Experimental and numerical studies on the restrike mode of a DC arc anode attachment

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The restrike mode is an important arc anode attachment mode under the cross flow in DC arc device, which often causes a large amplitude of arc voltage fluctuations and therefore has an important impact on the performance of arc thermal plasma device. Previous experiments and theoretical analysis have demonstrated the close relationship between the thickness of the boundary layer and the restrike process. It is necessary to further investigate the effects of arc current and gas flow on restrike characteristics such as arc root movement range and frequency.

A transferred arc device with planar anode parallel to gas flow direction is used to experimentally study the restrike mode characteristics under different operating conditions. High- speed photography is used to systematically observe the effects of gas flow and arc current on the characteristics of arc anode restrike. The relative intensity method of emission spectra is used to obtain the temperature distribution during the arc dynamic evolution in a period.

It is found that for the case of a fixed gas flow, the arc restrike frequency increases while the amplitude of arc voltage jump decreases with the increase of arc current. For the case of a fixed arc current, both arc restrike frequency and amplitude of arc voltage jump increase with the increase of gas flow rates. Further analysis shows that the restrike process in one period can be divided into two phases. The first phase corresponds to the generation and development of upstream new arc roots and the disappearance of downstream old root, and its time scale is less than the order of 1 ms. The second phase corresponds to the newly formed, single arc root moving downstream under gasdynamic drag force until new arc root appears upstream. The time-resolved temperature field measurement based on the relative intensity of emission spectrum method shows that the temperature at the junction of the arc column and the anode arc root is relatively low, while it still able to maintain the current conduction, which indicates the significant deviation from thermodynamic equilibrium state. The periodic reciprocal motion of the arc root along the anode surface under side-blown gas is simulated using a completely nonequilibrium model containing argon molecular ions with a flat plate anode. The spatial and temporal evolution of the arc characteristics over one completed motion cycle is analyzed. It is found that the increase in electrical conductivity and upstream electric field strength within the cold boundary layer upstream of the anode before breakdown occurs causes an increase in Joule heat, leading to the formation of a new arc root.

References

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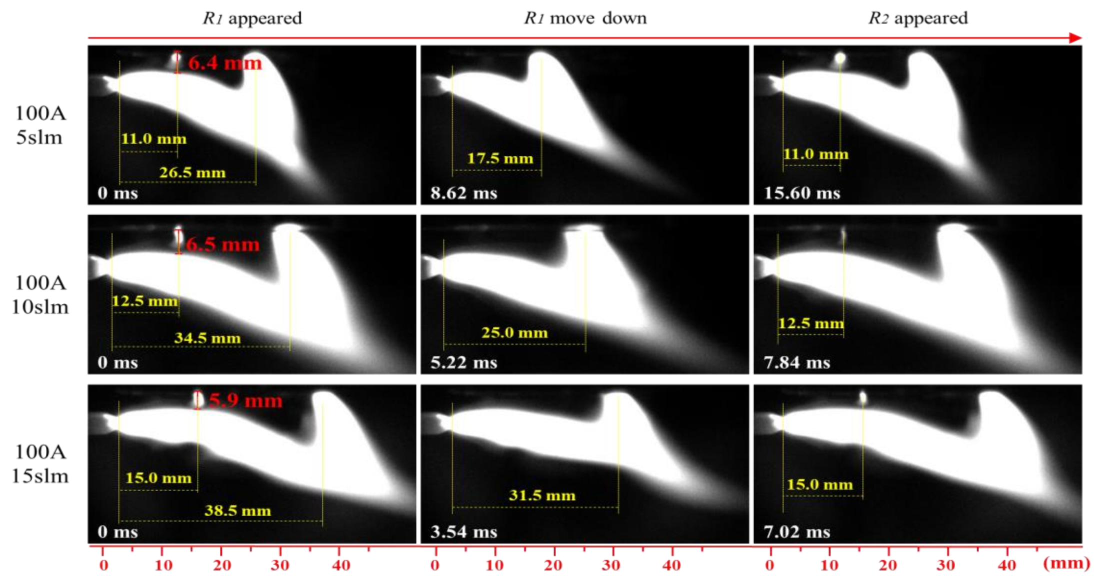

Figure 1. Frames from high-speed movie of argon in restrike mode of operation within one period, arc current of 100 A, gas flow rates of 5, 10, 15 slm