A THERMAL DESIGN APPROACH FOR ELECTRONIC EQUIPMENT BY USE OF
A PERSONAL COMPUTER AND FLOW VISUALIZATION

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ABSTRACT. An approach to the thermal design of electronic equipment is presented. Although recent progress in computer technology has enabled a complex analysis to be done, it is difficult to carry out numerical analysis for a practical electronic equipment cabinet. It has thus become important to set up an analytical model in order to apply computer simulation to the thermal design of electronic equipment. This paper reports on the approach based on lumped models and experimental data of the flow resistance coefficient and heat transfer coefficients. Simulation was carried out for a laptop computer and a copy machine by use of a personal computer and a flow visualization. The proposed method is proven to serve thermal designers satisfactorily.

1. Introduction

It has been a very important problem to remove the heat dissipated by electronic equipment and this problem is related to equipment reliability. This has led to many studies of electronic equipment cooling. Many useful results for electronic equipment design have been obtained. Most results, including cooling technology using air and liquid convection and boiling, have already been gathered from pertinent literature sources, journal papers (Nakayama, 1986), edited books (Aung; 1988; Antonetti, et al., 1989; Peterson and Ortega, 1990; Hwang, 1989 and Bergles, 1990) and book (Kraus and Bar-Cohen, 1983). Reports for air cooling have been very important, because most electronic equipment are cooled by air convection. Results have been obtained by numerical studies of heat transfer regarding electronic equipment models according to the above mentioned literatures. However, there are not many reports on the numerical thermal analysis technology using computers for designing practical electronic equipment: journal papers (Fukuoka and Ishizuka, 1989; Ishizuka, 1992 and 1993 and Chu and Agonafer, 1993). It has now become necessary to apply numerical simulation using a computer to the thermal design of electronic equipment to save time and speed up the work. With recent developments in computer performance, it has become possible to conduct a considerably detailed thermo-fluid analysis, and this should be applied to the thermal design of electronic equipment. However, it is necessary to incorporate extremely complicated boundary conditions, due to the various sized components mounted in electronic equipment. It is also not practical to divide into fine meshes in order to express the various-sized components on boards, which are stored in a three dimensional arrangement in the cabinet. Therefore, many problems are still left unsolved. Although several computer codes are available for the thermal design of electronic

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equipment in combination with a CAD system, many heat transfer coefficients for the component surfaces are needed as boundary conditions to calculate the temperature fields. Therefore, it is necessary to obtain the fluid flow fields which are the boundary conditions in the temperature field by some other means or experiments. Codes which are able to calculate both the fluid flow field and the temperature field are desirable. However, as mentioned above, many difficult problems including the lack of computer capacity are left unsolved, so it is necessary to form a simple model for the flow and thermal fields before it becomes possible to do a general thermo-fluid analysis.

In this paper, an approach to the thermal design of electronic equipment is presented. This is a simple analysis using a lumped model and including experimental values, such as flow resistance coefficients and heat transfer coefficients. The approach was applied to the design of a laptop computer and a copy machine by use of a personal computer and flow visualization.

2. Simple Thermo-Fluid Analysis Using a Personal Computer

As mentioned above, a complete thermo-fluid analysis for electronic equipment design appears impossible today, even using a supercomputer. However, a simple approach using a personal computer based on experimental values such as the flow resistance coefficient and the heat transfer coefficient is considered feasible.

2.1. FLUID NODAL POINT NETWORK

The flow field in a cabinet, shown in figure 1, will be considered. It is assumed that flow fields in the cabinet are obtained by flow visualization as shown in Figure 2. Next, the