Experimental study and numerical simulation of a DC plasma arc anode attachment characteristics

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DC arc has a very wide range of applications in aerospace, material processing, environmental protection and other fields. The arc attachment characteristics at the anode are closely related to the service life and performance of the arc device, and therefore it has received extensive attention. Because of the large plasma parameter gradients within the arc plasma device, a combination of numerical simulations and experimental studies is needed to obtain information about the physical mechanism of arc anode attachment.

Numerical simulation results show that the plasma in the near-anode region has a significant deviation from thermodynamic and chemical equilibrium, and the development of a reasonable physical-chemical model is essential to accurately simulate the different attachment modes of the arc at the anode and the arc re-strike process. The simulation results well reproduce the periodic re-strike motion of the arc along the anode surface, and obtain the arc voltage with sawtooth fluctuations in good agreement with the experiment.

The study shows that before the breakdown occurs, the upstream cold boundary layer already has a certain conductivity, and the current density and electron number density in this region appear to increase. At this time the increasing electric field strength will make the upstream Joule heating process is enhanced, ionization reaction is enhanced, the electron number density further increased, electron - heavy particle elastic collision frequency increase caused by heavy particle temperature rise, so that the arc attachment position from downstream to upstream. Based on the results of the numerical simulation analysis, several novel methods are proposed to regulate the anode arc attachment modes and suppress the anode ablation, which can help to promote the development of new, high-performance arc plasma devices.

References

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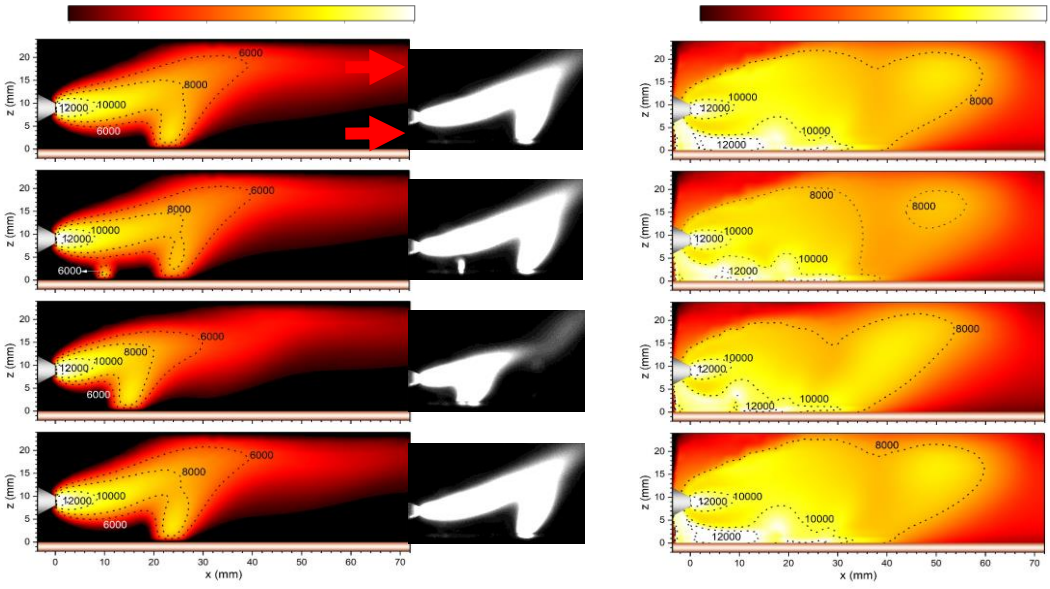

Fig.1 Distribution of heavy particles (left), experimental photos (middle) and electron temperature (right) during the re-breakdown process of DC arc anode apposition