INVESTIGATION OF THE THERMAL INTERACTION BETWEEN AN ISOTHERMAL CYLINDER AND ITS ISOTHERMAL ENCLOSURE OF AN ELECTRIC JUNCTION

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This article deals with numerical simulation of air flow and heat transfer in an electric junction box comprising conductive metal wire rods each having a cylinder shape in cross section. Results obtained by a commercial CFD package widely used for electronic system temperature predictions. The paper gives considerable insight into the nature of the enclosure heat transfer and an indication of the accuracy of a widely used predictive code.

Keywords: heat transfer, thermal design, CFD method, electric junction

1. INTRODUCTION

The transfer of heat from heated bodies in an enclosed environment is of considerable practical importance, particularly in the field of electronics cooling. Experimental difficulties arise in obtaining flow field information when more complex 3D systems are considered, leading to a dependence on numerical investigations. Some numerical investigations are not compared to experimental data, presumably owing to the difficulties associated with experimentation [1]. The temperature measurements are particularly useful in gaining an insight into the physics of the flow, and for comparison with CFD predictions [2], [3].

The purpose of this review is to examine the applicability of CFD predictions for qualitative and quantitative measurement of temperature fields in enclosure free convection. It is desirable to have a real-time system in which unsteady flows, which are often encountered in enclosure free convection, can be studied. Choice criteria are based on component junction temperatures, measured using thermal test and infrared thermography respectively.

2. OPTIMIZATION IN ELECTRONIC COOLING

Typical goals for an electronic design might include satisfying maximum component junction temperatures or minimum airflow requirements. Goals are often weighted against one another to give more importance to the most critical objectives. One then identifies all of the factors, or variables, that have influence over the design goals. Based on certain design constraints, these factors are subject to lower and upper bounds, which, when combined together, are usually referred to as the design space.

The CFD editor uses an analytical approach based on a Fourier series expansion. The continuity and temperature equations can be written as:

$$\partial\rho/\partial t + \partial(\rho u)/\partial x = 0 \quad (1)$$

$$\frac{\partial(\rho C_p T)}{\partial T} + \frac{\partial(\rho u C_p T)}{\partial x} - \frac{\partial}{\partial x}\left(\frac{\lambda \partial T}{\partial x}\right) = S \quad (2)$$

where u is the velocity resolutes in cartesian coordinate direction x, T is the temperature of the fluid and/or solid materials, ρ is the material density, C_p is the specific heat.

Eq. (2) or equivalent formulations allow the computation of the board thermal map and indication of the location of hot spots [5].

3. Experimental Study

An analytical model of the baseline geometry was created using the commercially available CFD software, FLOTHERM 6.1. A baseline model containing all of the requisite design factors was constructed by FLOMCAD software.

The test structure, shown in Fig. 1, is an electric junction comprising electrically conductive metal wire rods each having a cylinder shape in cross section. The metal wire rods are cut to a suitable length and bent into a suitable shape of the housing. The temperature profile of the electronic assembly is shown on Fig.2.

