Flow in a cylinder driven by rotating split-disk endwalls

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Flow of an incompressible viscous fluid contained in a cylindrical vessel (radius R, height H) is
considered. Each of the cylinder endwalls is split into two parts which rotate steadily about the central
axis with different rotation rates: the inner disk (r<r1) rotating at &Omega;1, and the outer annulus
(r1<r<R) rotating at &Omega;2. Numerical solutions to the axisymmetric Navier–Stokes equations
are secured for small system Ekman numbers E (≡ν/(ΩH2 )). In the linear
regime, when the Rossby number Ro
(≡2(Ω2−Ω1)/(Ω1+Ω2)) is
finite, the numerical
results are shown to be compatible with the theoretical prediction as well as the available
experimental measurements. Emphasis is placed on the results in the nonlinear regime in which Ro is
finite. Details of the structures of azimuthal and meridional flows are presented by the numerical
results. For a fixed Ekman number, the gross features of the flow remain qualitatively unchanged as
Ro increases. The meridional flows are characterized by two circulation cells. The shear layer is a
region of intense axial flow toward the endwall and of vanishing radial velocity. The thicknesses of
the shear layer near r=r1 and the Ekman layer on the endwall scale with E1/4 and E1/2, respectively.
The numerical results are consistent with these scalings.

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