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NUMERICAL STUDY OF HYDRODYNAMICS OF MULTIPLE TANDEM JETS IN CROSS FLOW*

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Abstract: The hydrodynamics of a single jet and four tandem jets in a cross flow are simulated by using the Computational Fluid Dynamics (CFD) software Fluent. The realizable $k-\varepsilon$ model is used to close the Reynolds-Averaged equations. The flow characteristics of the jets, including the jet trajectory, the velocity field and the turbulent kinetic energy are obtained with various jet-to-cross flow velocity ratios R in the range of 2.38-17.88. It is shown that a single jet penetrates slightly deeper than the first jet in a jet group at the same R, although the difference decreases with the decrease of R. It is also found that the way in which the velocity decays along the centerline of the jet is similar for both a single jet and the first jet in a group, and the speed of the decay increases with the decrease of R. The downstream jets in a group are found to behave differently due to the sheltering effect of the first jet in the group. Compared with the first jet, the downstream jets penetrate deeper into the cross flow, and the velocity decays more slowly. The circulation zone between the two upstream jets in the front is stronger than those formed between the downstream jets. The Turbulent Kinetic Energy (TKE) sees a distinct double-peak across the cross-sections close to each nozzle, with low values in the jet core and high values in the shear layers. The double-peak gradually vanishes, as the shear layers of the jet merge further away from the nozzle, where the TKE assumes peaks at the jet centerline.

Key words: multiple tandem jets, jet in cross flow, realizable $k-\varepsilon$ model, flow dynamics

Introduction

Jets in cross flow configurations exist in many natural environments and industrial applications, such as pollutant dispersion, fuel injection and dilution holes in combustors. These flow fields have an important bearing on the control of the mixing process, the industrial design and the environmental risk assessment.

In this field, a single jet is much studied. Margason[1] and Lee and Chu[2] provided an extensive review in this respect. The velocity evolution in the jet center-plane[3], the vortex development[4], the jet trajectories[5], the scalar-mixing and transport properties[6], the two-phase flow structure and the particle dispersion[7] were investigated, along with other associated phenomena.

Multiple jets in cross flow are widely used in discharging municipal wastewater due to their high mixing efficiency. Compared with a single jet in cross flow, multiple jets were not much studied. The earliest experimental studies on the twin jets in cross flow were performed by Ziegler and Wooler[8]. They obtained data for trajectories of tandem air jets in cross flow. Their main conclusion is that the rear jet is less deflected than the front jet due to the sheltering effect. Issac and Schetz[9] proposed a momentum integral method to analyze the interaction between jets. Their results show that the trajectory of the rear jet is signi-

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