Electromagnetic processing from AC to DC field and multiphysics modeling: a way for process innovation

M. Dumont1, R. Ernst2,3, Y. Fautrelle2,3, J. Etay2,3

1 Emdpi solutions, JAM, France – michael.dumont@emdpisolutions.com
2 Univ. Grenoble Alpes, SIMAP, 3 CNRS, SIMAP, F-38000 Grenoble, France

Introduction: Comsol Multiphysics is a useful modeling tool for the development of innovative EM processes from AC to DC field. Three examples are considered: (1) Cold crucible, (2) EM pump, (3) DC magnet. Application fields are respectively aeronautic, nuclear and automotive.

Computational Methods: MHD applications involve modeling Maxwell's and fluid flow equations with free surface motion.

Coupling example – EM pump case:

1- Electromagnetic: space harmonic (j o c r - o e i c r ) A + V x ( j 0 - i j ) = J e

2- Fluid mechanics: transient

3- Free surface: ALE formulation + surface tension

Results: 1- Cold crucible with improved energetic efficiency was defined and designed. A better levitation gives the opportunity to increase overheating of the melt: key parameter for investment casting.

2- Magnetohydrodynamics (MHD) effects resulting from a strong coupling between fluid flow and EM is evaluated in a large annular linear pump for nuclear applications with high flow rate of sodium (up to 4 m³/s). Significant ends effects are observed for large velocities with entrainment of magnetic field. Hartman effect leads to an explosion of the electric current and the corresponding forces near the wall.

3- Control of zinc coating thickness for hot-dip coating with DC magnetic field thanks to EM braking effect was demonstrate and seems very promising to increase strip velocity of the galvanizing lines.

Conclusions: Better understandings of each configuration thanks to a multiphysics modeling approach allows us to optimize design for industrial needs and to figure out more complex EM system.


2. C. Roman, M. Dumont, S. Letout, C. Courtesse, S. Vitry, F. Rey, Y. Fautrelle, HES 2013, Padova, Italy