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Cooling Performance Improvement of Electrical Equipment by Using Air and CO2

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ABSTRACT

Experimental investigation is conducted to look at the characteristics of forced convective heat transfer from electronic components, subjected to a confined occurrence circular jet of Air and dioxide. Parameters like Heat transfer constant, Jet velocities, Nozzle-to-chip spacing (aspect ratio) (H/d) are studied. Nozzle diameter ranged from 2mm to 8mm. Local heat flux measurements area unit created with completely different diameters of jet within the vary of Reynolds numbers from five,000 to 44,000 for dioxide and 2,500 to 23,000 for air. H/d is varied from three to forty five for each air and dioxide. Variations each within the native heat transfer constant and Nusselt range area unit determined as perform of Re. Variations of average Nusselt range and native heat flux with time area unit obtained in a wide vary of Re and H/d ratios. The results of the investigation area unit bestowed in graphical type and a comparative study of Air and dioxide as fluid is created.

1. INTRODUCTION

Impinging jets have received extended attention in the field of electronic cooling, owing to their inherent characteristics like simplicity and better rates of warmth transfer. The happening flow devices give short flow methods on the surface and comparatively high rates of cooling from a comparatively little extent. Single impingement jet will generate high heat transfer rate in specific areas, however result in a non-uniform temperature distribution on the cooled surface. Whereas impingement cooling has been used for larger electronic elements already, there square measure apprehensions regarding its relevancy for small, high heat density elements. Current cooling systems take up a good deal of house, and the volumetric quantitative relation of the cooling system to the electronic component is high. Impingement cooling, if tailored for electronic cooling, may well be lot of direct and house efficient cooling, may well be a lot of direct and house efficient different. One major application of jet impingement is within the cooling of electronic elements.

Other industrial uses of happening jets embody tempering of glass, tempering of metal and plastic sheets, drying of paper and textiles and cooling of turbine blades [1].

Due to the wide industrial relevancy of impinging jets, in depth analysis has been conducted to understand the warmth transfer characteristics. The heat transfer rate from the surface to the happening jet could be a complex operate of the many parameters particularly Reynolds number (Re), Prandtl range (Pr), ratio (H/d), and non-dimensional displacement from the stagnation point (r/d). The first aim of this experimental study is to research the warmth transfer characteristics of Air and greenhouse emission jet happening ordinarily on the surface of the electronic elements. Native Nusselt numbers, temperature profiles and stagnation Nusselt range square measure determined.

1.1 Abbreviations

A: extent of the electronic elements (m2)
d: Diameter of nozzle (m)
h: native heat transfer constant (W/m2 k)
H: Distance between nozzle-to-electronic part (m)
Nu: native Nusselt range (hd/k)
NuO: Stagnation purpose Nusselt range
Re: Jet Reynolds range
Q: Heat flux (W/m2)
Ts: Surface temperature of part before cooling (C)
Ta: close temperature (C)

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V: speed (m/s)
H/d: Nozzle-to-component spacing to nozzle diameter (aspect ratio)
K: Thermal physical phenomenon (W/m K)
Pr: Prandtl range
r: radial distance from the middle of the electronic equipment

2. LITERATURE SURVEY

Jambunathan et al. [2] conducted an in depth survey of jet. impingement cooling. They finished that the simplest correlation for native heat transfer constant is a operate of jet Reynolds range (Re), jet height-to-jet diameter quantitative relation (H/d), radial distance-to-jet diameter quantitative relation (r/d) and Prandtl range (Pr). Beitelmal et al. [3] analyzed two-dimensional happening jets and related to heat transfer within the stagnation purpose, stagnation region and wall jet region with approximate solutions, developed victimization simplified flow assumptions. Koseoglu and Baskayabv [4] studied the warmth transfer characteristics of confined circular and elliptical jet, observed that a rise in jet to plate thickness reduces the distinction between circular and elliptical flow fields. Baughn and Shimizu [5] through an experiment investigated the impact of jet-to jet spacing on the warmth transfer for a confined happening jet array. They found that, for giant plate spacing, jet interference causes a significant degradation of the warmth transfer. They proposed a correlation for native Nusselt range in impinging axisymmetric jets. Lee et al. [6] have studied effect of nozzle diameter (1.36, 2.16, and 3.40 cm) on impinging jet heat transfer and fluid flow. They reportable that native Nusselt numbers within the stagnation purpose region corresponding to 0.

