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A pressure-based algorithm for high-speed turbomachinery flows. (English) Zbl 0882.76057

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Summary: The steady-state Navier-Stokes equations which describe in transonic flows are solved by using an elliptic formulation. A segregated solution algorithm is established in which the pressure correction equation is utilized to enforce the divergence-free mass flux constraint. The momentum equations are solved in terms of the primitive variables, while the pressure correction field is used to update both the convecting mass flux components and the pressure itself. The velocity components are deduced from the corrected mass fluxes on the basis of an upwind-biased density, which is a mechanism capable of overcoming the ellipticity of the system of equations in the transonic flow regime. An incomplete LU decomposition is used for the solution of the transport-type equations and a globally minimized residual method resolves the pressure correction equation. Turbulence is resolved through the $k-\varepsilon$ model. Dealing with turbomachinery applications, results are presented for two-dimensional compressor and turbine cascades under design and off-design conditions.

MSC:

76M20 Finite difference methods applied to problems in fluid mechanics
76F10 Shear flows and turbulence
76N10 Existence, uniqueness, and regularity theory for compressible fluids and gas dynamics
76H05 Transonic flows

Keywords:

steady-state Navier-Stokes equations; elliptic formulation; pressure correction equation; primitive variables; corrected mass fluxes; upwind-biased density; ellipticity; LU decomposition; globally minimized residual method; two-dimensional compressor; turbine cascades

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References:

[1] Issa, AIAA J. 15 pp 182– (1977) · Zbl 0354.76052 · doi:10.2514/3.7313
[2] Karki, AIAA J. 27 pp 1167– (1989) · doi:10.2514/3.10242
[3] McGuirk, AIAA J. 28 pp 1751– (1990) · doi:10.2514/3.10470
[4] Zhou, Computational Fluid Dynamics 2 pp 749– (1992)
[5] Demirdzic, Int. j. numer. methods fluids 16 pp 1029– (1993) · Zbl 0774.76066 · doi:10.1002/fld.1650161202
[6] Lien, J. Fluids Eng. 115 pp 717– (1993) · doi:10.1115/1.2910204
[7] Giannakoglou, Int. j. numer. methods fluids 21 pp 1067– (1995) · Zbl 0863.76051 · doi:10.1002/fld.1650211105
[8] Numerical Computation of Internal and External Flows, Wiley, Chichester, (1990).
[9] and , 'The prediction of laminarization with a two-equation model of turbulence', Int. J. Heat Mass Transfer, 15, (1972).
[10] Majumdar, Numer. Heat Tranfer 13 pp 125– (1988)
[11] Leonard, Comput. Methods Appl. Mech. Eng. 19 (1979) · Zbl 0423.76070 · doi:10.1016/0045-7825(79)90034-3
[12] Hayase, J. Comput. Phys. 98 (1992) · Zbl 0743.76054 · doi:10.1016/0021-9991(92)90177-Z
[13] Schneider, Numer. Heat Transfer 4 pp 1– (1981) · doi:10.1080/01495728108961775
[14] and , 'Design and testing of a controlled diffusion airfoil cascade for industrial axial flow compressor applications', ASME Paper 90-GT-140, (1990).
[15] , and , 'Losses prediction in axial flow compressor cascades using an explicit k-{\(\epsilon\)} Navier-Stokes solver', Proc. 85th PEP/AGARD Symp. on Losses Mechanisms and Unsteady Flows in Turbomachines, Derby, May (1995).
[16] , and , '2-D transonic bump flow calculations using an explicit fractional-step method', Proc. Efficient Turbulence Models for Aeronautics (ETMA) Workshop, Manchester, November (1994) Vieweg, Braunschweig, (1997).

[17] and , 'Experimental analysis data on the transonic flow past a plane turbine cascade', ASME Paper 90-GT-313, (1990).