# PLASMA FLOW CHARACTERIZATION BY MEANS OF OPTICAL EMISSION DIAGNOSTICS

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Characterization of the free-stream plasma jet produced by the VKI Plasmatron ICP facility is of high importance to rely Thermal Protection System (TPS) testing, ablation and catalyticity measurements, among others. However, it is not possible to obtain a complete picture using exclusively conventional intrusive techniques, such as the ones based on heat-flux and Pitot probes. The aim of the present DC project is to provide complementary information about free-stream plasma jet, using optical emission diagnostics based on High-Speed Camera imaging (HSC) and Optical Emission Spectroscopy (OES).
First part of the work is devoted to the investigation of the unsteady features of the plasma jet. Light emitted by $N_2$ plasma has been recorded by means of high-speed CCD camera (Figure 1) and suitable time and spectral domain processing tools have been applied to investigate the main mechanisms ruling the unsteady behavior of the jet. The plasma has been found to be a heterogeneous medium containing inter-dispersed pockets, having different compositions, temperatures and velocities, which experience significant metamorphoses when changing test conditions, in particular the test chamber pressure. Applying an innovative approach in the spectral domain, the origin of the unsteadiness has been observed to be essentially ruled by two mechanisms occurring at different time-scales: the hydrodynamic instabilities, due to the interaction between plasma jet and cold surrounding gas, and instabilities arising from complex coupling between the heating of the gas mixture and the recirculation patterns induced by the injection mechanism in the ICP torch.

Regarding the second part of the work, high resolution OES has been applied to rebuild the thermodynamic state of the plasma jet. Spectra emitted by Air, $CO_2$ and $N_2$ plasmas have been recorded at different locations and test conditions. Experimental spectra have been calibrated and local emissivity has been rebuilt. A numerical tool has been developed to determine rotational and vibrational temperature radial profiles (Figure 2) of the plasma jet. The software is based on the comparison between experimental spectra and spectra predicted by the HTGR code (developed at EM2C), through a fitting procedure. In particular, the rotational temperature is strictly related to the plasma jet temperature, which is of high importance to rely plasma jet characterization obtained by intrusive techniques.

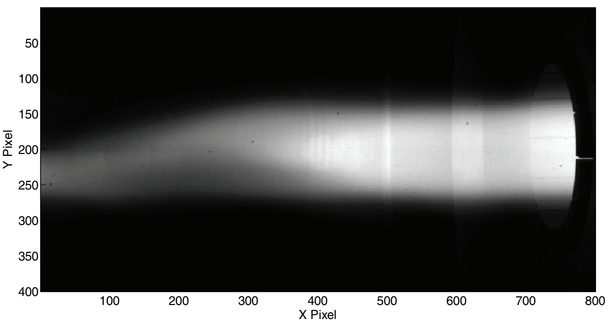


*Figure 1: High-speed CCD camera frame of $N_2$ plasma jet*

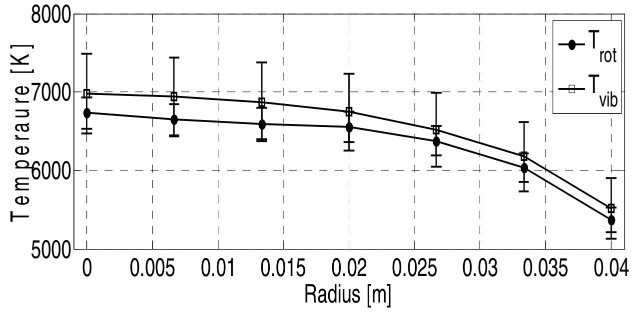


*Figure 2: Radial Temperature profiles for $CO_2$ plasma*