On naturally oscillating axial secondary flow on wall shear stress in Taylor Couette flow (TCF)

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Abstract:

Present study investigates Taylor Couette flow (TCF) with helical corrugated surface for the three values of pitch to wavelength ratios (P*) (1, 2 and 3) and amplitude to wavelength ratio (A*) of 0.25. As reported in Razzak et al. (2020) for TCF with longitudinal corrugated surface, the emergence of an oscillating axial secondary flow with an increasing trend on its magnitude with Reynolds number (Re) results in the occurrence of torque reduction. This provides an idea about the possibility of enhancing torque reduction by maintaining a consistently increasing trend in the magnitude of axial secondary flow with Re. This has motivated us to study TCF with helical corrugated surface on the stationary outer cylinder and rotating smooth inner cylinder. From the variation of axial secondary flow with Re for all the three values of P*, it is found that axial secondary flow is observed for Re ranging between 60 to 650. Based on the behaviour of axial secondary flow, a total of three flow regimes are observed. In the first flow regime, a single stationary helical vortex (SHVF) is observed in the maximum gap region at Re = 60 for the three values of P*. As Re is increased to 100, the emergence of another single vortex at the inner wall results in the formation of periodic helical wavy vortex flow (PHWVF) for the three values of P*. Increasing Re beyond 145, 135 and 140 for P* =1, 2 and 3, respectively, a third single vortex at the inner wall of maximum gap region results in the occurrence of non-periodic helical wavy vortex flow (NPHWVF). It is found that the sudden increase in the magnitude of axial secondary flow in PHWVF results in the occurrence of torque reduction in TCF with helical corrugated surface than TCF with smooth surface. For NPHWVF, torque reduction is observed only when there is no axial secondary flow in TCF with smooth wall or magnitude of axial secondary flow increases with Re in TCF with the helical corrugated surface. The magnitude of axial secondary flow and torque reduction are found to be higher for TCF with helical corrugated surface than that of longitudinal corrugated surface.

References:

MA Razzak, BC Khoo, KB Lua, “Numerical study on wide gap Taylor Couette flow with flow transition”. Phys Fluids 31 (11) (2019).

MA Razzak, BC Khoo. & KB Lua, “Numerical study of Taylor Couette flow with longitudinal corrugated surface”. Phys Fluids 32(5) (2020).

MA Razzak, KB Lua, CMJ Tay, BC Khoo, “Drag reduction study of naturally occurring oscillating axial flow induced by helical corrugated surface in Taylor Couette flow”, Phys Fluids, Accepted (2023).