MODELLING AND DIAGNOSTICS OF PLASMA CHEMICAL PROCESSES IN MIXED-GAS ARCS

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Most industrial plasmas are derived from mixtures of gases. The large number of species present in such plasmas and the occurrence of demixing, the diffusive separation of the component gases, make their experimental characterisation very difficult. Reliable numerical modelling is thus very important in such plasmas.

It is usual in such models to assume that the plasma is in local chemical equilibrium (LCE), dispensing with the need to explicitly consider chemical reactions and simplifying the calculation of the transport coefficients. However, difficulties remain with the treatment of diffusion. In a plasma containing q species, a total of $(q^2 - q)/2$ ordinary and $q - 1$ thermal diffusion coefficients have to be calculated for each temperature and composition. The combined diffusion coefficient formulation [1], which is applicable to mixtures of non-reacting homonuclear gases, allows these $(q^2 + q - 2)/2$ diffusion coefficients to be replaced by just three. This greatly simplifies the treatment of a wide range of important phenomena, such as vaporisation of metal electrodes and particles in arcs, and demixing in mixed-gas arcs.

The focus of this paper is demixing. Use of the combined diffusion coefficient formulation allows the different physical processes that lead to demixing to be easily distinguished [2]. A two-dimensional model of a free-burning arc that incorporates this formulation has been developed and used to investigate demixing in various gas mixtures. It is demonstrated that different diffusion processes dominate demixing in different gas mixtures, and that demixing can have a large influence on macroscopic arc parameters. The predictions of the model are compared with spectroscopic measurements [3].

The limitations of the assumption of LCE are demonstrated by considering the case of an argon–hydrogen arc. Comparison of laser-induced fluorescence measurements of atomic hydrogen densities with calculations indicates that atomic hydrogen diffuses too rapidly for LCE to be maintained in the arc fringes [4].

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