Study of Pulsating (Synthetic) Air Jet Heat Sink Cooling

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Abstract: Synthetic jet is new technique of heat sink cooling. Synthetic Jet operates on simple technique, due to flexible membrane of loudspeaker ambient air taken into and out of jet. Synthetic jet is operated by various device like piston cylinder, acoustic loudspeaker, piezo electric material etc. In this paper acoustic loudspeaker is used to cool the Heat sink.Loudspeaker operated under different frequencies of 10 to 500 Hz. Synthetic air-jet impingement cooling method combined with a miniature pin-fin heat sink will provides equivalent fluid flow to each IC package in a module (CPU) and achieves a high heat transfer rate per volume.Pin fin Heat sink is tested with constant heat supply and different frequencies (10- 500Hz). The work is carried out for various parameters such as excitation frequency, Nozzle to plate distance, Orifice diameter, Constant heat supply.

IndexTerms - Synthetic air Jet, Heat sink cooling, nozzle impingement

Introduction: The current method of heat removal, involving extended surfaces and fan arrays, frequently used in electronics is clearly insufficient, especially as the electronic components become more and more powerful, dissipating more heat, whereas the space around these components continues to be reduced due to miniaturization trends. The existing methods of heat removal from compact electronic devises are known to be deficient as the growing technology demands more power and accordingly better cooling techniques with time. Impinging jets can be used as a satisfactory method for thermal management of electronic devices with limited space and volume. Pulsating flows can produce an additional enhancement in heat transfer rate compared to steady flows. Synthetic jet is a novel flow technique which synthesizes stagnant air to form a jet, and is potentially useful for cooling applications. Synthetic jets are a particular class of jet flows arising from the periodic oscillation of pressure and velocity at a fluid boundary without net mass transfer across it. A typical synthetic jet actuator is a resonant cavity provided with an orifice or a nozzle and bounded by a moving wall. The oscillation of the wall causes time-periodic variations of the cavity volume and pressure; hence the fluid is alternately pushed out and into the cavity across the orifice [2]. A synthetic jet is a flow that is synthesized directly from the fluid in the system in which it is embedded. A synthetic jet is commonly formed when fluid is alternately sucked into and ejected from a small cavity by the motion of a diaphragm bounding the cavity, so that there is no net mass addition to the system [3] Synthetic jet devices consist of an oscillating driver, a cavity, and a small opening such as a circular, square or rectangular orifice. When the driver is oscillating, it produces a series of vortex rings at the orifice. The device generates the zero net mass flux (ZNMF) because the identical fluid mass and the mass flow are sucked and flowed out across the orifice. Although there is no net mass transfer to its surroundings, the ZNMF device has the interesting property of causing a finite amount of momentum transfer to its surroundings [4].

I. LITERATURE:

Smith & Glezer [5]1998. In this paper smith and glazer investigated the evolution of synthetic air jet.The process of evolution of jet at jet plane is dominated by the time periodic formation and moving of these vertex pairs away from the orifice. These vertex pairs artificially are turbulent in nature then gradually undergo transition becoming slow down and lose their coherence. The flexible motion of the diaphragm which is mounted on one side of the cavity wall is driven at resonance which creates the counter rotating vertex pair at the edge of an orifice.

Mangesh Chaudhari et al [06] 2010, they studied the effect of shape of the orifice of a synthetic jet assembly on impingement cooling of a heated surface is experimentally investigated in his study.

Mangesh Chaudhari et al. [12] Heat Transfer Characteristics of Synthetic Jet Impingement Cooling. Mangesh investigated the impingement of heat transfer characteristics of synthetic air jet. Due to fast operation of electronic circuit components gets heated and large heat is dissipated which causes the failure of such a component.

Craig Marron and Tim Persoons,2014,they studied the comparison of the performance of different heat sink geometries in combination with the same synthetic jet flow shows that at any spacing a modified heat sink with pins surrounding a flat impingement zone provides superior cooling to either a flat surface or a fully pinned sink.

Udaysinh S. Bhapkar et al. [12] (2013) Acoustic and heat transfer aspects of an inclined impinging synthetic jet, Here they carried out study of acoustic and heat transfer due to the effect of orifice dimensions and operating parameters on the noise level generated and heat transfer capabilities of synthetic jet.

As it can be observed from literature survey, interest in synthetic jet has grown for the last few decades and still remains the active region of research work. A lot of researchers have done efforts in explaining the various parameters affecting the heat transfer rates during impingement.

The present work focuses on local heat transfer coefficients on pin fin heat sink that is subjected to synthetic jet impingement. The work is carried out for various parameters such as excitation frequency, Nozzle to plate distance. These results could find a significant role in designing and modifying the cooling application.

