FLOW ANALYSIS OF A COMBUSTION BURNER IN COLD FLOW V3V-9000-TS SYSTEM

APPLICATION NOTE V3V-9000-TS-004 (A4)

Combustion Burner

Combustion Burner design is critical in determining the efficiency and flame type generated by the burner. Flow analysis at the exit of the burner is one of the validation methods for burner design. The V3V system was used to analyze the flow at the exit of a burner at ICARE CNRS, France (http://www.icare.cnrs-orleans.fr).

The burner used in this study consisted of two concentric tubes with a swirler placed in an annular arrangement which supplied the oxidant flow (air or oxygen-enriched air) as shown in Fig. 1a. Eight guide vanes were designed with various vane angles in order to induce swirl with varying levels of intensity. The central pipe delivers fuel (methane) radially through eight holes symmetrically distributed along the periphery of the tube, just below the burner exit plane. The fuel injection method, as well as the ratio between the fuel and the oxygen-enriched air, determines the combustion mode from the burner that can be changed from diffusion-type, to partially premixed type, swirling flames. In the present work, the radial injection of fuel is used to enhance mixing at the near field of the burner exit.

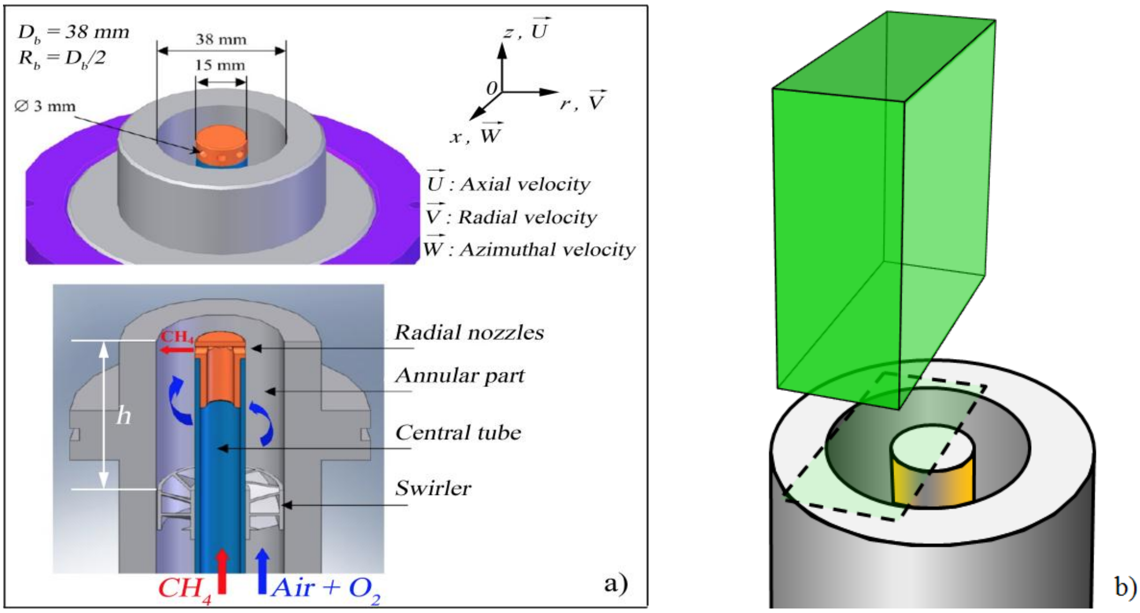

Fig. 1: Schematic showing the burner configuration (***a***), and location of the measurement volume (***b***).

Courtesy of: Nazim MERLO, Toufik Boushaki, Christian Chauveau and Iskender Gökalp

Institution: CNRS – ICARE, 1C avenue de la Recherche Scientifique. CS 50060
45071 Orléans Cedex 2, France

The experiments were conducted within a chamber with a square cross-section of 48 x 48 cm^2 and a height of 1 m that operated at atmospheric pressure. The walls of the combustion chamber were water cooled on the outside and refractory-lined inside. Six quartz windows were configured on each face of the chamber allowing optical access to all the potential flame zones.

During the experiment with the V3V system, the condition of non-reacting (without flame) flows was tested with 250 L/min of air in the annular part. The bulk velocity was approximately 4.7 m/s. The Al_2O_3 particles used for seeding the flow had a mean diameter near 1 µm.

