Review on fin analysis and various heat transfer enhancement techniques

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Abstract - **Thermal performance of heat transfer devices can be improved by various heat transfer techniques. In present study heat transfer from rectangular fin to fluid with the convergent divergent arrangement of fin array is experimentally studied. The fin having dimple on it and they are made up of different material composition. All the required parameters like inlet and outlet temperature of fluid as well as fluid flow rate are measured. Effect of inlet fin temperature and other relevant parameters on heat transfer characteristics are studied. The inner convective heat transfer, heat transfer coefficient, fin effectiveness, fin efficiency is determined.**

***Keywords* —Heat Transfer, Extended surface, Enhancement, Dimpled fin, Fin Array, Twisted tape.**

I. INTRODUCTION

Heat transfer is a subject of widespread interest to the student of engineering curriculum, practicing engineers & technicians engaged in the design, construction, testing and operation of the many diverse forms of heat exchange equipment required in our scientific and industrial technology.

Electrical engineers apply their knowledge of heat transfer for the design of cooling systems for motors, generators & transformers. Chemical engineers are concerned with the evaporation, condensation, heating & cooling of fluids.

An understanding of the laws of the heat transfer flow is important to Civil engineers in the construction of dams, structures and to the architect, in the design of buildings. The Mechanical engineer deals with problems of heat transfer, in the field of internal combustion engines, steam generation, refrigeration and heating & ventilation.

II. MODES OF HEAT TRANSFER

The literature of heat transfer generally recognizes three

distinct modes of Heat Transmission. Heat transfer is the energy in transits due to temperature difference.

Whenever there is exist temperature difference in a body, heat flows from regions of high temperature to the region of low temperature. This heat transfer takes place by three different processes called as modes of heat transfer.

These are:

a) Conduction b) Convection c) Radiation

These three modes are similar in that a temperature differential must exist and the heat exchange is in the direction of decreasing temperature. Each method has, however, different physical picture and different controlling laws.

Conduction:

"Thermal conduction is a mechanism of heat propagation from a region of higher temperature to a region of low temperature with in a medium (solid, liquid or gaseous) or between different medium in direct physical contact." Radiation:

Radiation heat transfer is defined as the transfer of energy across a system boundary by means of an electromagnetic mechanism which is caused solely by a temperature

Difference. Convection:

The process of heat transfers between surface & moving fluid when they are at different temperature is called as convection. In this process flow of energy is obtained because of movement of fluid molecules. When the fluid flows over the surface, a thin region is formed over the surface. Where the fluid molecules flow in different layers' parallel to the surface. Layer of the fluid in contact with surface is stationary. Velocity of the other layers of fluid increases with the distance from the surface & finally becomes same as that as free stream velocity. This region above the surface known as film region.

Convection is classified in two types:

(a) Forced convection (b)Natural convection

Forced convection: In forced convection "when flow of fluid over the surface is caused by some external means such that by a fan, a blower. It is called as forced convection; they are very high rates of heat transfer."

Natural or free convection: process involving mass movement of the fluids. When temperature difference produces a density difference, which results in mass movement, the process is called "free or natural convection"

Heat Transfer Enhancement Techniques:

The various types of heat transfer enhancement techniques are broadly classified into three different categories

a. Passive Techniques

These techniques do not require any direct input of external power; rather they use it from the system itself which ultimately leads to an increase in fluid pressure drop. They generally surface or geometrical modification to the flow channel by incorporating inserts or additional devices. They promote higher heat transfer coefficients by disturbing or altering the existing flow behavior except for extended surfaces. Heat transfer augmentation by these techniques can be achieved by using;

1. Treated surfaces: such surfaces have a fine scale alteration to their finish or coating which may be continuous or discontinuous. They are primarily used for boiling and condensing duties

2.Rough surfaces: These are the surface modifications that promote turbulence in the flow field in the wall region, primarily in single phase flow, without increase in heat transfer surface area.

3.xtended surfaces: They provide effective heat transfer enhancement. The newer developments have led to modified finned surfaces that also tend to improve the heat transfer coefficients by disturbing the flow fields in addition to increasing the surface area.

