Euro Analytica 2020 : Analysis of heat transfer in a closed cavity ventilated inside

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Abstract

In this work, we presented a numerical study of the phenomenon of heat transfer through the laminar, incompressible and steady mixed convection in a closed square cavity with the left vertical wall of the cavity is subjected to a warm temperature, while the right wall is considered to be cold. The horizontal walls are assumed adiabatic. The governing equations were discretized by finite volume method on a staggered mesh and the SIMPLER algorithm was used for the treatment of velocity-pressure coupling. The numerical simulations were performed for a wide range of Reynolds numbers 1, 10, 100, and 1000 numbers are equal to 0.01,0.1 Richardson, 0.5,1 and 10.The analysis of the results shows a flow bicellular (two cells), one is created by the speed of the fan placed in the inner cavity, one on the left is due to the difference between the temperatures right wall and the left wall. Knowledge of the intensity of each of these cells allowed us to get an original result. And the values obtained from each of Nuselt convection which allow to know the rate of heat transfer in the cavity.Finally we find that there is a significant influence on the position of the fan on the heat transfer (Nusselt evolution) for values of Reynolds studied and for low values of Richardson handed this influence is negligible for high values of the latter.1. Introduction The transfer of heat by mixed convection aroused the considerable interest of several researches for technological applications such as: the ventilation of the buildings, the chemical plating of the thin layers, the cooling of the electronic parts, squanderers of heat in the solar collectors and nuclear reactors. Several simple and complex geometrical configurations were examined by report to a theoretical, digital end experimental approach. A large number of numerical studies were interested on fixing of only one entry and exit [1-3] with an isothermal wall. Others research considered the wall heated with a heat flow [4-5], where [6] studied various configurations of the entry and exit position in order to detect the best possible position of the entry and exit opening, and to obtain a more effective cooling. Other numerical and experimental [7-9] studies treated the effect of the geometry of an obstacle like the source of heat inside the cavity in order to maximize the total conductance. The position of the air entry and the exit has a great effect of the hydrodynamic and thermal structures [10]. One cavity that has several entries [11] improves its ventilation. The lattice Boltzmann method (LBM) being a digital method relatively recent and original which came out at the beginning of the Nineties. It is interested, either with the macroscopic quantities (celerity, pressure and density), but directly the distribution of the various particles constituting a fluid. We speak then about mesoscopic representation. What makes it competing with the other conventional methods such as finite volume, finite elements and the finite differences. It is initially resulting from the lattice gas method [12], from the automata cellular theory [13] and while being based on the physic statistical formalism [14]. It is important to be able to locate its performances compared to those of the classical .digital methods used to simulate and reproduce the flows with the heat transfer in the ventilated enclosures. The purpose of the study presented in this work is the analysis of the phenomenon of the heat transfer with mixed flow of the convection in the laminar mode, in a square cavity provided with two openings. The interior walls are supposed to be adiabatic except for the located on the low side, it is considered isothermal. The thermal model of the lattice Boltzmann method with nine celebrities (D2Q9) is used to reproduce the dynamic field and that simplified at five celebrities (D2Q5) is used

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for the temperature field. Thus, a thermal analysis will have to be carried out with LBM. That will enable us to determine the performances of this new digital method in this field. 2. Physical description of the problem The model chosen is square cavity of coast H filled with two ventilation openings, the first located in the lower left corner of L1 side and the second located in the upper right side L2 = L1 = 20% H. The walls of this cavity are adiabatic except the lower wall. The walls of this cavity are adiabatic except the low wall which is maintained by a source of heat at a constant temperature Th. Air entering through the left opening of the wall with a temperature T0 and a uniform velocity U0 as fig.1 shows it. The assumptions used are summarized in the case of a incompressible fluid, Newtonian in two dimensions, laminar, satisfying the assumption with Boussinesq, stationary with a transfer of heat by radiation and a dissipation of heat by effect of viscosity negligible. 3. Lattice Boltzmann method In statistical physics, a gas is described by a cloud of particles obeying the Boltzmann equation. This continuous equation as it was proposed by Boltzmann in 1872 can be written as follows: µ□ µ □ ..G µ□ µ □ G µ□ µ□ □ ȳ□ˆ □. (1) This equation is the basic equation of the kinetic theory of gases. It describes gas molecules distribution function which is a function of time, space and velocity of the molecule.

Key Words: Thermal transfer, mixed convection, square cavity, finite volume method

This work is partly presenting at 10th World congress on Mass Spectrometry and Analytical Techniques on December 07-08,2020 held at Paris,France