PERFORMANCE EVALUATION OF SYNTHETIC JET COOLING FOR CPU

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Abstract - ***Synthetic jet cooling increases the rate of heat transfer as compared to other cooling techniques. In the study, a synthetic jet is created for a single and multi-nozzle orifice with the help of vibrations of sound system. The heat transfer characteristics of a synthetic jet are studied in this work. The behavior of the average heat transfer coefficient on the impinged heated surface with variation in the axial distance between the jet and the heated surface is measured. The maximum heat transfer coefficient with the synthetic jet is found to be 9.6 times more than that of natural convection and 3 times more than that of cooling fan used in CPU. It is observed that a single nozzle synthetic jet gives better result as compared to a multi-nozzle synthetic jet for all axial distances and frequencies.***

Key Words: *Synthetic jet, heat transfer coefficient, axial distance, single nozzle, multi-nozzle.*

1. INTRODUCTION

Synthetic jets are the well-directed zero-mass flux of air flow on the heated surfaces. It is fluid flow with finite momentum with no mass addition to the system. The synthetic jet can be produced by a periodic motion of diaphragm using techniques like piezoelectric, electromagnetic, and electrostatic and combustion based systems. In this work, speakers are used for the production of synthetic jet. The bits of sound, forces the diaphragm to vibrate in linear direction. These vibration of diaphragm is used as source of periodic suction and compression of surrounding air which will result into formation of synthetic jet.[3]

Complex electronic circuitry is always subjected to thermal overstressing. It is one of the major causes of failure of electronic components. To avoid thermal overstressing an effective cooling systems are used.[2] The conventional cooling fan system in CPU has limitation to cope up with the advancement in electronic circuitry designed considering space as a constraint. Such next generation electronic circuitry will demand higher cooling rate which will lead to safe and long lasting of electronic systems.

Synthetic jets are having advantage over conventional cooling system. It gives more heat transfer rate as compared to traditional cooling system. In this work the periodic motion of diaphragm for production of synthetic jet is achieved by a sound system and its performance is compared with a fan cooling system of CPU.

2. METHODOLOGY

The experimental set up shown in the figure no.1 consists of 4 studs which make a traverse stand which allows variation between nozzles to heated plate distance. This heated was connected through a dimmer stat to vary the voltage and helps in control heating. The surface temperature is measured with one pre-calibrated K-type thermocouple, which is placed over the aluminum plate, thus k providing a spatially averaged temperature over the exposed surface of the aluminum plate. A synthetic jet is synthesized at the edge of an orifice by a periodic motion of a diaphragm mounted on one side of a sealed cavity. In the present study, an electromagnetic actuator (acoustic speaker) of diameter 76 mm, power rating 30W and impedance 4 n. Readily available Microsoft audio amplifier circuit in the woofer is used to amplify the sinusoidal signals generated by the signal generator. The experiments are conducted for single nozzle and multi nozzle plates, for both the cases total air flow area is maintained same obtain comparative results. Shape of the cavity is conical, to the larger end of cone acoustic speaker is fixed and to the lower end nozzle plate is attached.

The input voltage to the actuator is maintained constant and the frequency of excitation is controlled by a signal generator and monitored by an oscilloscope. The jet issuing from the orifice impinges normally onto the plate at a distance of Z from the orifice. The distance between the orifice surface and the aluminum plate is varied with the help of a traverse stand of 4 studs.

