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Numerical Modeling of TIG Arc with Molten Cathode

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Summary

In TIG arc at atmospheric pressure, electrons are emitted from a thermionic cathode of the tungsten electrode, of which the work function would be reduced by generally adding an emitter material such as thorium oxide (ThO_2), lanthanum oxide (La_2O_3), and so on. However, there is still a lack of practical understanding of the physical behavior in the electrode region. The emitter materials such as ThO_2, La_2O_3, etc would not affect only work function of the cathode but also current attachment at the cathode. The current attachment at the cathode affects plasma state of the arc column due to change in the cathode jet induced by the Lorentz force at the cathode region. It is well known that arc flames are dependent on kinds of the emitter materials which are added to the tungsten electrode.

The present paper presents a methodology for predicting the current attachment at thermionic cathode for TIG arc at atmospheric pressure in argon. We use a numerical model of a TIG arc where the arc and its electrodes are treated as a unified system. In this model, the experimental results of work function of cathode are given to a unified arc-electrodes model to take into account the close interaction between arc plasma and thermionic cathode, and four types of tungsten electrode, namely, pure W, W-2% ThO_2, W-2% La_2O_3 and W-2% CeO_2 are calculated. In the case of pure W cathode, molten cathode shape is concerned.

Theoretical results are compared with experimental results in current attachment area, shape of self-stabilized arc and temperature distributions of cathode surface. And these results are good agreement with experimental results. It is concluded that the current attachment at thermionic cathode for TIG arc at atmospheric pressure is dependent on work function, melting point and Richardson constant of emitter materials.

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