

---

# Effect of an external magnetic field on a DC plasma spray torch with a cascaded anode

Rodion Zhukovskii\* , Christophe Chazelas<sup>1</sup>, Armelle Vardelle<sup>2</sup>, and Vincent Rat<sup>3</sup>

<sup>1</sup>IRCER CNRS UMR 7315 University of Limoges (IRCER) – Université de Limoges – 16, rue Atlantis  
87068 Limoges Cedex, France

<sup>2</sup>IRCER, CNRS UMR 7315, University of Limoges (IRCER) – University of Limoges – France

<sup>3</sup>IRCER, CNRS UMR 7315, University of Limoges (IRCER) – University of Limoges, Limoges – France

## Résumé

Plasma spraying is a well-established surface engineering technology used in all industrial fields, in particular aeronautics, industrial gas turbines and automotive. However, the basic tool of the process, a non-transferred arc plasma torch, still has two main drawbacks: plasma jet instabilities and electrode erosion. Torch manufacturers are trying to overcome them by using high arc voltage rather than high current (roughly, the anode erosion is proportional to the square of the arc current), fixing the mean arc length and using some modifications (e.g., swirling injection of the plasma-forming gas) to rotate the anode arc attachment in a plane orthogonal to the torch axis.

For example, the SimplexPro™ plasma torch of Oerlikon Metco uses a large rounded cathode (12.7-mm in diameter), an insert between cathode and anode to fix the arc length longer than the self-setting arc length and a vortex injection of the plasma gas. The arc voltage can reach about 100 V with a mean fluctuation in the order of 5-20 % but observations of the anode surface and calculations have shown that the arc attachment is displaced along a line on the anode wall and may cause rapid erosion. Since the vortex injection is not strong enough to act on the anode arc attachment, another well-known tool is the use of an axial magnetic field. The SimplexPro™ plasma torch involves a stack of copper rings insulated from each other and ending with an anode-ring on which the arc attaches. However, the stability of the plasma jet issuing from the torch when the external magnetic field is imposed on this last ring has been questioned.

This study attempts to answer this question using a 3-D, time-dependent MHD model of the plasma torch operation that couples the gas phase and electrodes. The self-magnetic field reaches a maximum value of 0.055 T for an arc current of 500 A and a gas flow rate of 60-slm Argon. The external magnetic field was imposed, through the Lorentz force in the momentum equation, inside the anode ring with values ranging between 0.05 and 0.2 T and outside the anode with a smooth linear transition to zero. The reattachment of the arc at the anode wall was modeled by using the model proposed by Nemchinsky that assumes the electron temperature in the cold boundary layer next to the anode wall, does not decrease as much as the heavy particle temperature and, so, some residual electrical conductivity subsists in this layer.

---

\*Intervenant