Numerical Investigation of Natural Convection Heat Transfer Rate For Heat Sink

Juhi Verma, Dr. Satyendra Singh

Abstract- In this paper Heat Transfer Rate is investigated for Vertical Cylinder attached with Vertical Oriented Fins (Heat Sink) for natural convection using ANSYS. For this purpose three cases are considered. Here analysis is carried out for 3 types of heat sinks (by changing their height with same number of fins).Temperature Contours and Heat Flux Contours are studied for these three cases, in which it is observed that temperature is maximum in the inner portion of heat sink where heater is inserted and minimum at the outer portion of it. Convection is maximum at outer portion of vertical oriented fins which are attached to the cylinder. Heat transfer rate is calculated using the results of heat flux contours and it is maximum for heat sink with N=12, H=30mm for given input parameters.

Keywords- Fins, Heat sink, Heat flux, Heat transfer rate, Temperature

1 INTRODUCTION

At the present age there is development in technology day by day, so for fulfilling the demand of industries, electronic devices with high power is must. Due to large capacity highest operating temperature is increased that's why thermal management of these devices is necessary. Junction temperature increases and working capacity decreases so cooling of electronic devices is essential. Cooling is also must for long working life of these devices. Cooling by Natural Convective Heat Sinks is one of the most appropriate methods. Natural convection is most suitable and easy process of cooling because there are no extra components as in forced convection. "HEAT SINKS" are basically a cylindrical base attached with different shape of fins. B. H. An et al. [4] proposed the Nusselt number correlation for vertical cylinder attached with vertical oriented fins for natural convection. K. T. Park et al. [5] experimentally investigated vertical cylin der with branched fins. Z. Ning et al. [6] numerically investigated natural convection heat transfer from vertical cylinder attached with longitudinal fins. J. R. Senapati et al. [7] investigated natural convection heat transfer numerically from vertical cylinder attached with annular fins. Sparrow & Brahmi have experimentally Investigated to find out heat transfer rate from square vertical fins attached with vertical cylinder. In the present study vertical cylinder with vertical oriented fins are shown in fig.2. is numerically investigated ,generally used for cooling of LED's. In this work modeling is done with SOLID WORKS and for analysis purpose ANSYS is used. For geometrical configuration data is taken from the experimental results of B. H. An et al. [4] to estimate the heat transfer rate from heat sink.

Fig. 1 Cylindrical heat sink with Vertical plat fins for cooling of LED's [4]

2 METHODOLOGY

ANSYS is a software package for high-performance numerical computation and visualization. TRANSIENT THERMAL is used for heat transfer analysis. It has become critical tool to solving the many complicated heat flow problems. FLUENT is used for fluid flow problems. FLUENT uses a finite volume method and requires from the user to supply the grid system, physical properties and the boundary conditions.

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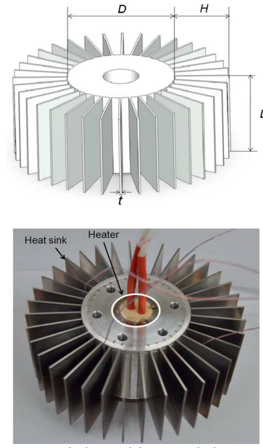

Fig. 2 Heat sink and heat Sink assembly [4]

NOMENCLATURE	
D	Diameter of cylinder.
d	Diameter of hole where heater is inserted
H	Fin height
h	Heat transfer Coefficient
N	Number of fins
K	Conductivity
L	Fin Length
q	Heat input
T_{amb}	Ambient temperature
T_{base}	Base temperature
T_{max}	Maximum temperature at heat sink
t	fin thickness
A	Area
Q	Heat transfer rate

2.1 MODELLING OF HEAT EXCHANGERS:

Table 1 Heat sink geometry

No. of fin (N)	Cylinder Diameter (d mm)	Fin height (H mm)	Heater Power (W)	Fin Thickness (t mm)	T_{amb} -T_{base} (°C)
12	60	10	1.21	1	11.6
12	60	20	2.12	1	11.7
12	60	30	2.87	1	12.2

Table 2 Material properties

Parts	material
Cylinder	Al alloy (K=167 W/m^2-K)
Fins	Al alloy (K=138 W/m^2-K)

