# Fluid Dynamics Analysis of Gas Stream in a Plasma Torch Reactor

Natan Padoin[1], Felipe A. Cassini[1], Mauricio Sanchez[2], Cíntia Soares[1]
1. Federal University of Santa Catarina, Florianópolis, SC, Brazil;
2. University of Oklahoma, Norman, OK, USA.

**Introduction**: Plasma technology has shown potential application in several areas. The knowledge about the fluid behavior in such systems has a central role, since the stability of the flow in the region of the electrical arc is essential for the development of a well-behaved torch. In this work, the fluid flow in a three-dimensional plasma torch reactor was investigated, aiming to the optimization of the device.

**Computational Method**: The computational domain is presented in Fig. 1:

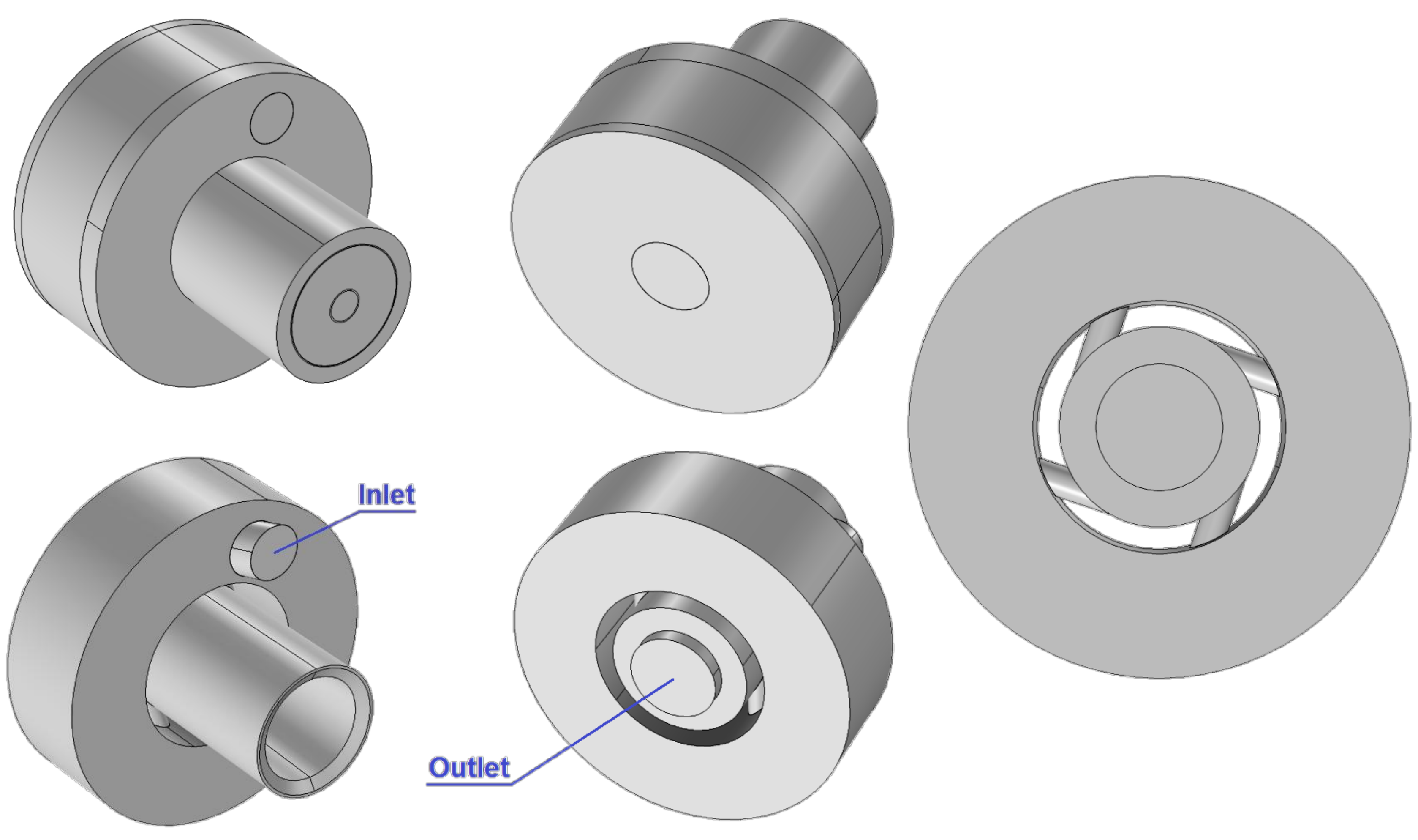


**Figure 1.** . Computational domain.

The simulations were carried out with COMSOL Multiphysics®, through the CFD Module. In particular, the steady-state Navier-Stokes equations were solved:

$$-\nabla\cdot\eta\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^T\right)+\rho(\mathbf{u}\cdot\nabla)\mathbf{u}+\nabla p=0$$

$$\nabla\cdot\mathbf{u}=0$$

Nitrogen was used as working fluid. Reynolds-Averaged Navier-Stokes (RANS) equations were employed to describe the turbulence in this process, through k-ε model. A nozzle placed on the bottom of the pre-chamber fed the gas stream, with different velocities, ranging from 10 m/s to 50 m/s.

**Results**: Figs. 2-4 indicate that the flow was equally distributed among the four constrictions. Furthermore, a stabilized rotational upward flow with high velocity was observed in the region of the electrical discharge, indicating the development of a viable torch.

