Experimental Analysis To Enhance The Heat Transfer By Using Dimpled (Cashew And Capsule) Surface” A Review

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ABSTRACT

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 (i.e. 1) Cashew dimples, and 2) Capsule dimples) of different diameters on a flat copper plate under external laminar flow conditions. Experimental measurements of 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.

Keywords: - *Heat Transfer, Laminar Flow, Dimples Shape (Cashew & Capsule)*

1. INTRODUCTION

The maximum temperature of the component is one of the main factors that control the reliability of electronic products. Thermal management has always been one of the main issues in the electronics industry, and its importance will grow in coming decades. The use of heat sinks is the most common application for thermal management in electronic packaging. Heat sink performance can be evaluated by several factors: material, surface area, the flatness of contact surfaces, configuration, and fan requirements. Although there are a few investigations for the use of dimples under laminar airflow conditions, there exist no experimental data with respect to the use of different dimple shapes for heat sink applications. Therefore, this study evaluated the heat transfer characteristics using two different dimple shapes on a heat sink fin by experimental methods: 1) Cashew dimples, and 2) Capsule dimples.

The conventional heat transfer enhancement approaches to increase either the heat transfer rate or the turbulence of fluid stream, in general, it involves the incorporation of fins, baffles, nebulizers and etc. Although, these approaches are the effective method to improve the heat transfer performance; however, the increasing of fluid stream pressure drop should be concerned. The dimpled surface is one of the effective methods to improve the heat transfer rates without the significant pressure drop. Normally, the dimpled surface generates the vortex flow within its hole and the augmentation of heat transfer is obtained. [1]

Enhancement techniques can be separated into two categories: Active and Passive.

A. Active Method

This method involves some external power input for the enhancement of heat transfer. Some examples of active methods include mechanicals aids, surface vibration, fluid vibration, electrostatic fields, suction or injection and jet impingement requires an external activator/power supply to bring about the enhancement

B. Passive Method

This method generally uses surface or geometrical modifications to the flow channel by incorporating inserts or additional devices. For example, inserts extra component, swirl flow devices, treated surface, rough surfaces, extended surfaces, displaced enhancement devices, coiled tubes, surface tension devices and additives for fluids

C. Compound Method

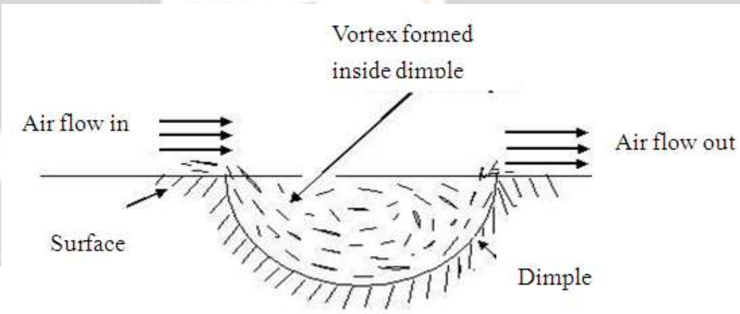
If two or more techniques can be utilized simultaneously to produce an enhancement larger than that produced by only one Technique than it can be said as Compound Method. A compound method is a hybrid method in which both active and passive methods are used in combination. The compound method involves complex design and hence has limited applications.

2. VORTEX HEAT TRANSFER TECHNIQUE

Each dimple acts as a "Vortex Generator" which provides an intensive and stable heat and mass transfer between the dimpled surface and gaseous heating/ cooling media. Taking advantages of vortex heat transfer enhancement (VHTE), as

a) Higher heat transfer coefficient
b) Negligible pressure drop penalty
c) Potential for fouling rate reduction
d) Simplicity in design and fabrication
e) Compactness and/or lower cost

This method is potentially used in heat transfer enhancement in convective passages for industrial boilers, process heaters, furnaces, heat exchangers and variety for other industries like automotive (radiators, oil coolers etc.), heat treating(recuperate), aerospace, military, food processors etc.



