Development of an AUTODESK CFD-Based 3D Model of a Hall-Héroult Cell Hooding System and HF Capture Efficiency

Marc Dupuis[1], Michaël Pagé[2] and Frédéric Julien[3]
1. Consultant, GeniSim Inc, Jonquière, Canada
2. Owner associate, Simu-K inc, St-Nazaire-Du-Lac-St-Jean, Canada
3. Business Development Manager, Estampage JPL Ltd, Trois-Rivières, Canada
Corresponding author: marc.dupuis@genisim.com

Abstract

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A full 3D model of a section of a Hall-Héroult anode cover and hooding system was developed using the code AUTODESK CFD. The model solves the thermo-electric behavior of the anode, the radiation between the solid surfaces in the model and the air flow inside and outside the cell hooding system. In addition of the heat dissipated by the anode panel, the model takes into account the production or evolution of hot CO, CO_2 and HF by the cell and the combustion of the CO at the surface of the crust as source of heat. The model directly solves for the concentration of HF in the gas, so the cell hooding HF capture efficiency is directly predicted by the model taking into account all the physics involved.

Keywords: Cell hooding efficiency, CFD model of cell hooding, HF capture, HF emission

1. Introduction

The cell hooding design and the HF capture efficiency are important aspects of a cell design. This is true today but it will become even more important in the future as in addition to the aim of maintaining a very high HF capture efficiency, the desire to further reduce the environmental impact of the Hall-Héroult process will lead to cell designs dissipating less and less heat through the anode panel. This could be done by increasing the gas temperature under the hood and using the heat of the exhaust gas to produce electricity and even by capturing the cell CO_2 emission. In order to achieve those objectives, the exhaust gas suction rate will need to be significantly decreased in order to increase the average gas temperature under hood and increase the CO_2 concentration in the exhaust gas while maintaining a very high HF capture efficiency. This in turn translates into the need to design a very tight superstructure and hooding panels system and hence the need to design hooding panels that will resist higher gas temperature under the hood without mechanically weakening or deforming them too much and limit the heat loss through them.

In order to be able to predict the cell hooding HF capture efficiency and hooding panels operating conditions under a wide range of cell operating conditions like cell amperage, anode cover thickness and especially hooding design and exhaust gas sucking rate, a full 3D model of a section of a Hall-Héroult anode panel and hooding system was developed using the code AUTODESK CFD.

2. AUTODESK CFD Full 3D Model of a Section of a Hall-Héroult Anode Panel and Hooding System

The full model will include both the 3D thermo-electric model of the anode, the 3D CFD model of the gas under the hood and outside in the potroom and the solid surface to solid surface radiation exchange model. As a first step, the 3D thermo-electric model of the anode was developed in order to reproduce using AUTODESK CFD the ANSYS based 3D thermo-electric model previously published [1].

2.1. AUTODESK CFD 3D Thermo-electric Model of the Anode

The model developed in this work is only a demonstration model so it is not reproducing any commercially available cell design. The anode geometry is the same geometry as the previously published ANSYS based demonstration 3D thermo-electric model, itself inspired from the VAW 300 cell design published in 1994 [2].

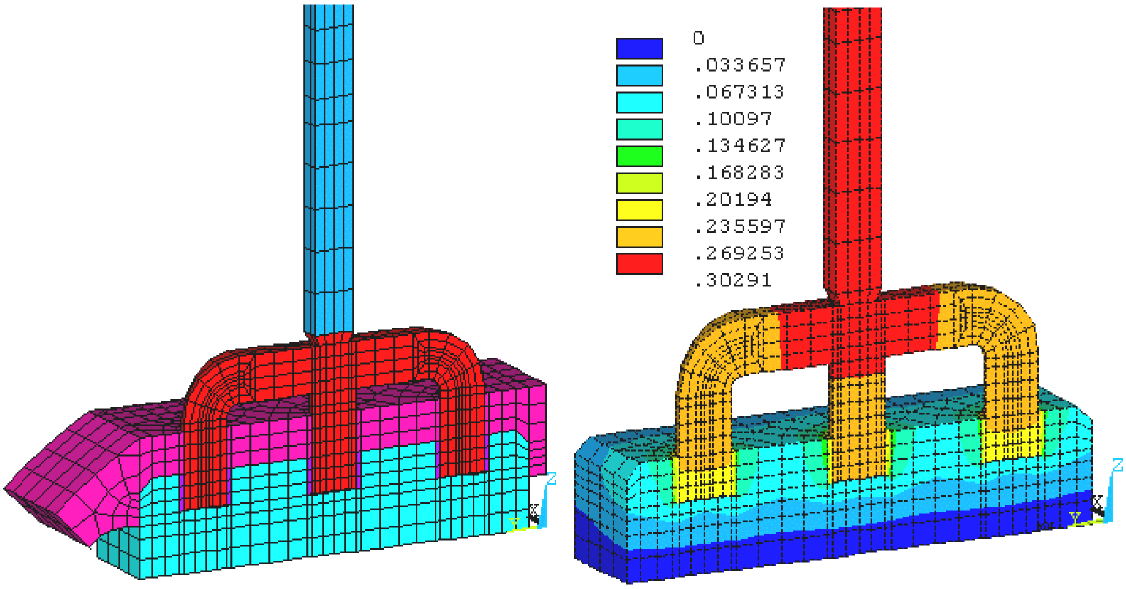

Figure 1. ANSYS based 3D thermo-electric demonstration model from [1].

