International Journal of Thermal Sciences 50 (2011) 1532–1542

Contents lists available at ScienceDirect

International Journal of Thermal Sciences

journal homepage: www.elsevier.com/locate/ijts

A computation of flow and heat transfer past three heated cylinders in a vee shape by a double distribution MRT thermal lattice Boltzmann model

M.A. Moussaoui [a], A. Mezrhab [a,*], H. Naji [b,c]

[a] Laboratoire de Mécanique & Energétique, Département de Physique, Faculté des Sciences, Université Mohammed 1er, 60000 Oujda, Morocco
[b] Université Lille Nord de France, F-59000 Lille, France
[c] Laboratoire Génie Civil et géo-Environnement (LGCgE - EA 4515), Université d'Artois/FSA Béthune, F-62400 Béthune, France

ARTICLE INFO

Article history:
Received 21 June 2010
Received in revised form
11 March 2011
Accepted 16 March 2011
Available online 22 April 2011

Keywords:
Lattice-Boltzmann method
MRT-D2Q9 model
MRT-D2Q5 model
Forced convection heat transfer
Square cylinders
Plane channel

ABSTRACT

Laminar convective flow heat transfer from a three heated square blocks arranged as a vee shaped inside a two-dimensional plane channel is numerically investigated. We propose a numerical scheme to solve the flow and the temperature fields using the MRT-D2Q9 model and the MRT-D2Q5 model, respectively. The fluid considered here is air ($Pr = 0.71$) and the analysis is carried out for Reynolds numbers ranged between 10 and 100 and for gap-to-diameter ratio 1 and 2. The velocity plots and isotherm patterns obtained are systematically presented and discussed to interpret the flow and heat transfer visualization. The variations of drag coefficient and time-averaged local Nusselt number around the surface of the three cylinders as well as the surface-averaged values of the time-averaged Nusselt number for each block are also investigated and discussed. It is found that the numerical results agree well with other numerical results. This demonstrates that the presented numerical model is a promising tool to investigate the simultaneous solution of fluid flow and heat transfer in complex geometries.

1. Introduction

The study of fluid flow and heat transfer behaviour around a bluff body is important in number of practical fields such as heat exchanger systems, gas turbine blades, flame stabilizer, electronic cooling, vehicle, and building aerodynamics. This research is also useful for validation of numerical codes to compute complex flows with huge experimental database on drag force and heat transfer. Thus, during last years, a host of experimental and numerical investigations has been carried out to understand flow and heat transfer past a single square, circular or any other geometric shapes of cylinder in cross flows. Nevertheless, substantially few works have addressed the interference effects between multiple cylinders and the number of publications available becomes drastically smaller as the number of cylinders involved increases.

Lam and Cheung [36] studied the shedding frequency characteristics and flow interaction between three circular cylinders arranged in an equidistant triangular cluster at different angles of incidence and spacing ratios. In their experiment, they clearly showed that some well-known flow patterns in two-cylinder arrays have been significantly changed owing to the presence of a third cylinder. Igarashi [26] studied experimentally the aerodynamic forces acting on three cylinders having different diameters composed of a main cylinder and two sub-cylinders closely arranged in line. They indicated that the flow patterns were changed by the reattachment of the separated shear layer from the upstream cylinder to the downstream cylinder. Horibe et al. [25] conducted an experimental work to determine the effects of the distance between three cylinders formed across and its axial variation on the forced convection heat transfer characteristics at a Reynolds number of 4.6×10^4. Experimental investigation employing a digital particle imaging velocimetry (DPIV) method and laser induced fluorescence flow (LIF) visualization technique was conducted by Lam et al. [37] to examine the characteristics of the flow pattern observed around the four cylinders in an in-line square configuration.

Kundu et al. [31] adopted a numerical approach using the stream function-vorticity formulation to simulate laminar flow and heat transfer over a row of in-line cylinders placed between two parallel plates. They concluded that the shape and appearance of standing vortices and the shedding of vortices which affect the heat transfer of the flow are controlled by the spacing between cylinders and the distance between plates control. Chatterjee et al. [8] have performed numerically the unsteady forced convection heat transfer from a row

* Corresponding author. Tel.: +00 212 5 36 50 06 01/02; fax: +00 212 5 36 50 06 03.
E-mail addresses: mezrhab@fso.ump.ma, amezrhab@yahoo.fr (A. Mezrhab).

1290-0729/$ – see front matter
doi:10.1016/j.ijthermalsci.2011.03.011