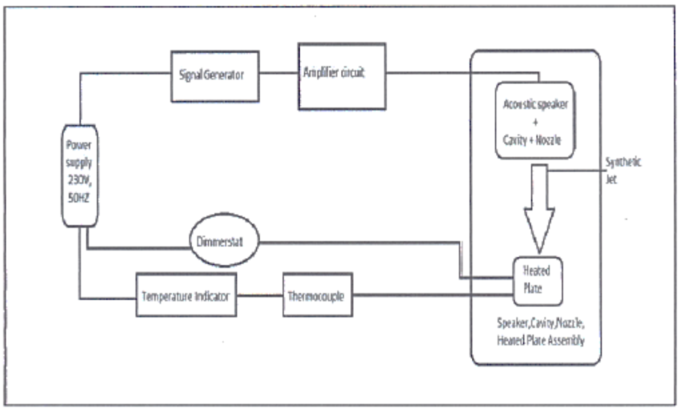

Fig -1: Block diagram of experimental set up

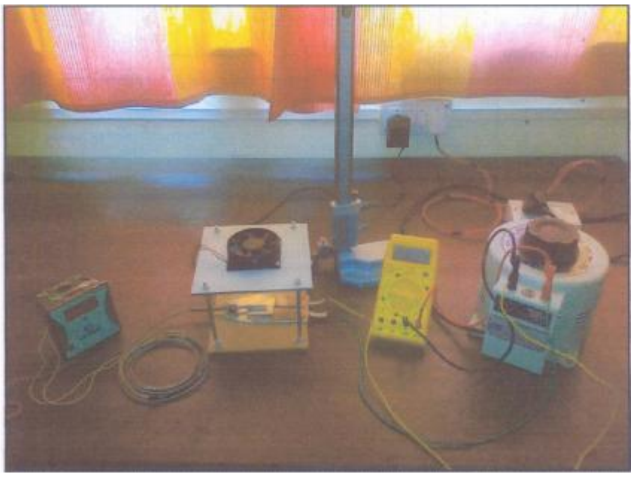

Fig- 2: Set up for forced convection cooling

The synthetic jet impingement technique for cooling of electronic circuits/chips for a single fan CPU which resembles the heater maintained at maximum temperature of 94°C. The computer chips are designed to attain maximum temperature in the range of 90°C to 100°C.

Due to low temperatures involved in this experiment, the heat loss from the surface due to radiation is neglected. The effects of the synthetic jet impingement cooling are investigated by measuring the surface and ambient temperatures for different operating frequencies and other geometric parameters for a known power supplied to the heater. To compare the results obtained during synthetic jet impingement cooling with conventional cooling fan in the CPU is replaced by the acoustic speaker and cavity assembly.

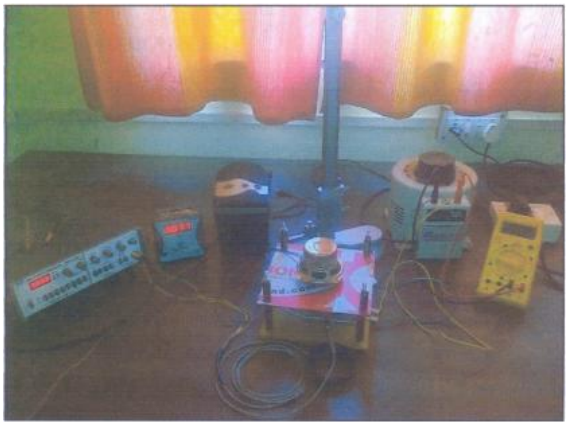

Fig- 3: Set up for synthetic jet cooling

3. RESULTS AND DISCUSSION

The results include the comparison between various parameters for single nozzle and multi nozzle.

In synthetic Jet Impingement values of Havg is function of excitation frequency i.e. diaphragm frequency, Nozzle-heated plate distance, Nozzle diameter.

