Thermal analysis to estimate heat transfer from heat sink by natural convection through closed enclosure

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ABSTRACT

Electronic devices are strategic devices such as radars, communication sets, and amplifiers, twt's controls which are used in aircraft, space vehicles, missiles and ground stations. The use of these devices in strategic and military application is rapidly increasing and these equipments are becoming more and more sophisticated. Plate fin heat sinks are commonly used devices for enhancing heat transfer in electronics components. In this thesis, investigations will be carried out to determine the heat transfer rates in a heat sink by means of varying pitch of the fin with air as the working fluid. Analysis is carried out for heat sink with closed enclosure constant wall heat flux. Analysis is done with Aluminum alloy 6061, where Aluminum alloy 6061 was having highest temperature, heat transfer coefficient and better efficiency values. PRO-E is used for the modeling of plate fins. Analysis is performed in ANSYS software. CFD analysis is performed for different cases to determine heat transfer coefficient, pressure drop, mass flow rate and heat transfer rate. From the analysis done on the mentioned softwares finally we get the results of pressure, velocity and heat transfer coefficient values for Reynolds number 8000 and 14000

Keywords: - *Natural convection, FLUENT (14.5), plate-fin heat sink , Heat transfer characteristics .*

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1. INTRODUCTION:

Heat transfer by convection may occur in a moving fluid from one region to another or to a solid surface, which can be in the form of a duct, in which the fluid flows or over which the fluid flows. In recent years, with the rapid development of electronic technology, promoting the heat transfer rate under the working process at the desired operating temperature may play an important role to ensure reliable operation of the electronic components. A heat sink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature at optimal levels. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink.

Plate fin heat exchanger is significant now-a-days and most widely used due to high heat transfer rate. It is investigated that compact heat exchangers such as plain fin strip, offset fin, wavy fin, perforated fin, etc the pressure drop decrease with respect to increasing the turbulence in working fluid.

A heat sink is usually made out of copper and aluminum. Copper is used because it has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Copper is three times as dense and more expensive than aluminum. Aluminum is used in applications where weight is a big concern

Natural convection heat transfer with heat sink and extended surfaces has been widely used in engineering applications [1]. The investigation was done on plate fin heat sink with consideration of zero equation turbulence models to study the heat transfer and fluid flow characteristics using fluent [2]. The results are shown by doing the experiments on circular fin with material Aluminum Alloy 6061 is better since heat transfer rate, and effectiveness of the fin is more [3]. The laminar natural convection on vertical surfaces was investigated computationally. CFD simulations are carried out using fluent software. Governing equations are solved using a finite volume approach. Relation between the velocity and pressure is made with simple algorithm [4].

The natural convection from a radial heat sink was done experimentally and numerically. Parametric studies were performed to compare the effects of the number of fins, fin length, fin height, and heat flux on the thermal resistance and the heat transfer coefficient. The thermal resistance decreased and the heat transfer coefficient increased in proportion to the heat flux applied to the heat sink base [5].Analysis was done to find the different values of thermal gradient vector sum, nodal temperature and thermal flux vector sum for different materials of aluminum, aluminum alloy 2024, copper and stainless steel by varying the heat flux values [6]

Design of a heat sink with an open enclosure in refrigeration is analyzed for the heat transfer by forced convection using CATIA V5. Here even designed a modified model also for the heat sink. Design has been modified as to compare the results with the original and even to get the better efficiency and even the better heat transfer rate [7]

2. MODELING AND CALCULATIONS:

Modeling of plate fin was designed using Pro-E. Two different kinds of the models were designed by varying pitch between the fins to know the effect of pitch difference on natural convection. Models were designed with base height of 4mm and width of 100mm and series of 27 and 18 fins were extruded on base surface with pitch difference of 2mm and 4 mm respectively as shown in figure**.**

