Experimental Analysis of Heat Sink and Optimizing The Fin Height using ANSYS

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Abstract- Keeping electronics devices cool is critical to ensure their long life and reliability. Utilizing heat sinks can help achieve this but determining the proper type and configuration can be a challenge. This paper reviews pin fin heat sinks of different cross-sections, low density pin configurations, and more factors in determining what is needed for an application. Electronic systems have become substantially more sophisticated and powerful in recent years. As a result, the majority of these systems contain large arrays of power hungry electronic components that require high-performance heat sinks to prevent them from overheating and being damaged or destroyed. One of the best-performing heat sink technologies available today is the pin fin technology. Pin fin heat sinks efficiently cool components; can be adapted to a range of component sizes, power levels, and air speeds; and are fabricated in a highly consistent manufacturing process. Because of these qualities, pin fin heat sinks are especially suitable for a wide array of medical applications. Moreover, a recent innovation in the technology provides even higher levels of cooling performance in a smaller space.

Keywords: heat sink, electronic component, Pin fins, Supervisory Circuit, heat dissipation.

I. INTRODUCTION

Some Integrated circuits draw so little current that their Junction temperature is assumed to be the ambient air temperature surrounding the device, when this is the case there would be no heat sink required up to the maximum operating temperature of the component. However; the guideline stated above would still apply recommending to keep the junction temperature at or below100^{0}C. As an example the TPS (Thermal power station) 3808 Supervisory Circuit may operate from 40^{0}C to 100^{0}C, but the derating factor would limit the maximum operational temperature to 75^{0}C. This insures that the junction temperature of the device is never exceeded, allowing for 25^{0}C margin of safety. In fact in this case the absolute maximum junction temperature allowed is 100^{0}C, so there would be a total of 25^{0}C of head room before the device is damaged. Recommended Maximum junction temperature is limited to 75^{0}C.When possible use the smallest available power supply the device will accept. Remember these are recommendations and are based on the engineering organization and design reports to.

In this case the guidelines come from NASA and may seem a bit strict. Of course there could be a tradeoff between added reliability and increased complexity. Violating the derating guidelines in favor of reduced complexity is a trade-off that would need to be discussed at the design review. The overall performance of a pin-fin heat sink depends on a number of parameters including the dimensions of the base plate and pin-fins, thermal joint resistance, location of heat sources. These parameters make the optimal design of a heat sink very difficult. Traditionally, the performance of heat sinks is measured experimentally or numerically and the results are made available in the form of design graphs in heat sink catalogues.

Analytical and empirical models for the fluid friction and heat transfer coefficients are used to determine optimal heat sink design. Pin-fin heat sinks consist of a base and an array of integral attached pins. They can be classified in many ways, e.g. (i) low or high density (Fig. 1) the effective cooling scheme for pin-fin heat sinks is forced convection where forced air creates a significant amount of air in between the pins and enhancing the heat sink's efficiency. Fin spacing for Low density pin fin heat sinks is 5.5d to 6d and for the high density pin fin heat sinks is 1.5d to -2d.i have selected a low density and inline pin fin heat sink of foot print 195x418 Fig.2 and fig.3 shows the model of heat sink with circular and square cross-section respectively.

The diameter of circular fin is of 0.006m similarly the square fin of size 0.006x0.006m and height 0.03m with different arrays of 5x5,5x6,5x8,5x10,5x12 with low density stream wise fin spacing of S_L=32mm and span wise S_T=32mm was considered for experiment. The model is tested in the wind tunnel. The main body of the rectangular cross-sectioned wind-tunnel duct was manufactured from wood and it is of constant internal width of Different duct heights were obtained by means of an adjustable roof approximately halfway along the length of the wind tunnel duct is the test section. The roof and side walls of the test section were made up of 7mm thick wood. A small opening is placed at the middle of the test section so enabling the fin array (and the air) to be observed. The low speed wind tunnel is composed of the following sections an inlet contraction, test section, diffuser and exhaust. The wind tunnel is operated in the suction mode that is the fan sucks atmospheric air through the fin assembly and the test section via the bell-mouthed entrance section with the fan and motor assembly on the exhaust side of the system. This avoids the airstream being heated by the motor prior to its passage through the heat exchanger assembly. A standard differential pressure gauge is used in order to evaluate the velocity of flow rate. Aluminum heat sinks in order to guide the thermocouples out of the heat sink without affecting the surface contact between the aluminum heat sink and the copper block. A 5hp A.C motor powers the wind tunnel. Air flow speed can be controlled by a dimmer stat. Location of thermocouples placed over the model is shown in fig.4