II. EXPERIMENTATION:

From the literature it is noticed that a number of researchers use a piezo-actuated membrane as the oscillating diaphragm for the creation of a synthetic jet. A piezoelectric actuator requires relatively high voltage (Vrms≈90 V) as compared to that required for an electromagnetic actuator. Furthermore, a piezo-actuator operates at certain discrete input frequencies. For these reasons, piezo-actuators have not been used here. It is also observed from the literature review that the depth and diameter of the cavity along with the orifice length and diameter are the geometric parameters, while frequency and plate to jet distance are the control parameters pertinent in the study of heat transfer enhancement with synthetic jet.In the present study, an electromagnetic actuator (acoustic speaker) of diameter 76 mm and operating at an input voltage (Vspeaker) of 5 V is employed. The experiments are conducted for 5mm orifice diameter; cavity diameter (D) and length (L) are 50mm each. i.e. L/D=1 throughout the experiment. The input voltage to the actuator is maintained constant and the frequency of excitation is controlled by a signal generator and monitored by using a knob present in sine/signal generator. The jet issuing from the circular orifice impinges normally onto the target plate at a distance of z from the orifice. The distance between the orifice surface and the target plate is varied with the help of a traverse stand. the influence of diameter of orifice, distance between the orifice surface and the target plate (Z/d) and the frequency (100 to 500 Hz) of excitation of synthetic jet generator on local heat transfer characteristics has been evaluated experimentally by measuring the surface and ambient temperatures for different operating frequencies and other geometric parameters for a known power supplied to the heater. The results are presented in terms of the local heat transfer coefficient.

III. EXPERIMENTAL SETUP AND METHODOLOGY:

The main elements of the experimental set up are synthetic jet generator, target plate (Heat sink) and temperature measurement. The fig. shows the schematic diagram of experimental set up. The other constituents of the set up are DC power supply, milivoltmeter, amplifier, DC regulated voltage supplier and signal generator. A part of experimental set up consisting the synthetic jet assembly, heat sink target plate and temperature measurement are mounted on table. The synthetic jet assembly is fixed on the table by using rod as a fixture.

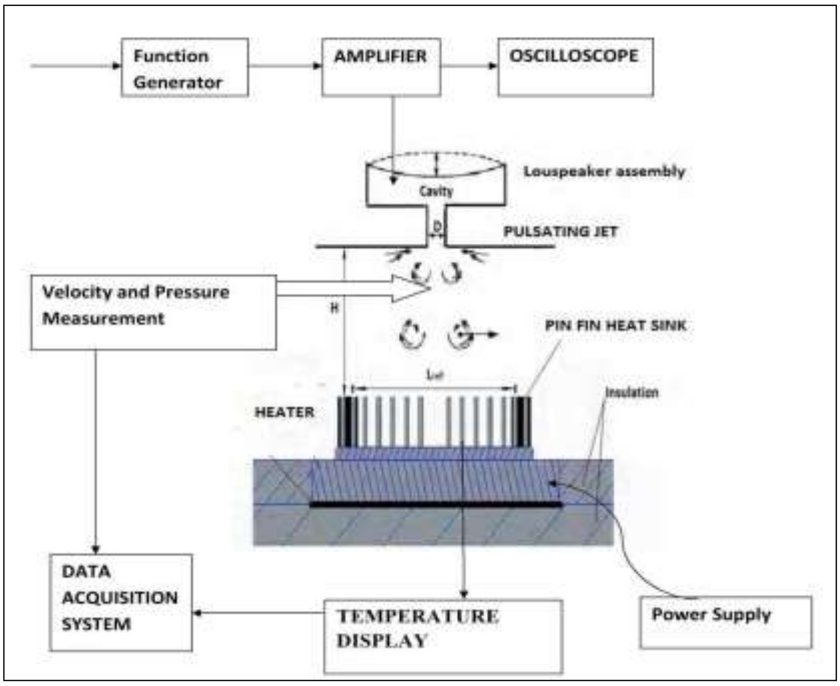
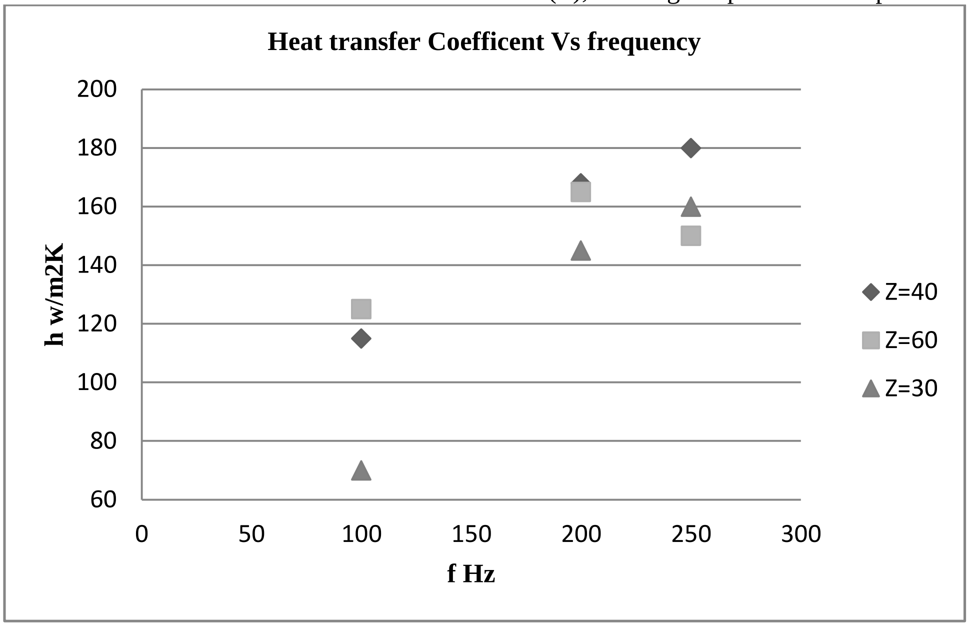


