Flow structure identification with PIV and high speed imaging in cold flow combustor model

T.A. Kowalewski*, F. Lusseyran+, S. Blonski*

*IPPT PAN, PL 00-049 Warsaw, Poland
+LIMSI-CNRS, F- 91403 Orsay, France

A cold flow simulation of the gas turbine combustor is performed using small, transparent laboratory model. The main target of the investigation is to get physical insight of the main vortex, responsible for the efficient mixing of fuel. Measurements performed for the laboratory model deliver details of a flow structure, important for optimisation of combustor geometry and verification of numerical models. Such models are necessary for predictions and optimisation of real combustors[1].
A high speed camera FASTCAM (Ultima 40K), a high resolution PIV camera (SensiCam), a 5W Ar^+ laser and a double pulse Nd:Yag laser are used for the flow investigations. The special suction pump installed at the outlet is used to run the flow of air. The typical range of investigated flow velocities is 10-15m/s. The optical arrangement allows for the flow visualization and PIV measurements of the flow velocity field. For the flow visualisation the constant output power Ar^+ laser is used and the flow is recorded with a high-speed digital camera. It allows to record 8000 full size 256x256 pixels images with 4500 f/s. Beside visualization, these images are used to compute vector velocity fields using Optical Flow algorithm [1]. The combination of high-speed imaging and PIV evaluation allows for better understanding of the flow structure and permits accurate measurements in time and space (velocity vector for each pixel location at 8000 time points).
The first observations of the flow show beats of the jet, which interacts with the two vortex surrounding. We will try to bring to the fore, the relationship between the shear layer instabilities and the mixing efficiency between inlet jet and main flow in the cavity. This mixing process determines the resident time of the fuel inside the cavity and therefore is essential for the whole combustion process. To identify main flow structure, a Fourier analysis of the velocity fields both in space and time is performed for long sequences of images. The spatial instability modes along the main jet are identified using minimization procedure.
The classical PIV system equipped with the high resolution PIV camera is used to analyse turbulent statistics of the flow. Two evaluation procedures are used, cross-correlation PIV from TSI and high resolution method based on Optical Flow. Parallel to the experiment, numerical simulations using Fluent are performed. Results of the simulations are compared with the PIV evaluations of the main flow characteristics.

[1] Quénot GM, Pakleza J., Kowalewski TA: Exp. Fluids **25**, 177 (1998)

[1]This work was performed as a part of EU 5th Framework Programme FLOXCOM.