Numerical Analysis of Three-dimensional Turbulent Flow in Curved Pipes

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Abstract

The three-dimensional turbulent flow in curved pipes has been predicted numerically by employing the body-fitted non-orthogonal curvilinear coordinate system and a standard $k-\varepsilon$ turbulence model with wall function method. The finite volume method has been used to discretize the governing equations. The convection term is approximated by a high-resolution and bounded discretization scheme COPLA. The cell-centered, non-staggered grid arrangement is adopted and the resulting checkerboard pressure oscillation is prevented by the application of modified momentum interpolation scheme. The SIMPLE algorithm is employed for the pressure and velocity coupling. The present numerical method has been well-verified by showing the excellent agreements between the predicted results for a three-dimensional transient laminar stratified flow in an inverse U-duct with the available experimental data. As an illustrative problem of the turbulent flows in curved pipes, the steady turbulent flow in a 90 curved pipe has been analyzed in this study. Detailed discussions have been made on the distributions of the primary and secondary flow velocities, pressure and shear stress on the inner surface of the pipe. As a result, the present numerical method is considered to be valid and effective to predict the susceptible systems or their local areas where the fluid velocity or local turbulence is so high that the structural integrity can be threatened by wall thinning degradation due to flow accelerated corrosion.