Fig 1 Experimental Set Up

Synthetic Jet Generator: The synthetic jet generator consists of cavity of dimensions (Di=50mm, L=50mm) whose one end is covered with oscillating electromagnetic actuator i.e. acoustic speaker of 76mm diameter in size and other end is covered with orifice plate of circular of diameter 5mm. The acoustic speaker is connected to amplifier which filters the signal; signal generator is used to generate the sinusoidal signal and excitation frequency by using the knobs. Input voltage (5V) to acoustic speaker is maintained constant by using DC regulated power supply. The speaker is supplied with a sinusoidal wave of specific amplitude and frequency so as to obtain the desired stroke length and Reynolds number.

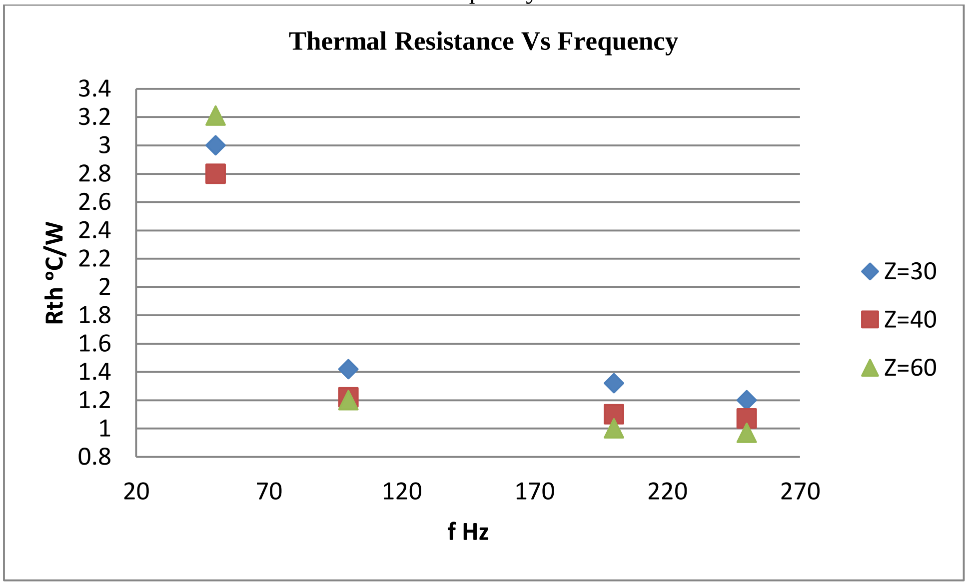
IV. RESULTS AND DISSCUSSIONS:

This study presents the results of an impinging synthetic jet issuing from a circular orifice on to a heated pin fin heat sink. The variation in the heat transfer coefficient as a function of axial distance (Z), for range of parameters is presented.