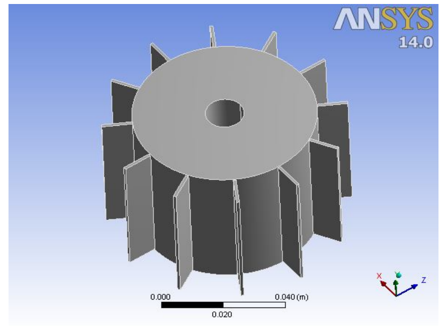

Fig. 3 Heat sink (N=12, H=10mm)

From the body heat is transferred in the following Ways-:

- Heat transfer occurred by conduction from inner wall to outer wall.
- From outer wall to fin tip it is occurred also by conduction
- From fin tip to atmosphere it is transferred by convection.
- Heat transfer rate can be calculated from the following formulas-:

$$\mathbf{Q= (T_{in}-T_{base})\ (2\pi LK)\ /\ ln\ (r_2-r_1)}$$

$$\mathbf{Q= (T_{base}-T_2)/\ (L\ /\ KA)}$$

$$\mathbf{Q_{conduction} = Q_{convection}}$$

$$\mathbf{A= L\ t}$$

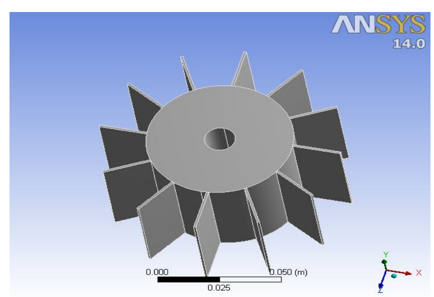

Fig. 4 Heat sink (N=12, H=20 mm)

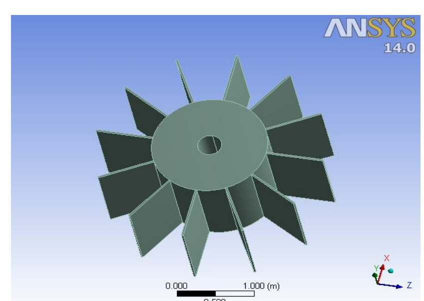

Fig. 5 Heat sink (N=12, H=30 mm)

Table 3 Boundary conditions

Heater	Inlet
Momentum	Wall motion
Moving speed	26 m/sec
Temperature (K) (N=12, H=10, 20, 30 mm)	284.6 284.7 285.2
Heat transfer coefficient (h) (W/m^2-K) (N=12, H=10, 20, 30 mm)	155 235 307
pressure	outlet

3 RESULTS AND DISCUSSION

3.1 Estimation of temperature and heat transfer rate

Heat flux and temperature contours are found using transient thermal analysis for all the three heat sink configurations. Temperature contour shows the temperature distribution at the body as shown in figure following figure 6,7,8 and heat flux contour shows the heat transfer distribution as shown in figure 10,11,12.

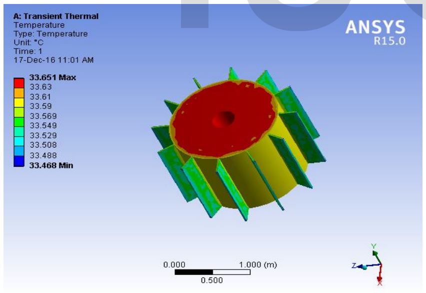

Fig. 6 Temperature contour (N=12, H=10 mm)

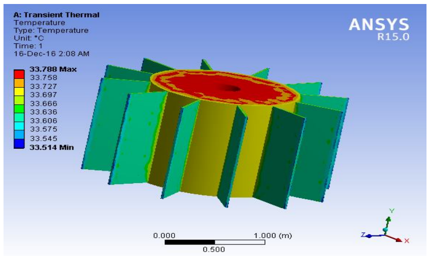

Fig. 7 Temperature contour (N=12, H=20 mm)

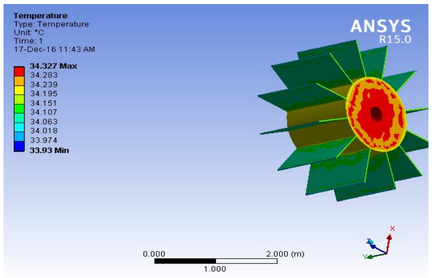

Fig. 8 Temperature contour (N=12, H=30 mm)

It is observed that temperature is maximum at the inner portion of heat sink, where heater is inserted and minimum value is at the fins. For heat sink configuration N=12, h=10mm, maximum value of temperature is 33.6°C, for N=12, h=20mm it is 33.788°C and for N=12, h=30 mm it is 34.327°C as shown in figure 9.

