EFFECT OF DIFFERENT OPERATING PERAMETERS ON HEAT TRANSFER CHARECTRASITIC USING IMPINGEMENT SPRAY COOLING-A REVIEW ARTICLE

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ABSTRACT

In this paper review of experimental work carried out by different researchers to study the effect of operating parameters on heat transfer characteristic using impingement spray cooling being studied. The experiment parameters considered for review are Spray properties[1], Fluid propertise[2], Calorimeter design[3].

In the spray cooling properties under consideration are the droplet size, droplet number flux per second, droplet velocity, cooling effect, nozzle to surface distance. fluid properties under consideration and experimental investigations are thermal conductivity of liquid, surfacetension of liquid, specific heat of liquid, latent heat of vaporization and lastlyCalorimeter design properties are: super heat of heater, surface wet ability surface size, thermal diffusivity of subtract. It can be concluded that parameter which are the most significant parameter and sub significant parameters further used to these parameters to optimize and the considered parameters on heat transfer characteristic (HTC) using impingement spray cooling.

Keywords*: *Heat transfer coefficient, Size of nozzle, Droplet size, Spray cooling

I. INTRODUCTION

Spray cooling processes are known to yield high heat transfer coefficients due to high rate heat absorption associated with latent heat absorption during liquid vaporphase transition of the spray cooling methods employed in current electronics cooling applications. Heat transfer enhancement is one the major parameters required to improve the performance of the thermal system in any industries such as Electronics, Aerospace, Automotive and steel manufacturing. Jet impingement cooling and spry impingement are two of the most effective ways to improve the rate of heat transfer from the hot metal surface. Impingement cooling helps to achieve desired cooling rates from the surface by appropriate parametric control during the cooling process. Hence this process finds its use in many cooling application in particular to metal processing industry.

In this technique the spray is done by a nozzle. Spray in general find wide use in applications including agriculture food processing, painting, combustion, fire suppression and metal Quenching as well as high heat flux electronics. This method provides an excellent option for tackling with high heat transfers rate requirements but with the primary disadvantages of large, weight, cost and complexity. However, attainment of exceptionally high heat transfer rates has made the technique a still lucrative one compared to the single phase or even two phase systems. This article is aimed to study the effect of different operating parameters on heat transfer characteristics during spray cooling & to see the relative dominance of one parameter over another

II. LITERATURE REVIEW

2.2 Martin Chabičovský, Miroslav Raudenský

In this paper, the spray cooling of stainless steel plates was studied using different orientations of the cooled surface. A 1.5 mm-thick test plate was moved vertically or horizontally with a velocity of 3 m/s. Experiments were conducted with mist nozzles oriented either vertically with the spray flowing down or horizontally. The water impingement density was between 0.93– 9.68 kg m2 s-1. It was found that the heat transfer coefficient is similar for horizontally and vertically down oriented nozzles within the surface temperature range of 700–900°C. The vertically down spray yields a higher heat transfer coefficient for surface temperatures below 300 °C. Furthermore, it was observed that the Leiden frost temperature is slightly higher for vertically down spray for lower water impingement densities. This shift of the Leiden frost temperature was not observed for higher water impingement densities.

2.3 R. Reji Kumar, Nigussiemulugeta

In this paper, impingement cooling is a technique used for cooling the electronic systems. In this work, heat transfer and pressure drop characteristics of deionized water and Al2O3/water nanofluid in an electronic heat sink having aluminium plate fins and provision for jet impingement cooling have been studied. A novel heat sink contains two rows of plate fins of size 29mm x 24mm x 0.56mm. A thin plate having 110 holes of diameter 2.5 mm is used to produce number of jets. The plate is kept inside the heat sink in such a way that H/dn is 5.2 mm and adjacent jet spacing is 2mm. The overall dimension of the heat sink is 60x60x 65 mm. For this work they prepared a Al2O3/water nanofluid by dispersing specified quantity of nanoparticles in to deionized water by using a ultrasonic bath. Experiments were conducted under constant heat flux condition and the volume flow rate of the fluid was in the range of 1.315 to 2.778. It was found from the results that the nanofluid removes heat better than water in the jet impingement cooling with very low rise in pressure drop.

