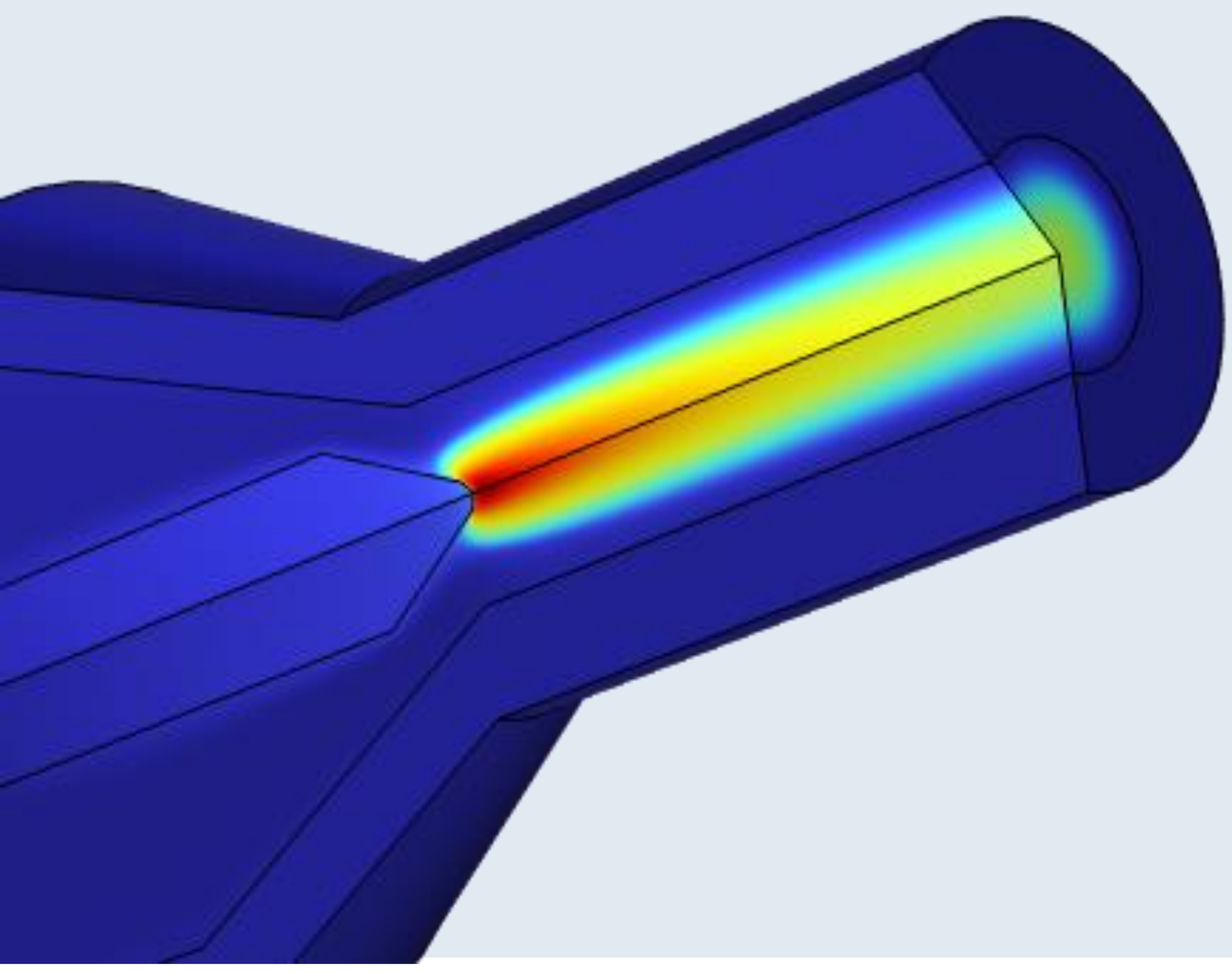

Thermal Plasma Modeling Using COMSOL Equilibrium Discharges Interface

Study the influence of the radiative transfer and the arc-electrode interactions after modeling different thermal plasma systems : free-burning arc, non-transferred torch to finish with arc-tracking.

A. Truilhé, Y. Cressault, F. Valensi

LAPLACE, Université de Toulouse, CNRS, INPT, UPS, Toulouse, France

Introduction & Goals

Thermal plasmas are fundamental in processing of materials and in energy industry, especially for welding, cutting, deposition by projection or in analysis. However, this type of plasma is not always desired: a short circuit can cause an electric arc which generally manifests itself in the form of a high current discharge. Particularly in the aeronautical field, when this problem occurs between two cables of an electrical network, there is a risk that the arc will remain for a few tens to a few hundred milliseconds and will propagate along the cables: we call this “arc-tracking”. To model this thermal plasma, we used the Equilibrium Discharges interface of the COMSOL® Plasma Module, firstly learning how to manipulate the software with the case of a free burning arc, then with a non-transferred plasma torch. Now, the aim is to develop a model for an arc-tracking geometry to study the influence of the different radiative transfer calculation methods : the Net Emission Coefficient, the P1 approximation, the Rosseland approximation or the Discrete Ordinates Method.

