APPLICATION AND DIAGNOSTICS OF HIGH PRESSURE RF DISCHARGES

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1. Introduction

During several years we investigated different systems with nozzle working both at reduced and atmospheric pressure, in subsonic and supersonic regime, etc. (see [1-4]) and references herin). The large variety of experimental conditions allows to drive both corona and torch arc discharge and the systems working in transition regimes.

While in previous papers we studied for example the system with the rf plasma jet burning at atmospheric pressure and its interaction with liquid in this contribution we draw attention to the configuration of the nozzle and ground plate as the system appears to be perspective for industry applications such as cleaning of surfaces or deposition of thin films at atmospheric pressure, etc. As working gas can be used argon, nitrogen and mixtures with an other compounds (oxygen,...).

Fig. 1: A view into the nozzle. The inner diameter of the nozzle is 1 mm.

In the last contribution [4] we presented basic parameters of the nozzle burning at atmospheric pressure. The parameters were compared with the systems investigated before, too. Here, we want to add other dependencies and simulations of electric field around the nozzle in order to obtain more complex picture.

2. Experimental set-up

The powered electrode is made from thin pipe the inner diameter of which is 1 - 2 mm and length several cm and the discharge was driven at 13.56 MHz. The power absorbed in the torch discharge has been adjusted in such a manner that at the electrode edge the torch discharge was created. The working gas, argon, which flows from the nozzle stabilizes the torch discharge. A schematic block drawing of the experimental set-up including the detail of the nozzle is given in [2].

Basic parameters of the discharge have been used by means of optical diagnostics (i.e. estimation of temperatures in the discharge, monitoring of equiintensities) and electrical measurements like is the RF voltage on powered electrode.

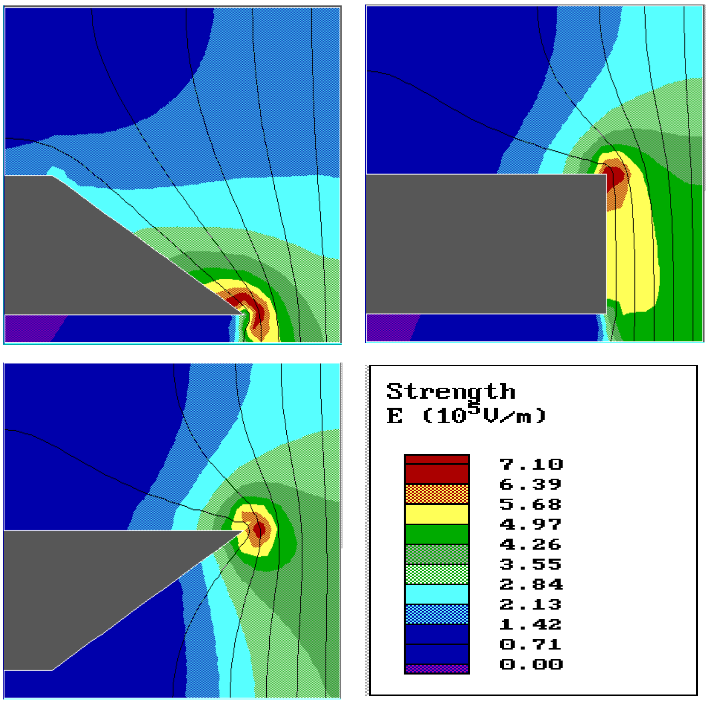

Fig. 2: Distribution of electric field around the nozzle calculated for different form of the nozzle. The form influences significantly the distribution of the electric field. The distance of the nozzle from the ground electrode is 2 mm. No spatial charge is taken into consideration in the simulation.

We must point out that the RF discharge stabilized by working gas flow is unexpected stable (in the presented configuration) which is very important for the applications mentioned above.

3. Result and Discussion

To obtain basic information on the discharge optical emission spectroscopy have been used. Namely, optical spectra have been recorded by means of the HR 640 monochromator, Jobin-Yvon equipped with CCD detector and photo-multiplier and using the color CCD camera Panasonic NV-MS5EG (S-VHS/VHS format) [4].

A typical photo of the torch discharge and the equiintensity map are shown in Fig 1.

To obtain some first imaginations about distribution of electric field around the nozzle the program QuickField (shareware version) was used. A typical example of such simulation is shown in Fig. 2. As in the experiment the cylindrical configuration, i.e. real dimensions were used. Even in case of this simple program we obtain distribution that corresponds with intensity of light emitted by plasma. On the other hand the program makes possible to simulate only first stage close to break of the discharge and in fact the maps do not reflect effects which occur from flow gas, etc.