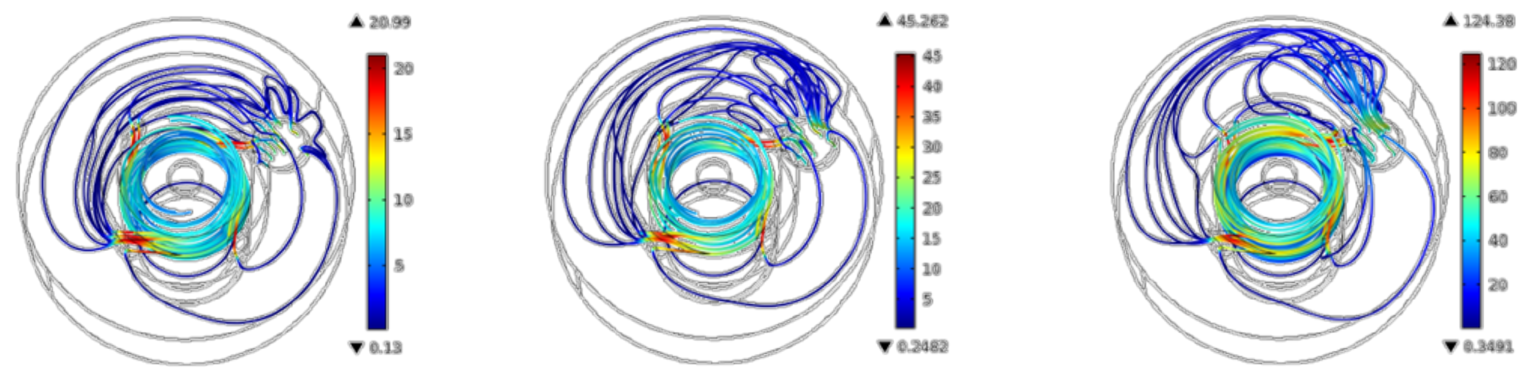

**Figure 2.** Stable vortex at the outlet of the model.

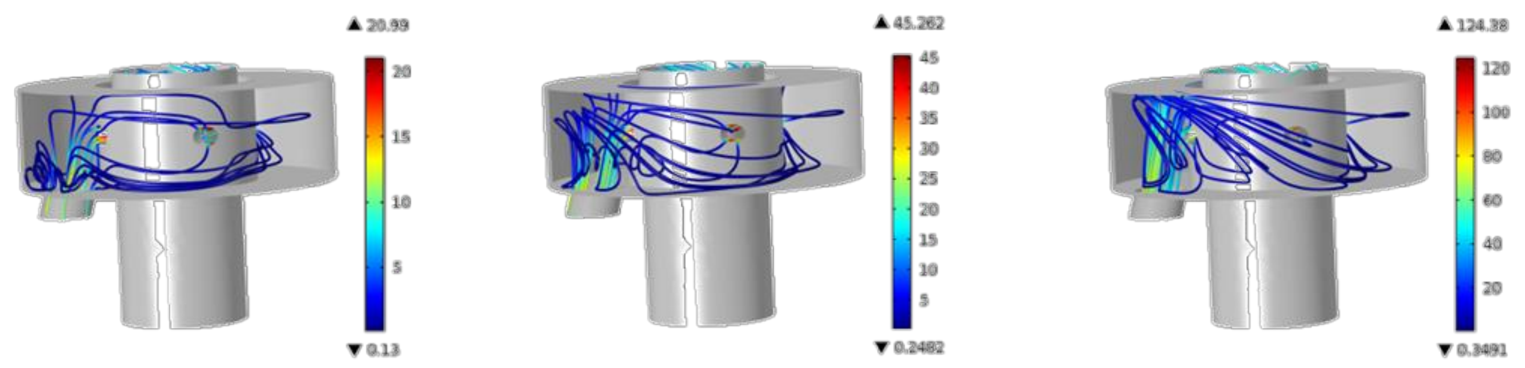

**Figure 3.** Streamlines for inlet v of 10, 20 and 50 m/s.

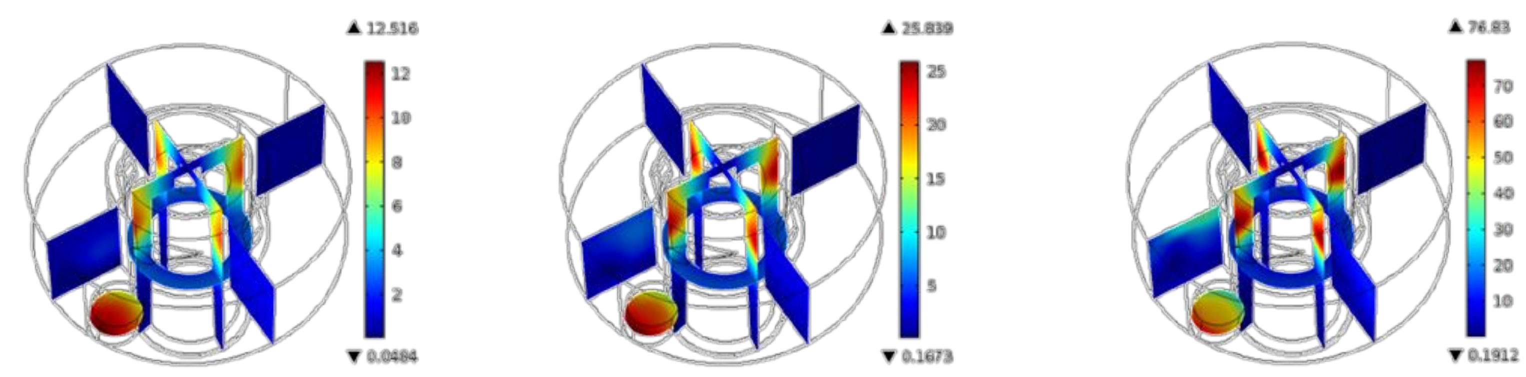

**Figure 4.** Slices indicating the v profile inside the model.

**Conclusions**: COMSOL Multiphysics can be successfully applied to the numerical simulation of fluid flow in plasma reactors, allowing for optimized designs and cost reductions during project development.

**References**:

1. Edward Koretzky, Spencer P. Kuo, Simulation study of a capacitively coupled plasma torch array, IEEE Transactions on Plasma Science, 29, 5 p. (2001).
2. Spencer P. Kuo et al., Methods and apparatus for generating a plasma torch, Int. Cl. B23K 9/00, US 6,329,628 B1, Dec. 10 1999, Dec. 11 2001.

Excerpt from the Proceedings of the 2014 COMSOL Conference in Curitiba

COMSOL CONFERENCE 2014 CURITIBA