Optical Emission Spectroscopy Investigations in a Non-Transferred DC Plasma Torch

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We present the nitrogen species evolution and plasma temperature measurements [1] at different operating conditions of a non-transferred dc plasma torch. For estimations of plasma parameters, high resolution optical emission spectroscopy (OES) is performed for wide range of gas flow rates (20 to 60 lpm) in the presence of external magnetic field (100 to 300 G) for various currents (70 to 120 A) at atmospheric pressure with nitrogen as working gas. These OES investigations allow us to study the variation of the dominant species with various operational parameters of the torch. The plasma temperature is estimated from three independent techniques: (i) intensity analysis of molecular bands of first negative systems of N_2^+, (ii) Boltzmann plot of neutral atomic lines and (iii) line broadening analysis of the same neutral nitrogen lines. For the former two techniques, local thermodynamic equilibrium (LTE) is assumed. These estimations yield plasma temperature in the range of 3000 – 8000 K for the range of parameters mentioned above. Additionally, influence of various operating parameters on the plasma temperature is also presented and discussed in this work.

A comprehensive study on the fluctuations of the arc root and column in a non-transferred dc plasma torch requires estimations of plasma parameters for various operational conditions of the torch. Such studies are necessary to understand the complex interaction between different forces that act on the plasma column and lead to the above mentioned fluctuations. In the present work, OES on a dc plasma torch was performed using 0.5 m ARC spectrograph with PI CCD and 1800 l/mm grating. Studies on the behaviour of the species evolution and presence of dominant species are carried out. The plasma temperature is obtained using N_2^+ FNS bands (Fig. 1) and excited emissions from neutral Nitrogen atoms (wavelength range: 740 nm to 1100nm).

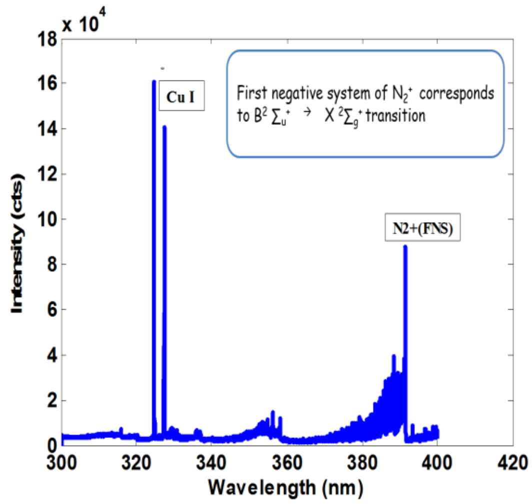

Figure 1 - Experimental data of N_2 FNS band for 20 lpm, 70A discharge current and 100 G external magnetic field.

Study further shows that neutral atomic nitrogen is the dominant species in the discharge. The intensity of dominant specie is maximum at nozzle exit and decreases along the plume. The intensity v/s pressure scaling shows a decrease of intensity indicating a lower temperature at higher gas flow. Few N_2^+ FNS molecular bands (Fig. 2) are also simulated using LIFBASE software to benchmark the experimentally obtained temperature values and show good agreement.

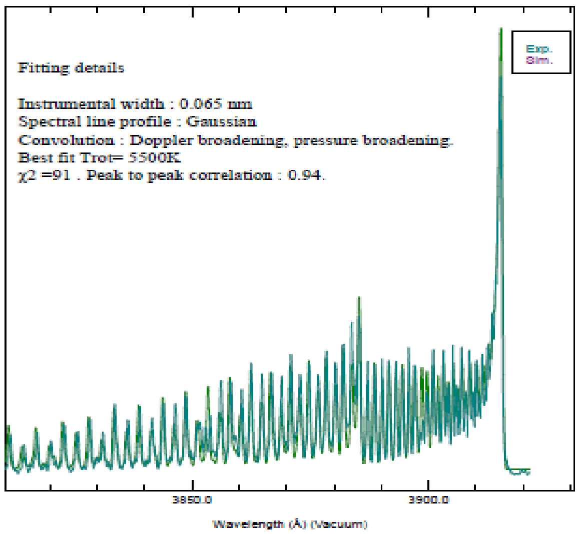

Figure 2 - N_2 FNS band simulation for 20 lpm, 70A discharge current and 100 G external magnetic field.

3. References

[1] Boulos, M. I., Fauchais, P., and Pfender E., Thermal Plasmas: Fundamentals and Applications, Plenum Press, New York, (1994)