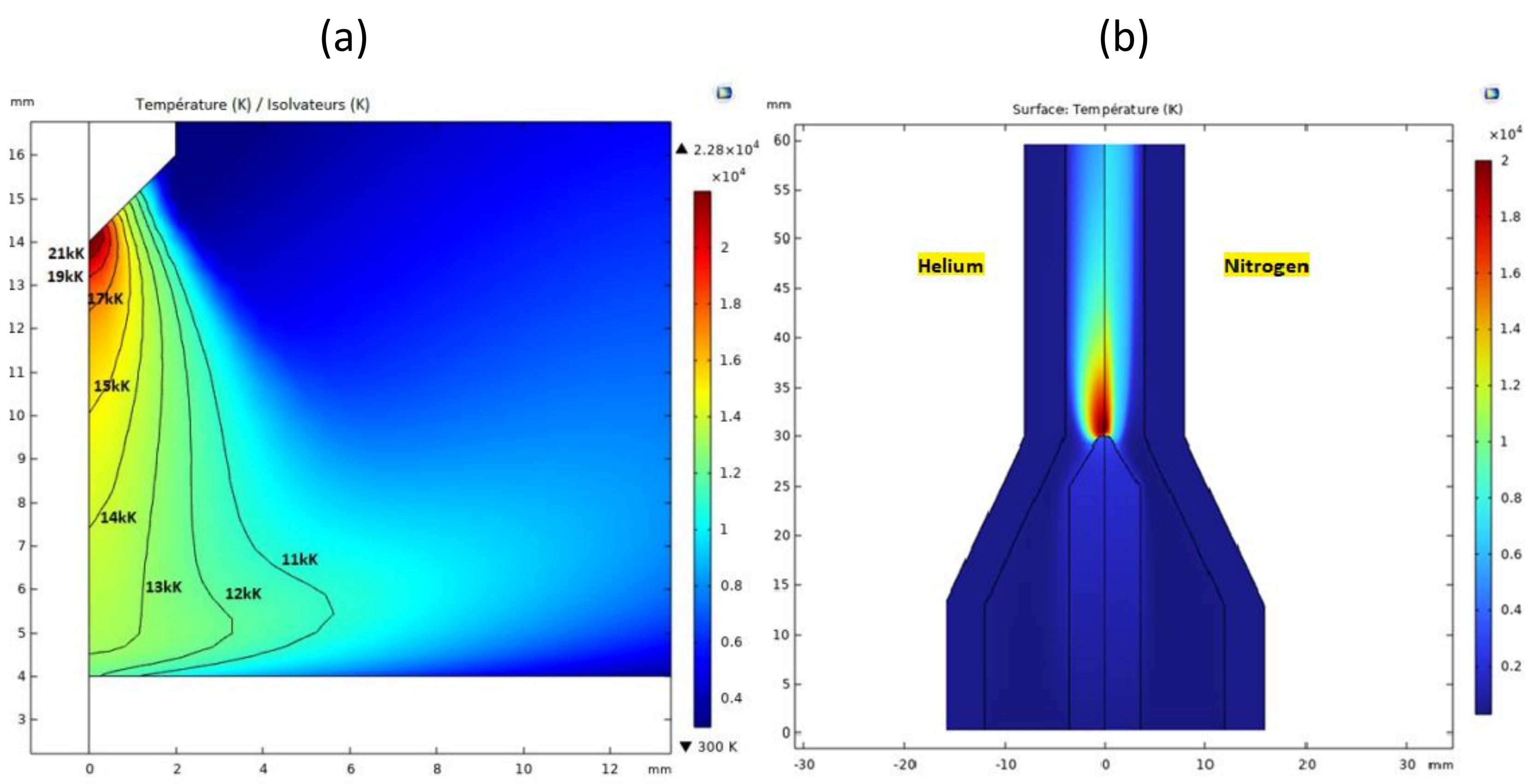

FIGURE 1: Temperature profile of a 200 A free-burning arc in argon (a) / Impact of the gas nature inside a plasma torch (b)

Methodology

To obtain these two models, we used the Plasma Module to work with several coupled phenomena due to the interaction between electric, magnetic, thermal and fluid flow fields with highly nonlinear plasma flow, presence of strong gradients and chemical / thermodynamic non-equilibrium effects. The plasma was modeled by using the MHD equations: we solved the system by imposing some initial values and boundary conditions depending on the geometry of the study (temperatures, current densities, velocities, flux,…). After that, we validated our models by comparing with the literature [1][2] (models or experiences) and then we modified some parameters in order to evaluate their impact on the temperature of the plasma in the system (Figure 1-b)

Results

Using the knowledge of the two previous studies, we build a new geometry of two cables of 2.75 mm of diameter in copper facing each other. Adding some boundary conditions (Figure 2-a) in temperatures, flux and current densities, we obtained first results in temperature between and around the two cables. From there, we evaluated the impact of different parameters and noticed that the temperature imposed on the cathode rounded tip is very important.

