INFLUENCE OF DEMIXING ON SF_6 ARC PROPERTIES

J. J. Gonzalez, J. B. Belhaouari, B. Chervy, H. Riad and A. Gleizes
Centre de Physique des Plasmas et de leurs Applications de Toulouse
URA du CNRS n° 277, Université Paul Sabatier, 118 route de Narbonne
31062 TOULOUSE CEDEX, France

1 - INTRODUCTION

Experimental analyses of wall stabilized SF_6 arcs have shown that demixing effect changes the chemical composition of the plasma [1-2]. This effect, which is due to diffusion and to the difference between the ionization potential of fluorine and that of sulphur, leads to a depletion of sulphur near the axis. So in this region, the ratio M (called the demixing factor) between the fluorine concentration (atoms + ions) and the sulphur concentration is greater than 6 (6 being the stoichiometric value). On the other hand the usual modelling of these arcs is based on the hypothesis of the stoichiometric equilibrium coupled with LTE assumption. In this communication we present first the calculation of the material functions (transport coefficients and radiation losses) of S + F plasma for different values of the M factor, and second, the calculation of the temperature in these kinds of mixture, in order to study the influence of demixing on the axis temperature of SF_6 wall stabilized arcs.

2 - MATERIAL FUNCTIONS

Two types of material functions are required: the transport coefficients such as electrical and thermal conductivities and the net emission coefficient. The first ones have been computed by the classical method of Chapman and Enskog, already used for SF_6 and SF_6-Cu plasmas [3]. The second type has been calculated following the method given in [4] for SF_6, assuming an isothermal and homogeneous cylindrical plasma of radius Rp. Figure 1 shows an example of the variations of the net emission coefficient versus temperature, at atmospheric pressure, for Rp = 2 mm and for 3 values of M : 6, 10 and 15 (corresponding respectively to SF_6, SF_{10} and SF_{15} plasmas). As M increases, the relative proportion of sulphur decreases and then the net emission decreases because radiation emitted by sulphur is much more important than radiation from fluorine species.

3 - WALL STABILIZED ARC MODELLING

Assuming a homogeneous plasma in LTE, with no flow, the model is very simple and the temperature can be calculated by the energy balance (which takes the form of the Elenbaas-Heller equation) coupled with the Ohm's law (with constant and uniform electric field). In order to have a crude approximation of the demixing effect, our calculation is based on the following additional assumptions : in the central part of the arc, the M factor is constant (and equals to 10 or 15 for example), whereas in the outer part we consider the stoichiometric equilibrium (M = 6). The limit between the two regions corresponds to the position of the isotherm T = 9 500 K. In practical calculations we use the material functions of SF_6 for T < 9 500 K, and those of SF_M (M > 6) for T > 9 500 K. In experimental situations, M depends on various parameters such as the arc diameter, the current intensity and the radial position. Our purpose here is not to simulate very precisely the arc behaviour, but to quantify approximatively the effect of demixing on the axis temperature. From previous measurements given in the literature [5-7], we can consider as a first approximation, that the axis values of M are close to 10 for a 5 mm diameter arc and close to 15 for a 4 mm diameter arc, when the current is of the order of several tens of A. The variations of the axis temperature versus the current intensity for an arc diameter of 5 mm, are plotted in figure 2. The calculated curves (obtained respectively for M = 6 (SF_6) and M= 10 and considering Rp = 2 mm for the net emission coefficient) are compared with experimental values. Two comments can be deduced from these results :

- the axis temperature for M = 10 (SF_{10}) is higher that that for SF_6. This is mainly due to the reduction of the radiation losses when M varies from 6 to 10, leading to an increase of temperature.
- the agreement between experimental and theoretical values is better when demixing is taken into account in the calculation (M = 10).

This agreement is confirmed if we consider the variations of the electric field versus the current intensity, plotted in figure 3 for an arc diameter of 5 mm. For an arc diameter of 4 mm we have obtained similar results concerning the agreement between experimental and theoretical temperature values.

4- CONCLUSION

In conclusion this communication has shown that demixing should be taken into account in the physical models of stationary arcs established in a mixture of gases or in a multi-species gas. This work is a first step of a general model which should iteratively calculate the diffusion fluxes and the local material functions versus temperature and demixing factor.

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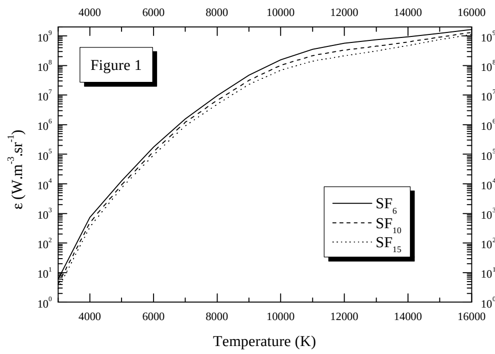

figure 1: Variations of net emission coefficient versus temperature for SF_6, SF_{10}, SF_{15} at atmospheric pressure for Rp=2mm.

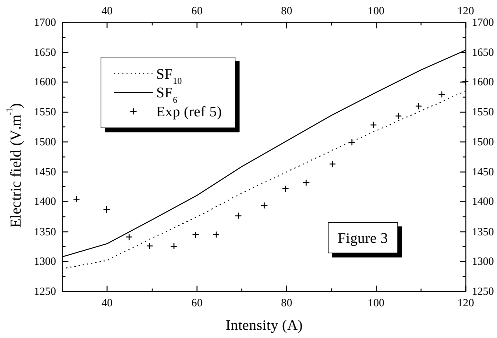

figure 3: Electric field versus current intensity for an arc diameter of 5mm.

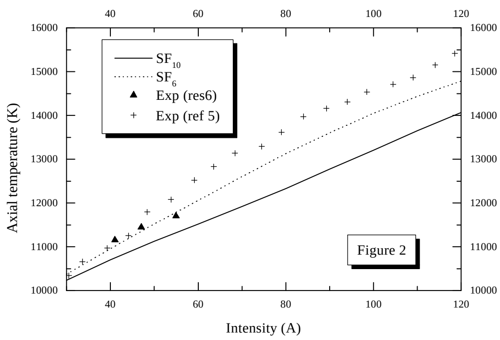

figure 2: Temperature versus current intensity for an arc diameter of 5mm.