3. LITERATURE REVIEW

3.1 Saurabh R Verma, P. M. Khanwalkar, V. N. Kapatkar , [2]

This paper presented is a review on Heat transfer augmentation for various dimpled geometries. Heat transfer enhancement over surface Results from the depression forming recesses rather than projections. Such features are known as dimples and may be formed in an infinite variation of geometries which results in various heats transfer and friction characteristics. Heat Transfer enhancement using dimples are based on the principle of scrubbing action of cooling fluid taking place inside the dimple and phenomenon of intensifying the delay of flow separation over the surface.

Spherical indentations or dimples have shown good heat transfer characteristics when used as surface roughness. The technology using dimples recently attracted interest due to the substantial heat transfer augmentations it induces, with pressure drop penalties smaller than with other types of heat augmentation. From all the research work studied the researchers have used various dimple shaped geometries such as triangular, ellipsoidal, circular, square out of which ellipsoidal shape gives better results due to prior vortex formation than other shapes.

3.2 Prof.S.A.Wani, Prof.N.V.Hargude, Mrs.S.P.Mane, Prof.K.S.Kamble,[3]

This paper presented is a review of the Experimental investigation of an inline dimpled plate by natural convection heat transfer. Heat transfer describes the exchange of thermal energy, between physical systems depending on the temperature and pressure, by dissipating heat. The fundamental modes of heat transfer are conduction or diffusion, convection, and radiation. The exchange of kinetic energy of particles through the boundary between two systems which are at different temperatures from each other or from their surroundings. Heat transfer always occurs from a region of high temperature to another region of lower temperature. Heat transfer changes the internal energy of both systems involved according to the First Law of Thermodynamics.
Natural convection is a mechanism, or type of heat transport, in which the fluid motion is not generated by any external source (like a pump, fan, suction device, etc.) but only by density differences in the fluid occurring due to temperature gradients. In natural convection, fluid surrounding a heat source receives heat, becomes less dense and rises. The surrounding, cooler fluid then moves to replace it.

3.3 Ashif Ramjan Shekh, Prashant D Nikam, Siddhant B Bhagwat, Sanket S Satpute,[4]

This paper presented is on Heat transfer enhancement using dimpled surface. The importance of heat transfer enhancement has gained greater significance in such areas as microelectronic cooling, especially in central processing units, macro and micro-scale heat exchangers, gas turbine internal airfoil cooling, fuel elements of nuclear power plants, and bio medical devices. A tremendous amount of effort has been devoted to developing new methods to increase heat transfer from fined surface to the surrounding flowing fluid. The experiment will be carried out for laminar forced convection conditions with air as working fluid.

The objective of the experiment is to find out the heat transfer and air flow distribution on dimpled surfaces and all the results obtained are compared with those from a flat surface.

3.4 Sagar R Kulkarni, Dr. R.G.Tikotkar,[5]

This paper presented is on Experimental Investigation of Heat Transfer Enhancement over the Dimple Surface under Forced Convection.An experimental study has been conducted to study heat transfer over the dimpled plates under forced convection. The Reynolds number is varied in the range of 10000 to 30000 based on hydraulic diameter. The dimpled depth is varied from 0.2 to 0.4 keeping 0.1 frequency and keeping the dimple density constant in both the arrangements. The dimple print diameter is kept as 10mm where dimple depths are 2mm,3mm,4mm.A constant heat of 0.5 amperes was given. It is noticed that heat transfer is augmented for a depth of 0..3 in both the arrangements.0.4 depth plate shown very least augmentation. The maximum thermal performance is for staggered arrangement and for 0.3 depth. The maximum thermal performance for inline arrangement is the lowest value of thermal performance of staggered plate.

3.5 IftikarAhemad H. Patel et al. [6]

Investigated heat transfer enhancement over the dimpled surface. The main objective of his experiment ware to find out the heat transfer and air flow distribution on dimpled surfaces and all the results obtained are compared with those from a flat surface. For obtaining the results, the spherical type dimples were fabricated, and the diameter and the depth of dimple were 6 mm and 3 mm respectively. Channel height was 25.4mm, two dimple configurations were tested. The Reynolds number based on the channel hydraulic diameter was varied from 5000 to 15000. From experimentation, it was observed that thermal performance is increasing with increase in Reynolds number. But the thermal performance of inline dimples arrangement is poor as compared to the plate with staggered dimple arrangement.