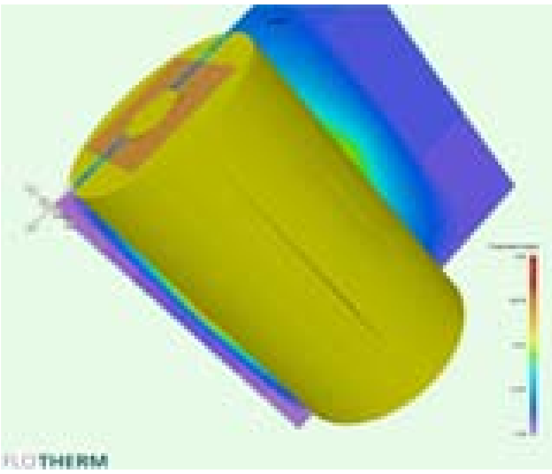

Fig. 1. The test structure

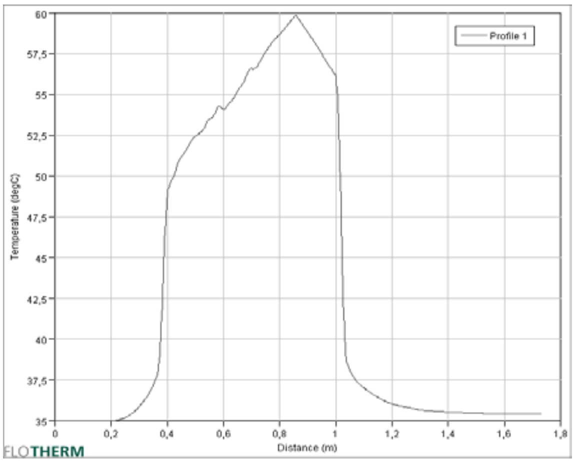

Fig.2. Temperature profile in Y direction

In view of obtaining simple solutions, the thermal problem is further approximated by separating the electronic junction into two rings - the inner ring with the inner and outer radii of a and c, and the outer ring with the inner and outer radii of c and b, as illustrated in Figs. 3 and 4. With an assumed isothermal boundary condition at c, each of these two ring-regions can be solved now by means of the method of separation of variables in two-dimensional, cylindrical coordinates. It is to be noted that the ongoing approximations become closer to the actual conditions if both the interracial contact area and the plate thickness are small. To account for the effect of thick plates, an adjustment is made in the analysis such that, if the thickness is greater than the contact-ring width (c – a), the thickness of the inner-ring plate is made equal to the ring width, and the isothermal boundary condition prescribed at r = c is imposed only over a restricted partial surface area [4].

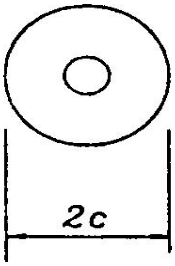

Fig.3. The inner ring

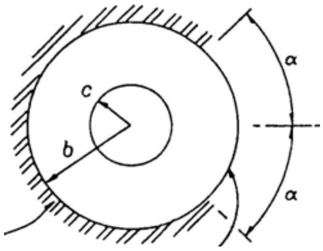

Fig.4. The outer ring

Numerous simulations were undertaken by changing the height of the outer ring and the extend to which the inner ring gets into the housing. A 3D temperature distribution picture of the rings is given on Fig.5. Their temperature profile is shown on Fig.6. The maximum temperature of the structure is 80°C and is radiated from the common axis of the rings.

