Numerical Study of Natural Unsteadiness Using Wall-Distance-Free Turbulence Models

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Abstract

The periodic vortex shedding past a cylinder is presented. The program was validated by the solution of one-dimensional Stokes' second problem first. Then, a two-dimensional steady flow through a cylinder at Reynolds number 1.54 was used to compare with the streamlines with experiment and also at Reynolds number 28.4, to check the separation point and the length of wake. At Reynolds number 280 where the wake is laminar, the solution becomes un-symmetric after 25 cycles of iterations automatically and becomes fully periodic flow after 56 cycles of iterations. For Reynolds number 1000 with a turbulent wake, the numerical solution starts to un-symmetric after 2 cycles of iterations, and becomes fully periodic after 3 cycles of iterations. The streamlines of the periodic solution are compared very well with Arnone's result. Using 3500 steps in a cycle, the error on the Strouhal number is 19%. However, increasing to 70000 steps in a cycle, the error on the Strouhal number is less than 1%. Wilcox's high and low Reynolds number $\kappa-\omega$ models, Jones-Launder $\kappa-\varepsilon$ model and Launder-Sharma $\kappa-\varepsilon$ model were used to study the structure of turbulent vortex street at Reynolds number 2000. The high Reynolds number $\kappa-\omega$ model gives the largest eddy viscosity among these turbulent models. On the other hands, the solution using Jones-Launder $\kappa-\varepsilon$ model was similar to laminar one. The spreading angle and the distance between trailing vortex are better simulated by using high Reynolds number $\kappa-\omega$ model, Besides, based on the accuracy of the predicted Strouhal number, the Wilcox’ s high Reynolds number $\kappa-\omega$ models is suggested.

Keyword：Stokes’ second problem, Strouhal number, wall-distance-free turbulence models