3.6 M. A. Saleh, H.E.Abdel-Hameed [7],

Studied the flow and heat transfer performance of a parallel/ counter flow heat exchanger, when the heat transfer surface is provided with dimples on one or both sides i.e. on the cold fluid side and hot fluid side. The experimental set up consists of two parallel identically and geometrically passages: one for the hot fluid and the other for the cold fluid. The average duct height is 10 mm and duct width is 110 mm The Results consist of flow characteristics (mainly pressure distributions) and heat transfer characteristics (Nusselt number distributions) comparison against the non-dimpled case (smooth surface) was held. Authors also studied that the cases with various dimples depths (d/D= 0.2, 0.3 and 0.4) and arrangements (in line and staggered) were tested over a range of Reynolds number (50 to 3000). It was found that the overall heat transfer rates were 2.5 times greater for the dimpled surface compared to a smooth surface and the pressure drop penalties in the range of 1.5-2.0 over smooth surfaces.

3.7 Nopparat Katkhaw and Nat Vorayos [8]

Flat surface with the ellipsoidal dimple of external flow was investigated in this study.10 types of dimple arrangements and dimple intervals are studied. The stream of air flow solver the heated surface with dimples. The velocity of the air stream varies from 1to5m/s. The temperature and velocity of the air stream and temperature of dimpled surfaces were measured. The heat transfer of dimpled surfaces was determined and compared with the result of a smooth surface. For the staggered arrangement, the results show that the highest heat transfer coefficients for dimpled surfaces are about 15.8% better than smooth surface as dimple pitch of ST/D min or¼ 3.125 and SL/D min or¼ 1.875 yield the highest the at transfer coefficient values. And for the inline arrangement, the results show that the heat transfer coefficients for dimples surfaces are about 21.7% better than smooth surfaces dimple pitch of ST/D min or¼ 1.875 and SL/D min or¼ 1.875 yield the highest heat transfer coefficient values.

3.8 Nopparat Katkhaw and Nat Vorayos [9]

In the present study, heat transfer analysis of dimpled surfaces of external flow was investigated. A total of 14 types of dimpled surfaces is studied. The effect of dimple pitch was examined. The experiments were carried out with air stream flows over the heated surface with dimples. The temperature and velocity of the air stream and temperature of dimpled surfaces were measured. The heat transfer of dimpled surfaces was investigated and compared with the result of a smooth surface. For the staggered arrangement, the computed results show that the maximum Nusselt number for dimpled surfaces are about 26% better than a smooth surface. And for the inline arrangement, the results show that the maximum Nusselt number for dimples surfaces are about 25% better than a smooth surface.

4. SUMMARY OF REVIEW

The above-mentioned researchers investigated natural and forced convection from the extended surfaces and very few have worked on Dimpled Plates concept. From the present study, the following conclusion are found out –

1. Due to dimples heat transfer enhancement characteristics and lesser pressure loss penalties, their use for thermal management application has attracted many researchers.

2.It is concluded that the maximum heat transfer rate will take place in largest diameter of the circular dimpled surface.

3.The vortices formed inside the dimples results in thinning and to disturb the thermal boundary layer formed over the surface during coolant flow and serve ultimately to bring about the enhancement of heat transfer between the fluid and its neighboring surface at the price of less increase in pressure.

4.Introducing the dimples on the surface not only increase the surface area available for heat transfer but also reduces the hydrodynamic resistance for the fluid flow over the surface, resulting in less pressure drop.

5. It was observed that thermal performance is increasing with increase in Reynolds number. But the thermal performance of inline dimples arrangement is poor as compared to the plate with staggered dimple arrangement.

5. OBJECTIVES

It is observed that the extensive work has been carried out for the heat transfer enhancement on Plate surface, rough surface, and ribbed surface. All these geometries are studied for better enhancement. So, the use of dimple plates for the experimentation. The work is concerned with experimental set up for enhancement of the forced convection heat transfer over the dimple surface.

1.The objectives of the present work are to find out the heat transfer rate and thermal performance for the flat plate for selected range of Reynolds number.

2.To find out the heat transfer rate and thermal performance for a plate with the compound geometry of dimples with a different flow.

3.Comparison of heat transfer coefficient and thermal performance of the plates with the compound geometry of dimples with that of a flat plate.

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