EXPERIMENTAL INVESTIGATION OF CIRCULAR PURE JET ACCORDING TO THE VARIATION OF REYNOLDS NUMBER

SEOK JAE KWON [1] and IL WON SEO [2]

[1] PhD Candidate, Department of Civil Engineering, Seoul National University, Shinlim-dong, Kwanak-Gu, Seoul, 151-742, Korea
(Tel: +82-2-880-7356, Fax: +82-2-887-0349, e-mail: sj79kwon@chollian.net)
[2] Professor, Department of Civil Engineering, Seoul National University, Shinlim-dong, Kwanak-Gu, Seoul, 151-742, Korea
(Tel: +82-2-880-7345, Fax: +82-2-887-0349, e-mail: seoilwon@snu.ac.kr)

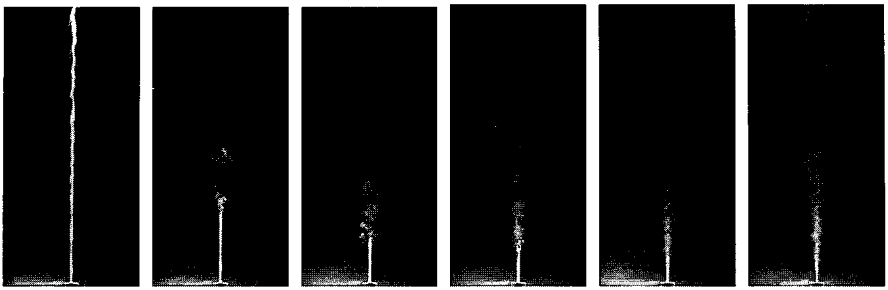
Since the circular jets into a stagnant ambient are widely applied in the disposal of wastewater or gaseous releases, numerous studies for the subject of a turbulent round pure jet have been conducted experimentally and analytically. When the wastewater is discharged into lakes, rivers and oceans through proper treatments of sewage, the discharge flow rate can significantly vary according to the amount of the disposed wastewater. Therefore, a relatively wide range with laminar flows as well as the transitional and turbulent flows needs to be considered in experimentally examining and comparing the behavior of a circular pure jet. The investigation of both the mean flow characteristics and the turbulent behavior of the jets is required to understand the mechanics of a circular jet.

In this study, the behavior of a non-buoyant round water jet through a contraction nozzle was investigated for the Reynolds numbers ranging of from 177 to 5,142 based on the experimental results of the mean velocity field obtained by the PIV. Fig. 1 shows the evolution of the circular jet from the instantaneous images in that range of the Reynolds numbers. This figure shows that the axial length of laminar or transitional region prior to the turbulent flow decreases with the increase of Reynolds number.

The mean axial velocity profile near the nozzle for the Reynolds number of 177 did not show a top-hat profile whereas the other cases with the Reynolds number higher than 437 showed almost top hat distributions. The dimensionless length of ZFE was observed to decrease as the Reynolds number increased. The centerline velocity with the Reynolds number higher than 437 was found to decay more rapidly, gradually approaching to theoretical line earlier near the nozzle as the Reynolds number increased. The decay constant was estimated to be 5.5 for the turbulent cases probably because the contraction nozzle was used rather than a pipe. The fact that the measured centerline velocity was somewhat lower than those conducted by previous investigators might also be the result of having used a contraction jet.

The similarity of the axial velocity profiles was checked by fitting the experimental data to the Gaussian distribution. The Gaussian curve was not a proper approximation for the cases with the low Reynolds numbers while the Gaussian curve tended to fit the overall shape of the velocity data for the cases where the high Reynolds numbers were relatively high. The average Gaussian constant for the turbulent case between x/d=20 and 70 was estimated to be 84.5. The half width seldom spread with axial distance for the laminar and transitional flows whereas the jet width more rapidly grew with increasing x/d after the potential core. The spreading rates gradually decreased with the increase of the Reynolds number higher than 1,305. The spreading rate of 0.106 for the Reynolds number of 5,142 was in good agreement with the values proposed by Papanicolaou and List (1988) and Hongwei (2000).

In the turbulent characteristics, the peak values of the turbulent intensity on the shear layers near the nozzle gradually increased as the Reynolds number increased. The turbulent intensity along the centerline was found to increase more rapidly with the increase of the axial distance as the Reynolds number increased and showed tendency of approaching the constant values reported by previous investigators. Most Reynolds shear stress levels seemed to also increase as the Reynolds number increased.



(a)R100J(Re=177) (b)R200J(Re=437) (c)R400J(Re=1,305) (d)R500J(Re=2,163) (e)R600J(Re=3,208) (f)R900J (Re=5,142)

Fig. 1 Evolution of Circular Jet with Increase of Reynolds Number (Instantaneous Images)

REFERENCES

Hongwei, W., 2000. Investigations of Buoyant Jet Discharges Using DPIV and PLIF. Ph.D. Thesis in Civil & Structural Engineering, Nanyang Technological University, Singapore.

Papanicolaou, P.N., List, E.J., 1988. Investigations of Round Vertical Turbulent Buoyant jets. J. of Fluid Mech., 195, pp. 341-391.