3. ARCHITECTURE

The schematic illustration of one occurrence jet is shown in Fig. 1. The jet problems from a circular nozzle of diameter d, with a speed v, and impinges perpendicularly on surface, wherever the electronic components are mounted, at a distance H from the nozzle. Within the impingement jet flow, as seen in Fig. 1, there are 3 regions of distinct flow particularly free-jet region, wall-jet region and impingement region. Within free jet region are 2 sub regions, the potential core with speed adequate the jet exit speed and also the lower velocity shear layer, which ends from the entrainment of the encompassing fluid. Downstream of the nozzle, the shear layer more and more grows and displaces the potential core, eventually reaching the jet line.
The wall jet region is wherever the dominant speed component is radial and also the physical phenomenon thickens as it moves radically outward.

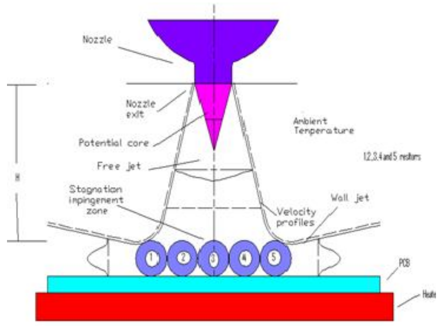


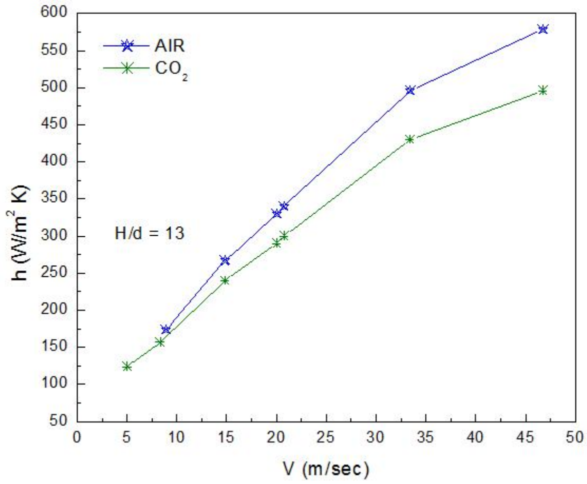
Fig. 1: Schematic diagram of flow regions

4. EXPERIMENTAL SETUP AND PROCEDURE

4.1 Experimental Setup

Figure two shows the general experimental setup with the relevant equipment and instruments. The setup is composed of 4 major parts: (1) 2 stage reciprocating compressor, (2) rotameter, (3) electrical heater, and (4) control board. throughout experiment, a large reciprocating compressor provided the hard-hitting air for jet impingement. This hard-hitting air was stored in a very massive vessel of 20-bar pressure and one hundred sixty liters capability. A pressure regulator is put in at the exit of the tank to stabilize the pressure of the provision air.
Compressed air flows through associate air cleaner, an air filter/regulator then through a flow meter (Rotameter) with ±1 foretelling accuracy. A pressure gauge connected at the outlet of the flow meter is employed to correct the flow. greenhouse gas is additionally one among the operating fluid used. That a special heater for greenhouse gas heater is used to convert it into vaporific type. The control board consists of meter (0–250 V), meter (0–240 mA), Autotransformer, and temperature show unit. An aluminum heater plate rated five hundred W and 240 V, insulated on

all sides by mineral sheets, is employed to heat the written circuit board (PCB). 5 cylindrical electrical wire wound resistors with five watt heat capability, 220 ohms resistance area unit fastened on computer circuit board of diameter 100 and a couple of millimeter thick area unit settled centrally on the aluminum heater plate. A chip assembly on PCB is simulated with the electrical resistors that area unit twenty five millimeter long and five millimeter in diameter. the ability is provided to the heater through the variable resistor stat (Auto transformer) to control the heating rate to the bottom plate. The total power provided is monitored exploitation 2 digital multimeter one for the voltage and also the different for the current. Teflon coated J-type (Iron–Constantan) thermocouples live} accustomed measure the surface temperatures of the electronic parts (resistors).



All thermocouples area unit completely mark by employing a constant temperature water bathtub, and their accuracy has been calculable to be ±0.1%. The central resistance within the jet array is taken into account for the analysis. Two thermocouple leads live the temperature of the recent aluminum plate. One thermometer is employed solely to measure the temperature of the air within the enclosure. All these eight thermocouples area unit connected to a temperature show unit referred to as the info acquisition system (masibus scanner eighty five XX). A custom engineered software capable of effort temperature knowledge as a function of your time is loaded on to a private pc. This package incorporates a provision to line the sampling frequency of temperature as low as zero.1 sec. The storage capacity of the info acquisition system is unbroken sufficiently massive in order that the temperature knowledge are often acquired over an oversized interval of your time. The axis of the nozzle is usually aligned with the central resistance and is normal to the plane on that heat sources area unit mounted.

