Numerical modeling of 3D natural convection in a horizontal concentric annulus with a GPU-accelerated SPH method

***Yibo Ma [1], Zhilang Zhang [2] and †Moubin Liu[3,4]**

[1] School of Mechanical and Electrical Engineering, Central South University, Changsha, 410083, China
[2] Department of Mechanical Engineering, National University of Singapore, 119260, Singapore
[3] State Key Laboratory for Turbulence and Complex systems, Peking University, Beijing 100871, China.
[4] College of Engineering, Peking University, Beijing 100871, China.

*Presenting author: mayibodevin @163.com
†Corresponding author: mbliu@pku.edu.cn

Abstract

Natural convection in a horizontal concentric annulus has raised interests of many researchers due to its wide applications in heat exchangers, electronic devices, and aerospace systems. It presents great challenges for numerical methods to simulate natural convection with high Rayleigh numbers. As a Lagrangian particle method, smoothed particle hydrodynamics (SPH) [1] has many advantages in modeling different problems associated with moving interfaces or heat transfer. However, due to the larger computational cost, the 3D natural convection at high Rayleigh numbers have not been well simulated by SPH so far. In this work, an improved SPH model is presented to deal with this problem, where the particle shifting technique and δ-SPH model are integrated to improve the computational stability and alleviate numerical oscillations respectively [2,3]. The graphics processing unit (GPU) through multi-threading is employed to enhance the computational performance in terms of efficiency and scale. With the GPU-accelerated SPH model, some underlying mechanisms of natural convection in a horizontal concentric annulus are investigated, which is of great helpful to engineering applications.

Keywords: Smoothed particle hydrodynamics; Meshfree method; Natural convection; GPU acceleration

References

[1] Liu, M. B., & Liu, G. (2010) Smoothed particle hydrodynamics (SPH): an overview and recent developments, *Archives of Computational Methods in Engineering* **17(1)**, 25-76.
[2] Zhang, Z. L., Walayat, K., Huang, C., Chang, J. Z., & Liu, M. B. (2019) A finite particle method with particle shifting technique for modeling particulate flows with thermal convection, *International Journal of Heat and Mass Transfer* **128**, 1245-1262.
[3] Yang, P. L., Huang, C., Zhang, Z. L., Long, T., & Liu, M. B. (2021) Simulating natural convection with high Rayleigh numbers using the smoothed particle hydrodynamics method, *International Journal of Heat and Mass Transfer* **166**, 120758.