Exterior Stokes Flows With Stick-Slip Boundary Conditions

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Steady two-dimensional creeping flows induced by line singularities in the presence of an infinitely long circular cylinder with stick-slip boundary conditions are examined. The singularities considered here include a rotlet, a potential source and a stokeslet located outside a cylinder and lying in a plane containing the cylinder axis. The general exterior boundary value problem is formulated and solved in terms of stream function by making use of the Fourier expansion method. The solutions for various singularity driven flows in the presence of a cylinder a derived from the general results. The stream function representation of the solutions involves a definite integral whose evaluation depends on a non-dimensional slip parameter λ_1. For extremal values, $\lambda_1 = 0$ and $\lambda_1 = 1$, of the slip parameter our results reduce to solutions of boundary value problems with stick (no-slip) and perfect slip conditions, respectively.

The slip parameter influences the flow patterns significantly. The plots of streamlines in each case show interesting flow patterns. In particular, in the case of a single rotlet/stokeslet (with axis along y-direction) flows, eddies are observed for various values of λ_1. The flow fields for a pair of singularities located on either side of the cylinder are also presented. In these flows, eddies of different sizes ands shapes exist for various values of λ_1 and the singularity locations. Plots of the fluid velocity on the surface show locations of the stagnation points on the surface of the cylinder and their dependencies on λ_1 and singularity locations.

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