4. Coated surfaces: They involve metallic or non-metallic coating of the surface. Examples include a non-wetting coating, such as Teflon, to promote dropwise condensation, or a hydrophilic coating that promotes condensate drainage on evaporator fins, which reduces the wet air pressure drop. A fine-scale porous coating may be used to enhance nucleate boiling.

5.Swirl flow: Swirl flow devices include a number of geometrical arrangements or tube inserts for forced flow that create rotating or secondary flow.

6. isplaced Enhancement devices: These are the inserts that are used primarily in confined forced convection and they improve energy transport indirectly at the heat exchange surface by displacing the fluid from heated or cooled surface of the duct with Coated surfaces

7. Additives for liquids: Additives for liquids include solid particles or gas bubbles in single-phase flows and liquid trace additives for boiling systems.

8. Additives for gases: Additives for gases are liquid droplets or solid particles, either dilute-phase (gas-solid suspensions) or dense-phase (packed tubes and fluidized beds).

b. Active techniques:

1. Mechanical aids: They involve stirring the fluid by mechanical means or rotating the surface. Mechanical surface scrapers, widely used for viscous liquids in the chemical process industry, can be applied to duct flow of gases. Equipment with rotating heat exchanger ducts is found in commercial practice

2. Surface vibration: Surface vibration at either low or high frequency has been used primarily to improve single-phase heat transfer. A piezoelectric device may be used to vibrate a surface and impinge small droplets onto a heated surface to promote "spray cooling.

3. Fluid vibration: It is more practical type of vibration enhancement because of the mass of most heat exchangers. The vibrations range from pulsations of about 1 Hz to ultrasound. Single phase fluids are of primary concern.

4. Electrostatic fields: They are applied in many different ways to dielectric fluids. Generally speaking, electrostatic fields can be directed to cause greater bulk mixing of fluid in the vicinity of the heat transfer surface.

5. Injection: It is utilized by supplying gas through a porous heat transfer surface to a flow of liquid or by injecting the same liquid upstream of the heat transfer section. The injected gas augments single-phase flow. Surface degassing of liquids may produce similar effects.

6. Suction: It involves vapour removal, in nucleate or film boiling, or fluid withdrawal in single phase flow through a porous heated surface.

7. Jet impingement: It forces a single-phase fluid normally or obliquely toward the surface. Single or multiple jets may be used, and boiling is possible with liquids.

The heat conducted through solids, walls or boundaries has to be continuously dissipated to the surroundings or environment to maintain the system in steady state condition. In many engineering application large quantity of heat is dissipated from small areas. Heat transfer by convection between a surface and fluid surrounding it can be increased by attaching to the surface thin strips of metal called fins. The fin increases the effective area of surface, thereby increasing the heat transfer by convection. The fins are also referred to as 'extended surfaces'.

III. LITERATURE REVIEW

Ambeprasad.S. Kushwaha, Prof. Ravindra Kirar[1] Carried out the comparative study of heat sink having fins of various profiles namely Rectangular, Trapezoidal and Parabolic as heat sinks are the commonly used devices for enhancing heat transfer in electronic components. For the purpose of study heat sink is modeled by using the optimal geometric parameter such as fin height, fin thickness, base height, the simulation is carried out with a commercial package provided by fluent incorporation. The result obtained taking into consideration only the thermal performance. As per the current era of the technological development everything is needed to be compact; whether it is a normal computer or laptop or the rack server we need everything that can be placed in a small space, so here the space constraint plays a major role as you cannot install a large heat sink for your device as it increases the size and the cost. For all the three profile compared for the maximum temperature attained on the basis of result governed by the CFD analysis, with the fin pitch 2mm the Trapezoidal heat sink shows that the maximum temperature attained is minimum as compared to the Rectangular and Parabolic heat sink and the parabolic heat sink shows the highest maximum temperature attained which is not desirable. **Rafeek Shaikh [2]** studied the extended surfaces employed to increase the convective heat transfer from a surface for increasing heat dissipation. Fins with various geometries have been designed and used in various cooling application the selection of particular fins configuration in any heat transfer application is an important state in designed process and takes into account the space, weight, manufacturing technique and cost consideration as well as the thermal characteristics it exhibits. Fins cross section profiles have profound influence on thermal characteristics of Annular Fins and the surface area changes with change of cross section of fins. This study deals with studying the performance of various available fins profiles. Widely used fins profile viz. Rectangular, Triangular, Trapezoidal, Circular, Rhombic, and Elliptical Fins. In addition to the normal configuration of fins, to new configurations were designed and created. This includes length of each fins its thickness at the base and number of fins on each model this provided a basis for proper comparison of different fin profiles. The result was tabulated and studied for comparison of different fin profiles. The best performing fin was then selected on the basis of maximum heat dissipation from the circular model this study shows the performance of annular fins of different profiles under similar conditions and to quantify the heat losses and finally compare it with fin profiles on the basis of heat dissipation and thermal stress include. The fin profile was then arranged on the basis of performance.

