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Research Article

COMPUTER SIMULATION OF THE CONVECTION PROCESS BETWEEN TWO VERTICALLY LOCATED HEAT SOURCES

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Abstract

This article simulates the process of the formation of dynamic and temperature boundary layers between two vertically located rods, which are heat sources. The formulated system of partial differential equations with boundary conditions is solved numerically and its algorithm is implemented using the DELPHI graphical environment. Chart component was used to draw graphs.

Key words. Dynamic boundary layer, temperature boundary layer, heat source, mathematical model, heat transfer, natural convection, boundary layer equations, laminar regime.

In [1], laminar convective transport near a vertically located heat source was studied. In this work, we numerically investigate a stationary, laminar transport in an adjacent layer immersed in a resting ambient gas between two vertical surfaces.

It is assumed that the ambient temperature is constant and equal t_0; the temperature on the surface of the rods is also maintained at constant temperatures equal $t_1, t_2 \quad (t_1 > t_0, t_2 > t_0)$.

The considered physical process is mathematically modeled on the basis of the boundary layer approximation equation by the following system of differential equations:

$$\left.\begin{aligned} &\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho \upsilon) = 0, \\ &\rho u \frac{\partial u}{\partial x} + \rho \upsilon \frac{\partial u}{\partial y} = \frac{\partial}{\partial y}\left(\mu \cdot \frac{\partial u}{\partial y}\right) + \frac{\rho \beta (T - T_1)}{Fr}, \\ &\rho u \frac{\partial E}{\partial x} + \rho \upsilon \frac{\partial E}{\partial y} = \frac{1}{\Pr} \quad \frac{\partial}{\partial y}(\mu \cdot \frac{\partial E}{\partial y}). \end{aligned}\right\} \quad (1)$$

In these equations, the unknown are: u, υ - longitudinal and transverse components of the velocity; ρ - density, T- absolute temperature, E – total energy, as well as dynamic coefficient of viscosity. Fr - hydrodynamic Froude number, Pr-Prandtl number.

To close the system of differential equations (1), we supplement it with the algebraic equation of total energy, the equation of state. The dependence of the gas viscosity coefficient on

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temperature is represented by the Sahterland formula [2].

Let us formulate the boundary conditions in the following form:

$$\left.\begin{aligned} x=0: &\begin{cases} u=0,\ v=0,\ E=E_1,\ \rho=\rho_1 & npu\ \ y=0 \\ u=0,\ v=0,\ E=E_0,\ \rho=\rho_0 & npu\ \ 0\prec y\prec a \\ u=0,\ v=0,\ E=E_2,\ \rho=\rho_2 & npu\ \ y=a \end{cases} \\ x\succ 0: &\begin{cases} u=0,\ v=0,\ E=E_1,\ \rho=\rho_1 & npu\ \ y=0 \\ u=0,\ v=0,\ E=E_2,\ \rho=\rho_2 & npu\ \ y=a \end{cases} \end{aligned}\right\} \qquad (2)$$

Schematic flow pattern according to (1) is shown in fig.1.

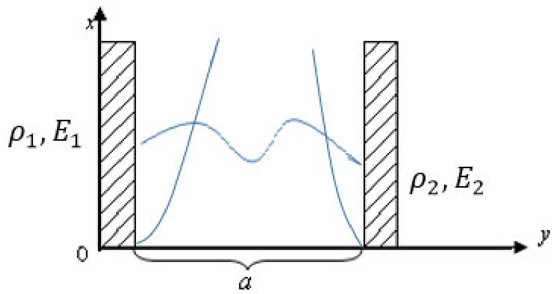

Fig. 1. Schematic flow pattern according to (1).

The above problem is solved numerically using a two-layer, four-point implicit finite-difference scheme and the iteration sweep method.

At the same time, on the basis of the compiled algorithm, a program in the DELPHI language was compiled. During the work of the program, the results were expressed in the form of graphs, for this we used the Chart component.

Figure 1. the appearance of axial velocity and expansion of the dynamic boundary layer at Pr = 0.7 are shown. As can be seen from the figure, the higher along the rod, the higher the speed. Air temperature 300K.

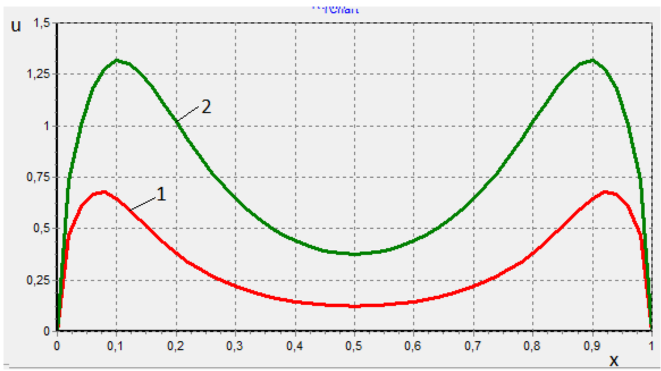

Fig. 1. The emergence of air velocity near heat sources, which have temperatures of 500K, respectively. 1-for $\bar{x}=5$, 2-for $\bar{x}=10$.

Figure 2. the appearance of axial velocity and expansion of the dynamic boundary layer at different temperatures of heat sources are given.

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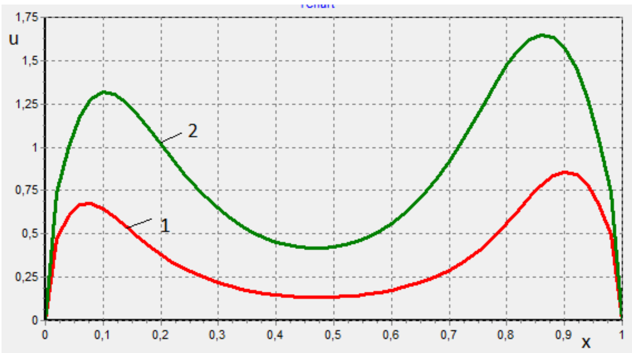

Fig. 2. The emergence of speed near heat sources, which have temperatures of 500K and 800K, respectively. 1-for $\bar{x} = 5$, 2-for $\bar{x} = 10$.

As can be seen from the figures, the higher the temperature of the source, the higher the air velocity near it. This is consistent with the physics of flow.

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