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Experimental and Numerical investigations of mixing and axial diffusion in Taylor-Couette flow patterns

Marouan Nemri^{(a, b)*}, Fabrice Lamadie^(a), Eric Climent^(b), Sophie Charton^(a)

Two-phase Taylor-Couette flows between two concentric cylinders have great potential applications in nuclear engineering. They are particularly convenient for small scale devices enabling solvent extraction operations. The flow has been characterized by means of simultaneous PIV (particle image velocimetry) and PLIF (planar laser induced fluorescence) measurements. Moreover, direct numerical simulations have been used to investigate mixing properties of different flow patterns (from steady TVF Taylor vortex flow towards MWVF modulated wavy vortex flow).

Taylor-Couette flow is known to evolve towards turbulence through a sequence of flow instabilities. Macroscopic quantities such as the axial dispersion coefficient are extremely sensitive to internal flow structures. This specific issue has been emphasized by comparing experimental and numerical approaches. The effective diffusion coefficient was estimated using tracer particles tracking in the different Taylor-Couette regimes. Simulation results have been compared to literature data and original experimental results. Residence time distributions are supplemented with PIV and PLIF measurements in order to characterize the flow patterns and the different mechanisms leading to mixing (fig. 1). PLIF visualization and numerical simulations of particle streaklines show clear evidences of different transport mechanisms from intra-vortex mixing to tracer fluxes through neighbouring vortices. Under the WVF and MWVF regimes, intra-vortex mixing is controlled by chaotic particle paths, due to the 3D nature of the flow, while inter-vortex transport occurs due to the presence of waves between neighbouring vortices. The combination of these two mechanisms results in enhanced axial dispersion. We show that hysteresis may occur between different regimes depending on flow history and this has a dramatic effect on mixing for a given Reynolds number.

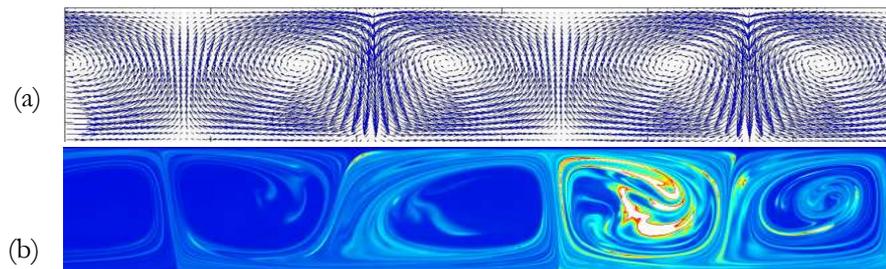


Figure 1: Mixing in Taylor-Vortex Flow.
(a) Velocity field (PIV). (b) Concentration field (PLIF)

^a CEA, DEN, F-30207, Bagnols-sur-Cèze, France

^b Institut de Mécanique des Fluides de Toulouse, F-31400, Toulouse, France