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LARGE EDDY SIMULATION OF THE INTERACTION BETWEEN WALL JET AND OFFSET JET*

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Abstract: The interaction between a plane wall jet and a parallel offset jet is studied through the Large Eddy Simulation (LES). In order to compare with the related experimental data, the offset ratio is set to be 1.0 and the Reynolds number Re is 1.0×10^4 with respect to the jet height L and the exit velocity U_0. The Finite Volume Method (FVM) with orthogonal-mesh (6.17×10^6 nodes) is used to discretize governing equations. The large eddies are obtained directly, while the small eddies are simulated by using the Dynamic Smagorinsky-Lily Model (DSLM) and the Dynamic Kinetic energy Subgrid-scale Model (DKSM). Comparisons between computational results and experimental data show that the DKSM is especially effective in predicting the mean stream-wise velocity, the half-width of the velocity and the decay of the maximum velocity. The variations of the mean stream-wise velocity and the turbulent intensity at several positions are also obtained, and their distributions agree well with the measurements. The further analysis of dilute characteristics focuses on the tracer concentration, such as the distributions of the concentration (i.e., C/C_0 or C/C_m), the boundary layer thickness δ_c and the half-width of the concentration b_c, the decay of the maximum concentration (C_m/C_0) along the downstream direction. The turbulence mechanism is also analyzed in some aspects, such as the coherent structure, the correlation function and the Probability Density Function (PDF) of the fluctuating velocity. The results show that the interaction between the two jets is strong near the jet exit and they are fully merged after a certain distance.

Key words: wall jet, offset jet, dilute characteristic, coherent structure

Introduction

A vast amount of waste-water is discharged into rivers, seas and other water channels every day. In a sewage disposal project, the characteristics of the wall jet or the offset jet are often to be considered. A wall jet is generated when a flow is injected to a region near the wall with an initial momentum. The mechanism of the wall jet was much studied in the past few years. Huai et al.[1] studied the buoyant wall jet using a realizable $k-\varepsilon$ model and obtained results of cling length, centerline trajectory and temperature dilutions. Kechiche et al.[2] demonstrated that the inlet conditions only affect the region near the nozzle rather than the auto-similar region. George et al.[3] showed that both with inner scaling and outer scaling, the profiles could collapse perfectly in the inner and outer layers only in the limit of infinite Reynolds number. In the wall shear layer, streaks occur because of the roughness geometry boundary and it plays an important role in the breakdown process. Due to these streaks, a pairing of span-wise vortices originally suppressed and being broken down to turbulence is enhanced[4]. On the other hand, a turbulent plane jet is discharged parallel to a bottom wall with an offset distance, which is known as the offset jet. An offset jet will deflect to the wall due to the presence of a sub-atmospheric pressure region and then attach to the wall at the impingement point. The flow will develop into a wall jet downstream the attachment region.

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