§11. Fundamental Investigation on Quenching Process of High Heat-Flux Plasmas Due to Polyatomic Molecular Gases Injection

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Controlling and quenching of high heat-flux plasmas by neutral gases are considered to be important for the divertor plates to avoid being thermally damaged. To understanding interactions between high power density plasma and especially molecular gases is greatly desired for this purpose. The plasma quenching is markedly influenced by the association and dissociation of molecular particles in gases. In this work, we developed thermofluid model for Ar-CO_2-H_2 plasmas considering 33 particles and 194 reactions among the particles to study fundamentally interactions between molecular gas and thermal plasmas [1),2)].

The following 33 particles were taken into account in plasma : CO_2, C, C^+, HO_2, O_2, O_2^+, CO_2^+, CH_2O, CHO, CHO^+, CO, CO^+, H_2O, OH, C_2O, C_2, O, O^+, C_2H, CH_4, CH_3, CH_2, CH, CH^+, H_2, H_2^+, H, H^+, C_2H_2, Ar, Ar^+,C_2H_4 and electrons. Ionization reaction rates were calculated from Maxwellian velocity distribution function and ionization cross-section data [3)]. Chemical non-equilibrium effects were also considered by solving mass conservation equations for each particle with diffusion, convection and net production terms resulting from 97 forward reactions (totally 194 reactions including backwards). Thermodynamic and transport properties were self-consistently calculated using the first-order approximation of the Chapman-Enskog method at each iteration using the local particle composition.

Fig.1 shows the plasma torch configuration and calculation space. The plasma torch has an eight-turn induction coil and quartz tubes. At the downstream portion of the torch, a straight reaction chamber is installed. The calculations were made for 98%Ar-1%CO_2-1%H_2. For comparison, calculation was also made under local thermodynamic equilibrium condition.

Fig.2 presents the two dimensional temperature distributions for both chemical equilibrium (CE) and non-equilibrium conditions (NCE) at atmospheric pressure. The maximum temperature contour for chemical equilibrium condition is 10.5 kK whereas it is 10 kK for non chemical equilibrium condition. Also it is noticeable that the plasma is more shrunk to the core region for equilibrium condition as compared to NCE condition. Fig.3 shows the radial temperature distribution at an axial position of 155 mm for both conditions which also supports the fact that plasma seems to widen itself due to high diffusion process of electrons.

1) Y.Tanaka and T.Sakuta: J.Phys.D:Appl.Phys. **35** (2002) 468.
2) Y.Tanaka, J.Phys.D:Appl.Phys. **37** (2004) 1190.
3) http://physics.nist.gov/cgi-bin/Ionization/atom

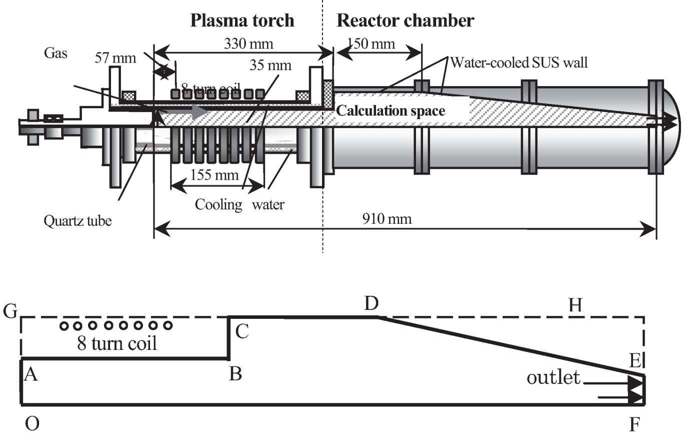

Fig.1 Plasma torch configuration and calculation space

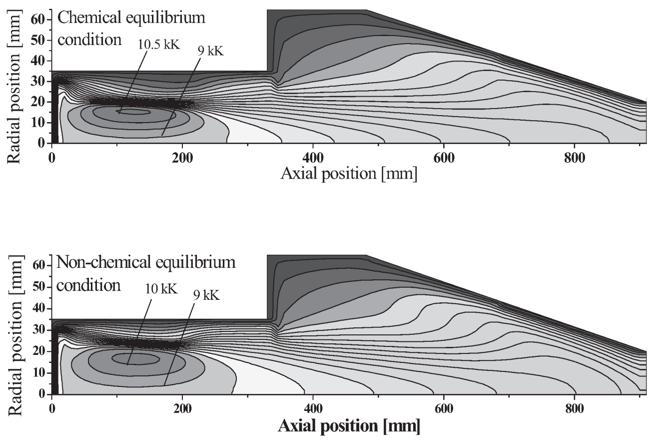

Fig.2 Two dimensional temperature distributions for both CE and NCE model at atmospheric pressure

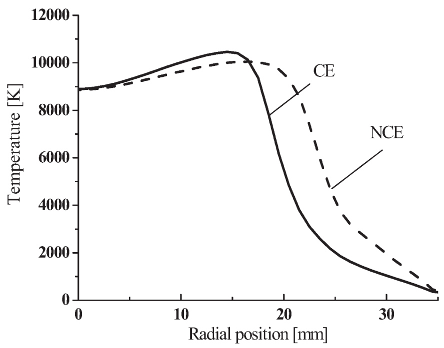

Fig.3 Radial distribution of temperature at an axial position of 155 mm for both CE and NCE model at atmospheric pressure