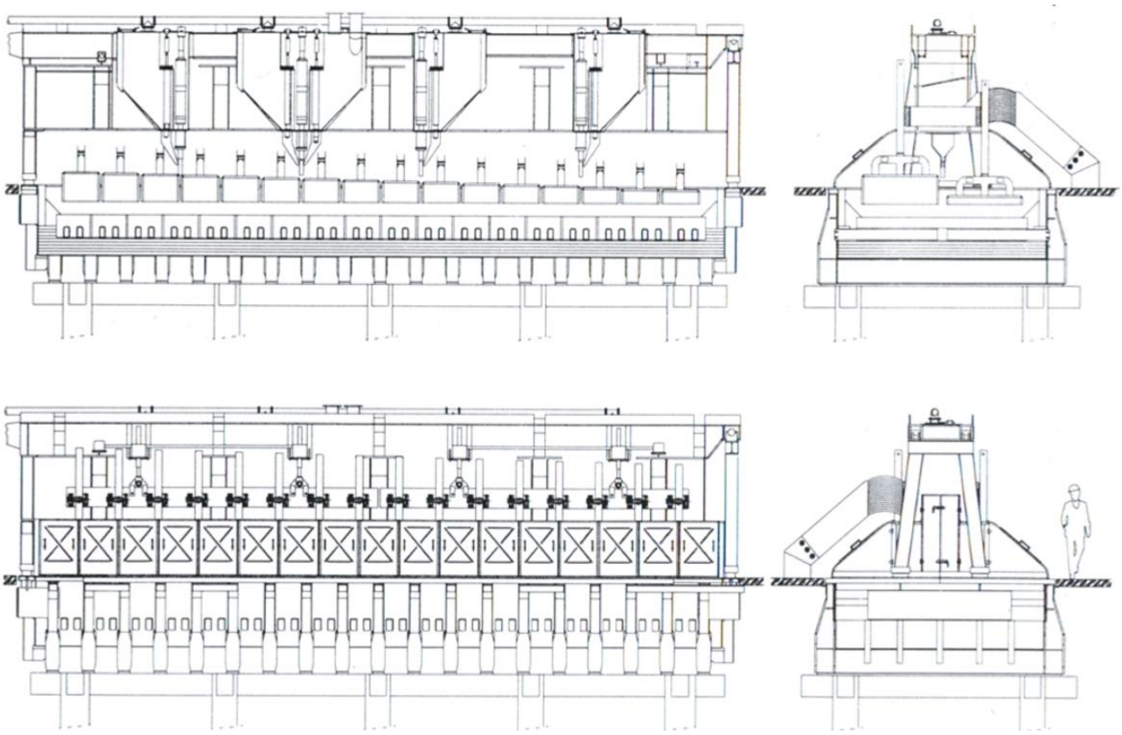

Figure 2. Sketch of the VAW 300 cell design from [2].

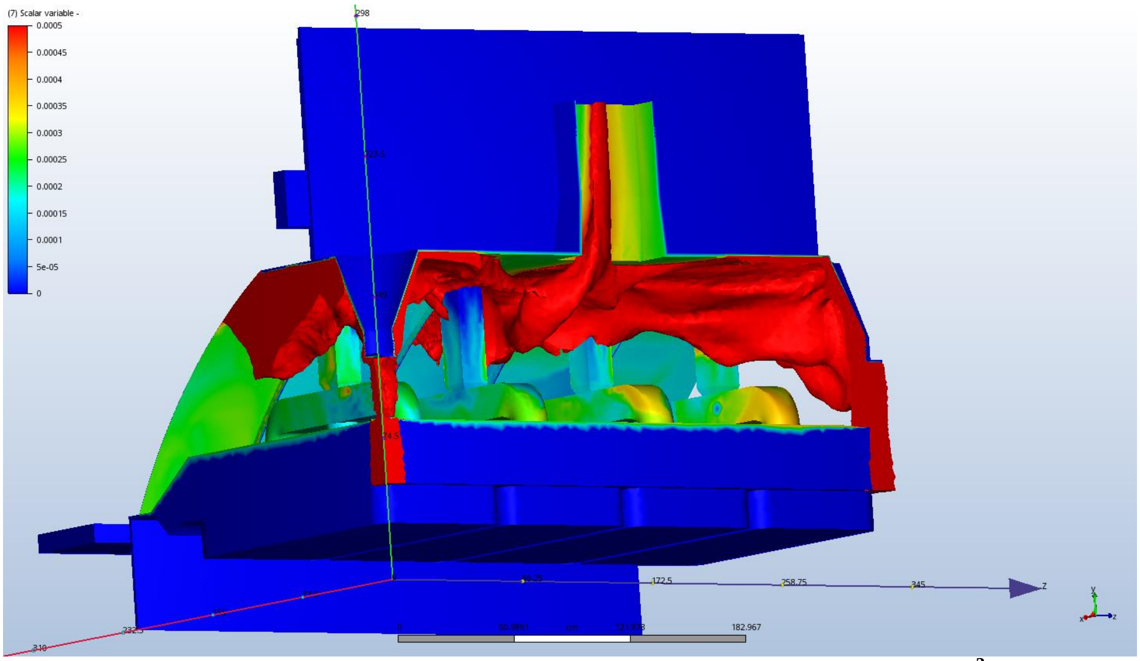

Figure 16. Isosurface of the HF concentration at 0.0005 kg HF/Nm^3.

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