COMPUTATION OF STEADY LAMINAR NATURAL CONVECTIVE HEAT TRANSFER FROM LOCALIZED HEAT SOURCES IN ENCLOSURES

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ABSTRACT: Natural convective cooling of localized heat sources located on walls of a three dimensional rectangular enclosure is studied numerically in the present study. Heat sources are placed on an insulated side of the enclosure. The remaining faces of the enclosure are considered to be at a uniform temperature. Size of heat sources are considered to be relatively small compared to the dimensions of the enclosure. The physical problem considered is aimed to simulate cooling of heat producing surfaces in electronic systems. SIMPLEM method introduced by Acharya and Moukalled is used to solve the steady state three dimensional laminar natural convection heat transfer problem using a nonuniform nonstaggered grid arrangement. Formulation of the numerical problem is realized using primitive variables. Equations which are solved numerically are dimensionless forms of the three momentum equations in the x, y and z directions, the energy equation and the equation of continuity. Effects of aspect ratios $Az (=H/W)$, $Ay (=D/W)$, Grashof number, Prandtl number, and the different orientations of heat sources on the magnitude of heat transfer are investigated.

1. Introduction

Effective cooling of electronic components has become increasingly important as power dissipation and component density continue to increase substantially with the growth of electronic technology. In modern electronic equipment, a large number of high power dissipating components such as transistors, resistors, and power transformers are being packaged in modular rectangular enclosures. Heat dissipation components are mounted on flat parallel plates in many electronic cooling situations. The simplest method of cooling these components is air circulated by naturally generated bouyant forces. Natural convection provides low-cost, reliable, maintenance-free, and electromagnetic interference-free cooling. Placement of high power dissipating components within an electronic package which are cooled by natural convection heat transfer requires accurate predictions for natural convection heat transfer processes.

Söylemez [1] developed a computer code for computation of steady state laminar natural convective heat transfer in rectangular enclosures as in Figure 1 over a wide range of Rayleigh and Prandtl numbers, $H/W$, $D/W$, $S/H$, $L/H$, $Ah/A$ and angles of inclination by using the SIMPLEM method proposed by Acharya and Moukalled [2]. Chu [3] studied the effect of localized heating in rectangular two dimensional channels by solving the partial differential equations for the conservation of mass, momentum, and energy numerically.
using an unsteady state formulation and the alternating direction implicit method for $0 < Ra < 10^5$ and for values of $W/H$, $S/H$, $L/H$ and $Pr=0.7$ as given in Fig. 2.

Fig. 1. Geometry of the Three Dimensional Enclosure

Fig. 2. Geometry of the Two Dimensional Enclosure

Sparrow [4] performed experiments for natural convection in an open channel in which a heated wall was maintained at a uniform temperature opposite to an unheated opposing wall while all other walls were insulated. He developed a correlation for Prandtl numbers in the range $0.7 < Pr < 10$ and for Rayleigh numbers of $200 < Ra < 10000$. Keyhani [5] experimentally investigated natural convection heat transfer in a tall vertical cavity ($A_z=16.5$), with one isothermal vertical cold wall, and eleven alternately unheated and flush-heated sections of equal height on the opposing vertical