C1-O-950301

A HIGH-VOLTAGE AC PLASMA TORCH: COMPUTATIONAL STUDY*

A.V. SUROV[1], *N.V. OBRAZTSOV*[2,1], *A.A HVATOV*[1], *M.A. MASLYAEV*[1], *N.Y. BYKOV*[1]

[1] *ITMO University, Saint-Petersburg, Russian Federation*
[2] *Peter the Great St. Petersburg Polytechnic University, Saint-Petersburg, Russian Federation*

In modern technologies, the function of a plasma torch is not limited to increasing the enthalpy of the working gas for its subsequent use in a plasma-chemical reactor. When using multi-species gaseous mixture, chemical reactions occur in electric discharge chambers and in the jet. The processes occurring in electric arc systems are non-stationary even when DC is used [1]. In AC devices [2] this is further enhanced by a periodically changing release of energy. The design features of plasma generators significantly complicate the diagnosis of physical parameters. Comprehensive research involves the use of computer simulation and validation based on available experimental data.

Significant differences in the shapes of arc column in the channels and outside for high voltage plasma torch with rod electrodes were noted in [3]. To study processes in powerful plasma torch with hollow electrodes [4] shown in Fig.1, it is also important to consider the processes in the vicinity of electrodes.

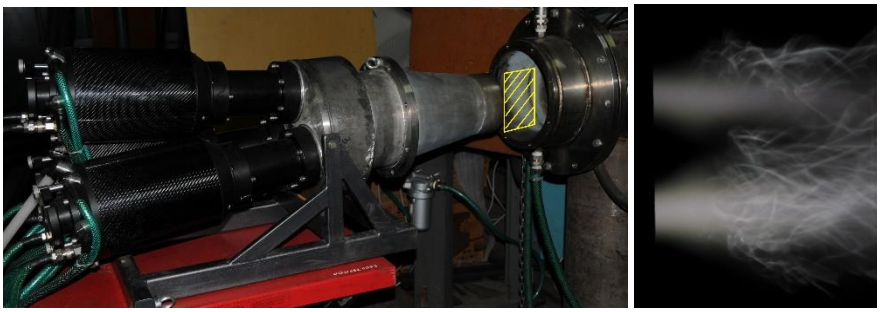

Fig.1. Photo of a powerful high-voltage plasma torch by IEE RAS (left) and arc columns at the outlet of the channels (right). The arc shooting area in the photo of the plasma torch is marked in yellow.

Computation of time-dependent flow for simplified linear axial configuration of the arc without considering near-electrode processes using a supercomputer takes several days. To reduce the complexity and resource for the more complicated case, an approach is proposed that involves the hybrid computational model. In it, the movement of the electric arc spot is described by a differential equation, restored by the generative design method [5] from experimental data. Data on the movement of an electric arc for various conditions were obtained in the laboratories of the IEE RAS. The arc spot motion equation complements the non-stationary 3-D model of the gas flow in the channels and in the jet of the plasma torch. The results of applying the hybrid modelling approach to solving a non-stationary problem describing the operation of a high-voltage plasma torch are presented in the report.

REFERENCES

[1] J.Mostaghimi, M.I.Boulos, “Thermal Plasma Sources: How Well are They Adopted to Process Needs?”, Plasma Chem. Plasma Process. 35, 421–436, 2015. https://doi.org/10.1007/s11090-015-9616-y.

[2] L.Fulcheri, F. Fabry, S. Takali, V. Rohani, “Three-Phase AC Arc Plasma Systems: A Review”, Plasma Chem. Plasma Process. 35, 565–585 2015. https://doi.org/10.1007/s11090-015-9619-8.

[3] A.V. Surov, S.D.Popov, V.E.Popov, D.I.Subbotin, E.O.Serba, V.A.Spodobin, Gh.V.Nakonechny, A.V.Pavlov, “Multi-gas AC plasma torches for gasification of organic substances”, Fuel, vol. 203, pp. 1007-1014, 2017.

[4] P.G. Rutberg, G. V. Nakonechny, A. V. Pavlov, S.D. Popov, E.O. Serba, A. V. Surov, “AC plasma torch with a H2O/CO2/ CH4 mix as the working gas for methane reforming”, J. Phys. D. Appl. Phys. 48, (2015).

[5] M. Maslyaev, A. Hvatov, A. V. Kalyuzhnaya, Partial differential equations discovery with EPDE framework: application for real and synthetic data, J. Comp. Sci., 101345, 2021.

* This research is financially supported by The Russian Science Foundation, Agreement No. 21-11-00296, https://rscf.ru/en/project/21-11-00296/.
The authors thank the Institute for Electrophysics and Electric Power of Russian Academy of Sciences (IEE RAS, St. Petersburg) and partially Peter the Great St. Petersburg Polytechnic University for the data provided.