Experimental and numerical study of a swirling air jet with coflow

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Experimental measurements using Particle Image Velocimetry (PIV), together with both axisymmetric and 3D numerical simulations, have been carried out to analyse the structure of a swirling air jet with coflow, and to characterize the conditions for the onset of vortex breakdown, at a relatively low Reynolds number of the jet ($Re \approx 60$). Vortex breakdown is an important phenomenon in combustion systems, which is searched for flame stabilization, to enhance mixing and reduce pollution. The swirling jet was generated by a rotating nozzle, so that an almost solid body rotating flow was issued at the nozzle exit for varying swirl numbers L, discharging into an air coflow for different values of the ratio between the axial coflow velocity and the axial bulk velocity of the jet, W_O. An exhaustive comparison between the flow structures measured experimentally with the PIV technique and the numerical simulations is reported. In particular, special attention is paid to the flow structure for values of the swirl number in the vicinity of vortex breakdown for several values of the coflow ratio. Figure 1 summarizes the main results for the critical swirl number for vortex breakdown (L_c) as a function of the coflow ratio W_O. As a relevant difference with previous results obtained for high Reynolds numbers using a quasicylindrical approximation (QA) of the Navier-Stokes equations,[1] the present experimental and numerical results show a minimum value of L_c as W_O increases. This qualitative difference in $L_c(W_O)$ is explained from the analysis of the flow structure obtained with the 3D numerical simulations, where it is shown that the axial friction component, which is neglected in the QA, plays now an important role for the Reynolds number considered.

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[1]J.M. Gallardo-Ruiz *et al.*, *Phys. of Fluids* **22**, 113601 (2010).

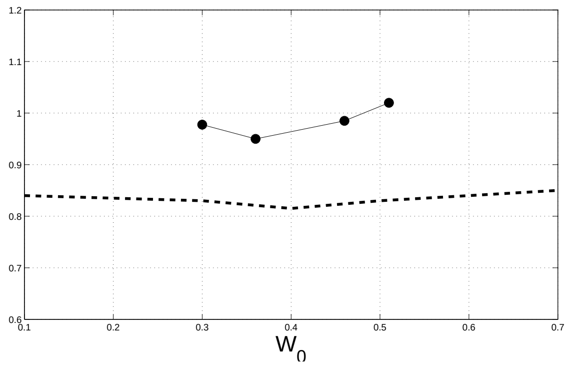

Figure 1: Critical swirl parameter L_c versus coflow parameter, W_0, obtained experimentally (circles) and with 2D numerical simulations (dashed line). $Re \approx 61$.

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