Exploration of the Fluid Flow in the Unsteady Lid-Driven Cavity Problem with Magnetic Field Under the Influence of Internal Obstacles

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1. INTRODUCTION & OBJECTIVE

Natural The lid-driven cavity (LDC) is a celebrated benchmark problem for viscous incompressible fluid flow which is a canonical hydrodynamic problem. In this paper, a 2-D vertical lid driven cavity flow of electrically conducting, laminar, incompressible fluid is analysed numerically with finite difference scheme under the effect of without magnetic field, with weak and strong magnetic fields in the presence of internal square obstacles with square obstacle installed Part 1) in centre of the cavity with obstacle's aspect ratio (AR=0,0.25,0.50L) and Part 2) at lower corners of cavity with obstacle's aspect ratio (AR=0,0.25,0.50L) with three different configurations: bottom corners of left, right and both sides of cavity. Code validation of Newtonian incompressible fluid (without obstacle and without magnetic field) is done with standard bench mark problem in the literature and then continued with the present computation.A coupled Maxwell Navier-Stokes equations are solved by the projection method. We analysed effect of various values of Reynolds number (Re), with amplitude magnetic field parameters (H1 ,H2) with 0,3,10 and with different aspect ratio (AR) of obstacle of the flow characteristics by means of streamlines, velocity components profiles, pressure field, drag force,temperature distribution, magnetic field effects in dynamics of vortices and recirculation zones withInsights into the interaction of magnetic fields and obstacles in fluid systems, in magnetohydrodynamics and magnetic force heat transfer in LDC.

2. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

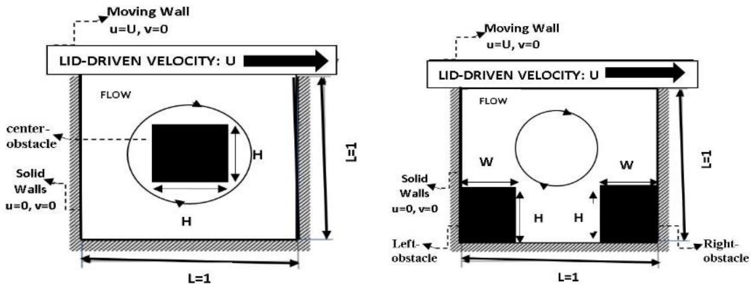

Figure 1.Configuration centered obstacle and cornor obstacles with AR=0,0.25,0.50L

$$\frac{\partial(u_i)}{\partial x_i} = 0 \qquad (1)$$

$$\frac{\partial(u_i)}{\partial t} + \frac{\partial(u_i u_j)}{\partial x_j} = -\frac{\partial(P)}{\partial x_i} + \frac{\partial^2(u_i)}{\partial x_i \partial x_j}\left(\frac{1}{Re}\right) + f_i, \qquad (2)$$

In the above Eqs. (1)-(2), Where $\boldsymbol{u_i}$ velocity in x_i for i=1,2, $\boldsymbol{P}$ the pressure, $\boldsymbol{f_1} = -(H_2{}^2 u_1 - H_1 H_2 u_2)$, $\boldsymbol{f_2} = -(H_1{}^2 u_2 - H_1 H_2 u_1)$.Where Ha=($H_1, H_2$) is variation of magnetization with magnetic field intensity Ha its components along x- and y- directions are H_1, H_2 respectively are governing equations[2],[3].Boundary conditions are u$= v = 0$ *except* at top wall with u=1,v=0; $\frac{\partial P}{\partial x} = 0$ *for left and right* walls. $\frac{\partial P}{\partial y} = 0$ *for top and right* walls.The finite difference method is used to discretize the Eqs.(1-2). The fractional step method in computational fluid dynamics is a numerical technique that sequentially solves advection, diffusion, and pressure correction steps to simulate fluid flow, enhancing stability and accuracy, successive over relaxation method for pressure eqn with optimal,stable SOR paramerter to accelate solution faster with less iterations.

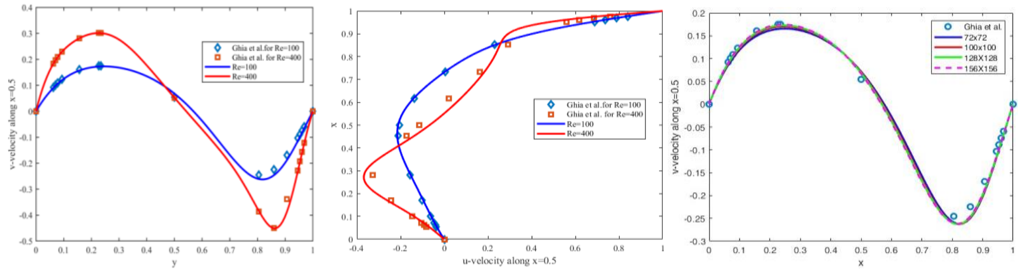

Figure 2. Re =100,400,1000 are compared for validation for H1,H2=0.for AR=0 Ghia et al [1].