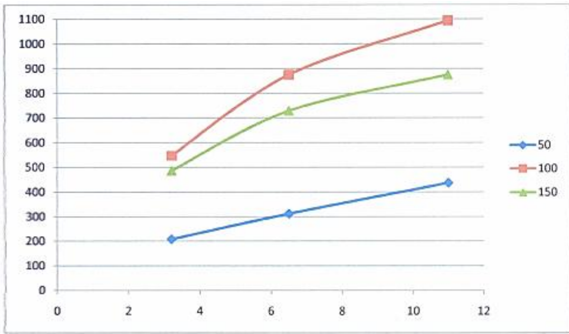

Chart-1 Havg v/s Z for single nozzle

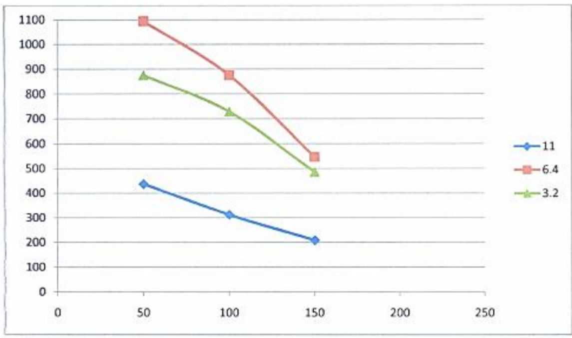

Chart-2 Havg v/s frequency single nozzle

It is found that at any particular frequency Havg increases with increase in nozzle heated plate distance till it reaches 110 mm. At nozzle plate distance 110 mm and excitation frequency 100 Hz we are getting the maximum value of Havg=1093.75 W/m2 0C. For all the excitation frequencies maximum Havg is obtained at nozzle-plate distance 110mm.

It is found that at any particular nozzle-plate distance Havg decreasing with increase in excitation frequency till it reaches 150Hz. At nozzle plate distance 110 mm and excitation frequency 100 Hz we are getting the maximum value of Havg=1093.75 W/m2 0C. For all the excitation frequencies maximum Havg is obtained at nozzle-plate distance 110 mm.

The diameter of multi nozzle and single nozzles and their numbers are chosen so as to get same cross section for the fluid flow.

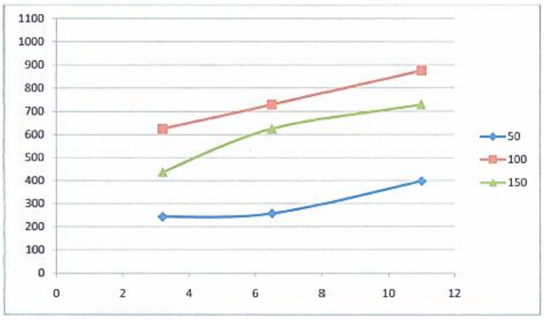

Chart-3 Havg v/s Z for multi nozzle

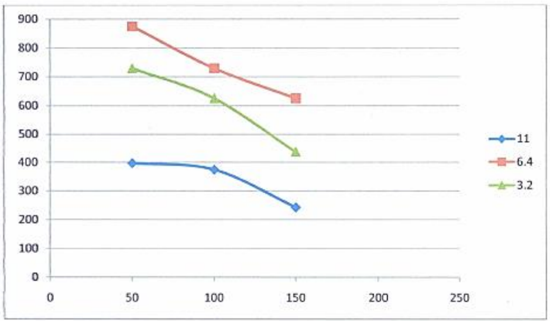

Chart-4 Havg v/s freq for multi nozzle

It is found that at any particular frequency Havg increases with increase in nozzle heated plate distance till it reaches 110mm. At nozzle plate distance 110 mm and excitation frequency 100 Hz we are getting the maximum value of Havg = 875 W/m2 0C.For all the excitation frequencies maximum Havg is obtained at nozzle-plate distance 110mm.

It is found that at any particular nozzle-plate distance Havg decreasing with increase in excitation frequency till it reaches 100 Hz. At nozzle plate distance 110 mm and excitation frequency 100 Hz we are getting the maximum value of Havg = 875 W/m2 0C.For all the excitation frequencies maximum Havg is obtained at nozzle-plate distance 64mm.