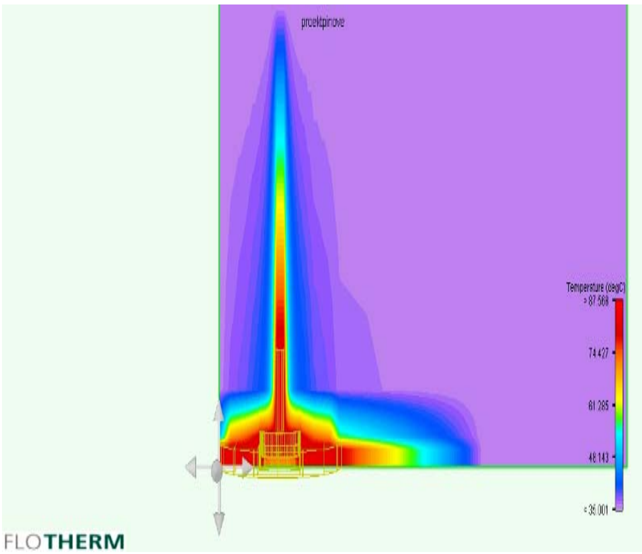

Fig.5. A 3D temperature distribution picture of the rings

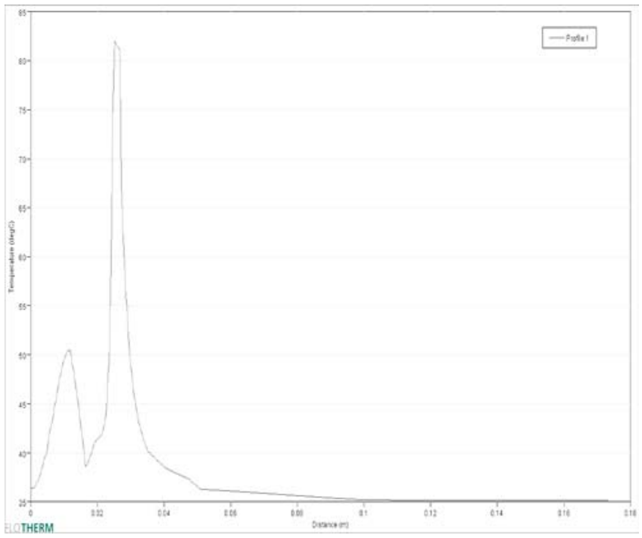

Fig.6. Temperature profile

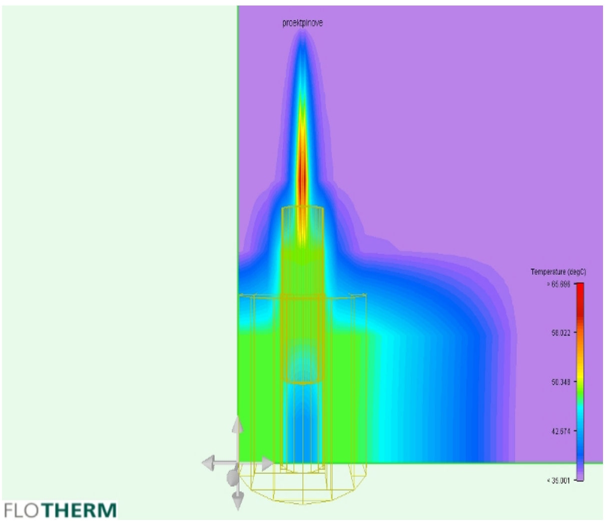

Fig.7. A 3D temperature distribution picture of the rings

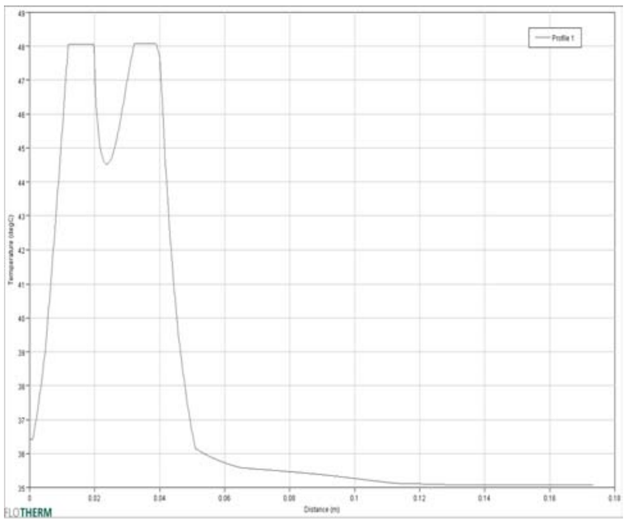

Fig.8. Temperature profile

On Fig.7 and Fig.8 are given pictures and temperature profiles of higher outer ring. The extend to which the inner ring fills the outer ring is less that on Fig. 5. The maximum radiated temperature is 100°C.

4. CONCLUSIONS

The investigated structure of contacted rings has an application in the modern UHF multichip micro modules for making contact structures. The appropriate materials for their creation are such as copper, gold and nickel. The proposed simulation procedure for the investigation of heat transfer through the contact system allows optimization of geometry sizes of the contact construction during the design process of the system and a choice of a proper material for obtaining the best possible heat transfer and reliability respectfully as well as decreasing the design time and the expenses because of the test reduction.

5. REFERENCES

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