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Experimental Study of Unconfined and Confined Isothermal Swirling Jets

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Abstract : A 3C-2D PIV technique was applied to investigate the swirling flow generated by an axial plus tangential type swirl generator. This work is focused on the near-exit region of an isothermal swirling jet to characterize the effect of swirl on the flow field and to identify the large coherent structures both in unconfined and confined conditions for geometrical swirl number, S_g= 4.6. Effects of the Reynolds number on the flow structure were also studied. The experimental results show significant effects of the confinement on the mean velocity fields and its fluctuations. The size of the recirculation zone was significantly enlarged upon confinement compared to the free swirling jet. Increasing in the Reynolds number further enhanced the recirculation zone. The frequency characteristics have been measured with a capacitive microphone which indicates the presence of periodic oscillation related to the existence of precessing vortex core, PVC. Proper orthogonal decomposition of the jet velocity field was carried out, enabling the identification of coherent structures. The time coefficients of the first two most energetic POD modes were used to reconstruct the phase-averaged velocity field of the oscillatory motion in the swirling flow. The instantaneous minima of negative swirl strength values calculated from the instantaneous velocity field revealed the presence of two helical structures located in the inner and outer shear layers and this structure fade out at an axial location of approximately z/D = 1.5 for unconfined case and z/D = 1.2 for confined case. By phase averaging the instantaneous swirling strength maps, the 3D helical vortex structure was reconstructed.

Keywords : acoustic probes, 3C-2D particle image velocimetry (PIV), precessing vortex core (PVC), recirculation zone (RZ)
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