Topic number

Model and Simulation of the formation of cathode spot in vacuum arc

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Abstract: A 2D axisymmetric swirl hydrodynamic model has been developed to describe the formation of cathode spot in vacuum arc. The model includes hydrodynamic equations and thermal conductivity equation which considers surface evaporation and Joule heating. In this model, cathode spot maintains 30μs and during this time, all parameters are fixed. The simulation results show that when the energy flux density coming from the interacting between arc plasma and cathode is 1.5~3*10^{12}W/m^2 and current is 3~6A, the crater diameter is 3~7μm, the crater depth is 1.5~2.5μm and the maximum temperature is 2500~5500K. Besides, in the chromium cathode, the temperature is higher but the molten metal is less because of the lower specific heat and higher melting point.

1. INTRODUCTION

Kesave[1] has shown that vacuum arc in cathode consists of independent cathode spots. During the whole lifetime, cathode spots kept moving. The cellular structure and moving track of a cathode spot have been observed in experiment [2]. Based on these observations, the ecton mechanism was proposed [3]. According to the experimental results, ecton model assumed the size of cathode spot was several microns and the lifetime was several tens of nanoseconds. Old cathode spots extinguished at the edge of contact while new cathode spots appeared in the center of the cathode contact. The beginning of a cathode spot was a micro explosion which resulted in the initial electron emission [4].

Energy flux density coming from interacting between arc plasma and cathode and Joule heat injected energy to cathode contact. Surface evaporation took away a part of energy and the left energy heated cathode material, the temperature could reach several thousand degrees. At such a high temperature, whether copper or chromium, the cathode material was melting. And the pressure caused by cathode plasma extruded the melting material leaving the center of cathode spot, splashing away and becoming droplets, finally, cathode micro jet appeared [5].

To simulate this process, in this paper, A 2D axisymmetric swirl hydrodynamic model has been developed, hydrodynamic equations and thermal conductivity equation are necessary, and the parameters are obtained by fitting the experimental data and predecessors' work[6]. The energy flux density is in magnitude of 10^{12}W/m^2. The current in each cathode spot is limited, however, because the size of cathode spot is only several microns, the current density can reach 10^8A/m^2. Joule heat is produced throughout the contact while the energy flux density only acts on the cathode surface. The cathode plasma pressure is in magnitude of 10^8Pa.

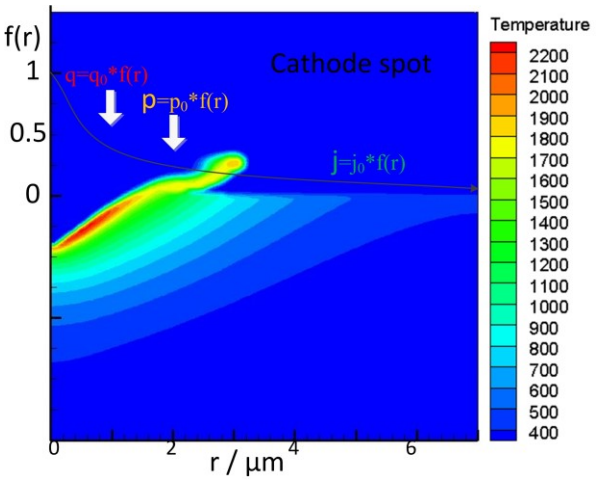

Fig.1 Model of cathode spot

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