Three-dimensional viscous flow through a rotating channel: A pseudospectral matrix method approach. (English) [Zbl 0887.76045]

The authors present a three-dimensional, time-dependent numerical algorithm for studying the flow of an incompressible liquid in a rotating channel of square cross-section with realistic no-slip boundary conditions in both, the vertical and spanwise, directions. In doing so, a Fourier-Chebyshev pseudospectral matrix method is used. The Navier-Stokes equations are integrated in time by applying a fractional step method, and the Poisson equation and Helmholtz equation for the velocity are solved by using a matrix diagonalization method (eigenfunction decomposition). With that the authors are able to reduce the three-dimensional matrix problem to a simple algebraic vector equation. This results in significant savings in computer storage requirements, particularly for large-scale computations. Verification of the numerical algorithm is carried out in a limiting case, where an exact steady-state solution for one-dimensional channel flow is available, and also in the case of a two-dimensional rotating channel. In the numerical experiments, two-cell and four-cell two-dimensional flow patterns are observed. Moreover, it turns out that the four-cell flow pattern is stable with respect to symmetrical disturbances, but is unstable to asymmetric disturbances.

Reviewer: J. Siekmann (Essen)

MSC:
76M25 Other numerical methods (fluid mechanics) (MSC2010)
76D05 Navier-Stokes equations for incompressible viscous fluids
65M70 Spectral, collocation and related methods for initial value and initial-boundary value problems involving PDEs
76U05 General theory of rotating fluids

Keywords:
two-cell flow pattern; Fourier-Chebyshev method; eigenfunction decomposition; square cross-section; no-slip boundary conditions; fractional step method; Poisson equation; Helmholtz equation; matrix diagonalization method; algebraic vector equation; limiting case; four-cell flow pattern

Full Text: DOI

References:

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