Interior Stokes Flows with Stick-Slip Boundary Conditions

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Two-dimensional Stokes flows generated by line singularities inside a circular cylinder are studied in the presence of stick-slip boundary conditions. For simplicity, line singularities are assumed to be parallel to the cylinder axis, all axes in the same plane. The interior boundary value problem associated with these flows is solved in terms of a stream function. Analytic solutions are obtained for flows induced by a rotlet, a potential-source and Stokeslets with axes radial (normal) or tangential to the cylinder by the Fourier expansion method. These solutions are used to plot streamline topologies of these flows and the flow patterns are studied as the slip parameter and the locations of the singularities are varied. Eddies of various sizes and shapes appear as the slip parameter is varied.

Interesting flow patterns are observed in flows generated by a pair of rotlets. In this case, streamline patterns reveal interesting flow topologies. Some of the flow patterns observed here are similar to that of vortex mixing flows. Interior saddle points are found in these flows for certain values of the slip parameter and locations of the rotlets. The flows induced by a source and a sink and a pair of Stokeslets also exhibit interesting features. The plots of the fluid velocity on the surface of the cylinder show the locations of surface stagnation points, if they exist. A study of the movement of surface stagnation points as the slip parameter and the locations of the singularities are varied shed some light on the qualitative features of the flow patterns. The results presented may be relevant for a variety of applications including vortex mixing and journal bearing flows.

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