L.Prabhu, M.Ganesh Kumar et al. [3] The heat transfer performance of fin 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 was compared. In this thermal analysis, Aluminium was used as the base metal for the fin material and for various configurations. Fin of various configuration were design with the help of CATIA V5R16 software Analysis of fin performance done through the software ANSY 15.0. On comparison, rectangular configuration provides the greatest heat transfer than that of other configurations having the same volume. The effectiveness of rectangular fin is greater as compare to other configuration of fin.

Amol B. Dhumne [4] investigated heat transfer analysis of cylindrical perforated fins in staggered arrangement. The present paper gives the review on heat transfer enhancement and the corresponding pressure drop over a flat surface equipped with cylindrical cross sectional perforated rectangular fins in a rectangular channel. The channel had a cross sectional area of 25-100 mm^2. The experiments covered the following range: Reynolds number 13,500–42,000, the clearance ratio (C/H) 0, 0.33 and 1, the inter fin spacing ratio (Sy/D) 1.208, 1.524, 1.944 and 3.417. Correlation equations were developed for the heat transfer, friction factor and enhancement efficiency. The experimental review shows that the use of the cylindrical rectangular fins may lead to heat transfer enhancement. Enhancement efficiencies varies depending on the clearance ratio and inter-fin spacing ratio. Both lower clearance ratio and lower inter-fin spacing ratio and comparatively lower Reynolds numbers are suggested for higher thermal performance. Nusselt number and friction factor were considered as performance parameters.

Jorge Duarte Forero, Guillermo Valencia Ochoa et al. [5] carried out study on the proper length of straight rectangular fins for different materials and the consideration that must be taken during the design of the fins. Two case studies were performed, the temperature profile of straight rectangular fins as a function of length for different materials, and the effect of thickness on the proper length of the fin and the heat transfer rate for copper and aluminium. It was found a poor heat removal along the length of the iron fins compared with copper and aluminium fins. Low thickness involves low temperature in the extreme of the fin resulting in a low heat transfer in that zone. The higher the thickness, the higher the proper length

S. V. Naidu, K.V. Sharma et al. [6] investigated The problem of natural convection heat transfer from fin arrays with inclination is studied experimentally and theoretically to find the effect of inclination of the base of the fin array on heat transfer rate. A numerical model is developed by taking an enclosure, which is formed by two adjacent vertical fins and horizontal base. Results obtained from this enclosure are used to predict heat transfer rate from the fin array. All the governing equations related to fluid in the enclosure, together with the heat conduction equation in both the fins are solved by using Alternate Direct Implicit method. Numerical results are obtained for temperature along the length of the fin and in the fluid in the enclosure. The experimental studies have been also carried out on two geometric orientations viz., (a) vertical base with vertical fins (vertical fin array) and (b) horizontal base with vertical fins (horizontal fin array), with the five different inclinations like 0, 30, 45, 60, and 90. The experimental results are compared with the numerical results computed by the theoretical analysis shows the good agreement.

