Journal of Visualization, Vol. 12, No. 3 (2009) 192

Portfolio Paper

Investigation of Axisymmetric Underexpanded Air and Helium Jets by Background Oriented Schlieren

Dubois, J.*[1,2], Amielh, M.*[1], Anselmet, F.*[1] and Gentilhomme, O.*[2]

*1 Institut de Recherche sur les Phénomènes Hors Equilibre (IRPHE), CNRS-Universités Aix-Marseille, Technopôle de Château-Gombert, 49 rue F. Joliot Curie, B.P. 146, 13384 Marseille Cedex 13, France

*2 Institut National de l'Environnement industriel et des RISques (INERIS), Parc Technologique ALATA - B.P. N°2, 60550 Verneuil-en-Halatte, France

Received 10 February 2009 and Revised 31 March 2009

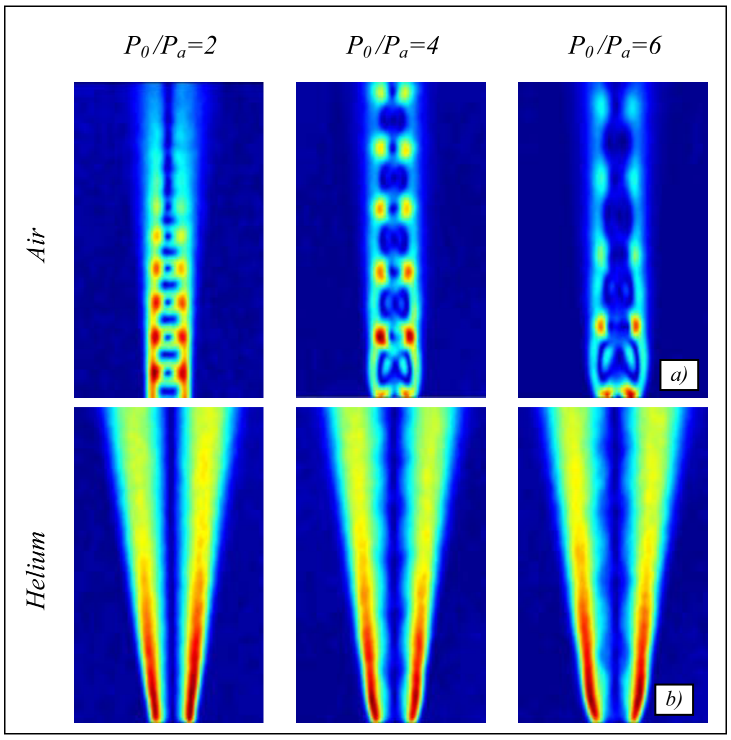

Fig. 1. Magnitude of mean density gradient in air or helium underexpanded free jets. *The red color is significant of strong density gradients.*

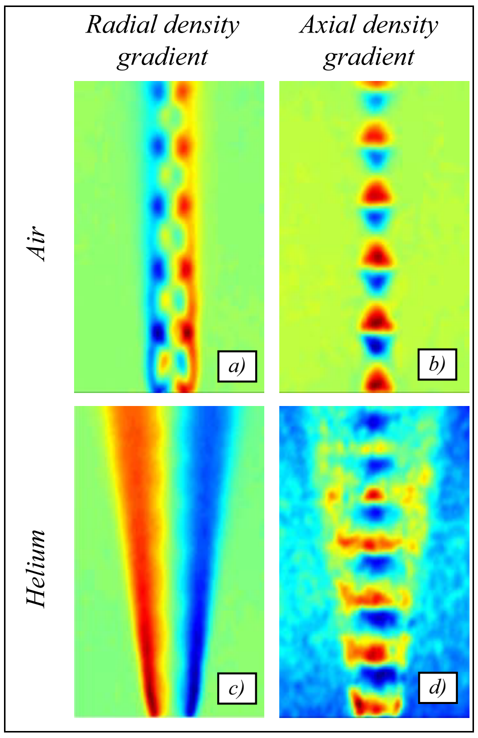

Fig. 2. Oriented magnitude of radial and axial mean density gradients in air or helium underexpanded free jets at *P_0/P_a=4. (Automatic scaling for density gradients: red >0, blue <0).*

Mean density gradients are highlighted by the background oriented schlieren (BOS) technique applied in the near field of axisymmetric underexpanded jets of air or helium. The displacement fields related to the refractive index variations and therefore to flow density gradients are obtained by cross-correlating with a PIV algorithm one image of an illuminated speckled background without the jet and one with the jet. The gaseous jet (either air or helium) is released through a D_j = 2 mm orifice from a high pressure source at P_0 into the ambient air at P_a. Figure 1 reveals the shock cell structure for both air (a) and helium (b) as a function of pressure ratio P_0/P_a = 2, 4 or 6. As the tank pressure increases, the diamond structure of the weakly underexpanded air jet is switched to the barrel structure of a moderately underexpanded air jet (Fig.1a). In the helium jet (Fig. 1b), the BOS visualization is sensitive not only to the compressible effect but also to the helium concentration. The shock cells induced by compressible effects in the near field (x/D_j < 5) can be identified and quantified in terms of the Mach disk dimension and barrel shock length when the density gradient is decomposed along the axial and radial directions. In figure 2, the radial projections show the barrel shocks for air (a) and the concentration repartition for helium (c) at P_0/P_a = 4 while the shock cells are located in the jet by the axial component of the density gradient respectively in air : b) and helium : d).

Acknowledgments

This work is carried out in the frame of the french programme DRIVE (= experimental Data for the assessment of hydrogen RIsks onboard vehicles, the Validation of numerical tools and the Edition of guidelines). Therefore, the authors would like to thank the French National Research Agency (ANR) and particularly its hydrogen programme PAN-H for its financial support.