Journal of Visualization, Vol. 9, No. 1 (2006) 4

Visualization of Axis-Switching of Elliptical Slot Jets

Shibu, C.*, Murugan, K. N.* and Rathakrishnan, E.*
* Department of Aerospace Engineering, Indian Institute of Technology Kanpur, India.
Received 2 August 2005

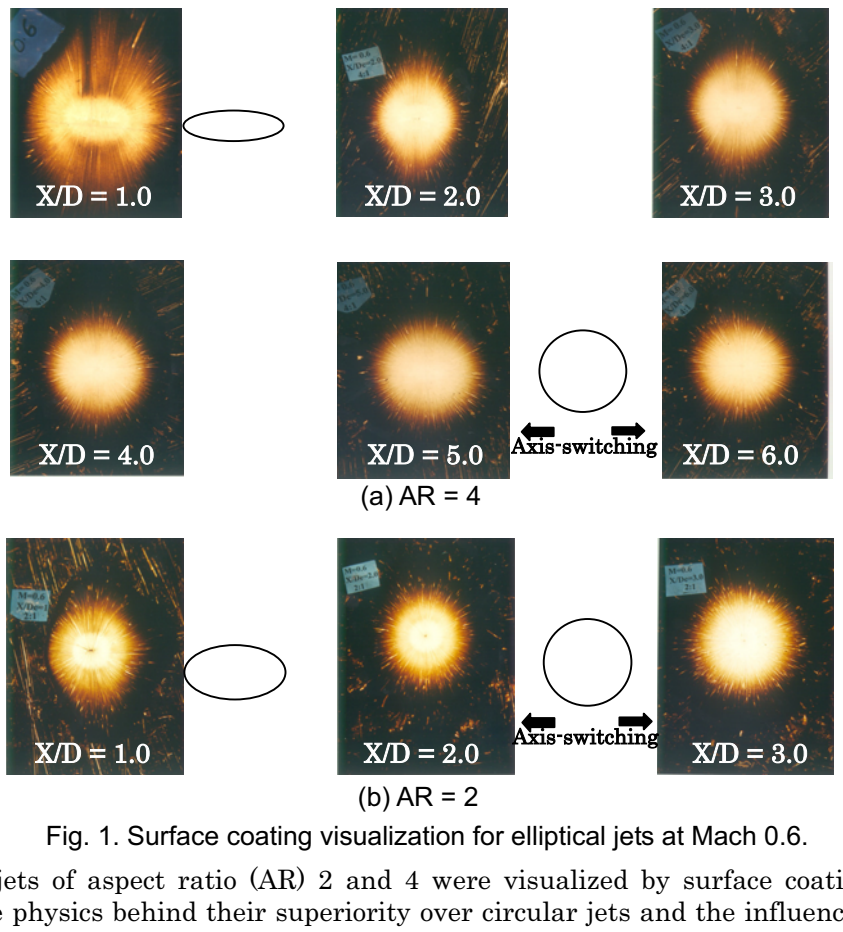

Fig. 1. Surface coating visualization for elliptical jets at Mach 0.6.

Elliptical slot jets of aspect ratio (AR) 2 and 4 were visualized by surface coating technique to understand the physics behind their superiority over circular jets and the influence of aspect ratio on axis-switching phenomenon. The jets were made to impinge on the flat surface of a transparent plate, which was coated with lamp black and pump oil. The plate was kept normal to the jet axis at different axial locations. When the jet impinges on the flat surface of the transparent plate, the surface coating was eroded due to the shearing action. After exposing the coated plate to the jet, it was taken out and the pattern on the plate surface was photographed with a diffused light projected from the uncoated side of the plate. The presence of vortices of various sizes starting from the largest ones at the ends of minor axis and the smallest ones at the major axis ends for Mach 0.6 jet is clearly inferred from the visualization pictures, shown in Fig. 1. For the present aspect ratio elliptical jets at X/D = 1.0, the coating at the minor axis ends are almost intact, indicating that the vortices were large in size, since the large size vortices are good entrainers but poor promoters of mixing. In contrary the small vortices are efficient mixing promoters but weak entrainers. The presence of small vortices is inferred form the significant erosion of the surface coating near the major axis extremities. For the AR 2 jet, axis-switching occurs between X/D = 2 and 3 and for higher AR jet like AR 4, axis-switching occurs between X/D = 5 and 6 (where X is the axial distance from the elliptical slot and D is the equivalent diameter of the elliptical slot). It implies that for AR 2, the entrainment is more compared to AR 4. The visualization pictures demonstrate the generation of vortices from largest to smallest size with continuous variation in their size, owing to the continuous variation of the radius of curvature of the ellipse along its azimuth. These vortices of varying size are responsible for the improved entrainment and enhanced mixing of the elliptical jets compared to circular ones. Among the different aspect ratios tested, AR = 2 is found to be best from jet mixing point of view.