A new aluminium electrolysis cell busbar network concept

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Abstract

In recent years, the author has presented results of magnetohydrodynamic (MHD) cell stability studies obtained using a completely new busbar network concept. This new busbar concept has the advantage of being easily extendable to any cell size. To date, results have been presented for cells operating at 500 and 740 kA in an article published in the magazine ALUMINIUM in May 2006, for a cell operating at 600 kA in an article of the magazine ALUMINIUM in February 2011 and finally, for a cell operating at 1500 kA in an article of the magazine ALUMINIUM in February 2014. This paper presents in detail, for the first time, this new cell busbar network concept, and presents in more detail some of the MHD cell stability studies that were carried out to test its validity.

Keywords: MHD cell stability; busbar design; mathematical modeling.

1. Introduction

A considerable amount of literature is available on the subject of MHD cell stability. It turns out that the main factor influencing cell stability is the magnitude of the vertical component of the magnetic field (B_z) in the metal pad, or more precisely, the gradient between the positive value of the B_z at one end of the cell, and the negative value of the B_z at the other end. Urata [1] described the wave dynamics of a combined (2, 0) gravity mode wave with a (0, 1) gravity mode wave generating an MHD-driven rotating wave due to the presence of the longitudinal B_z gradient.

In Chapter 11 of his MHD book, Davidson [2] complements the Urata description by explaining how mechanical energy can be pumped into that system - energy that is required to grow an initial perturbation in order to generate and then sustain a high amplitude MHD wave. According to his work, the most probable MHD-driven rotating wave is a combined (3, 0) gravity mode with a (0, 1) gravity mode. This small discrepancy with Urata's work can be explained by the increase of the cell aspect ratio that was close to 2 to 1 when cell amperage was below 200 kA, and is now closer to 3 - 4 to 1 with cell amperage above 350 kA.

2. State of the art in busbar design

The magnetic field in the metal pad of a cell is generated by all the currents flowing in and around the cell. The major contributor of the magnetic field, and especially of its vertical component, B_z, is the network of busbars carrying the current from one cell to the next, as well as the return pot row. This is the reason why the proper design of the network of busbars and the location of the return pot row are so critical to cell stability.

Currently, three busbar network concepts are being used in the industry for high amperage cells. The first concept consists of designing an asymmetric busbar network that minimizes the B_z by mixing busbar paths, such as directing some busbars under the cell and some around the cell. The busbar network is typically not symmetric because it must compensate for the asymmetric effect of the return pot row in order to produce a symmetric magnetic field. This is the preferred approach for busbar network design for high amperage cells in China for example. A recent paper [3] presents and compares several Chinese busbar network designs for 400 kA cells. Figure 1 shows model-drawn 3-D perspective view of four Chinese busbar designs.

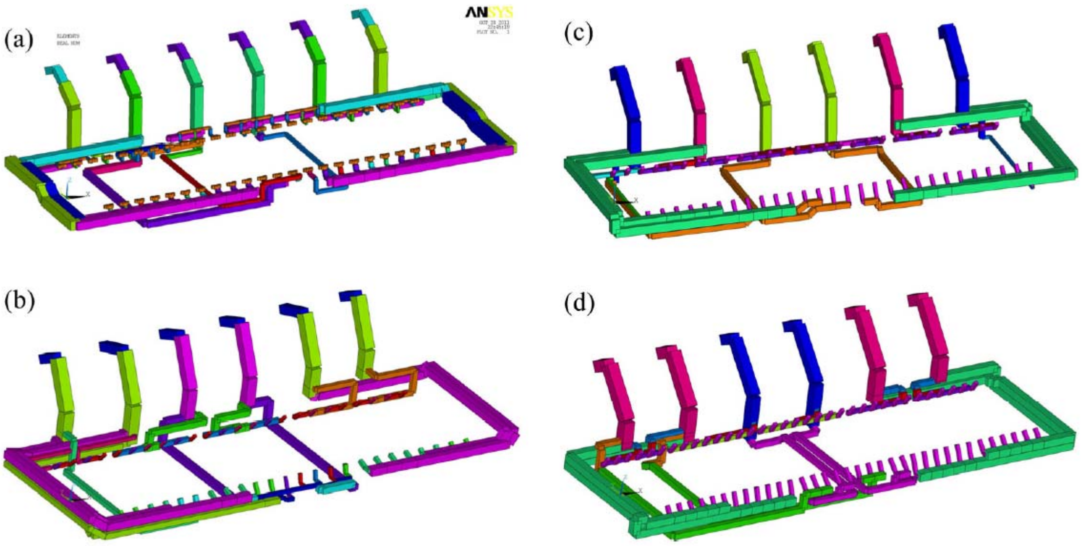

Figure 1. Busbar model of four 400 kA cells: (a) GY420; (b) SY400; (c) NEU400; (d) QY400 (Figure 4 of [3]).

