Having developed confidence through modeling and engineering, DX+ cells are larger than DX cells: the potshell is 0.3 m wider. DX+ cells were designed to operate at 420 kA initially and are ultimately anticipated to operate at up to 460 kA. Accordingly, DX+ cells are larger than DX cells: the potshell is 0.3 m wider and 0.6 m longer. However, the pot-to-pot distance is 6.3 m, the same as for DX cells. The busbar configuration has also been maintained, but the busbar cross-sectional area in DX+ industrial cells will be larger to accommodate the higher amperage without increase of external voltage drop. While both cells have 36 anodes, the size of the DX+ anode was increased to match greater potshell dimensions and to maintain the current density at higher amperage. Neither DX nor DX+ technology requires forced potshell cooling or external magnetic compensation.

Having developed confidence through modeling and engineering design, five DX+ demonstration cells were installed in DUBAL’s Eagle section, replacing the five DX prototype cells. The DX+ cells were energized between June and August 2010. Figure 1 shows a view of the Eagle section that houses the DX+ cells. The cells achieved the desired performance from November 2010 onwards. This allowed DX+ technology to be assessed as “bankable” by the EMAL Phase II lender’s technical advisor. Thus, a potline of 444 DX+ cells with a production capacity of 520 000 tonnes per year will be installed at EMAL Phase II and is scheduled for start-up in December 2013.

**Introduction**

Over many years of technology development, DUBAL has accumulated a great deal of knowledge and the tools required for in-house development of modern reduction technology. This has enabled the development of technologies to be fast-tracked in the recent past. After successfully implementing DX technology in 40 demonstration cells in DUBAL in 2008, the same technology was installed in the EMAL Phase I project (two potlines with 378 cells each) [1]. Meanwhile, technology development at DUBAL continued. By August 2009, DUBAL completed the design of a newer generation cell design, called DX+. As the name indicates, DX+ technology is an extension of the DX design; it promises the same outstanding performance at lower capital cost per installed tonne of capacity.

DX+ cells were designed to operate at 420 kA initially and are ultimately anticipated to operate at up to 460 kA. Accordingly, DX+ cells are larger than DX cells: the potshell is 0.3 m wider and 0.6 m longer. However, the pot-to-pot distance is 6.3 m, the same as for DX cells. The busbar configuration has also been maintained, but the busbar cross-sectional area in DX+ industrial cells will be larger to accommodate the higher amperage without increase of external voltage drop. While both cells have 36 anodes, the size of the DX+ anode was increased to match greater potshell dimensions and to maintain the current density at higher amperage. Neither DX nor DX+ technology requires forced potshell cooling or external magnetic compensation.

**Keywords:** High amperage, DX technology, DX+ technology

**Abstract**

Since the 1990’s, DUBAL has engaged in self-development of proprietary aluminium reduction technology. DX and DX+ technologies, both being in-house designed, modeled, tested and optimized, are the latest products of this development process. In quest to decrease capital cost per tonne, DUBAL designed DX+ technology and started up five demonstration cells between June and August 2010. DX+ cells are similar to DX cells, but larger in size: the productivity per square metre of potroom is increased by more than 17%. This paper describes the DX+ cell design evolution from DX technology. It also summarizes the on-target performance achieved by the DX+ demonstration pots during their first year of operation at 420 kA. DX+ technology has been selected for the EMAL Phase II project. The project FEED study, completed in June 2011, is based on one potline of 444 DX+ pots. The design allows for an operating amperage increase to 460 kA.

**DX+ Design Modeling and Validation**

In an effort to optimize DX technology, mathematical modeling and engineering evaluations were carried out. These activities enabled the development of an alternative design, requiring less capital expenditure while maintaining the technical performance of the cells.

At the design stage, models were developed for magneto-hydrodynamic (MHD), thermo-electric and mechanical evaluations of the cell design. MHD modeling included metal heave, metal and bath circulation patterns, magnetic field, and stability analysis. Thermo-electric modeling was used to evaluate the cell heat balance, freeze profile, busbars temperature and current distribution, collector bar current distribution and potshell temperature. Potshell deformation was also studied using mechanical modeling.

The model results were compared to those of DX technology for conformance on acceptable ranges. These models were later validated through data collection from the actual operating DX+ cells. The design validation measurements showed consistent figures compared to those expected from the model results.

In terms of MHD modeling, the metal circulation pattern, shown in Figure 2, and velocities were comparable to those of DX technology. Metal velocity measurements in the DX+ cells also showed similar patterns to those which the model predicted. Metal velocity measurements were taken using iron rods positioned between the anodes on upstream and downstream sides of the cell, as well as at the tap and duct ends. Figure 3 shows a comparison between the model (blue arrows) and actual measurement (red arrows). Except for a few locations, very good agreement was
observed between the two patterns, both in terms of magnitude and direction.

Figure 2. DX+ metal circulation patterns and velocities: modeling results.

Figure 3. DX+ metal circulation patterns and velocities: modeling (blue arrows) vs. measured (red arrows) results.

Furthermore, stability limits were measured by squeezing the anode-to-cathode distance (ACD) until the cell no longer was stable. The stability analysis showed that at the present operating voltage, DX+ cells have a large margin of ACD above the instability limit. Additionally, the impact of changing anodes on cell stability was analysed and found to be easily mitigated with the pot control system.

From a thermo-electric perspective, the DX+ models showed similar trends in cell heat balance as observed in DX cells. Freeze profile measurements also reflected similar trends to those predicted by the model. Figure 4 shows the freeze profile generated by the model, while Figure 5 plots the measured side freeze averaged for the five DX+ cells from November 2010 to June 2011. The two profiles agree well in shape and thickness. The model predicted a freeze thickness of 5 cm at the metal bath interface, while the measured data gave 4.2 cm.

Figure 4. DX+ cathode model showing freeze profile.

Figure 5. DX+ measured side freeze.

Another important design parameter obtained from the thermo-electric modeling was the collector bar current distribution. Modeling showed an excellent balance between upstream and downstream currents of 50.5% upstream and 49.5% downstream. This compared well with the measured data of 51.3% upstream and 48.7% downstream. Figure 6 shows the current distribution in upstream and downstream collector bars, plotted against the measured current at these locations.

Figure 6. Current distribution in collector bars in DX+ (measured vs. predicted).

Moreover, the potshell temperature was measured at several locations and found to be in general agreement with the modeling results. The potshell design of DX+ is different than the original DX potshell design. The impact of this is reflected in the potshell temperature being on average 25 °C cooler in DX+ cells.

Finally, mechanical models were used to analyze the potshell deformation. Figure 7 shows the model results along with the measurements in the DX+ cells. The model predicted a maximum vertical deflection of 1.3 cm and a maximum horizontal deflection of 3.5 cm. This was very close to the measured data, which showed a maximum vertical deflection of around 1.5 cm and about 3.5 cm (maximum) horizontal deflection.