2.4 Purna C. Mishra, Santosh K. Nayak, Rajeswarichaini, Durga P. Ghosh, Bibhuti B Samantaray

The heat transfer characteristics of air-water spray impingement cooling of stationary steel plate was experimentally investigated. Experiments were conducted on an electrically heated flat stationary steel plate of dimension 120 mm x 120 mm x 4 mm. The controlling parameters taken during the experiments were air-water pressures, water flow rate, nozzle tip to target distance and mass impingement density. The effects of the controlling parameters on the cooling rates were critically examined during spray impingement cooling. Air assisted DM water was used as the quenchant media in the work. The cooling rates were calculated from the time dependent temperature profiles were recorded at the desired locations of the bottom surface of the plate embedded with K-type thermocouples. By using MS-EXCEL the effects of these cooling rate parameters were analysed The results obtained in the study confirmed the higher efficiency of the spray cooling system and the cooling strategy was found advantageous over the conventional cooling methods in the present steel industries.

2.4 Dr. R. Carriveau, Dr. D. Ting, Dr. R. Barron, Dr. R. Balachandar

The impingement of sprays onto dry and wet walls and the associated heat transfer occurs in many engineering applications. These applications include internal combustion engines, gas turbines, spray drying, spray coating and spray cooling. The fluid dynamics and heat transfer characteristics of liquid films created by spray impingement are very complex and determining the underlying physics requires fundamental studies. In this study, an efficient and practical approach is devised for tackling many aspects of the spray cooling process. The computational fluid dynamics (CFD) methodology used here includes numerous droplets and it is designed to predict the spray-wall impact outcome based on reliable correlations. Even though it is not an exact representation of the interaction between the spray and the liquid layer due to computational considerations, it provides an acceptable picture of the transport phenomena. The STAR-CCM+ CFD code has been used to solve continuity, momentum, and energy equations coupled with a Lagrangian-Eulerian solver capable of simulating droplets as well as thin fluid film. The model is validated against relevant experimental data available in the literature and good agreement is observed for heat transfer coefficient (HTC) values for cases involving spray impact and fluid film formation over a flat solid surface. The effect of mass flux and spray Reynolds number on the spray behaviour has been studied. The model is extended to predict the cooling performance of sealed cans containing hot liquids when the cans are cooled by the impingement of spray formed from a cold liquid. The CFD results are compared with field data obtained at Heinz Canada, Leamington, ON. The effect of the can rotational speed on the cool-down behaviour is investigated. The results show that there is an optimum rotational speed beyond which the heat transfer enhancement will not be as significant. This research is the first study which solves the transport phenomena of fluid and heat outside, through and inside a sealed solid can containing a hot liquid while being cooled by the spray of a cold liquid.

2.5 Xiejinlong, Zhao Rui, Feiduan, Wong Teck Neng1

Spray cooling, a high heat flux thermal management, has received great attention from modern industrial and technological applications, such as power electronics, high-power lasers, and conversion systems etc. The focus of the present work is to investigate the spray characteristics and heat transfer of a swirl nozzle under a low pressure drop range. An open loop spray cooling system is developed to examine the heat transfer performance of the swirl nozzle by considering the effects of nozzle pressure drop, impinged spray height. A Phase Doppler Anemometry (PDA) system is applied to characterize the droplet Sauter Mean diameter, droplet velocity, spray angle, and spray pattern. It is found that the swirl nozzle under lower pressure drop helps to generate a full cone spray with a smaller spray angle, while the higher pressure drop produces better atomization quality. The heat transfer experimental results indicate that the droplet impingement is the primary cooling mechanism in the non-boiling regime of spray cooling, and increasing the pressure drop generally improves the heat transfer performance.

III. HUSEYIN BOSTANCI

Many critical applications today, in electronics, optics and aerospace fields, among others, demand advanced thermal management solutions for the acquisition of high heat loads they generate in order to operate reliably and efficiently. Current competing technologies for this challenging task include several single and two phase cooling options. When these cooling schemes are compared based on the high heat flux removal (100-1000 W/cm2) and isothermal operation aspects, as well as system mass, volume and power consumption, spray cooling appears to be the best choice. The current study focused on high heat flux spray cooling with ammonia on enhanced surfaces. Compared to some other commonly used coolants, ammonia possesses important advantages such as low saturation temperature, and high heat absorbing capability. Moreover, enhanced surfaces offer potential to greatly improve heat transfer performance. The main objectives of the study were to investigate the effect of surface enhancement on spray cooling performance, and contribute to the current understanding of spray cooling heat transfer mechanisms. These objectives were pursued through a two stage experimental study. While the first stage investigated enhanced surfaces for the highest heat transfer coefficient at heat fluxes of up to 500 W/cm2, the second stage investigated the optimized enhanced surfaces for critical heat flux (CHF). Surface modification techniques were utilized to obtain micro scale indentations and protrusions, and macro (mm) scale pyramidal, triangular, rectangular, and square pin fins. A third group, multi-scale structured surfaces, combined macro and micro scale structures.