V3V-9000-TS System

The V3V system was made up of the V3V-9000-TS camera mount with three 4MP-HS cameras running at 30 fps. Two dual-cavity Evergreen PIV lasers (200 mJ/pulse, each) were used to provide the illumination of the volume. The two lasers were synchronized to fire simultaneously, resulting in a total energy output of 400 mJ per pulse. The final volume size was 50 x 50 x 22 mm. The measurement volume included the central axis of the burner and extended outward to encompassed approximately one-half of the burner, as shown in Fig. 1b. Figure 2 shows an image of the system with the cameras mounted in the V3V-9000-TS (left-center), and one Evergreen laser (behind the monitor). The second Evergreen laser was placed on the opposite side of the chamber (not shown in the picture).

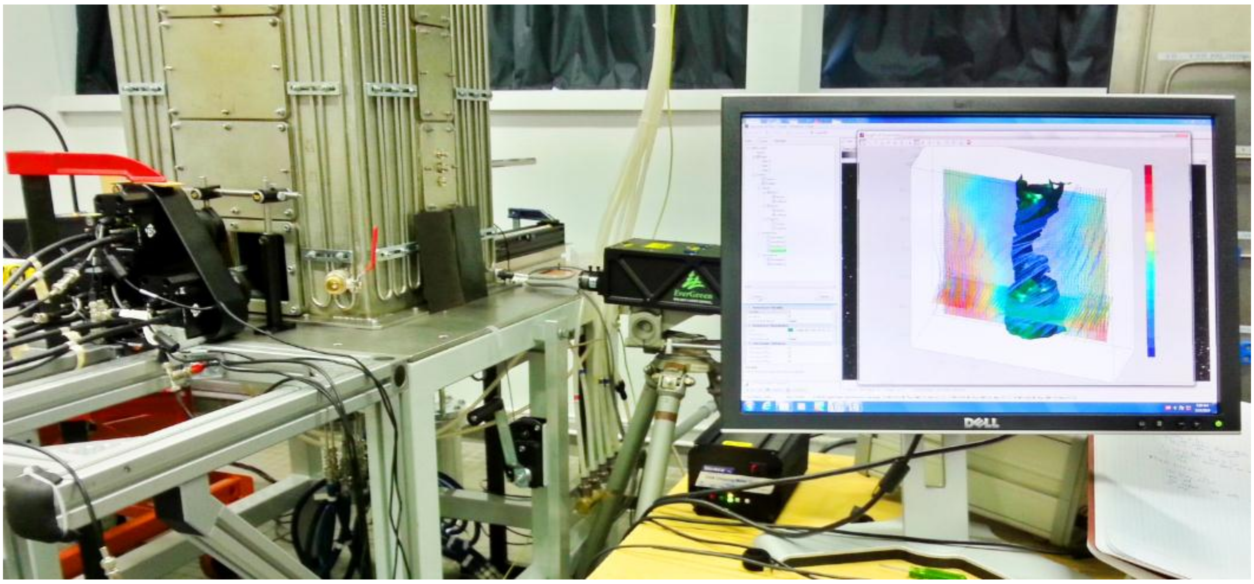

Fig. 2: Experimental setup with the combustion chamber and the V3V system

Figure 3 is a plot of the mean velocity field, and it illustrates the “swirl” present in the flow due to the burner design. The isosurface shows the downward moving flow at the core (negative v-velocity), and the slices show velocity vectors overlaid on contours of v-velocity. The gray streamlines show the swirling flow from the combustion burner. The plot in Figure 4 is an instantaneous plot of “Q criterion” where a “helix” of counter rotating vortices extending from the center of the burner, is observed.