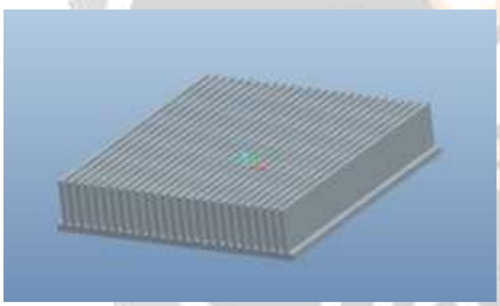


Fig -1: Pitch2; Height24

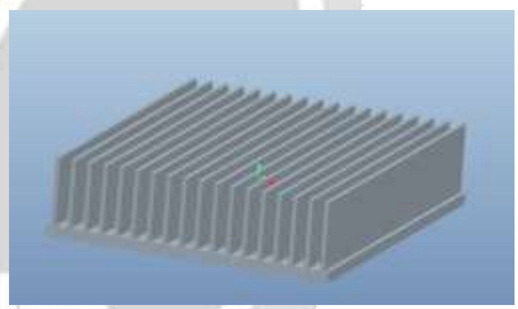


Fig-2: Pitch4; Height24

2.1 VELOCITY CALCULATIONS:

Velocity of the flowing air on the plate fins were calculated for the Reynolds number values of 8000 and 14000 using this equation (1). Theoretically the values 4.86911 m/sec and 8.52095 m/sec rate of velocity were obtain for Reynolds number 8000 and 14000 respectively.

$$\text{Reynolds number, Re}=\frac{\rho\times V\times L}{\mu} \quad \text{----------------------} \quad (1)$$

Where, ρ=density of air, kg/m^3; V=velocity of air, m/s ; L=length of the fin, m; μ=dynamic viscosity of air, kg/m-s
The pressure values were found from the known values of velocity.

3. RESULTS AND DISCUSSIONS:

In this present study two case studies were conducted. Case study 1 studies about the pitch2; height 24 with Reynolds number as 8000 and 14000. Case study 2 studies about the pitch4; height24 with Reynolds number as 8000 and 14000.

In case 1 with pitch2; height24 with Reynolds number 8000 and 14000 the various output parameters pressure, velocity and heat transfer coefficient were studied. In case 2 with pitch4; height24 with Reynolds number 8000 and 14000 the various output parameters pressure, velocity and heat transfer coefficient were studied.

CASE 1- PITCH2; HEIGHT24:

From the analysis done on the plate fin heat sink through natural convection, the result of the parameters obtained for the fin of pitch2 and pitch4 with same height after varying Reynolds number 8000 and 14000 are observed and shown below in detail through the graphs

In graph1, with pitch2; height24 shows the variations of pressure with respect to Reynolds number. The maximum pressure at Re 8000 is 1.697e+000 Pa and at Re 14000 is 4.678e+000 Pa. For graph2, with pitch2; height24 shows the variations of velocity with respect to Reynolds number. The maximum velocity at Re 8000 is 4.951e+000 m/sec and at Re 14000 is 8.667e+000 m/sec. For graph 3, with pitch2; height24 shows the variations of heat transfer coefficient with respect to Reynolds number. The maximum heat transfer coefficient at Re 8000 is 3.619e+001 W/mm^{2}K and at Re 14000 is 5.600e+001 W/mm^{2}K

