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Turbulent cylinder-stirred flow heat and momentum transfer research in batch operated single-phase square reactor

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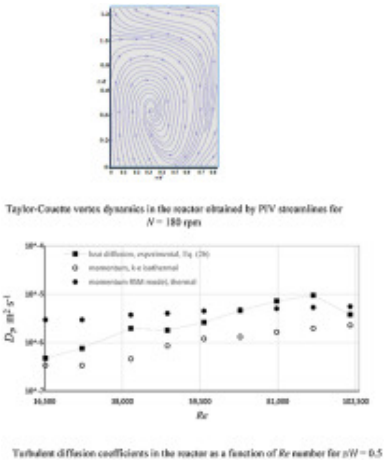
Highlights

- Heat and momentum diffusion in a square reactor cylinder-stirred increase for *Re*.
- The turbulent angular momentum rate changes in the corner direction.
- For this reactor heat diffusivity is faster than the momentum improving mixing.
- A Nusselt number correlation was developed for a range of rotating *Re* number.

Abstract

Heat transfer and momentum transfer due to water flow in a cylinder-stirred reactor of square cross section were investigated. Important industrial processes like mixing depend on combined effects of heat transfer and fluid flow which can be understood by analyzing the turbulence structure. A reactor of aspect ratio $\eta = 0.21$ (diameter of cylinder to tank side wall) was considered. It uses a small-diameter cylinder to stir the water in batch condition with rotating Reynolds number in a range $1.68 \times 10^4 < Re < 10.1 \times 10^4$. The cylinder released a constant heat flux rate of 158 W/m^2 through its surface. The steady state mean flow was numerically simulated using two models for turbulence, isothermally with a k-ε and thermally with the RSM model. The results revealed a fluid motion like Taylor-Couette vortex which was validated with PIV streamlines for $Re = 6.1 \times 10^4$ and 10.1×10^4. Turbulent angular momentum and shear rate revealed differences for the corner direction as the Re number increased compared with the wall direction. Temperature fluctuations and thermal gradient in the gap allowed to analyze the turbulent heat diffusivity coefficient and the ratio to predicted diffusivity for momentum. The results revealed that heat and momentum diffusivity increase for higher Re number and show that heat diffusivity is faster than momentum in the gap. The main frequencies of fluid motion showed large-scale structures and secondary cells of fluid motion. The averaged heat transfer as a function of Re number indicate that this reactor is an enhanced mean for mixing process compared to concentric cylinders reactors.

Graphical abstract



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Keywords

Rotating cylinder stirred flow; Heat and fluid flow; Flow in square reactor; Turbulent heat diffusivity; Single-phase thermal flow

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Data availability

Data will be made available on request.

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