Validate this step by comparing with the literature or with an experimental study will allow us to move on to the next one: we now want to implement different methods to consider radiative transfer in our plasma !

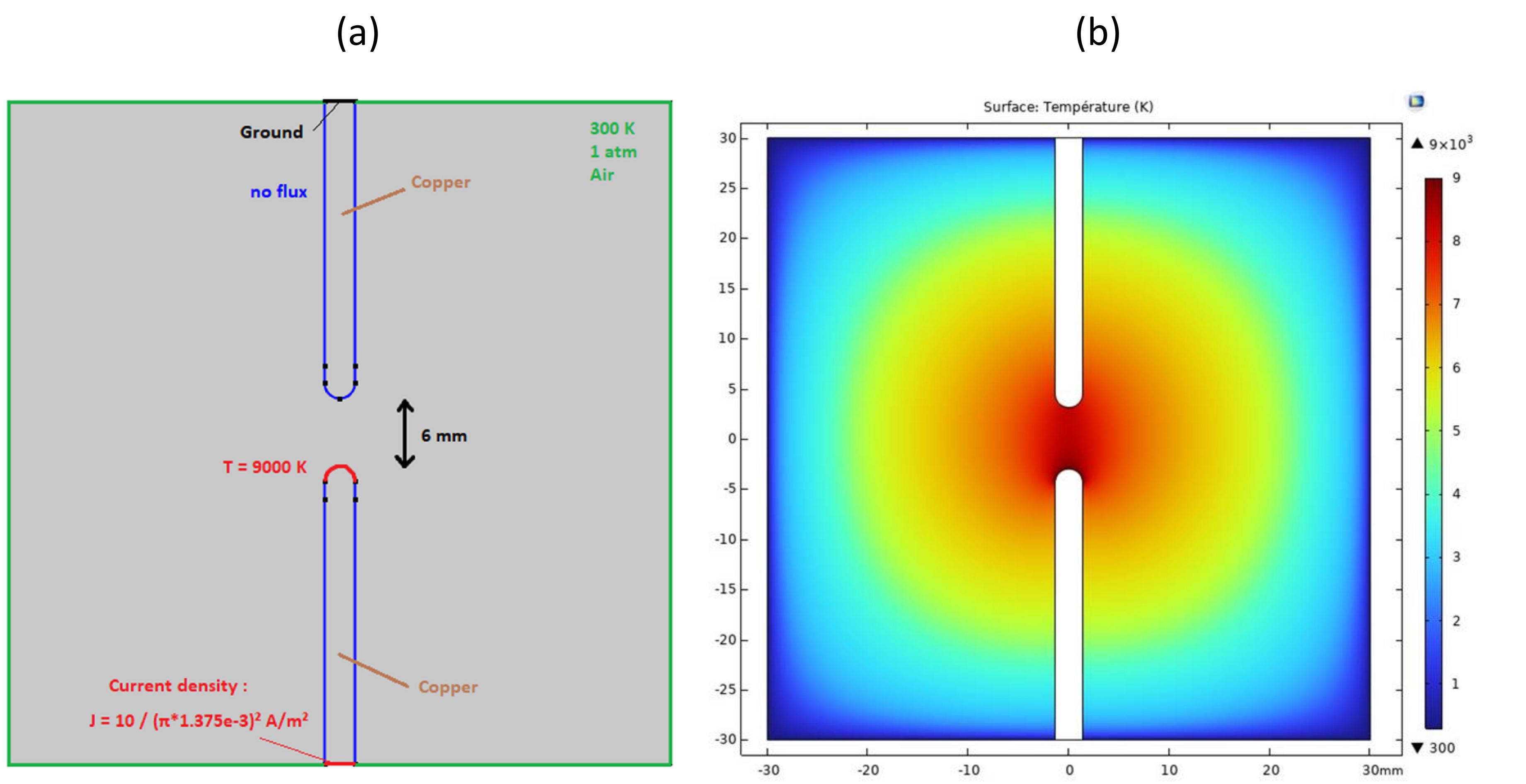

FIGURE 2: Boundary conditions (a) and first results of the plasma temperature between the two cables (b)

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