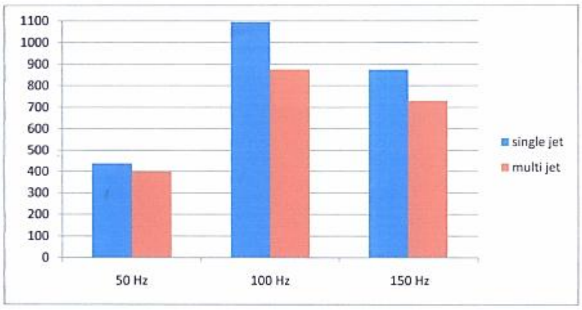

Chart-5 Havg v/s freq at Z = 110mm

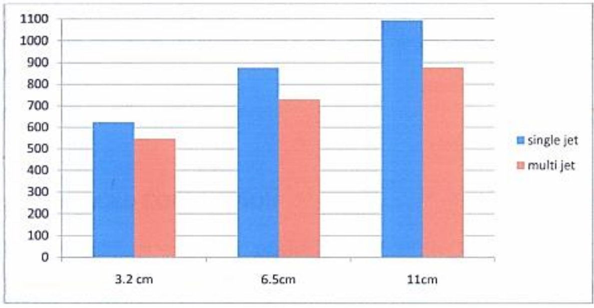

Chart-6 Havg v/s Z for excitation freq = 100Hz

The better cooling effect for single nozzle synthetic jet impingement than multi nozzle synthetic jet impingement for all the excitation frequencies at Z= 110 mm.

In continuous jets there is always better cooling effect for multi nozzles as compared to single nozzle plates if the flow area is kept same in both the cases.

The better cooling effect for single nozzle synthetic jet impingement than multi nozzle synthetic jet impingement at Z=110 mm. For all other values of Z there is a little difference in Havg. For lower values of Z multi nozzle synthetic jet impingement is giving slightly greater values of Havg.

Synthetic jet impingement cooling using single nozzle analysis is giving better results as compared to multi nozzle analysis. For comparison with cooling fan, we are choosing single nozzle analysis.

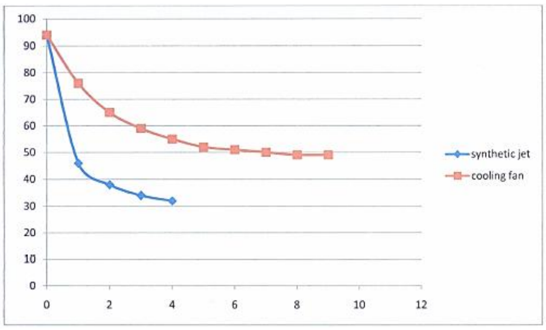

Chart-7 Temperature Fall v/s Times in minutes

The maximum steady state temperature attained by the heating plate is 32°C when constant Heat Flux of 7W is provided continuously at 100 Hz diaphragm frequency and distance between nozzle plate and heated plate is 110 mm. Havg for single nozzle is 1093.75W/m2 0C.

4. CONCLUSION

The synthetic jet impingement gives better cooling than the forced cooling using fan. The steady state temperature attained for forced cooling is 49°C while it is 32°C for cooling using synthetic jet. In addition, there is considerable difference in the time required to attain the steady state. 9 minutes are taken by Forced cooling using fan to attain the steady state at 49°C while 4 minutes are taken by the synthetic jet impingement to attain the steady state at 32°C.

Table-1: Comparison of Effectiveness

Type of cooling	Steady state temp attained(^0C)	Time required to attain steady state (min)	H_{avg} ($W/m^{2 0}C$)	Effectiveness (%)
Natural	94	--------	55.15	100
Forced	49	9	208.33	305
Synthetic jet impingement	32	4	1093.75	971

It gives 3 times more average heat transfer coefficient than forced convention using fan. So this technique can be widely used where there is need of cooling such as Textile Industries, Electronic chip cooling, Food industries etc. Multi-nozzle continuous jet gives better cooling performance than single nozzle jet for similar conditions. Surprisingly we found a single nozzle synthetic jet impingement gives better cooling effect than multi-nozzle plate.

The experiment is carried out in the range of freq. from 50 Hz to 150 Hz for single nozzle plate and varying the distance (Z). The height value of average heat transfer coefficient is obtained at 100 Hz frequency and 110 mm distance.

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