The effect of a sphere on a swirling jet in an open flow

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This work presents the results of an investigation into the effects of a solid body placed along the central axis of a swirling jet in an open tank. The experiment was conducted in an open tank apparatus similar in design to that used by Billant et al.[1] which enables independent control over axial flow rate (Re) and rotation imparted on the flow (ω_M). Previous work on controlling vortex breakdown in a swirling jet has focused on the shear layer between the relatively stagnant tank flow and the swirling jet, and although a stagnation point has been noted as occurring in a particular place, its distance P from the nozzle as a function of the varying swirl parameters has not been fully investigated.

For the current preliminary investigation into vortex core obstruction, a sphere of diameter equal to that of the nozzle was placed on the vortex core centreline at one nozzle diameter downstream of the nozzle. As the rotation rate ω_M was increased, a stagnation point was observed to occur upstream of the sphere, in much the same way as Mattner et al.[2] observed in their experiments in a pipe. This stagnation point appeared to be much steadier in its position than in the unobstructed case. P then became smaller as ω_M was increased for a given Re. As expected, it was found that with increasing Re, ω_M also needed to be increased to maintain the same stagnation point location. However, once the data were replotted against swirl number $S = f(\omega/Re)$, it appeared as though there was in fact an Re dependence of the the swirl number S required to maintain a specific P. Furthermore, for a given Re, the variation in P with S had an almost logarithmic dependence. Further work on the effects of varying the sphere size as well as location away from the nozzle will also be presented, along with stereoscopic PIV results to verify the Re dependence.

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[1]Billant et al., *J. Fluid Mech.* **376**, 183 (1998)

[2]Mattner et al., *J. Fluid Mech.* **481**, 1 (2003).

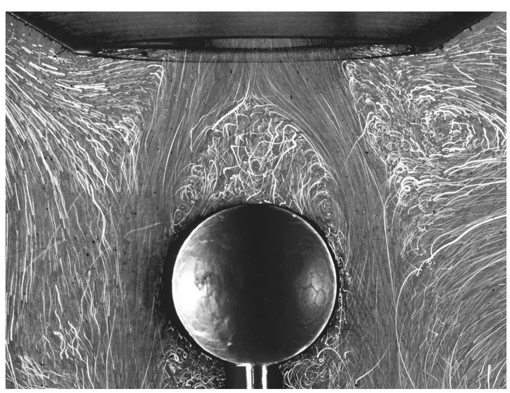

Figure 1: Processed image of flow visualisation showing the steady stagnation point upstream of the sphere surface.