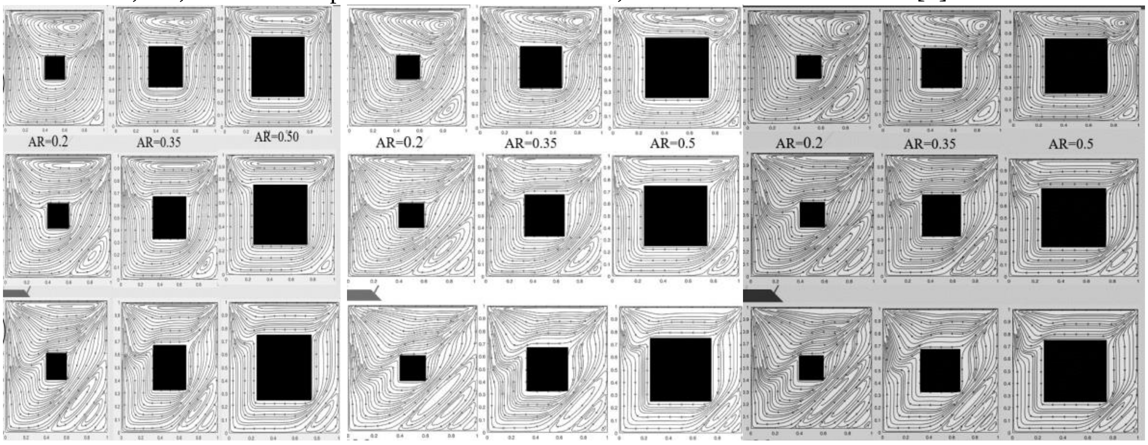

Figure 3. Amplitude magnetic field parameters (H1 and H2) with 0,3,10 and with different aspect ratio (AR) of obstacle of the flow characteristics streamlines with centered obstacle

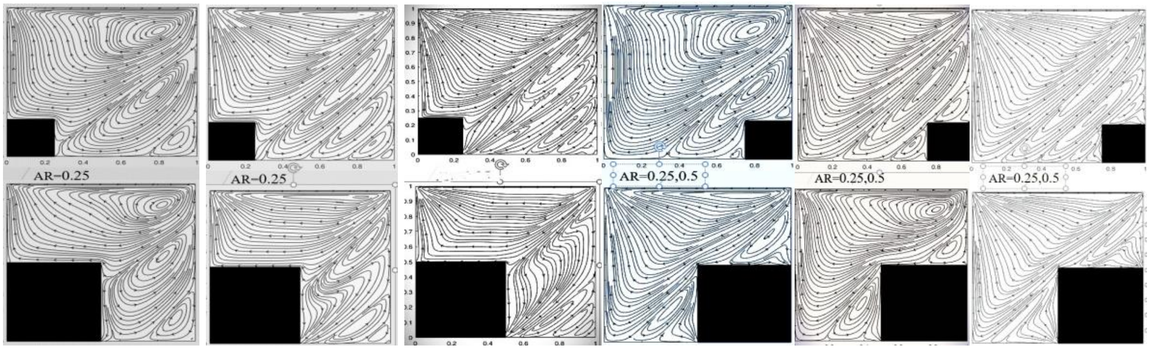

Figure 4. Amplitude magnetic field parameters (H1 and H2) with 0,3,10 and with different aspect ratio (AR) of obstacle of the flow characteristics streamlines with corner obstacle and many more in the full. In part a) Increasing aspect ratio (AR) of center obstacle from AR=0.20 to 0.50 leads to an decrease in the multiple secondary eddies and but interestingly as we increase the amplitude magnetic field (intensity) from Ha=0 to 10 on flow field inside LDC we observe velocity flow profile get suppressed leads to rise in recirculation zones (RSLV-VORTICES) at downstream secondary eddy (DSC) at the bottom right corner grows due to Lorentz force act in diagonal direction at right DSC zone (due positive value of it).Surprisingly no LSLV appeared under influence of Ha in both configuration of part a & b.In part b) Re=1000 chosen such that it demands in improved and complete mixing on the account of multiple generated vortices. we observe as the corner vortices AR increase , it lead break down of vortices on from left side by left obstacle which is good superior contactless tool to control of flow behaviour (were as at right corner obstacle is ineffective) due to vivid applications: in casting manufacturing process (as vortex affects quality of crystal production),in mixing (process engineering) apps for baffles ,we need to control the vortices at corners (dead zone) of it[4].

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