International Journal of Thermal Sciences 188 (2023) 108213

Contents lists available at ScienceDirect

International Journal of Thermal Sciences

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

Effect of the lid-driven on mixed convection in an open flexible wall cavity with a partially heated bottom wall

Duna T. Yaseen [a], Salah M. Salih [b,*], Muneer A. Ismael [c,d]

[a] Technical Institute/Basra, Southern Technical University, Iraq
[b] Engineering Technical College of Al-Najaf, Al-Furat Al-Awsat Technical University, Kufa, Iraq
[c] Mechanical Engineering Department, Engineering College, University of Basrah, Basra, Iraq
[d] College of Engineering, University of Warith Al-Anbiyaa, Karbala, Iraq

ARTICLE INFO

Keywords:
Flexible surface
Fluid-structure interaction FSI
Open lid-driven cavity
Mixed convection

ABSTRACT

The FSI-mixed convection heat transfer in a lid–driven vented cavity is studied in the present work. The heat source is set partially on the base of the cavity; the left flexible wall is cold, while the remaining walls are adiabatic. The top wall of the cavity moves in different cases depending on its movement; stationary wall (case 0), moving to the left (case I) and moving to the right (case II). The arbitrary Lagrangian-Eulerian formulation and finite element method are utilized to solve the governing equations. A two-dimensional incompressible laminar flow with an unsteady-state condition is used in the present model. The effects of relevant factors like the Richardson number $0.01 \leq Ri \leq 100$ and the ratio of the velocities of moving top wall to that of the air entering the cavity, which is governed by Reynolds numbers ratio $1 \leq Re_r \leq 4$ have been studied. The outcomes demonstrate the feasibility of using a flexible wall and a special movement of the top wall. The percentage increase of the Nusselt number due to the flexible wall alone is about 4.5% while when the top wall moving to the left (case I), the augmentation rises to 28%.

1. Introduction

Mixed convection in traditional open cavities plays a pivotal role in improving energy effectiveness in a variety of engineering applications. Enhancing the cooling process of enclosed spaces that involve a heat source by moving the upper lid is a crucial topic in thermal managements (Alleborn et al. [1]). In order to achieve healthy requirements, the cooled spaces should be provided with fresh air, thus the ventilated cavity is a privilege strategy to achieve this requirement (Younis et al. [2]). Thus, the concern of such a topic can be deduced by the interested studies investigating mixed convection in ventilated cavities [3–8].

Moreover, mixed convection in a two-dimensional vented cavity filled with air and heated solid cylinder was investigated by Chamkha et al. [9]. Their findings demonstrate that when the Reynolds and Richardson numbers rise, the average Nusselt number along the heated surface of the inner square values rises and the placement of the inner square cylinder and the aspect ratio are discovered to have significant impacts on the streamlines and isotherm contour patterns. Saha et al. [10] examined the laminar mixed convection in a 2D vented cavity heated from the bottom wall as a result of the numerical solution, the heat transfer coefficient, heat source temperature, and recirculation intensity increase with increasing Re or *Gr*.

Air convection in a horizontal channel using a discrete heat source was modeled numerically by Aminossadati and Ghasemi [11]. Different heating modes were tested depending on where the heat source was placed on each of the three walls (right, left, and bottom) of the cavity. Hamzah and Tarish [12] examined the fluid flow and heat transfer effects of combining a corrugated wall with a forward-facing step channel. For corrugated wall, they noticed a considerable increase in heat transfer. Other typical techniques for promotion the mixed convection in the cavities are the geometry's shape, non-uniformity in the boundary conditions, deformable or moving walls, etc. Lid-driven walls or rotating bodies within the cavity can both be moving surfaces. Moreover, mixed convection is believed to be more complex than other forms of convection for the combining of the buoyancy force generated by the temperature differential and the shear force created by the wall movement. Numerous studies have been published on this topic in the literature. Models of numerical research on driven cavity flow are reported by; Ambethkar and Kumar [13], Siva Kumar et al. [14] and Khanafer et al. [15] who used an externally stimulated sliding lid to simulate unstable mixed convection in a driven cavity. In a square cavity with a

* Corresponding author.
E-mail addresses: duna.yaseen@stu.edu.iq (D.T. Yaseen), sal20@atu.edu.iq (S.M. Salih), muneer.ismael@uobasrah.edu.iq (M.A. Ismael).

https://doi.org/10.1016/j.ijthermalsci.2023.108213
Received 6 August 2022; Received in revised form 23 January 2023; Accepted 3 February 2023
Available online 24 February 2023