Role of anode attachment and hydrodynamic instabilities in disturbing of thermal plasma flow

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1. Introduction

Non-transferred arc plasma torches are sources of thermal plasma flow applied in plasma spraying, synthesis of fine powders, gasification and so on. Typical plasma jets are highly fluctuating and resemble behavior of flame flow. Besides hydrodynamic instabilities the plasma jet generated by arc plasma troches has an additional source of disturbances. Hydrodynamic and magnetic interaction of plasma flow with an arc-anode attachment pushes the jet away from an anode surface. The anode attachment is often unstable itself and variation of its position leads to stochastic fluctuation of the plasma jet. This effect is difficult to distinguish from fluctuations arising from hydrodynamic instabilities. The aim of this work is to find the way to estimate influences of both effects and to compare their importance in flow disturbance.

2. Experimental procedure

The plasma torch used in the work has external anode which is situated below the plasma flow. Therefore the anode attachment was localized below the jet and its pushing effect forced the plasma flow to fluctuate in vertical plane. Analysis of the jet fluctuation in vertical and horizontal planes gives possibility to distinguish influence of the anode attachment and hydrodynamic instabilities.

The intensity of interaction between the anode attachment and the plasma jet was controlled by changes of the gap width between the anode surface and an arc boundary. Variation of the flow rate of argon, the secondary plasma forming medium in steam-argon mixture, led to change of plasma properties and resulted in variation of intensity of hydrodynamic instabilities. Plasma flow behavior for various conditions was studied.

The plasma jet was investigated by a fast shutter camera and high speed photodiodes. An analysis of time evolution of plasma radiation as well as statistical processing of jet photographs were used for characterization of the jet fluctuations. Short exposure times ensured capturing of momentary state of the plasma jet while the statistical processing showed a space distribution of plasma jet fluctuations. The statistical image processing was based on calculation of the maps of mean brightness and standard deviation of brightness.

3. Results and discussion

Besides the well known effect of the anode attachment on arc power fluctuations other processes in the anode region significantly influence structure of plasma flow. The anodic jet and magnetic interaction caused by the attachment disturbs the plasma jet and leads to intensive jet fluttering. An increase of the intensity of this interaction leads to shortening of the jet. However, at some conditions anode attachment shape becomes more stochastic. Then the plasma jet fluctuates less and visually becomes longer.

An increase of the argon flow rate results in an increase of a plasma velocity in the exit nozzle and significant shortening of a visible jet length. A frequency analysis of the jet radiation shows that fluctuation frequency increases with an addition of argon. The statistical image processing (Fig.1) demonstrates that intensity of plasma radiation fluctuations on the jet fringes is strongly increased by argon addition. It could be caused by a decrease of viscosity with an increase of argon content in hydrogen-oxygen-argon plasma.

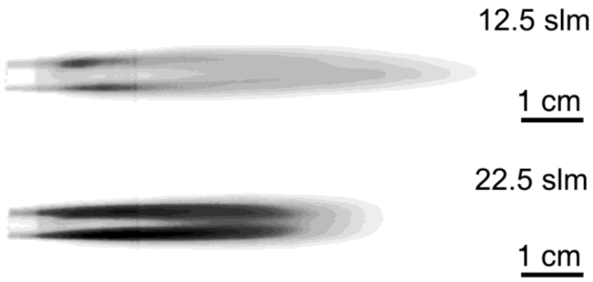

Fig.1 Structure of plasma flow at different argon flow rates (12.5 and 22.5 slm). Darker color means higher intensity of fluctuation of plasma radiation.

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