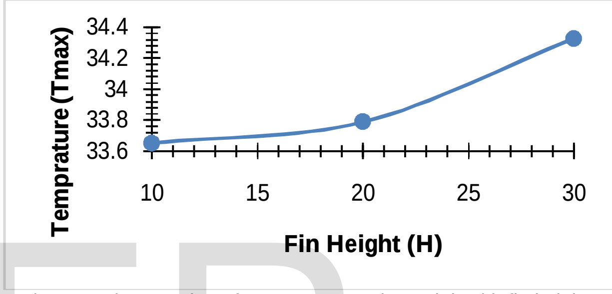

Fig. 9 maximum value of temperature at heat sink with fin height

It is concluded that the convection is maximum at fins portion. Maximum value of heat flux is 2240.6 W/m^2 for N=12, h=10mm as shown in figure 10. For N=12, h=20 mm it is 3440.5 W/m^2 as observed in figure 11 and 4899 W/m^2 for N=12, h=30 mm as shown in figure 12.

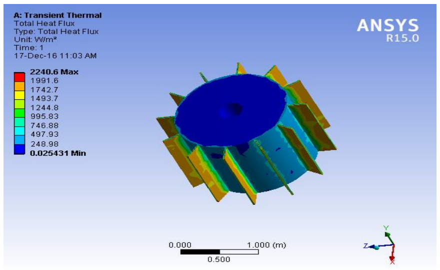

Fig. 10 Heat flux contour (N=12, h=10 mm)

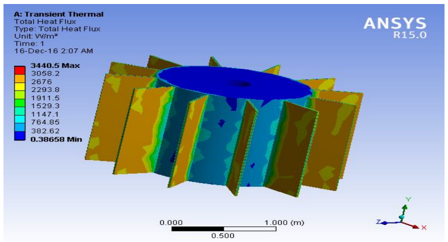

Fig. 11 Heat flux contour (N=12, h=20 mm)

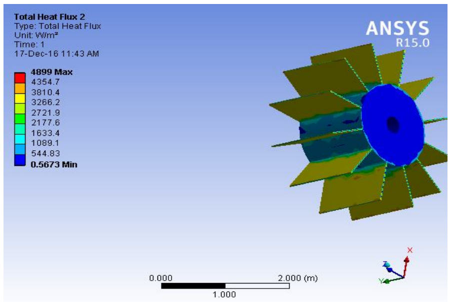

Fig. 12 Heat flux contour (N=12, h=30 mm)

Calculated heat transfer rate from above results is shown in table 4 and variation of heat transfer rate with fin height is shown in figure 13.

Table 4 Heat transfer rate

No. of fins (N)	Fin height (H) mm	Maximum Heat transfer rate (Q) W
12	10	0.9958
12	20	3.0582
12	30	6.532

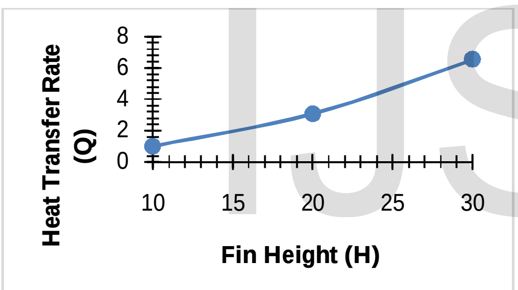

Fig. 13 Heat transfer rate for various fin height

4 CONCLUSIONS:

In the present work heat transfer rate is calculated for vertical cylinder with vertical oriented fins (heat sink) for 3 different geometrical configurations (N=12, H=10 mm, N=12, H=20 mm, N=12, H=30 mm). It is observed that heat transfer rate is increased with increment in fin height for given heater input. For given input parameters, it is maximum for heat sink with geometrical configuration N=12, H=30 mm. It is also concluded from Temperature contour that temperature is minimum at fins, maximum at the inner portion and it also increases when fin height is increased.

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