II. FIGURES

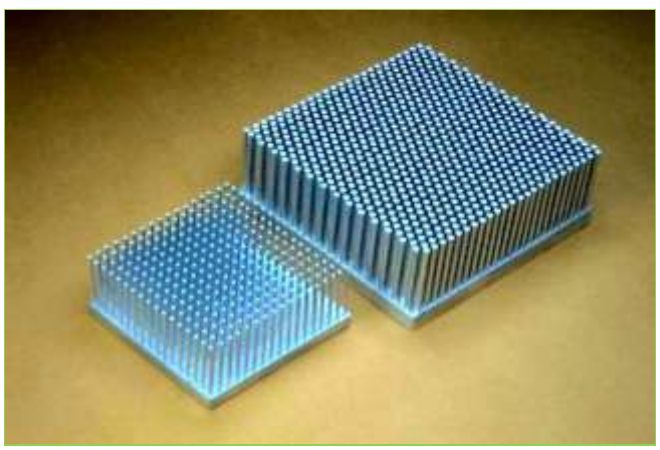

Fig. 1 Low density and high density pin fin heat sinks

Location of thermocouples placed over the model is shown in fig.4

T1=Base temperature

T2=T3=T4=Surface temperature

T5=T6=T7= Temperature of fin at 100,200,250mm lengt

Fig. 2 Heat sink with circular fins

Fig.3 Heat sink with square fins

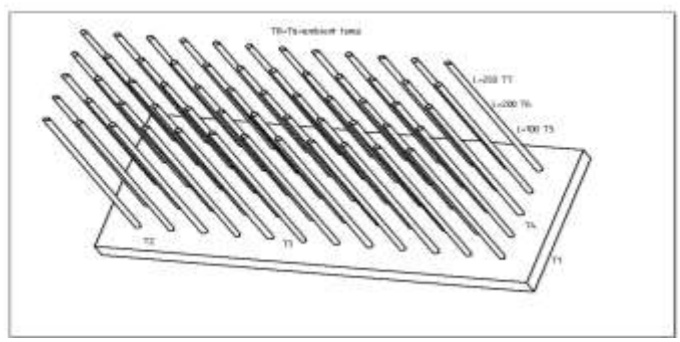

Fig.4 Base plate with fins

III. RESULTS

Table.1: The array consists of circular cross-sectioned fins 5x12=60fins

Sl. no	Q in watts	T1 Base Temp	Surface Temp			Fin Temp			T8 ambient Temp
			T2	T3	T4	T5 at L=0.1m	T6 at L=0.2m	T7 at L=0.25m	
1	250	62.2	56.5	57.5	56.9	32.1	28.6	28.2	28
2	500	93	86.6	87.8	86.5	36.8	29.3	28.5	
3	750	126	119.5	120.6	119.8	42.1	30.2	28.8	

Table.2: The array consists of square cross-sectioned fins 5x12=60 fins

Sl. no	Q in watts	T1 Base Temp	Surface Temp			Fin Temp			T8 ambient Temp
			T2	T3	T4	T5 at L=0.1m	T6 at L=0.2m	T7at L=0.25m	
1	250	56	49.8	50.6	49.7	49.7	31.1	28.4	28
2	500	79.3	73.6	74.9	73.5	34.9	29	28.5	
3	750	125	118.2	118	117.9	38.7	29.6	28.6	

IV. CALCULATIONS

Specimen calculation is done for the reading v=10m/sec and Q=250watts for 5x12=60fins

For Circular cross section fin arrangement

1. T_a=ambient temperature=28^0c
2. T_s=surface temperature (T2+T3+T4)/3 = (56.5+57.5+56.9)/3=57°C
3. T_f=film temperature (Ts+Ta/2) = (57+28)/2 = 42.5°C

Properties of air at 42.5°C from Data Hand book by interpolation

Thermal conductivity K=0.02773 W/mK

Kinematic Viscosity ν = 17.2X10-6 m2/s

Prandtl Number pr=0.676

i) To determine Heat transfer Co-efficient h1 over flat plate

Re=VL/ ν Where L=length of base plate in m

Re = (10x0.195/17.2X10-6)

Re =113372

Nusselt number

Nu=O.332 Re0.5 pr0.333 (from Data hand book)

Nu=O.332x (113372)0.5x (0.676)0.333

Nu=98.23

Also we know Nu=h1L/k

h1=NuK/L

h1= (98.23x0.02773 /O.195)

h1=13.96w/m^2 ^{0}K

Q1=h1a_p (Ts-Ta)

$a_{p\,=}$ area of plate in m^2

$a_{p\,=}$ 0.418x.195-((π□d2/4)xn)

=0.418x0.195 -(3.14x$0.006^{2/}$4)x60

a_p =0.0798144

Q1=13.97X0.0798144 (57-28)

Similarly Q2 across the fins is calculated we get

Q2=213.76

Net rate of heat transfer

Q=Ql+Q2

Q=32.2+213.76

Q=246.06 watts.

V. CONCLUSION AND DISCUSSION

In this study a comprehensive heat transfer analysis over a bank of pin fins has been conducted experimentally. The main conclusion drawn from the investigation are presented below

1. With circular cross-sectioned fins the maximum heat that can be removed is 300watts with optimum fin height of 254mm maintaining the temperature at 75°C

2. With square cross-sectioned fins the maximum heat that can be removed is 350watts with optimum Fin height of 250mm maintaining the temperature at 75°C

The testing described in this project incorporates several possible performance factors into two terms; temperature distribution and overall heat dissipation. This simplified term represents a combination of several factors such as material conductivity, lateral fin conduction, effective surface area. In comparing the circular pin heat sink with the square pin heat sink, the square pin enhances heat transfer. These results are in correlation and the basis of the pin fin design considerations.

This study would allow the increasing power devices currently being developed to use cost effective Air cooled heat sinks. If the fin is used as the transport means of heat, more effective and less costly designs will be apparent. The circular and square pin heat sink tested represents only one set of design parameters relating to pin spacing and shape based upon minor and major axes. There may exist other designs which produce better results in overall thermal performance study looking at reduced spacing, pin staggering would be advantageous to the heat sink industry

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