INVESTIGATIONS OF THERMAL PLASMA WITH METAL IMPURITIES.
PART II: PECULIARITIES OF SPECTROSCOPY BY WI, MoI, CuI SPECTRAL LINES

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Results of spectroscopic investigations of electric arc plasma between Cu-Mo and Cu-W composite electrodes in argon flow are presented. Technique for plasma diagnostic which allows simultaneous registration of spectral and spatial distribution of emission intensity was realized. Boltzmann plot method was applied for plasma temperature determination and analysis of MoI and WI spectral lines for purposes of plasma diagnostic.

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INTRODUCTION

Composite materials on copper base with addition of high-melting metals as molybdenum or tungsten have advanced electric and exploitation characteristics. They have applications as materials for switching devices’ contacts [1] and sliding contacts for mine slow-speed railway [2]. Arc discharges appear during operation of these devices and interact with electrodes material, so injection of electrode material into discharge gap has place. Therefore investigation of electric arc plasma between such composite electrodes can be useful for further optimization of contact materials.

Previous works [3, 4] deal with plasma-surface interaction in case of Cu-Mo and Cu-W composite electrodes. But in aforementioned works the spatial distribution of emission intensity of each spectral line registered separately step-by-step. Time dependent changing of spectral line intensities occurs in arcs between multicomponent electrodes due to irregular injection of electrode material into discharge gap. It can lead to situation when parameters of the arc are changing between registrations of different spectral lines. So, non-simultaneous registration of spectral lines can lead to inaccuracy results, especially in methods which are based on intensities comparison. Therefore, diagnostic technique for simultaneous registration of spectral and spatial distribution of emission intensity was applied.

Additionally, spectroscopic investigation of electric arc plasma between Cu-Mo and Cu-W can clarify some diagnostic problems of plasma with impurities of high-melting metals, respectively molybdenum and tungsten.

1. EXPERIMENT

1.1. EXPERIMENTAL SETUP

Diagnostic technique for simultaneous registration of spectral and spatial distribution of emission intensity was developed. Grating spectrometer and digital camera on charge-coupled device (CCD) base were used (Fig. 1).

The realized configuration of experimental setup with diffraction grating 600 g/mm permits simultaneous registration of spatial intensity distribution in spectral range 400…660 nm.

Fig. 1. Optical scheme of developed experimental setup
1.2. EXPERIMENTAL CONDITIONS

The arc was ignited in argon flow 6.4 slpm between the end surfaces of the non-cooled electrodes. The discharge gap was 8 mm, and the arc current was 3.5 A.

Cu-Mo composite electrodes fabricated by electron beam evaporation and following condensation in vacuum were used. These electrodes have layered structure, content of molybdenum changes from layer to layer in range 1...20 %; average content of molybdenum was 12 %.

Cu-W composite electrodes were fabricated by copper infiltration of the high-melting component. Ratio of copper and tungsten content in these electrodes was 50:50 % (by mass).

If plasma is in local thermodynamic equilibrium, then tilt angles of Boltzmann plot lines corresponding to each spectroscopic plasma components must be the same. This tilt appropriates to the excitation temperature of thermal plasma. Thereby, solid lines in Fig. 4,a,b and Fig. 5,a,b were traced through the points appropriate to copper spectral lines. Dashed lines with the same tilt angle were traced through the points appropriate to molybdenum or tungsten spectral lines.

One can see that proposed MoI spectral lines can be used for plasma diagnostic in realized conditions. Obtained temperature profiles for Cu-Mo electrodes are shown in Fig. 4,c.

In case of Cu-W electrodes WI spectral lines 488.6, 498.2, 500.6, 501.5, 505.3 nm, in our opinion, are acceptable for plasma diagnostic in realized conditions.

2. RESULTS AND DISCUSSIONS

Spectra of middle cross-section of arc between Cu-Mo and Cu-W electrodes are shown in Figs. 2 and 3, respectively. One can see that limited number of spectral lines is available for plasma diagnostic.

It is necessary to define applicable spectral lines and their spectroscopic data in the first stage of diagnostic. The selection of copper atomic spectral lines and analysis of their spectroscopic data was previously carried out in [6]. So CuI lines 510.5, 515.3, 521.8, 570.0 and 578.2 nm were used in present work.

Useful molybdenum atomic spectral lines 473.1, 476.0, 550.6, 553.3, 557.0, 603.6 nm were selected; these lines are bright enough for registration in present experimental conditions.

In case of Cu-W electrodes tungsten atomic spectral lines 429.4, 430.2, 468.0, 475.7, 484.3, 488.6, 498.2, 500.6, 501.5, 505.3, 522.4 and 551.4 were previously selected.

Obtained temperature profiles for Cu-Mo electrodes are shown in Fig. 5, c.

It must be noted, that mentioned tungsten spectral lines can be affected by self-absorption due to their relatively low excitation energies. It can play an important role in a case of significant power input into discharge.

CONCLUSIONS

The developed spectroscopic technique provides temperature measurements of electric arc plasma between Cu-Mo and Cu-W composite electrodes in argon flow. With the aim of application for plasma diagnostic the Boltzmann plot method was used in determinations of plasma temperatures and selections of MoI and WI spectral lines as well.
ИССЛЕДОВАНИЯ ТЕРМИЧЕСКОЙ ПЛАЗМЫ С ПРИМЕСЯМИ МЕТАЛЛОВ. ЧАСТЬ II: ОСОБЕННОСТИ СПЕКТРОСКОПИИ С ИСПОЛЬЗОВАНИЕМ СПЕКТРАЛЬНЫХ ЛИНИЙ

WI, MoI, CuI

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Представлены результаты спектроскопических исследований плазмы электрической дуги между Cu-Mo и Cu-W композитными электродами в потоке аргона. Реализована методика диагностики плазмы, которая позволяет одновременную регистрацию спектрального и пространственного распределения интенсивности излучения. Для определения температуры плазмы, а также анализа и селекции спектральных линий MoI и WI, использован метод диаграмм Больцмана.

ДОСЛЯЖДЕНІЯ ТЕРМІЧНОЇ ПЛАЗМИ З ДОМІШКАМИ МЕТАЛІВ. ЧАСТЬ II: ОСОБЛІВОСТІ СПЕКТРОСКОПІЇ З ВИКОРИСТАННЯМ СПЕКТРАЛЬНИХ ЛІНІЙ WI, MoI, CuI

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Представлено результати спектроскопічних досліджень плазми електричної дуги між Cu-Mo та Cu-W композитними електродами в потоці аргона. Реалізовано методику діагностики плазми, яка дозволяє одночасну реєстрацію спектрального та просторового розподілів інтенсивності випромінювання. Для визначення температури плазми, а також аналізу та селекції спектральних ліній MoI і WI, застосовано метод діаграм Больцмана.

REFERENCES

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