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NON-MONOTONY OF THE VOLT-AMPERE CHARACTERISTICS OF THE ARC DISCHARGE CAUSED BY EFFECTS OF HEAT CONDUCTIVITY

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Abstract

The interrelation of electrical and thermophysical properties of the electric arc plasma in air with an admixture of vapors of electrode materials at the local level are analyzed in this paper. The numerical solution of the Elenbaas-Heller energy equation for the arc channel is the basis for this consideration. The detailed functional temperature dependences for the electrical and thermal conductivity coefficients of this plasma, which are included in this equation, are convenient for practical applications. As the electrical conductivity coefficient is sensitive to the vapor content of the electrode material, their relationship is established also. It is shown that due to the nonmonotonicity of the dependence of the coefficient of thermal conductivity on

temperature, in turn, the nonmonotonicity of the dependence of the electric field in the arc discharge from the current may arise. The results of numerical simulation are compared with the experimental data. References 18, figures 5, table 1.

Key words: electric arc, Elenbaas-Heller equation, volt-ampere characteristic, copper-air plasma, coefficients of heat and electric conductivity.

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References

1. Sidorets V.N., Pentegov I.V. Deterministic chaos in nonlinear circuits with an electric arc. Kiev: Mezhdunarodnaia Assotsiatsiia Svarka, 2013. 272 p. (Rus)
2. Finkelburg V., Meker G. Electric arcs and thermal plasma. Moskva: Izdatelstvo Inostrannoi Literatury, 1961. 370 p. (Rus)
3. Asinovsky E.I., Kirillin A.V., Nizovsky V.L. Stabilized electric arcs and their application in a thermophysical experiment. Moskva: Fizmatlit, 2008. 264 p. (Rus)
4. Babich I.L., Veklich A.N., Zhovtyansky V.A. Investigation of the role of self-absorption of radiation in free-burning arcs in copper vapor by laser diagnostics. *Zhurnal Prikladnoi Spektroskopii*. 1989. Vol. 51. No 4. Pp. 571-575. (Rus)
5. Raiser Yu.P. Physics of gas discharge. Dolgoprudnyi: Intellect, 2009. 736. 592 p. (Rus)
6. Zhovtyansky V.A. Plasma chemical effects and some basic problems of gas discharge physics. *Ukrainskyi Fizychnyi Zhurnal*. 2008. Vol. 53. No 5. Pp. 488-494. (Ukr)
7. Bezpalij O.O., Fesenko S.O., Semenyshyn R.V., Veklich A.N. Investigation of electric arc discharge between composite electrodes. *XIVth International Young Scientists' Conference on*

Applied Physics

. Ukraine, 11-14 June 2014.

Pp. 163–164.

8. Aubrecht V., Bartlova M., Coufal O. Radiative emission from air thermal plasmas with vapour of Cu or W. *Journal of Physics. D: Applied Physics*. 2010. Vol. 43. 19 p.

9. Zhovtyansky V.A. Physical Properties of a Dense Low-Temperature Inhomogeneous Plasma: Dr. Phys.-Math. Sci. Diss.: 01.04.08. Taras Shevchenko Kiev University. Kiev. 1999. 300 p. (Rus)

10. Physical processes in welding and material processing. Theoretical study, mathematical modeling, computational experiment. Kiev: DIA, 2018. 642 p. (Rus)

11. Zhovtyansky V., Valincius V. Efficiency of Plasma Gasification Technologies for Hazardous Waste Treatment. *Gasification for Low-grade Feedstock*. London: InTechOpen, 2018. Pp. 165–189. Available from: <http://mts.intechopen.com/articles/show/title/efficiency-of-plasma-gasification-technologies-for-hazardous-waste-treatment>

12. Bose T.R., Seeniraj R.V. Two-temperature Elenbaas-Heller problem with argon plasma. *Plasma Physics and Controlled Fusion*. 1984. Vol. 26. No 10. Pp. 1163-1176.

13. Zhovtyansky V.A., Lelyukh Yu.I., Tkachenko Ya.V. Nonequilibrium of the dense nonuniform plasma due to radiation transfer. Proc. *XIX International Conference on Gas Discharges and their Applications*. Beijing, 2-7 September 2012. Pp. 40-47.

14. Ouajji H., Cheminat B., Andanson P. Composition and conductivity of a copper-air plasma. *Journal of Physics. D: Applied Physics*. 1986. Vol. 19. Pp. 1903-1916.

15. Gleizes A., Cressault Y. Teulet Ph. Mixing rules for thermal plasma properties in mixtures of argon, air and metallic vapours. *Plasma Sources Science and Technology*. 2010. Vol. 19. No 5. 055013.

16. Zhovtyansky V.A., Petrov S.V., Kolesnikova E.P., Lelyukh I.I., Tkachenko Ya.V., Poritsky P.V., Goncharuk Yu.A., Yakimovich M.V. Development of plasma electric arc technologies and methods for their modeling. Proceedings of the VIII *International Symposium Combustion and Plasma Chemistry and the Scientific and Technical Conference Energy Efficiency* 2015. Almaty, Kazakhstan, September 16–18, 2015. Pp. 323–326. (Rus)

17. Kagone A.K., Koalaga Z., Zougmore F. Calculation of air-water vapor mixtures thermal plasmas transport coefficients. Proc. *IOP Conference Series. Materials Science and Engineering*. 2004. Vol. 29. 012004. 15 p.

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