7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Research on Transport Characteristics of Vacuum Arc Plasma with Super Large Length-to-Diameter Ratio

Shuangwei Zhao[1], Xiaolong Huang[1], Shenli Jia[1,2]
[1] College of Electrical Engineering Sichuan University
[2] State Key Laboratory of Electrical Insulation and Power Equipment , Xi'an Jiaotong University
e-mail (speaker):13258103492@163.com

Vacuum arc is widely used in material surface treatment, metal smelting, aircraft propulsion device, medium and high voltage vacuum interrupter, etc. The development intensity of high voltage vacuum interrupter depends on the research of high current vacuum arc plasma characteristics. Vacuum arc plasmas are composed of various particles, including electrons, atoms, and ions of different charge states. The metal in a localized cathode surface area is continuously melted and evaporated to maintain the vacuum arc. The high-current vacuum arc is contracted on the anode side, and the longitudinal magnetic field is mostly used to control the high-current vacuum arc to suppress its contraction. There are complex physical processes in the vacuum arc, and it is difficult to fully reflect the dynamic change process of the plasma parameters inside the vacuum arc only through experimental research. Simulation research is an effective means for in-depth research on high-current vacuum arcs.[1]

The development of vacuum interrupters to higher voltage levels requires higher insulation levels. The active threshold current of the anode of the interrupter increases with the diameter of the anode and decreases with the increase of the contact gap. Therefore, the contact diameter of the interrupter and the maximum contact gap will be large. The characteristics of vacuum arc plasma with super large length-to-diameter ratiot are different from those of small contact opening distance (10mm) and small contact diameter (49mm) in previous studies. [2][3] In order to reveal the ultra-large aspect ratio vacuum arc plasma transport characteristics, we established a Two-dimensional magnetohydrodynamic model of a vacuum arc with super large length-to-diameter ratiot.

We explored the transport characteristics of the vacuum arc plasma when the arc extinguishing chamber (contact opening distance 70mm, contact diameter 150mm) interrupted 71kA power frequency current, as shown in Figure 1, the vacuum arc plasma under the longitudinal magnetic field Body characteristics, as shown in Figure 2. The vacuum arc with a large diameter and large opening distance presents a shrinking state, the control effect of the axial magnetic field in the arc area is weakened, and the vacuum arc current density shrinks to both sides under the axial magnetic field.

References

[1] S.L Jia *et al*, J. Phys. D: Appl. Phys. **47** 403001 (2014)

[2] L.H Zhao *et al*, J. Phys. D: Appl. Phys. **54** 105501 (2021)

[3] D.L Shmelev *et al*, IEEE T PLASMA SCI. **43**(8), 226 1-2266 (2015)

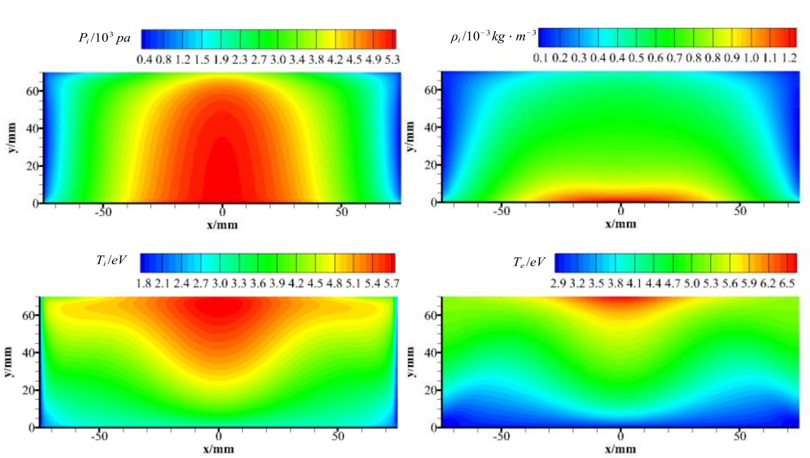

Figure1. Arc axial plasma pressure P_i , plasma density ρ_i , electron temperature T_e , ion temperature distribution T_i . The electrode opening distance and arc radius correspond to the vertical and horizontal coordinates in the figure. Anode on top, cathode on bottom

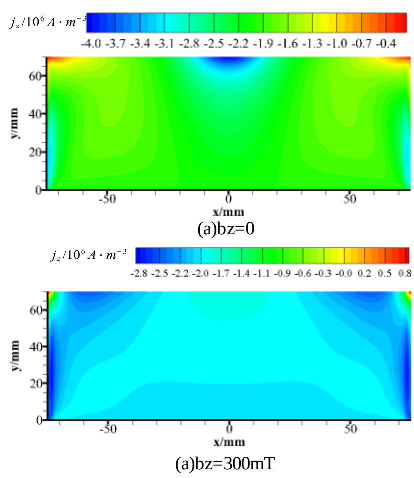

Figure2. Axial current density distribution. The electrode opening distance and arc radius correspond to the vertical and horizontal coordinates in the figure. Anode on top, cathode on bottom