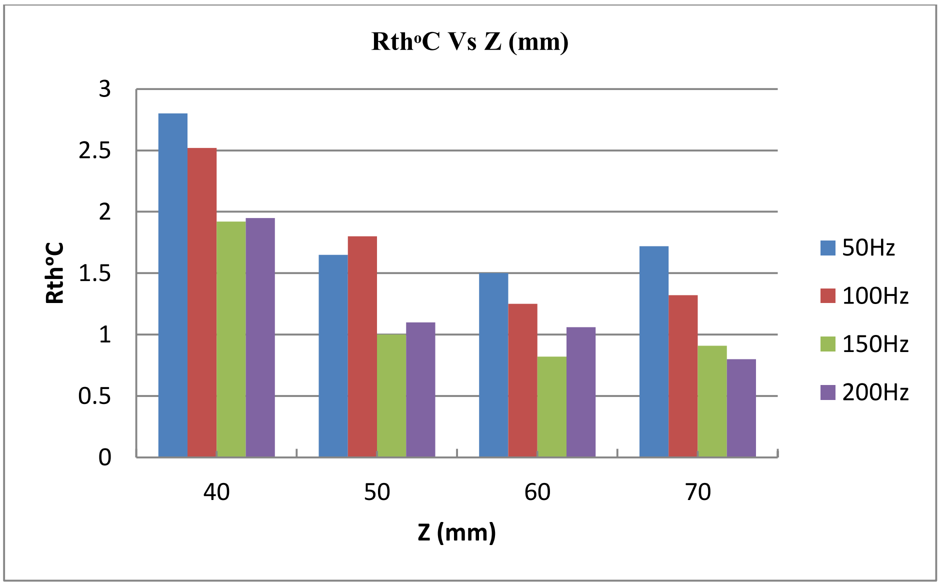


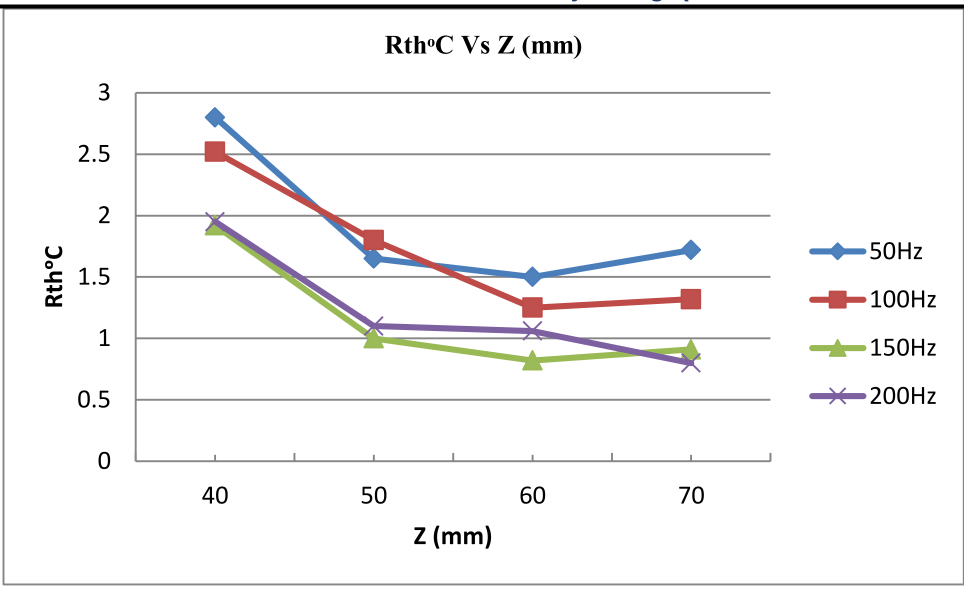
Graph 1 Heat Transfer Coefficent Vs frequency for different distance (Z)

Graph 1 shows Heat transfer coefficient between the frequencies of varies axial distances.Graphs 1 Shows the heat transfer coeffiecient increases with increasing the frequnicies for the axial distance in the range of 30 to 60mm for the freqincies in the range of 50 to 300 Hz.Maximum heat transfer coefficent was shown for frquency of 250Hz axial distance is 40mm.



Graph2 Thermal Resistance Vs frequency for different distance (Z)





Graph 3 Variations in thermal resistance Vs axial distance (Z)

Graph2 and 3 Shows the thermal resistance decreses the increasing freqencies.Graph show that for 60mm axial distance thermal resitsnce is less which is less than for the frequency 150 Hz.

Conclusion:

Preliminary Heat transfer tests have been conducted to study the performance of a heat sink and an impinging synthetic jet of circular orifice. Results show that heat transfer coefficient increases with increasing frequency and thermal resistance decreases.Synthetic Air Jet Cooling can be perform standard fan-fin CPU coolers and are more effective than similar steady impinging air jets. The current research addresses the limitations of conventional jet impingement cooling systems and Fan cooling. Preliminary results show that synthetic jets can be operated with multi jet arrays to achieve enhanced cooling of surfaces such as electronic devices.Preliminary Heat transfer tests have been conducted to study the performance of a heat sink and an impinging synthetic jet on circular orifice.It was observed that the number of orifice could be the increase the heat transfer enhancement The present results are expected to be useful fordesigning solutions for electronic cooling using a synthetic jet.

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