Hasibur Rahman Sardar, Abdul Razak Kaladgi et al. [7] studied dimples play a very important role in heat transfer enhancement of electronic cooling systems, heat exchangers etc. This work mainly deals with the experimental investigation of forced convection heat transfer over circular shaped dimples of different diameters on a flat copper plate under external laminar flow conditions. Experimental measurements on heat transfer characteristics of air (with various inlet flow rates) on a flat plate with dimples were conducted. From the obtained results, it was observed that the heat transfer coefficient and Nusselt number were high for the copper plate in which the diameter of dimples increases centrally in the direction of flow (case c) as compared to the other two cases.

Ashok Kumar [8] Studied the results of air flow and heat transfer in a light weight automobile engine, considering fins with dimple to increase the heat transfer rate. An analysis has been using ANSYS WORKBENCH version 12.0 was conducted to find the optimum number of dimples to maximizing the heat transfer across the Automobile engine body. The results indicate that the presence of fins with dimple shows improved results on the basis of heat transfer.

Mohammad A. Elyyan, Danesh K. Tafti et al. [9] investigated a novel split-dimple interrupted fin configuration for heat transfer augmentation. The use of an interrupted plate fin with surface roughness in the form of split-dimples is investigated High-fidelity time-dependent calculations are performed for a wide range of Reynolds number ranging from ReH = 240 to 4000, covering the laminar to fully turbulent flow regimes. The split dimples provide an additional mechanism for augmenting heat transfer by perturbing continuous boundary layer formation on the fin surface and generating energetic shear layers. High heat transfer regions are observed at the fin and split-dimple leading edges as a result of boundary layer restarts, in regions of flow acceleration between protrusions, and flow in rectangular arrangement on the protrusion surface. While the protruding geometry of the split-dimple also aids in augmenting heat transfer from the fin surface by generating unsteady or turbulent wakes, it also increases pressure losses. The split-dimple fin results in a heat conductance that is 60–175% higher than a plain interrupted plate fin, but at a cost of 4–8 times the frictional losses.

S. Naga Sarada1, A.V. Sita Rama Raju1 et al. [10] carried out experimental investigations of the augmentation of turbulent flow heat transfer in a horizontal tube by means of varying width twisted tape inserts with air as the working fluid. In order to reduce excessive pressure drops associated with full width twisted tape inserts, with less corresponding reduction in heat transfer coefficients, reduced width twisted tapes of widths ranging from 10 mm to 22 mm, which are lower than the tube inside diameter of 27.5 mm are used. Experiments were carried out for plain tube with/without twisted tape insert at constant wall heat flux and different mass flow rates. The twisted tapes are of three different twist ratios (3, 4 and 5) each with five different widths (26-full width, 22, 18, 14 and 10 mm) respectively. The Reynolds number varied from 6000 to 13500. Both heat transfer coefficient and pressure drop are calculated and the results are compared with those of plain tube. It was found that the enhancement of heat transfers with twisted tape inserts as compared to plain tube varied from 36 to 48% for full width (26mm) and 33 to 39% for reduced width (22 mm) inserts. Correlations are developed for friction factors and Nusselt numbers for a fully developed turbulent swirl flow, which are applicable to full width as well as reduced width twisted tapes, using a modified twist ratio as pitch to width ratio of the tape.

IV. CONCLUSION

1. The use of fins (extended surface), provide efficient heat transfer. Heat transfer through fin of trapezoidal configuration is higher than that of other fin configurations. The effectiveness of fin with trapezoidal configuration is greater than other configurations. Choosing the optimum size fin of trapezoidal configuration will reduce the cost for heat transfer process and also increase the rate of heat transfer.

2. The best working material was copper with the highest thermal conductivity (395W/m℃). Low thickness involves low temperature in the extreme of the fin resulting in a low heat transfer in that zone. The higher the thickness, the higher the proper length. Between copper and aluminum, the best material for the same thickness is aluminum because it has the shortest proper length. Though, it is necessary to see the amount of heat removed. Aluminum removes less heat than copper.

3. The overall heat transfer rate using fins along with dimples base been higher than without dimples.

4. It was found that the enhancement of heat transfers with twisted tape inserts as compared to plain tube varied from 33 to 39%.

V. REFERENCE

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