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The effects of particle groups vapor in arc plasma

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Mutual interaction between particle groups and arc plasma is closely related to the industrial application of arc plasma. In this paper, we develop a discrete phase model (DPM) to numerically study the effect of graphite particle groups on argon arc plasma.

DPM is applied for describing the behavior of particle groups. Lagrange method is used to calculate the particle groups trajectory while Euler method is used to present the performance of arc plasma. Track of the heat, mass, and momentum gained or lost by the particle groups that follows that trajectory and these quantities be incorporated in the continuous phase calculations. So that we develop a two-way coupling model[1]. The component diffusion equation is used to solve the evaporated fraction of the particles diffuses in the plasma gas which can drastically change its thermodynamic and transport properties[2]. To simplify the calculation, it is assumed that arc plasma is optically thin and in local thermodynamic equilibrium (LTE). To deeply understand the particle vapor effects on arc plasma, the numerical simulation using pure argon is studied.

The results show that: (1) the thermal conductivity is increased by the addition of graphite vapor, leading to increase of heat absorption of particle groups, as a result, the temperature of the plasma reduces; (2) increasing the particle feed rate and decreasing the particle size reduce wall heat flux, so particle groups have positive significance to improve the efficiency of plasma torch; (3) considering the change of thermodynamic and transport properties due to the particle groups evaporation, the heat absorption of particle groups and arc voltage are increased especially in the case of large particle feed rate.

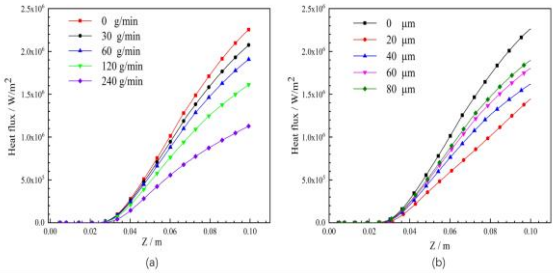

Figure 1. Wall heat flux along Z axis. (a) different particle feed rate and (b) different particle size

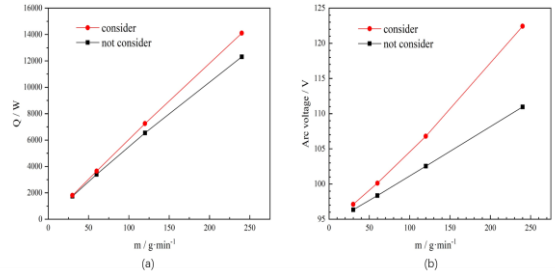

Figure 2. (a) heat absorption of particle groups and (b) arc voltage under different particle feed rate

Reference

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[2] Wang W Z, Rong M Z, Murphy A B, et al. Thermophysical properties of carbon–argon and carbon–helium plasmas[J]. Journal of Physics D: Applied Physics, 2011, 44(35): 355207.

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