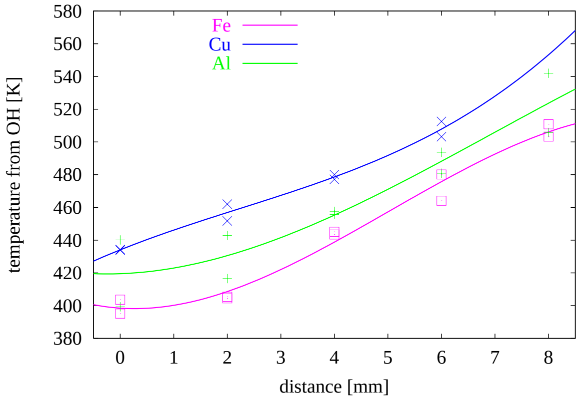

Fig. 3: Rotational temperature as a function of distance from the nozzle for fixed input power 75 W and gas flow 1100 ml/min and different material of the nozzle. Working gas is argon.

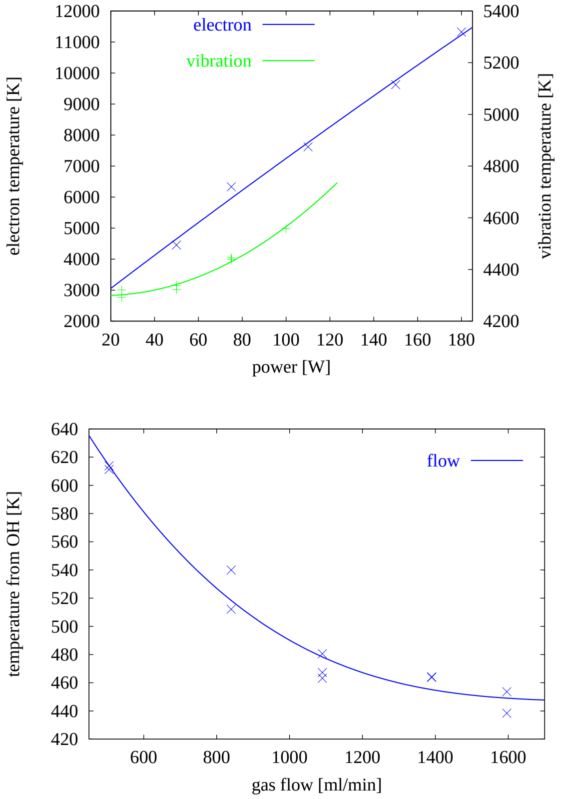

Fig. 4: Iron nozzle: Electron and vibrational temperature as a function of the input power for fixed gas flow 900 ml/min (see above) while the bottom graph shows rotational temperature as a function of gas flow at fixed input power. All dependencies were measured near the end of the nozzle. Working gas is argon.

Under various conditions we estimated rotational and vibrational temperatures from molecular bands of OH (306.4 nm system) and N_2 second positive system $C^3\Pi_u$-$B^3\Pi_g$, respectively. The electron temperature was estimated from isolated argon lines.

Typical dependencies of individual temperatures on the input RF power, distance from the end of the nozzle and gas flow are shown in Fig. 3, 4. A relative error of temperature in individual points were now below 10 %.

4. Conclusion

The comparison of recorded imagines, simulations as well as temperature dependencies satisfy great variety of the discharge which support hopeful application. Some of them have been already studied (e.g. surface cleaning of aluminium plates). From physical point of view we observed the unexpected behaviour of the rotational temperature as a function of the distance (Fig. 3).

Acknowledgements

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References

[1] Brablec A., Slaviček P., Klima M., Kapička V.: "RF discharge burning at atmospheric pressure and its interaction with water liquid." *Proc. 18th Symposium on Plasma Physics and Technology*, Prague, 1997, p.163

[2] Brablec A., Slaviček P., Klima M., Vaculik R., Kapička V.: "Optical diagnostics of rf discharge burning at atmospheric pressure and interacting with water solution." *Contributed papers, XIII ICPIG*, July 1997, Toulouse, France, p. I-128

[3] Brablec A., Kapička V., Slaviček P.: "Supersonic and subsonic plasma jet." *Proceedings of the 12th International Conference on Gas Discharges and Their Applications*, Greifswald, Germany, 1997, p.376

[4] Brablec A., Slaviček P., Klima M., Kapička V.: "High pressure RF discharge: Spectral diagnostics and perspective application." *Proc. 11th Symposium on Elementary Processes and Chemical Reactions in Low Temperature Plasma*, June 22 - 26, 1998, Low Tatras, Part 2, p.188