Influence of the sampling direction on Conditional Statistics at the TNTI of Variable Viscosity Jets

F. Patiño*, L.Voivenel*, M. Gauding*, F.Thiesset*, L. Danaila*, E.Varea*

Based on Kolmogorov's[1] original work, considering turbulent mixing, viscosity is presumed to be a quantity that only acts on small scales. However, in real-life applications, fluids with different properties are involved whether it is in reactive or non-reactive conditions. To better understand the turbulent mixing process, and the processes influencing it, viscosity variation must be taken into consideration. In this study, the effects of viscosity stratification are investigated. Velocity and concentration measurements of two cases are considered i: a nitrogen jet is issuing into a nitrogen coflow; this case is referred to as the baseline case as Constant-Viscosity Flow (CVF) ii: a propane jet (C_3H_8) issues into a nitrogen coflow; this is referred to as the Variable-Viscosity Flow (VVF) case. Reynold numbers between 8000 and 24000 are investigated. It is known that the use of conditioned statistics allows for characterizing more precisely the effects smoothed or hidden by the use of conventional average statistics. The calculation of conditional statistics is related to the interface that separates the turbulent part of the flow from the non-turbulent part, generally referred to as TNTI. Many efforts have been made to determine the appropriate way to identify the interface, either by choosing different criteria (e.g. vorticity, concentration, or velocity[2]) or by changing the threshold selection technique (Prasad[3] and Otsu[4]). However, to the author's knowledge, the influence of the sampling direction – which could be in the radial direction or normal to the interface – on conditional statistics is not yet discussed for active scalar flows. Using conditional statistics in the normal direction of the interface could be an effective technique for further highlighting flow properties such as scalar dissipation rate, transport, and dissipation as they involve velocity or concentration gradients. These aspects are essential to describe turbulent modeling including differential diffusion effects. This work aims to verify that sampling the statistics in the normal direction to the interface, estimated using the gradient of the scalar concentration, gives a more detailed description of what occurs in the vicinity of the TNTI. The results of the study show that the conditioned 2-D maps generated using simultaneous PLIF and PIV images exhibit a faster development of the jet when conditioned statistics are used in the normal direction of the interface. Furthermore, these maps provide a better visualization of the potential core, a critical region for understanding the flow dynamics in the jet. Kelvin-Helmholtz's instabilities presence can be better appreciated in one-shot images as the normal vector from the interface points closer to the center of the vortex.

*Normandie Univ., UNIROUEN, INSA Rouen, CNRS, CORIA, 76000 Rouen, France

[1]Kolmogorov, *Doklady Akademii Nauk SSSR* **30**, 16 (1941)
[2]Anand et al., *Exp Fluids* **47**, 995 (2009)
[3]Prasad and Sreenivasan, *Experiments in Fluids* **7**, 259 (1989)
[4]Otsu N, *IEEE Transactions on Systems, Man, and Cybernetics* **9**, 62 (1989)