3.1 M. Anwarullah, V. Vasudeva Rao, K.V. Sharma

An experimental investigation is conducted to study the effect of nozzle-to-surface spacing of the electronic components and Reynolds number on the heat transfer in cooling of electronic components by an impinging submerged air jet. Reynolds number based on nozzle diameter d is varied between 6000 to 23000. Distance from the tip of the nozzle-to-surface of the electronic components H varied from 2 to 10 nozzle diameters. Experiments are conducted with nozzle diameter of 5mm. Local heat transfer rates at a fixed radial location are measured and the stagnation Nusselt numbers for different H/d ratios calculated. They are correlated and compared with the data of earlier investigators. The following correlation for stagnation Nusselt number has been developed based on the experimental data. The results are expected to help the designers in coming up with more effective designs for cooling of electronic components.

IV. CONCLUSION

The aim of present study is to investigate the heat transfer characteristics of water spray impinging on a heated surface .Effects of operating parameters such as mass flux, nozzle diameter on heat transfer have been reviewed.Following conclusions are made.

1. With increase in mass flux of the water the heat flux as well heat transfer coefficient is continuously increasing because of higher liquid velocity over the surface resulting in thinner thermal boundary layer. Also, impact of the droplets onto the film agitates the liquid making local thinning the thermal boundary layer.
2. Rater of increase of heat transfer coefficient and heat transfer rate was not constant with increase in water spray mass flux. This is due to different nature of physics happening at different impingement mass fluxes. A phenomenon like strong splashing occurs at high mass fluxes resulting in decrease in effective mass flux striking and lesser heat transfer.
3. The steep rise in heat transfer rate larger mass fluxes for nozzles can be attributed to change in fluid-dynamics of the thick film because of striking of the droplets at very high velocities. This creates strong perturbations in the thick film formed at the target surface resulting in enhancement of mixing and higher turbulence hence faster heat transfer from the impingement surface.
4. Heat transfer coefficients and heat flux variations with mass flux follows almost similar trends for all types of nozzles.

5. for all types of nozzles the effect of nozzle diameter is almost negligible with decrease in nozzle diameter the droplet diameter decreases but it also increase the splashing and rebounding of water droplets for same mass flux with larger orifice diameter nozzle, this thing nullifies the effect of decrease in diameter of droplets on heat transfer.

The variation in Nusselt number is just because of change in Reynolds number. Still a small variation in the Nusselt number at same Reynolds number for different types of nozzles is because of difference in basic heat transfer mechanism followed by each nozzle.

V. FUTURE SCOPE

It has been found from the study that though the mechanism of heat removal during spray cooling is very complex due to its dependence on various parameters, also it is very difficult to vary each parameter independently so their effects are not easily measured. Lot of research had already been done on parameters under different sets of experimentation; still there are certain areas where this work is further extended.

1. For spray cooling there is always an optimal nozzle to surface spacing where heat transfer is maximum. The optimization of this stand-off distance need to be studied in some more detail under different spray conditions
2. Very limited studies are available to see the effect of addition of surfactant, as addition of surfactant increases the value of CHF and enhances the nucleate boiling, there is a need to explore it systematically
3. There is a contradiction on studies carried out to effect the surface roughness, some paper shows increase of HTC with roughness whereas some researchers find decrease inHTC with surface roughness
4. More detailed examinations are required to study the evaporation of liquid film in case of non boiling regime
5. To have a better and more clear understanding of this heat transfer in spray cooling new experimentation techniques are required to measure heat transfer, film thickness, shear stress, pressure etc, and the use of high speed photo video techniques with time resolved images further add new dimensions to get more insight about the physics of what actually happens during spray impingement over heated surfaces

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