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OPTICAL EMISSION SPECTROSCOPY OF DISCHARGE PLASMA BETWEEN ASYMMETRIC Cu AND Ni ELECTRODES

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This work deals with optical emission spectroscopy studies plasma of electric arc discharge between asymmetric copper and nickel electrodes at arc current of 3.5 A in four different modes. Namely, arc discharges were initiated at different polarities and with different electrodes' position. As an initial study, the possibility of using the Ni I spectral lines to determine the plasma temperature by the Boltzmann plot technique was investigated.

Introduction

Studies of properties of electric arc discharge plasma with metal admixtures attract attention of researchers both from the point of view of scientific challenges and from numerous applied problems. As known, processes of electric arc welding and cutting, plasma surface processing and current switching in electrical devices are accompanied by intense evaporation of details' and electrodes' materials. The alternate application of electric arc discharge plasma is production of nanomaterials. All the mentioned applications require the development of diagnostic techniques, specifically, for the case of electric arc discharge plasma with admixtures of metal vapours [1].

Since composites based on two or more metals are becoming more widespread, it is advisable to study the effect of increasing the number of components of the plasma-forming gas mixture on the state of the LTE plasma of the electric arc discharge between the contacts manufactured of composite materials.

In this regard, within the frame of this work, the plasma of electric arc discharge between asymmetric pair of electrodes was investigated. As an initial study, the possibility of using the Ni I spectral lines was investigated.

Experimental setup

Since electric arc in the given configuration of the electrode arrangement can easily change its position (so-called "non-stabilized arc") in the discharge gap, it is reasonable to use method of the fast tomographic recording of plasma emission.

The optical scheme based on the MDR-12 (Čzerny-Turner) monochromator [2] was used to register the spatial distribution of spectral lines' intensities of plasma emission.

Fast scanning of spatial distributions of spectral lines' intensities was provided by a linear 3000 pixels CDD sensor Sony ILX526A (B/W). Specific feature of the given scheme is the location of CCD sensor in a sagittal focal plane of an astigmatic spectral device, which avoids the use of additional optical devices.

Results and discussion

The measurements were carried out at arc current of 3.5 A in four different modes of arc discharge between asymmetric copper and nickel electrodes. Namely, the positions of vertically-oriented electrodes as well as polarity were changed.

In the first stage of experiment, the spectra of plasma emission were registered by spectrometer Solar LS SDH-IV to identify the spectral lines of nickel. It was found, that Ni I 464.9, 478.7, 485.5, 503.5 and 547.7 nm are most sufficiently isolated, have appropriated intensity and have good difference of energy of upper levels for determination of plasma temperature.

In the next stage, the emission intensity distribution of each of these spectral lines as well as previously selected Cu I spectral lines [3] was registered by monochromator and used in Boltzmann plot technique to obtain the plasma temperature. The spectroscopic data for Ni I spectral lines was taken from National Institute of

Standards and Technology (NIST) database [4]. The results of temperature determination for each of four modes of arc operation are shown in Fig. 1 and 2.