REYNOLDS NUMBER 8000

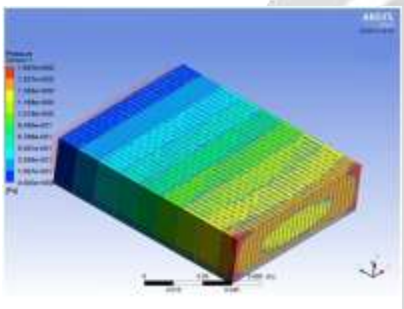


Fig -3: Pressure

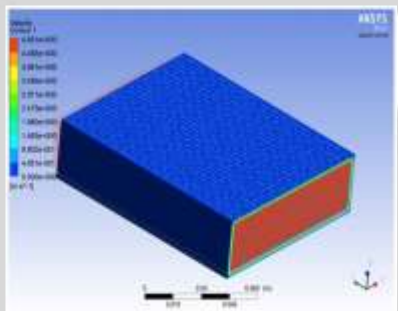


Fig -4: Velocity

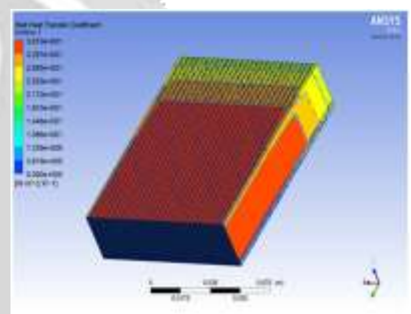


Fig -5: Heat transfer co-efficient

REYNOLDS NUMBER 14000

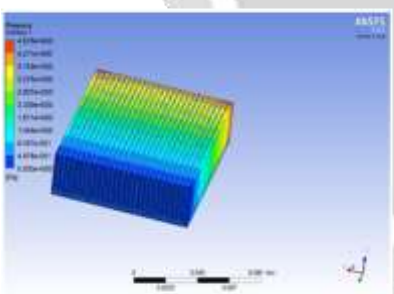


Fig -6: Pressure

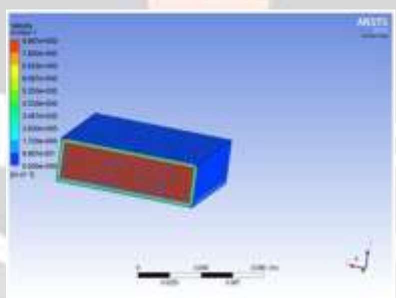


Fig -7: Velocity

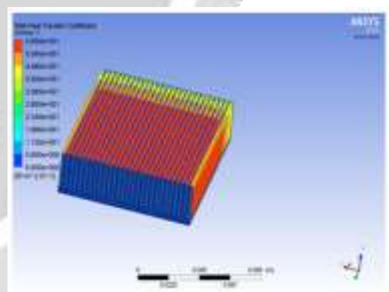
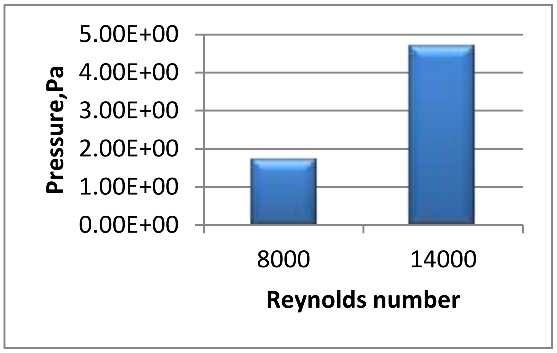
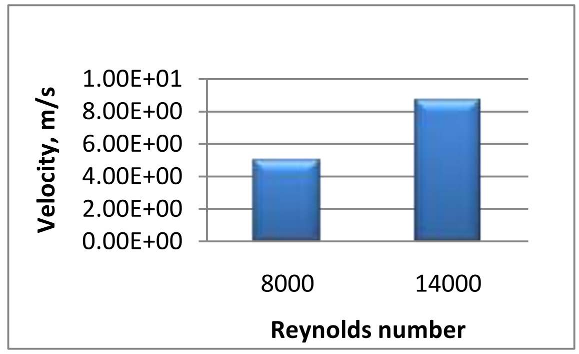


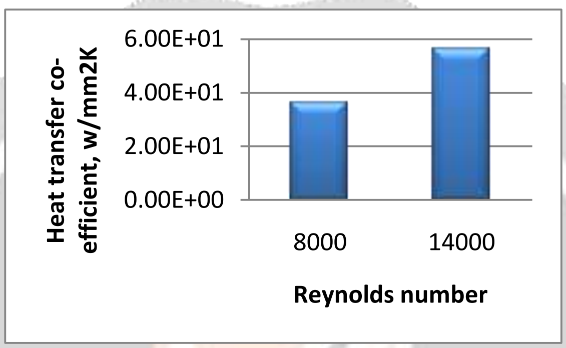
Fig-8: Heat transfer co-efficient



Graph 1



Graph 2



Graph 3

CASE 2 -: PITCH4; HEIGHT24:

In graph 4, with pitch2; height24 shows the variations of pressure with respect to Reynolds number. The maximum pressure at Re 8000 is 1.703e+000 Pa and at Re 14000 is 4.677e+000 Pa. In graph 5, with pitch2; height24 shows the variations of velocity with respect to Reynolds number. The maximum velocity at Re 8000 is 4.958e+000 m/sec and at Re 14000 is 8.666e+000 m/sec. In graph 6, with pitch2; height24 shows the variations of heat transfer coefficient with respect to Reynolds number. The maximum heat transfer coefficient at Re 8000 is 3.624e+001 W/mm^2K and at Re 14000 is 5.600e+001 W/mm^2K