As presented in Figure 5 and Table 4 of [3], all four designs produce fairly symmetric B_z magnetic fields within the range of ± 4.0 mT which according to [3], satisfies the *"basic magnetic field stability rules"*.

Figure 2 presents the model setup of a 500 kA cell using the first busbar concept as developed by the author, and presented in Figure 1 of [4]. Figure 3 shows the B_z field, generated by this design, also presented in Figure 1 of [4]. The B_z magnetic field is fairly symmetric within the range of ± 1.4 mT.

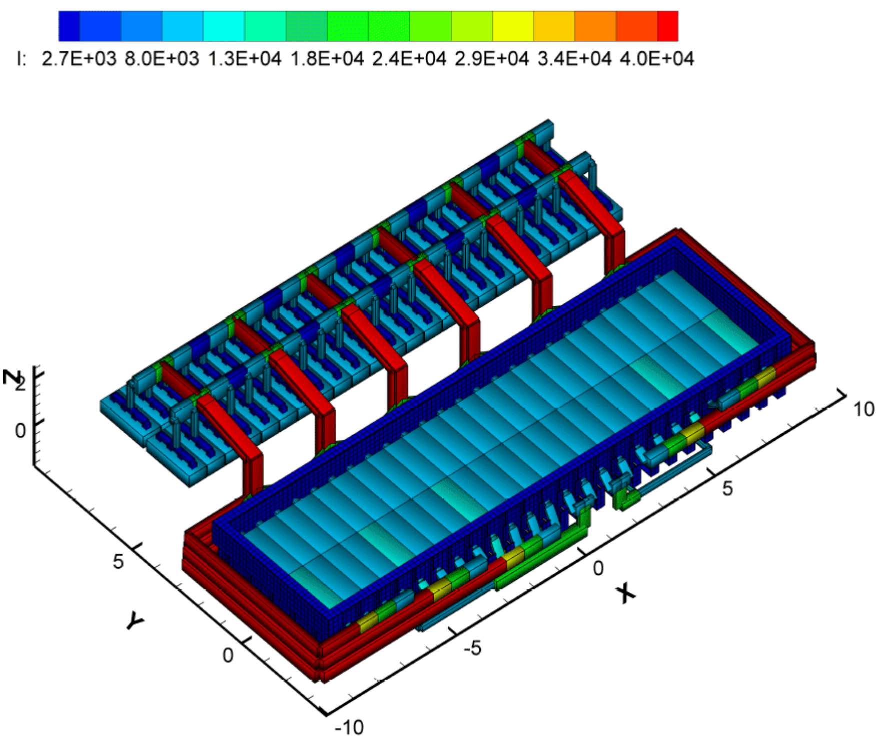

Figure 2. Busbar design of a 500 kA cell shown in Figure 1 of [4].

5. Conclusions

A completely new busbar network concept has been developed called RCC - reversed compensation current. RCC has the advantage of being easily extendable to any electrolysis cell size. RCC is similar to ECC for two reasons: there is no ICC, so no internal current busbars passes around the cells, and the B_z generated by the busbars passing directly under the cell is compensated by external current busbars. But contrary to ECC, these extra compensation busbars:

1) Are passing under the cell close to the internal current busbars already passing under the same cell.
2) Are carrying current traveling in the opposite direction as the potline current.

There are two major innovations in two different versions of RCC. In the initial version, the first and most important innovation is that the external compensation current is passing under the internal current busbars passing under the cell but in the opposite direction. In the second most recent version, there is a second innovation: downstream risers located on the downstream side of the cell. The usage of downstream risers ensures that the B_x is anti-symmetric so the bath/metal interface deformation is symmetric.

Results have been presented for cells operating at 500, 740, and 1500 kA, clearly demonstrating that the RCC busbar network concept is perfectly scalable to any cell size and amperage. RCC opens the door to the possibility to design smelters with an odd number of potrooms, and to locate multiple potrooms in a very compact footprint.

6. References

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