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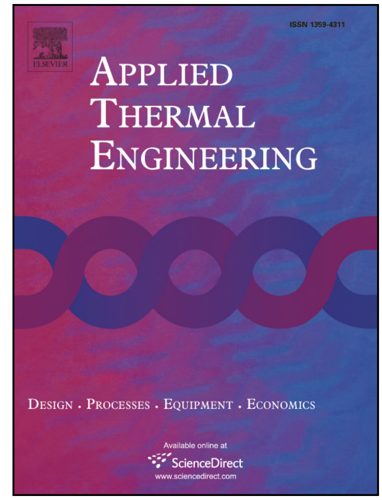

Research Paper

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Effects of conical nozzle and its geometry on properties of an inductively coupled plasma jet used for optical fabrication

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Abstract

The properties of a traditional inductively coupled plasma (ICP) jet, such as temperature and velocity, cannot satisfy the engineering application requirements in optical fabrication. Therefore, a conical nozzle was proposed to obtain a low-temperature jet with high stiffness and meet the requirements. Furthermore, the effects of the nozzle geometry on the plasma jet properties were analyzed. First, a numerical model was developed for ICP discharged from the nozzle into the ambient air. Second, the model was validated by comparing the computed temperature with three sets of experiments. A good agreement was obtained between the computed results and the experimental values, and the accuracy of the model was demonstrated. Subsequently, the properties of an argon plasma jet discharging from the nozzle into the air were examined by using the developed model. The effects of entrainment of cold air on the jet properties were also analyzed. The results indicated that the jet properties are considerably affected by entrainment of the air. Finally, the effects of nozzle geometry, such as length of the convergent section and the nozzle exit radius, on the jet properties were analyzed using single-factor simulations. An orthogonal study was then conducted for further optimization of the nozzle structure.

Keywords: Numerical modeling; Atmospheric pressure plasma; Conical nozzle; Plasma jet property; Nozzle structural optimization.

Nomenclature

C_μ, $C_{1\varepsilon}$, $C_{2\varepsilon}$	constants	c_p	specific heat of the plasma(kJ/(kg K))
$D_{j,m}$	mass diffusion coefficient for species j in the mixture(m^2/s)	g	gravitational acceleration(m/s^2)
		h	specific enthalpy(J/kg)
$D_{T_g,j}$	thermal diffusion coefficient(kg/m s)	j	species
G_k	generation of turbulence kinetic energy due to the mean velocity	k	turbulence kinetic energy(m^2/s^3)
		u_r	radial component of the velocity(m/s)