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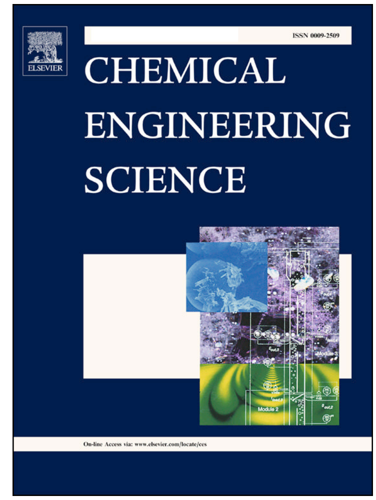

GPU-Accelerated Large Eddy Simulation of Stirred Tanks

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GPU-Accelerated Large Eddy Simulation of Stirred Tanks

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Abstract

A fast and economical solver, accelerated by the Graphics Process Units (GPU) of a single graphics card in a desktop computer, is developed for the simulation of stirred tanks, integrating Lattice Boltzmann Method (LBM), coherent Large Eddy Simulation (LES) and Immersed Boundary Method (IBM). The grid resolution can reach 13.8 million nodes in maximum, resolving considerable details of flow field in stirred tanks with only such a simple desktop computer. In the meantime, the computational speed is 1500-fold faster than that of the traditional transient simulation of Computational Fluid Dynamics (CFD) based on Navier-Stokes equations implemented on 16 CPU cores. It only takes less than two minutes to update the simulation of one impeller revolution, enabling the transient simulation of longer physical time of stirred tanks. We find that at least 4,000 impeller revolutions in simulation is needed to achieve an obviously time-independent macro-instability frequency. With the coherent LES model and reasonable grid resolution, the fast solver is able to resolve more than 95% of total Turbulent Kinetic Energy (TKE) for highly turbulent region, reproducing the monotonic decrease of TKE along the radial direction, much better than the Smagorinsky model. The average velocity and TKE predicted by the fast solver are in better agreement with the experimental data in literature. The solver is therefore more suitable for the fast simulation of stirred tanks using only a desktop computer without the need of much finer grid resolution and supercomputers.

Graphical abstract

This figure shows non-dimensional instantaneous velocity magnitude distributions (U/U_{tip}) in the two typical planes ($\theta=0^0$ and $z=T/3$) in our simulation. With a desktop computer of Graphics Process Units (GPU), the flow in stirred tanks can be resolved with considerable details without the need of supercomputers or computer clusters