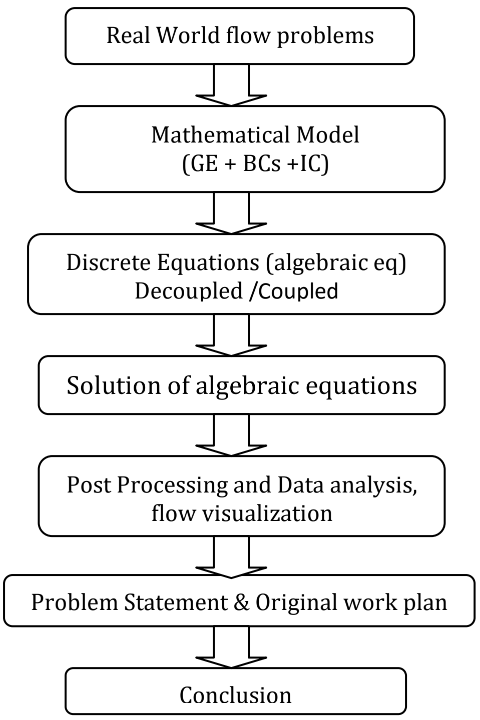

Fig.1.1. Steps of CFD Analysis diagram

1.3. STUDY OF COMPUTATIONAL ANALYSIS.

Computational methods are more and more widely applied to simulation rather than experimental analysis of any new object, to orient experimental planning and ultimately, to avoid costly experiment and waste of material and time.

One of the computational analysis method widely used is CFD. CFD is a" Computational Fluid Dynamics". CFD uses numerical methods to obtain the result of the fundamental nonlinear differential equations that describe fluid flow (the Navier-Stokes and allied equations) for predefined geometries and boundary layer conditions. The result is a wealth of predictions for flow velocity, temperature, density, and chemical concentrations for any region where flow occurs. Another major field in which Computational Fluid Dynamics is expensively used is heat transfer. ***Heat*** as the form of energy that can be transferred from one system to another as a result of temperature difference.

There are basically three modes of heat transfer:

1. Conduction
2. Convection
3. Radiation

A thermodynamic analysis is belonging with the amount of heat transfer as a system undergoes a process from one equilibrium state to another. The science that deals with the determination of the rates of such energy transfers is the heat transfer. The transfer of heat is always from the higher-temperature surface to the lower-temperature one.

1.4. BASIC DEFINITIONS RELATED TO HEAT TRANSFER.

a. CONDUCTION:

Conduction transfers heat via direct molecular collision. An area of grater kinetic energy will transfer thermal energy to an area with lower kinetic energy, higher speed particles will collide with slower speed particles. The slower speed particles will increase the KE. Conduction is the most common form of heat transfer via physical contact.

$$Q_{conduction} = -k * A * \frac{dT}{dx}$$

b. CONVECTION:-

The process of heat convection is due to the capacity of moving matter to carry heat energy. The transfer of heat by convection takes place between a solid surface and the adjacent liquid or gas layer that is in motion. In case the fluid is at rest then the transfer of heat between the solid surface and the adjacent layer of fluid is purely by convection.

TYPE'S OF CONVECTION:-

i. **Natural convection**:-

In case the fluid moves due to density difference caused by the heat transfer between solid surface and fluid it is said to be by natural convection. It is also called as free convection.

ii. **Forced convection**:-

If the fluid motion is imparted by external means like pump, fan, compressor, slope etc. the convection is called forced convection.

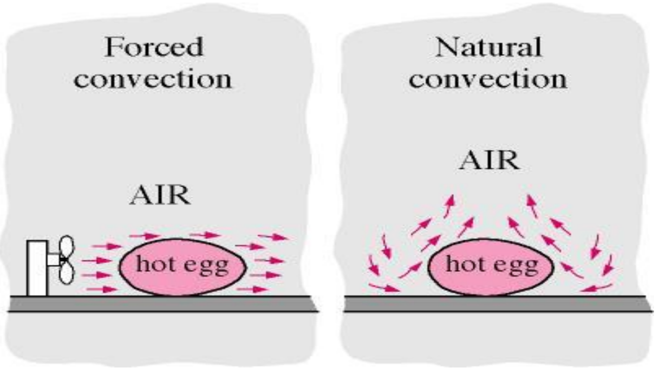

Fig.1.2. Types of convection

c. RADIATION:-

Thermal radiation is defined as the transfer of heat due to electromagnetic waves without requiring any medium.

