Quantitative assessment of vortical structure parameters on the basis of sound and velocity field measurements

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Abstract Coherent/vortical structures with the vorticity concentrated inside the core area have been identified to emerge in many industrial and natural vortex flows. Examples of the concentrated vortices include propeller tip vortices, trailing vortices behind the aircrafts, tip vortices above the delta wings, tornadoes, columnar vortices inside the cyclonic separators and swirl combustors. In case of the technological devices like gas-turbine combustors and cyclone dust cleaners a strong flow swirling associated with the high vorticity magnitude provides indispensable condition for their proper operation. On the other hand these vortices may produce undesirable vibrations and noise making it necessary to discover ways to restrain the danger they pose (Syred, 2006). For these reasons this phenomenon attracts permanent attention from the fluid mechanics research community.

Basically, access to the vortex dynamics implies determination of the main vortex characteristics such as vorticity distribution in the vortex core, the core size and total vortex intensity represented normally by the vortex tube circulation (Alekseenko et al., 2003). As an alternative to expensive (in terms of the time consumption and high cost equipment employed) detailed flowfield examination, which conventionally used to characterize the vortex properties, the pressure detection can be considered. Previously this approach has been used for nonintrusive measurements of the size and intensity of vortices based on the pressure measurements at a vortex chamber bottom (Alekseenko et al., 1999). Static pressure difference across the vortex has been taken to characterize the flow regimes in a model gas turbine combustor (Anacleto et al., 2003). Two-point acquisition of fluctuations of the instantaneous pressure has been also utilized to explore the unsteady vortex flow structure in a swirl-stabilized combustor under isothermal (Fernandes et al., 2006) and reacting (Fernandes et al., 2005; Shtork et al., 2006) conditions. In present study the acoustic technique will be applied to quantify characteristics of the precessing vortex generated in swirling jet flow over a model vortex burner (Fig. 1a) and the results will then be compared to the velocity data obtained with an LDV. Additionally a study will be carried out to assess the influence of the acoustic probe on the flow field as well aspects like: probe orientation, probe size and corresponding acoustic transfer function on the data interpretation.