

Flow regimes in turbulent co- and counter-rotating Taylor–Couette flows of very wide gaps.

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In this study, flow regimes in co- and counter-rotating Taylor–Couette flow (Taylor (1923)) of very wide radius ratios for various Reynolds numbers up to 1.5×10^4 are discussed. The study aims to understand the effect of curvature on the Taylor–Couette flow, particularly in cases where the circumferential length of the inner cylinder is smaller than the gap width, which occurs for $\eta < 0.14$. In the investigation centrifugally stable as well as centrifugally unstable flow regimes are realized. The flow is investigated using a visualization method as well as Particle Image Velocimetry. Here, flow states in the centrifugally-unstable regime are investigated in the case of counter-rotating cylinders and pure inner cylinder rotation. Beside classical known flow states as Taylor–Vortex flow and Wavy Vortex flow, a variety of new flow patterns in the cylindrical annulus is observed, especially for the transition to turbulence (see Merbold et al. (2023)). For strong counter rotation coexisting turbulent and laminar regions inside the system are observed and investigated in detail. Small turbulent Spots and bursts of turbulent motion detaching the wall are observed, as well as an irregular Taylor–Vortex flow and non-stationary turbulent Vortices. Especially, a single Axially-aligned Columnar Vortex between the inner and outer cylinder is found. The principle regimes observed in flow between independently rotating cylinders are summarized in a flow-regime diagram. For a more detailed quantitative study, a time-resolved velocity field measurement has been conducted using a High-speed Particle Image Velocimetry technique through the TC system end plate, taking into account the curvature of the cylinder wall /Hamede et al. (2023)). These measurements record the radial and azimuthal velocity components in the 2D horizontal plane, which is traversed at different axial positions to include known axial wavelengths. The recorded flow field is used to compute the angular momentum transport in terms of the quasi-Nusselt number. The results show a maximum in angular momentum transport for low counter-rotating rates of $0.011 < \mu_{max} < 0.0077$, which is associated with large-scale structures that span the entire gap. Moreover, the angular momentum transport decreases for counter-rotation rates higher than μ_{max} until it reaches a minimum value and then tends to increase again for higher counter-rotation cases, where second maximum of angular momentum transport is expected for higher speeds. The occurrence of such behaviour was attributed to the presence of novel structures observed during the investigation of flow configurations. It was determined that these flow structures emerge from the outer cylinder boundary layer and travel inward, thereby enhancing the momentum transport at such flow configurations (Hamede et al. (2023)).

References

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