Introduction

In the field of fluid flow research, the lid-driven cavity (LDC) is frequently used as a benchmark problem to test the numerical accuracy of a flow simulation. The LDC flow problem is popular due to the small domain size, simplicity of geometry for numerical formulation and it can be solved for large range of Reynolds number. The flow inside the cavity is not simple as its geometry, it offers many complexities like recirculation, turbulence, complex phenomena of vortex dynamics, hydrodynamic instability, impingement, flow separation, attachment with walls (moving and stationary both), fluid trapping inside the recirculation region, flow bifurcation and many other fluid flow phenomena. Beside of the fundamental interest the study of lid-driven cavity has many practical importance such as the flow in gate slots of water-reservoir dam-gates depends on the slot geometry (Vischer and Hager, 1998), short-dwell coating (Triantafillopoulos and Aidun, 1990; Aidun and Triantafillopoulos, 1997), continuous drying (Alleborn et al., 1999), transport processes in lakes can be studied by heating side wall of cavity (Stefanovic and Stefan, 2000) and development of industrial applications (Aidun et al., 1991; Zumbrunnen et al., 1996). The above reasons make the study of lid-driven cavity important for the fluid flow research.

The study of three-dimensional incompressible turbulent flow field inside the cubic cavities at $Re = 12000$ have been considered in the present work. The three configurations of cubic cavity have been considered for study, those are; The cavity flow driven by single lid; The cavity flow driven by two parallel lids moving in opposite directions; The Cavity flow driven by two parallel lids moving in same direction. The properties of flow field such as averaged velocity field, second-order turbulent statistics, turbulent production and dissipation, zone of inhomogeneous turbulence, shearing and swirling structures of flow, coherent structures of flow, time history and power spectra of various fluctuations (at the location of maximum turbulence) have been studied. More specifically, following are the objectives of this work:

1. To develop the finite difference code for large eddy simulation with dynamic Smagorinsky model of incompressible turbulent flow on staggered grid arrangement.

2. To validate the developed code and the study of cubic cavity flow driven by single lid at Re = 12000.

3. To the study of cubic cavity flow driven by two parallel lids moving in opposite directions at Re = 12000.

4. To the study of cubic cavity flow driven by two parallel lids moving in same direction at Re = 12000.

Bibliography

Aidun, C. K., Triantafillopoulos, N. G., 1997. High-speed blade coating. In: Kistler, S. F., Schweizer, P. M. (Eds.), Liquid Film Coating. Springer Netherlands, pp. 637–672.

Aidun, C. K., Triantafillopoulos, N. G., Benson, J. D., 1991. Global stability of a lid-driven cavity with throughflow: Flow visualization studies. Physics of Fluids A: Fluid Dynamics (1989-1993) 3, 2081–2091.

Alleborn, N., Raszillier, H., Durst, F., 1999. Lid-driven cavity with heat and mass transport. International Journal of Heat and Mass Transfer 42, 833–853.

Stefanovic, D. L., Stefan, H. G., 2000. Simulation of transient cavity flows driven by buoyancy and shear. Journal of Hydraulic Research 38, 181–195.

Triantafillopoulos, N. G., Aidun, C. K., 1990. Relationship between flow instability in short-dwell ponds and cross directional coat weight nonuniformities. TAPPI Journal 73(6), 127–136.

Vischer, D., Hager, W., 1998. Dam hydraulics. Wiley series in water resources engineering. Wiley.

Zumbrunnen, D. A., Miles, K. C., Liu, Y. H., 1996. Auto-processing of very fine-scale composite materials by chaotic mixing of melts. Composites Part A: Applied Science and Manufacturing 27, 37–47.