REYNOLDS NUMBER – 8000

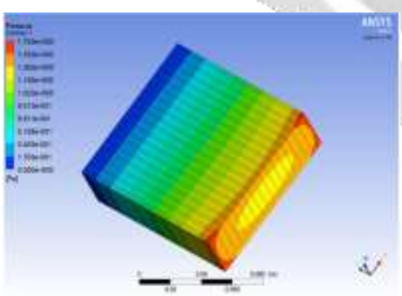


Fig -9: Pressure

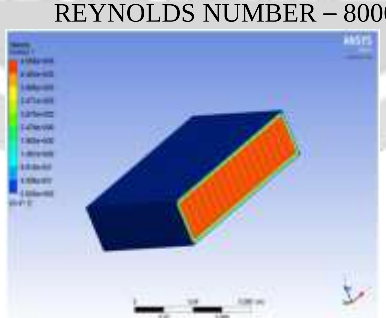


Fig -10: Velocity

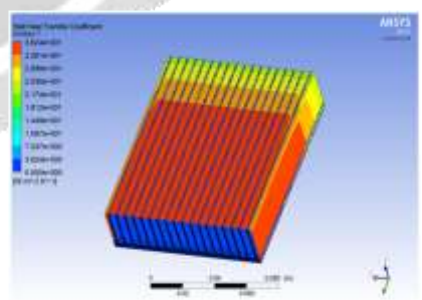


Fig -11: Heat transfer co-efficient

REYNOLDS NUMBER 14000

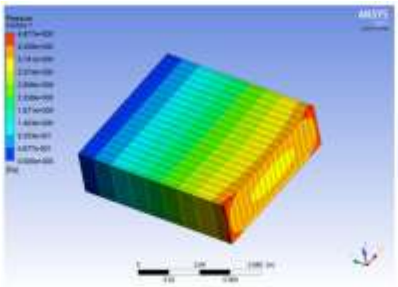


Fig -12: Pressure

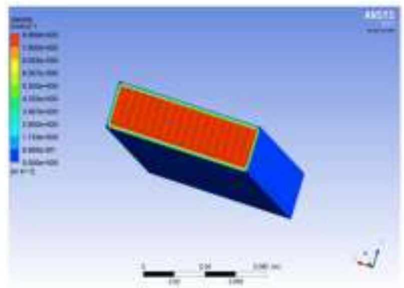


Fig -13: Velocity

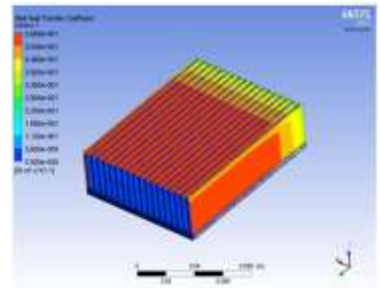
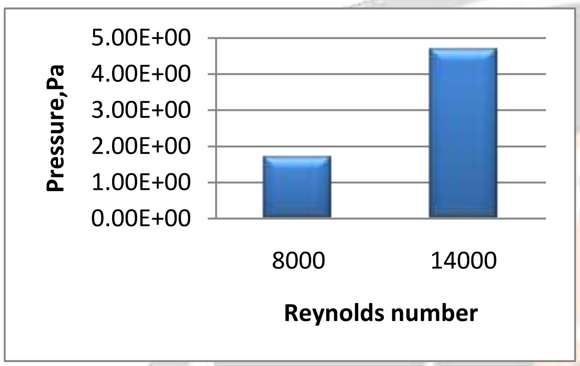
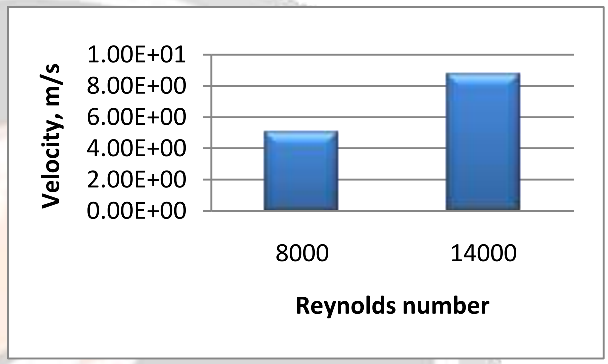


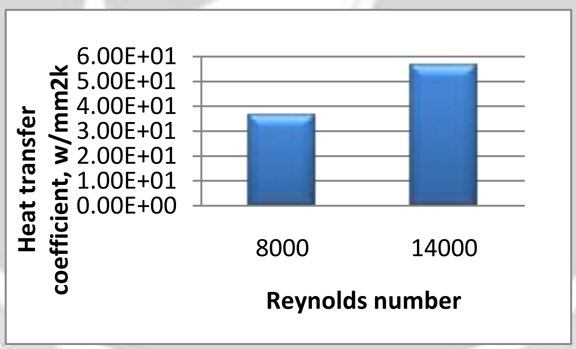
Fig-14: Heat transfer co-efficient



Graph 4



Graph 5



Graph 6

4. CONCLUSIONS:

The values of pressure drop, velocity and heat transfer coefficient values are compared in this analysis. Through this analysis, it was concluded that the values of pressure drop, velocity and heat transfer coefficient values were increased with the increasing of Reynolds number. Finally it can be concluded that for the heat transfer of natural convection through closed enclosure, for getting highest values of the result parameters Reynolds number with greater value is considered.

5. REFERENCES:

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