4.2 Procedures

The air jet emanating from the nozzle and impinging on the resistors is taken as free jet and wall jet region severally. Power is provided to the resistors through a step down electrical device and also the metallic element plate through associate Autotransformer. The volumetrically heat generation because of heating of resistance exploitation AC current is assumed to be uniform. The temperature of the resistors is allowed to get up to 950 C, then cooled by forced convection in the main from the highest surface by the air stream flowing within the wall jet region. The warmth loss from the bottom of the resistors is assumed to be negligibly small.

5. RESULTS

Figure three shows the variation of the temperature of the electronic part with time at one jet Reynolds variety 8500 and H/d ratios of five and thirteen for both Air and greenhouse gas. during this figure Air and greenhouse gas jets area unit impinged over the surface of equipment through a nozzle of 4mm diameter once the instrumentality attained a gradual state temperature of 94^{o}C. It is observed that, for each greenhouse gas and Air, the temperatures are lower for lower H/d magnitude relation. The temperatures area unit lower within the case of Air compared to greenhouse gas, indicating that heat transfer rates area unit higher for Air. this can be as a result of the distinction within the physical properties of Air and CO2, and therefore the distinction within the molecular structure of Air and CO2. Air could be a mixture of essentially gas and oxygen, whereas greenhouse gas could be a stable compound of carbon and atomic number 8 with a selected molecular structure. It also shows that, latent period depends on the kind of the gas being employed and therefore the H/d magnitude relation.

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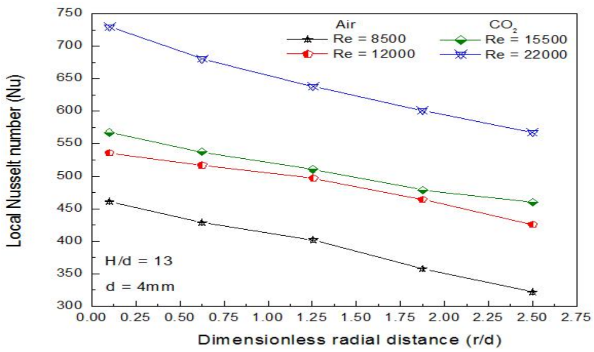

Variation of native Nusselt variety with dimensionless radial distance (r/d) is bestowed in figure 4. Experimental results area unit aforethought at painter numbers of 8500 and12000 for Air and 15500 and 22000 for CO2. During this experiment, Air and greenhouse gas from a circular nozzle of 4mm diameter directly impinges on the surface of associate electronic part at associate H/d magnitude relation of thirteen.
In the figure, obviously, the native Nusselt variety decreases with increase in ‘r/d’ for each Air and greenhouse gas. It is also determined from figure four, that the stagnation purpose heat transfer is operate of painter variety and is higher for higher painter variety. this can be true for each Air and greenhouse gas.
The variation of warmth transfer constant with velocity shown in figure five. indicates that among Air and greenhouse gas could be a higher cooling media. within the figure, the variation of warmth transfer constant with the speed is plotted for each Air and greenhouse gas at a continuing H/d magnitude relation of 13. From the figure it's determined that the warmth transfer rates area unit continually higher within the case of Air once compared to greenhouse gas for identical speed. As mentioned already this can be thanks to the inherent variations between Air and greenhouse gas although each area unit classified as gases.

6. CONCLUSION

Experimental investigation area unit conducted to review the heat transfer from the surface of electronic equipment once jet of Air or carbonic acid gas impinges with Re in the vary of 2500 to 23000 for air and 5000 to 44000 for CO2 with H/d ratios of three to forty five.
From the study it's ended that: As within the case of Air, for carbonic acid gas higher temperature radients area unit at lower H/d ratios. For a continuing Reynolds range, the temperature gradient is healthier for Air compared thereto of CO2. Nusselt range decreases with increase in dimensionless radial distance. At similar jet velocities for Air and carbonic acid gas, higher heat transfer rates area unit obtained for Air. Stagnation Nusselt range will increase with increase in Reynolds range for each Air and carbonic acid gas. Nusselt range may be a perform of Reynolds range and H/d quantitative relation and therefore the variation of Nusselt range with Reynolds range is totally different for various H/d ratios for each Air and carbonic acid gas.

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