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A TWO DIMENSIONAL MODEL FOR A FLOWING CASCADED ARC PLASMA

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In accordance with the applications, a significant experimental and theoretical research work has been done to understand the plasma flow in a cascaded arc DC plasma [1,2,3]. However, it has been recognized that two–dimensional modeling is needed, [4,5], in order to treat correctly phenomena such as highly non–isothermal flow, deviations from local thermodynamic equilibrium (LTE), as well as diffusion and heat conduction. In this paper a two dimensional model developed by Milojevic [6] is used to describe an argon plasma. In the approach adopted in the model the plasma is treated as a two–phase medium, which consists of heavy particles (neutral atoms and ions) and light particles (electrons). It is developed for the predictions of a strongly flowing mono–atomic cascaded arc plasma. The flow is assumed to be axisymmetric, two–dimensional, compressible and strongly non–isothermal. The argon plasma is considered as singly ionized, locally quasi–neutral ($n_e \simeq n_i$) with local temperature non–equilibrium ($T_e \neq T_h$). The electric field is assumed to be one–dimensional, uniform over the arc cross–section ($E_r = 0$, $\partial E_x/\partial r = 0$). The total current is specified as an input parameter and is kept constant along the arc channel. For the full description of this two–phase flow one needs to solve the mass, momentum and energy equations for both phases. However, due to the small electron mass, their momentum is neglected in comparison with the heavy particle momentum. Therefore a two–phase flow character is kept only with respect to the heavy particle and electron temperatures which are assumed to be different and described by separate energy equations. Ohmic heat input is consumed by electrons, who heat and ionize by frequent elastic and inelastic collisions the heavy particles. The elastic collisions are not always efficient enough to equalize the temperatures of the two phases, especially at inlet regions of the flow, where the cold gas is introduced, and in the vicinity of cooled walls. The system of 2 dimensional elliptic partial differential equations is solved by a control volume numerical method of Patankar and Spalding [7,8], extended by incorporating a non staggered grid approach of Peric [9] with momentum interpolation at control volume faces as suggested by Majumdar [10]. Density corrections from the equation of state are introduced into the pressure correction equation as proposed by Jensen [11], but with an additional upwind–like scheme. The system of algebraic discretization equations for each variable are solved by the strongly implicit 'SIP' procedure of Stone [12]. A numerical grid with 23x24 non–uniformly distributed points is used for all calculations. The calculations were performed on a IBM PC/RT.

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