Modeling a DC Plasma Torch with COMSOL Multiphysics® Software

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Abstract

Plasma torches are used in processing of materials and in energy industry for producing plasma. In a non-transferred arc plasma torch, an electric arc can be glowed by applying a direct current (DC) between the cathode and anode, both placed inside the torch. Then, the plasma (Fig. 1) is obtained by heating, ionizing and expanding a working gas, introduced into the chamber of the torch upstream of the cathode. Under hypothesis of local thermodynamic equilibrium (LTE), the electrons and heavy particles temperatures are approximately equal and the plasma can be modeled by using the magnetohydrodynamics equations.

In this work we use COMSOL Muliphysics® software, specifically the Equilibrium Discharge multiphysics interface of the Plasma Module, to model a DC non-trasferred arc plasma torch (Fig. 2). The equations of conservation of fluid mechanics, heat transfer and electromagnetics are implemented by using the appropriate Modules and the multiphysics couplings options available in COMSOL Multiphysics. In the model the plasma is considered optically thin and a net emission coefficient is used for the heat transferred through radiation mechanisms. Steady state regimes of both laminar and turbulent flows with swirl have been simulated for an axisymmetrical plasma torch with argon as working gas. In COMSOL, to set appropriate conditions of swirling flow at the inlet of the torch, different combinations of free and forced flow have been used. The computational results have been then compared with experimental results of literature, showing that the temperature and velocity patterns of the plasma in the torch have been reproduced satisfactorily. Finally, the analysis of the numerical data has allowed us to obtain fundamental understandings of the arc plasma physics and to optimize the design of a laboratory plasma torch.

Reference

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5. COMSOL Multiphysics AC/DC Module User's Guide, Version 5.1, COMSOL AB (2015).

6. COMSOL Multiphysics Heat Transer Module User's Guide, Version 5.1, COMSOL AB (2015).

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Figures used in the abstract

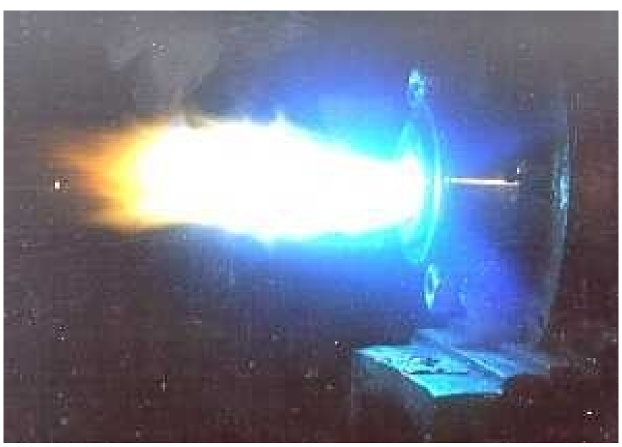

Figure 1: Plasma plume exiting the torch.

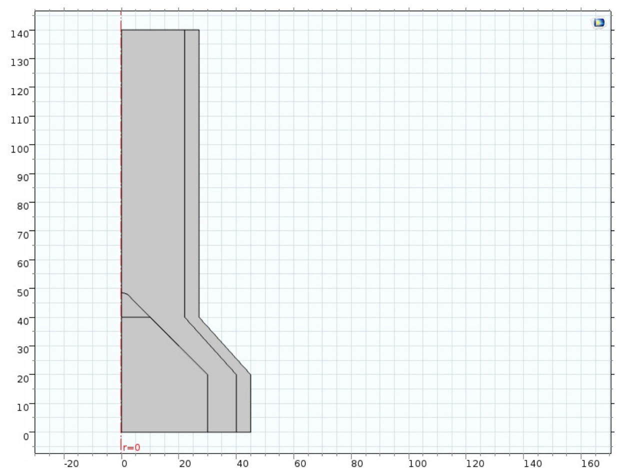

Figure 2: Axisymmetric geometry of the plasma torch.

Figure 3

Figure 4