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Optimal location of three heat sources on the wall of a square cavity using genetic algorithms integrated with artificial neural networks ☆

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ABSTRACT

In this work, optimization of location of heat sources in a square enclosure with natural convection is performed to maximize the global conductance in the enclosure. For this study we have taken a square enclosure with three adiabatic walls, one isothermal wall opposing the wall having three heat sources. Numerical simulations are done by changing positions of heat sources for different Rayleigh numbers using Fluent 6.3(2d, double precision). And for some configurations maximum temperature inside the enclosure is noted. Optimization is done using genetic algorithms (GA) combined with artificial neural networks (ANN). An ANN is trained using the above data obtained from numerical solutions. The trained ANN will be the simulation tool, whenever required by the GA for optimization. It is shown that at high Rayleigh number the spacing between the heat sources should be zero for optimum heat transfer. Variation in optimum solution for unequal heat fluxes are also studied.

1. Introduction

Electronic equipment cooling is one of the major research areas of heat transfer. For efficient and reliable working of these electronic equipments, they should be maintained at a constant low temperature as prescribed by the manufacturer. And also for low space and silent operation natural convection is very much preferred. For maximizing heat transfer for a problem optimization should be done. Using of evolution techniques yield great results in optimization [2,3].

Optimization of discrete heat sources has a considerable literature. Da Silva et al. [1] have done optimization of discrete heat sources with large number of line heat sources with natural convection. They showed that the heat sources must be positioned closer to the start of the boundary layer. In another study, Tito Dias Jr. and Milanez [2] did optimization of two heat sources in a square enclosure with natural convection through genetic algorithms. They have shown that, only 2% of numerical simulations are needed for optimization using genetic algorithms compared to an extensive search. Madadi and Balaji [3] have proposed a new methodology for optimization, by integrating artificial neural networks with micro-genetic algorithms. They have shown using this methodology; we can obtain optimal solutions faster since computational time can be reduced substantially.

In this paper we have done optimization of three heat sources on a vertical wall using artificial neutral networks integrated with genetic algorithms. While Madadi and Balaji [3] deployed an ANN and micro-GA combination for optimization of forced convection, we have used basic ANN–GA approach for natural convection. Here ANN is basically trained for the input–output combination. Subsequently GA was used for optimization. The procedure resulted in a simplified model which requires considerably reduced computational time.

2. Model and governing equations

2.1. Model

Fig. 1 describes the geometry of the problem considered. The size of the square enclosure, $L = 0.1$ m. There are three heat sources mounted on the left wall; top and bottom walls are considered to be adiabatic. The right wall is the cold one with constant temperature which helps in cooling the enclosure. The size of the heat sources is constant and is chosen such that $L_h = 0.2$ L. Following the procedure laid out in literature [1–5], the main emphasis of this work is on the optimization strategy and hence radiation is not considered at this moment.

2.2. Governing equations

The Boussinesq approximation is being considered here. The equations for a two dimensional, steady, incompressible flow and laminar natural convection heat transfer are as follows:

Continuity equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial x} = 0 \quad (1)$$

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