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Simulation and experimental validation of Taylor-Couette flow in square cross-section container for water treatment reactor

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ABSTRACT

A vortex flow developed by a rotational cylindrical rod centrally placed in a container of square cross section was investigated experimentally and numerically. This configuration was analyzed given its potential use in water treatment. We focused the analysis on a relation of inner radius and side length $L/r = 7.33$. This ratio represents a warranty for vortex flow stability. Large ratios have the advantage of handling larger volumes with a sustained control of residence. The study was based on measuring velocity using particle image velocimetry, PIV and modelling the flow by computational fluid dynamics (CFD). Taylor-Couette cells on laminar-turbulent regimes developed for all the rotating conditions examined with Reynolds numbers between 2750 and 4950. The measurements revealed that turbulence intensity T_u increases in the radial direction towards the corners. This is by interaction fluid-walls, where corners act as natural baffles. Numerical simulations showed that secondary flows develop in the corners, with high levels of turbulence, which is important for mixing. It is shown that present configuration consumes less energy than a Taylor-Couette flow from classical concentric-cylinder systems. Heat transfer rate produced by imposed temperature conditions on the walls of the container affect vortex size and position modifying the flow structure observed in the pure dynamics case. The results indicate that configurations like square container-rotating cylinder may enhance water treatment.

Keywords: Taylor-Couetteflow; PIV velocimetry; Stirring; Square container; Thermal analysis; Turbulence intensity

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