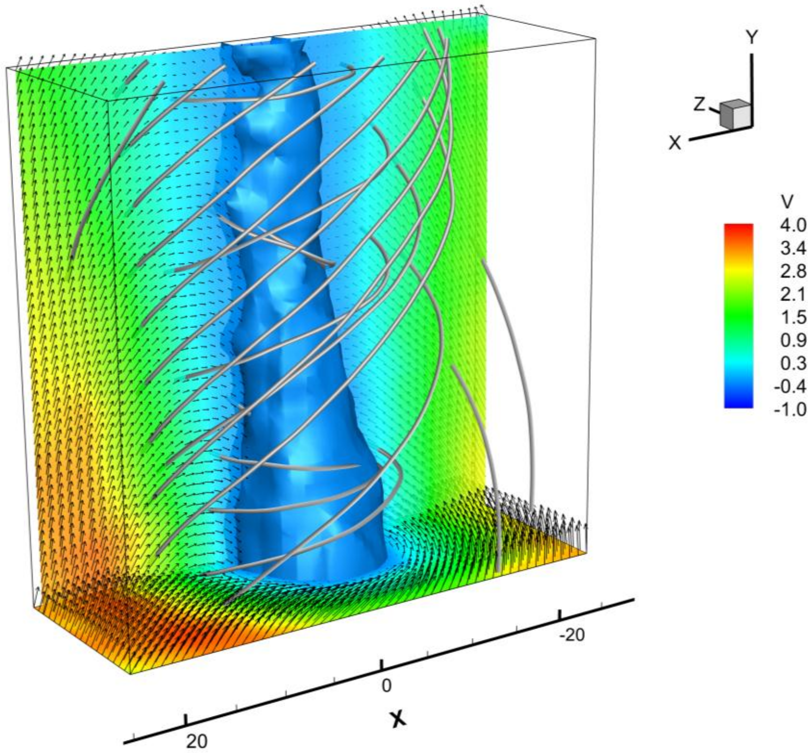

Fig. 3: Plot of the mean velocity at the core of the combustor. The blue isosurface encloses regions of negative vertical velocity. Slices show contours of vertical velocity. Swirling flow is highlighted by the streamlines.

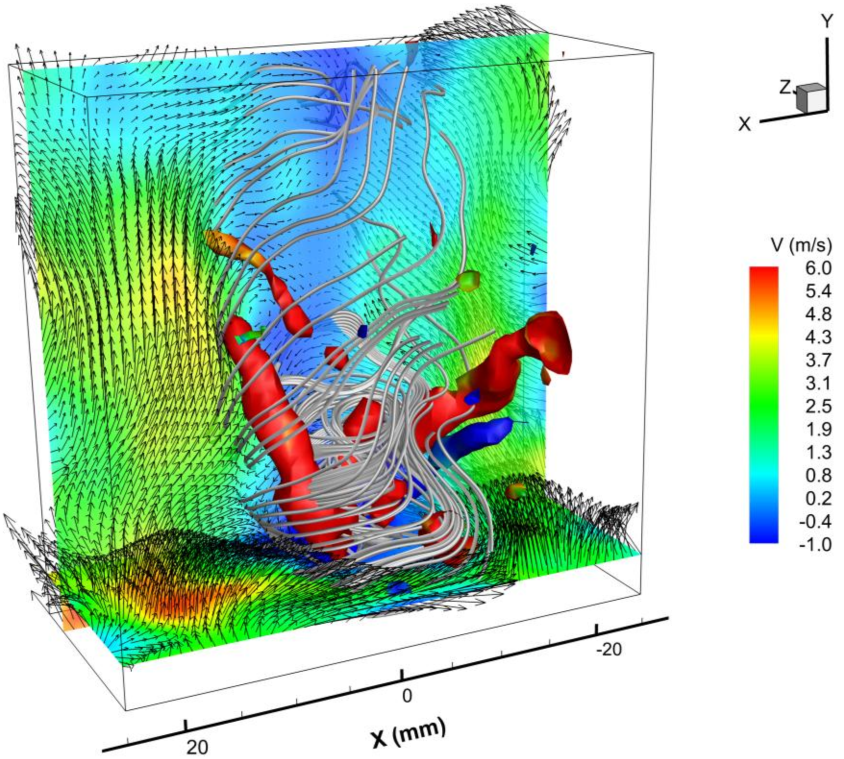

Fig. 4: Plot of Q-criteria (colored by vertical vorticity) showing counter-rotating vortices extending from the center of the burner. Slices show vertical velocity. Streamlines are also included.

Due to the strong 3-dimensional nature of the flow, the V3V-9000-TS system was considered a well-suited tool for the flow analysis. Moreover, the high spatial resolution of 1 mm^3 in the results provides a very detailed understanding of the flow, allowing useful methods for validating the burner design.

References

Merlo N, Boushaki T, Chauveau C, de Persis S, Pillier L, Sarh B, Gökalp I. "Experimental Study of Oxygen Enrichment Effects on Turbulent Non-premixed Swirling Flames." *Energy Fuels*. 2013; **27**:6191-7.

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Germany	**Tel:** +49 241 523030		