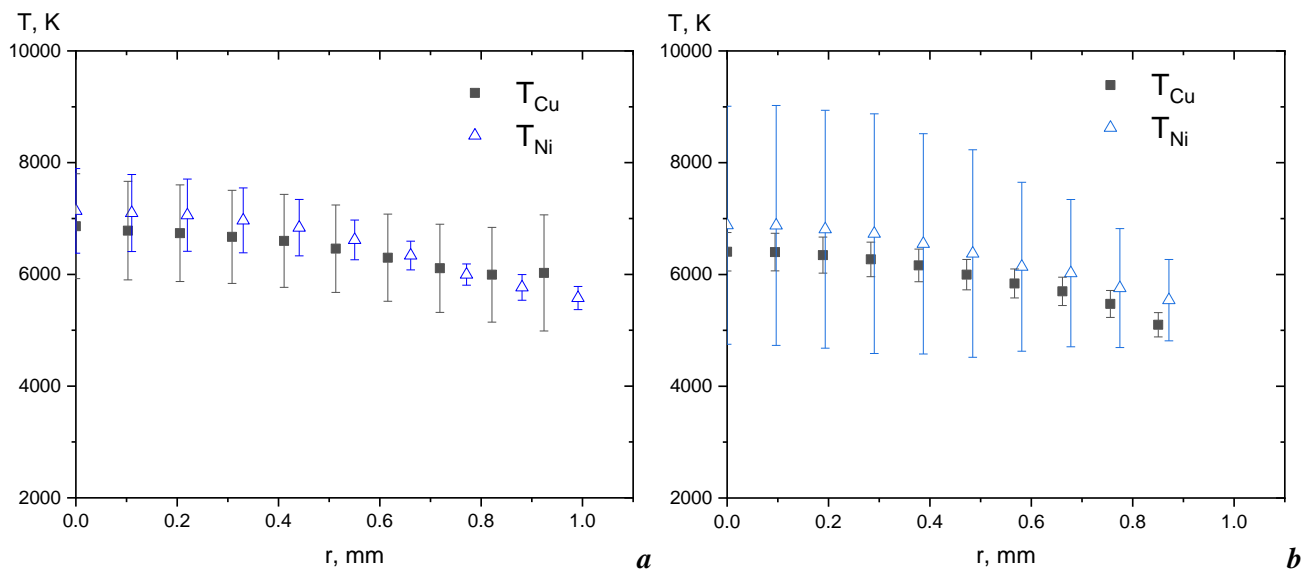


Fig. 1. Plasma temperature, obtained by Boltzmann plot technique on the basis of Cu I 465.1, 510.5, 515.3, 521.8, 570.0, 578.2, 793.3, 809.3 nm and Ni I 464.9, 478.7, 485.5, 503.5, 547.7 nm spectral lines for direct polarity: (a) copper bottom (anode); (b) copper top (anode).

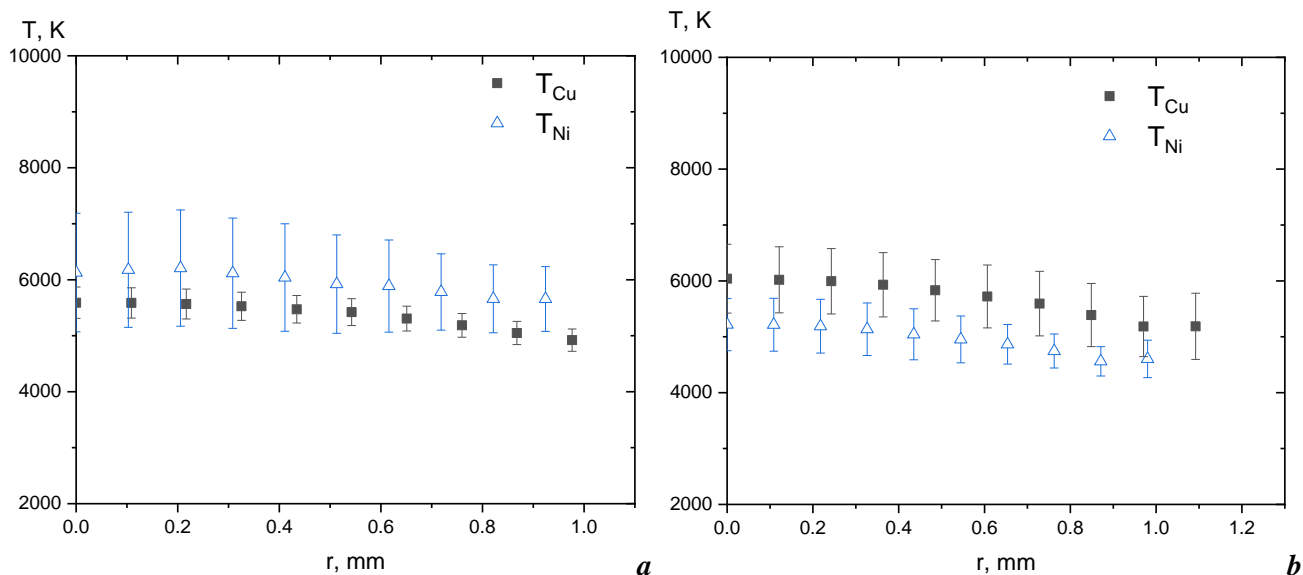


Fig. 1. Plasma temperature, obtained by Boltzmann plot technique on the basis of Cu I 465.1, 510.5, 515.3, 521.8, 570.0, 578.2, 793.3, 809.3 nm and Ni I 464.9, 478.7, 485.5, 503.5, 547.7 nm spectral lines for indirect polarity: (a) copper bottom (cathode); (b) copper top (anode).

One can see, that the temperatures, obtained from the spectral lines of copper and nickel, coincide within the measurement error. It indicates that plasma with copper and nickel vapour admixtures is in local thermodynamic equilibrium for all four modes of arc operation.

Conclusions

The plasma of electric arc discharge between asymmetric pair of electrodes was investigated in four different modes of arc operation (different polarity and electrodes' position). Boltzmann plot technique on the basis of Cu I and Ni I was used to determine the plasma temperature. It was found, that Ni I 464.9, 478.7, 485.5, 503.5 and 547.7 nm are most suitable spectral lines for determination of plasma temperature of electric arc discharge.

It was observed that the temperatures, obtained from the spectral lines of copper and nickel, coincide within the measurement error. It indicates that Boltzmann distributions of copper and nickel atoms are characterized by the same temperatures for all four modes of arc operation. It allows one to assume, that such plasma is in LTE state, which is important for future investigation of plasma of electric arc discharge between composites electrodes on nickel basis.

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