AN EFFICIENT METHOD TO SIMULATE JET IN WAVE ENVIROMENT

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Many industrial and environmental effluent discharges into wave environment can be categorized as jets in the ambient water. In the paper, we studied properties of jet in regular wave environment using multi-grid method.

When the size of orifice is relative small compared with the domain of wave propagation in 3 D spaces, a large amount of grid points are needed in order to simulate the flow field near the orifice accurately. If the operator splitting method developed by Li and Lin (2001,2003) is used to simulate the N-S equation, the solving of the propagation step will be exhausted on conventional computers with conventional method due to the requirements on memory and CPU time to obtain a solution with the required accuracy. The size of the resulting linear systems is usually so large that even modern computers may not be able to handle them directly (Jun Zhang,1997,1998). From this point of view, the present work aims to study a more efficient method than the conventional iteration method such as Jacobi iteration, Gaussian elimination etc. to solve the propagation step. A three-dimensional numerical model based on the full Navier-Stokes equations in σ - coordinate is used to study the problem of waves propagation. Turbulent effects are modeled by a subgrid-scale model. The operator splitting method, which splits the solution procedure into the advection, diffusion, and propagation steps, is used to solve the modified NSE. The multi-grid method with four-color Gauss-Seidel relaxation (see Fig.1) combining with 7-point finite difference scheme is adopted to solve the propagation steps. The model is used to simulate the momentum jet both in stagnant environmental water and in regular wave which is imposed from the inflow boundary. In the study, the number of pre-smooth, coarse grid correct and post-smooth are 3. Convergence rate is about 0.42 for the jet with wave and 0.49 for pure jet.

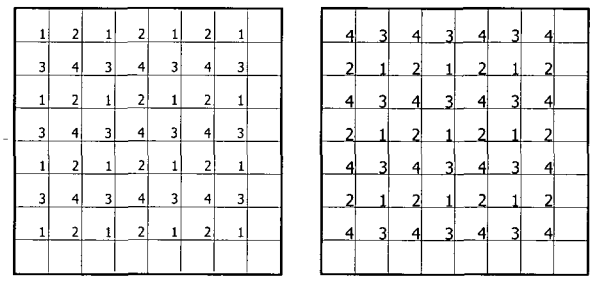

Fig. 1 Four Color Gauss-Seidel Sweep

The numerical results show wave enhances the mixing of the jet with the ambient fluid, and cause a periodic deflection of jet (see Fig.2). The spreading characterize constant α are 0.105 and 0.147 for pure jet and jet in wave, the result is in good agreements with the data obtained by Andreoppulos et al.(1986) and Kuang and Hsu(1998).

Numerical results are compared to that obtained by Gauss Seidel iteration method and Jacobi iteration. The CPU time needed by multi grid method is only around 76% and 54% of the time needed by previous two iteration methods respectively for the study case. It shows that the model is suitable for nonuniform grid with large number of grid points. It is an accurate tool in studying of jet with small orifice.

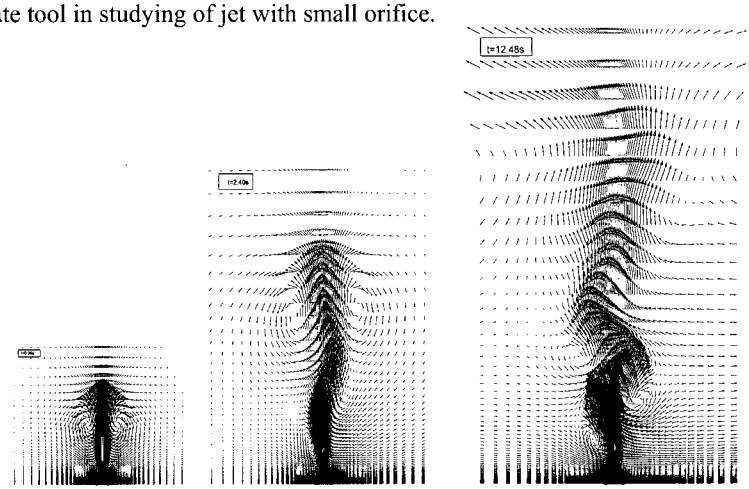

Fig.2 The snapshots of the flow field of jet with waves at different time

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