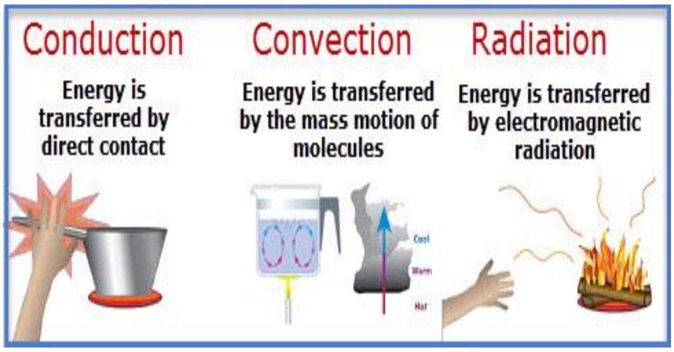

Fig.1.3. Three modes of heat transfer

1.5. STUDY OF THERMAL CONDUCTIVITY AND THERMAL CONDUCTIVITY OF DIFFERENT MATERIALS.

a. THERMAL CONDUCTIVITY: -

Thermal conductivity is the ability of material to conduct heat through it. It can also be defined as the amount of heat flow per unit area normal to the direction of heat flow through unit thickness of the material per unit temperature difference.

b. THERMAL CONDUCTIVITY OF DIFFERENT MATERIALS.

Material	Thermal conductivity k (W/mk)
Silver	417
Copper	386
Aluminium	202
Magnesium	171
Tungston	166
Zinc	112
Brass	108

Table 1.1. Thermal conductivity of various materials.

1.5.1 STUDY OF EFFECT OF VARIATION OF TEMPRATURE ON THERMAL CONDUCTIVITY.

The heat conduction in solids is both by transport of free electrons and lattice vibrations. When temp of metal increases, the lattice vibration impede the motion of free electrons. Due to this the thermal conductivity of most of the pure metals decreases with increase in temperature.

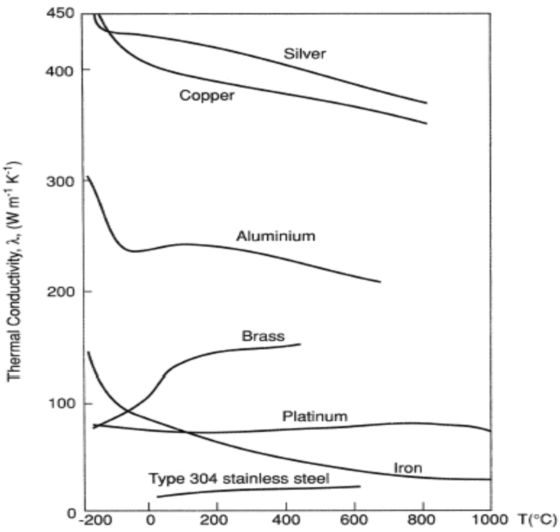

Fig.1.4. variation of thermal conductivity of metals with temperature

1.6. CONCLUSION

We are studied the computational fluid dynamics and different enhancement technique of heat transfer ,mode of heat transfer and thermal conductivity and its effect with respect to change in temperature of different material.

REFERENCES

1) Yunus A. Cengel, "Heat and Mass Transfer – A Practical Approach".

2) Xiaohui Zhang and Dawei Liu "Optimum geometric arrangement of vertical rectangular fin arrays in natural convection" (2010).

3) S.A.Nada, "Natural convection heat transfer in horizontal and vertical closed narrow enclosures with heated rectangular finned base plate" (2006).

4) R.L.Edlabadkar, N.K. Sane, and G.V. Parishwad, "Computational Analysis of Natural Convection with Single V-Type Partition Plate" (2006).

5)M. J. Sable, S. J. Sable , P. S. Patil , P. R. Baviskar, and S.B. Barve ,"Enhancement of Natural Convection Heat Transfer on Vertical Heated Plate by Multiple V-Fin Array" (2010).

6) S.H. Barhatte, M.R. Chopade and V.N. Kapatkar, "Experimental and Computational Analysis and Optimization for Heat Transfer through Fins with Different Types of Notch" "Heat Transfer in Natural Convection in Two Vertical and One Horizontal Plate – An Overview" by Mahendra P. Nimkar.

BIOGRAPHIES

Abhijit A. Rajole, SND COE Yeola, Pune University, Department of Mechanical Engineering.

Kailas C. Pardeshi, SND COE Yeola, Pune University, Department of Mechanical Engineering.

Firoj J. Pathan, SND COE Yeola, Pune University, Department of Mechanical Engineering.

Navnath B. Khokale, SND COE Yeola, Pune University, Department of Mechanical Engineering.

Prof. Manoj D. Ganage, SND COE Yeola, Pune University, Department of Mechanical Engineering.

Prof. Shashikant N. Dughad, SND COE Yeola, Pune University, Department of Mechanical Engineering.