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Mixed convection in channel with asymmetric discrete heating

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Abstract

Mixed convection from discrete heat sources is of interest in many practical applications, such as cooling of electronics equipments, positioning of heating elements in furnaces, etc... When the systems are subjected to discrete wall heat sources, the heat transfer behavior may rather differ to that of the situations if the wall heated continually. So, the arrangement of the heated section plays an important role in the power dissipation rate. Many experimental and numerical investigations on the characteristic of convective heat transfer in a parallel plate channel with discrete heating wall are available in the literature [1-7]

From the above literature review, it can see that the mixed convection heat transfer with multiple discrete heat sources under aiding and opposing buoyancy effect has received less attention. Thus, the aim of this paper is to conduct a detailed numerical of laminar aided mixed convection in a parallel plate channel with multiple discrete heat sources at one wall.

The physical configuration and notations considered for the numerical analysis are illustrated in Figure 1**.** In the present numerical investigation, the flow is assumed to be steady, laminar and two-dimensional in the range of parameters used. The incompressible Navier–Stokes and energy equations with the Boussinesq approximation in the Cartesian coordinate system form the governing equations of the flow.

At the inlet a uniform upward flow of constant temperature is prescribed. At the wall the non sleep boundary condition is applied for the velocity. A constant temperature is imposed at the heat sources location and a zero gradient elsewhere.

The governing transport equations associated with the boundary conditions are solved using the open source OpenFoam® 2.2.2 code (2013) using the Boussinesq approximation for estimating the density in buoyancy term in the momentum equation.

Validation of the numerical simulation was attained by performing calculations for the case of mixed convection in the entry region of vertical with symmetric heating [8] and a good agreement is observed between the two studies.

In the present work calculations have been performed for different values of *Reynolds* number and *Grashof* number at Richardson number ranged from 0.25 to 5 where both inertial and buoyancy forces have comparable effects.

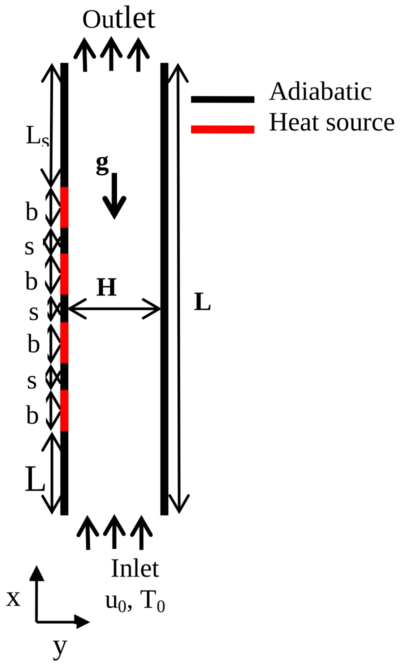

Fig. Schematic diagram of computational domain

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The results are presented as flow and temperature features in the whole channel. In addition the local Nusselt number evolution is evaluated to estimate heat transfer rate at different conditions.

An example of the results obtained is shown in Fig. 2. It represents the isotherms contours for Re=100, 200 and 400 at $Gr= 4\times10^4$. From this figure, it can be shown that the isotherms contours are crowded in the immediate proximity of the heat sources, indicating high temperature gradient. The thermal boundary grows as we moves from a heat source to the next one in the flow direction.

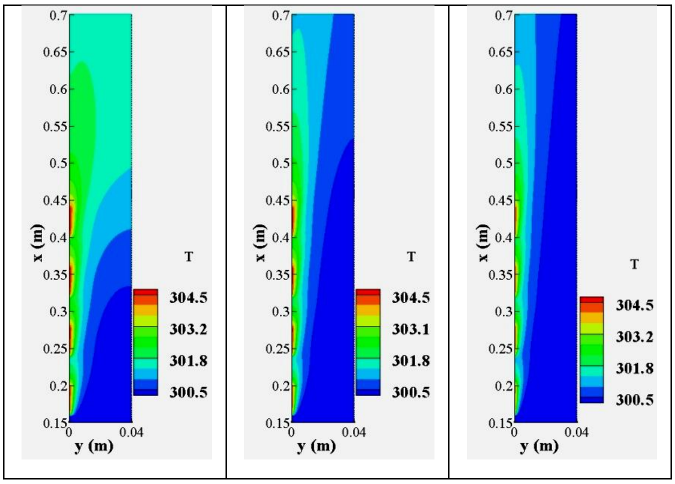

Fig. 2 Isotherms contours condition for (a) Re=100, (b) 200 and (c) 400 at $Gr=4\times10^4$

In general, the results revealed that the flow structure and temperature feature as well as the *Nusselt* number were strongly dependent on *Grashof* and *Reynolds* numbers. It was found that in that case of aided buoyancy flow, a dissymmetry of the flow generated by addition of secondary flow produces thinner thermal boundary layer leads to enhance heat transfer in all situations.

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