

Technology and innovation at Emirates Global Aluminium (EGA)

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Abstract

Dubai Aluminium (DUBAL), an operating subsidiary of Emirates Global Aluminium (EGA), has been involved in technology development for more than 25 years. This has entailed upgrading the erstwhile P69 Kaiser cells to D18 and subsequently to D18+, and developing the DX, DX+ and DX+ Ultra family. The resulting EGA cell technologies were fully designed, modelled, tested and optimised in the UAE. EGA has invested millions of dollars in developing in-house capabilities in cell modelling, design and engineering – a unique achievement for a young country. The focus of technology development has been on improving productivity, reducing energy usage, improving environment performance and reducing capital cost. Innovation has been a hallmark of the culture at EGA, with several awards won internationally by its employees through participation in an employee suggestion scheme and improvement programmes. EGA employees have presented many high quality technical papers in various industry forums. With the successful sale of its reduction technologies, a robust Intellectual Property base has been established, including several international patent applications. Equal importance is placed by EGA on respecting the Intellectual Property of others. With success already enjoyed in its DX family of technologies, EGA has now embarked on the development of next generation reduction cells, named DZ, which aim to operate at more than 600 kA.

Keywords: EGA; DUBAL reduction cell technologies; DX technology; DX+ technology; DX+ Ultra technology.

1. A brief introduction to EGA

From inception in 1979, DUBAL has been committed to continuous innovation in the aluminium smelting process while achieving maximum operating efficiencies. This has been clearly reflected over the last 35 years or so through continual in-house development and industrial-scale installation of enhanced proprietary cell technologies that deliver higher production, improved current efficiencies and environmental benefits.

This commitment continued after the formation of EGA in 2014 wherein DUBAL and Emirates Aluminium (EMAL) became fully owned subsidiaries of EGA. The combined production capacity of EGA's smelters of more than 2.4 million tonnes per year places EGA among the five largest primary aluminium producers in the world.

EGA is also active in developing upstream businesses:

Bauxite mining and alumina refining:

- Al Taweelah Alumina refinery with a planned capacity of 2.0 million tonnes per year in Phase I, scheduled to be commissioned at the end of 2017.
- Guinea Alumina Company, 100 % ownership since November 2013 (ratified by the Government of Guinea in June 2014) - An 8 to 12 million tonnes per year bauxite mine.
- Cameroon Alumina Limited (45 %)

Petroleum coke calcination:

- Jiangsu Suyadi Tancai Company Limited in Zhenjiang, China (49 %),
- Sinoway Carbon Energy Holdings in Shandong, China (20 %),

2. Our ambition and strategies

Our ambition is to be a reliable provider of smelter technologies. This will be realised through the following strategies:

- Continue developing energy efficient, environmentally responsible, low CAPEX and high performance reduction cells.
- Establish EGA as best-in-class operator of carbon facilities that will compliment EGA reduction technologies.
- Explore opportunities for modernising old smelters in the world and develop cost-effective solutions through in-house modelling and process capabilities.
- Ensure that EGA know-how and technologies are protected through developing a portfolio of Intellectual Properties (IP)/Copyrights and active monitoring of development in the industry.

3. Upgrade of former P69 Kaiser cells to D18 and subsequently to D18+

3.1. D18 Technology

The original 360 P69 cells at DUBAL were modified in-house to D18 with a new cathode design, longer anodes and improved alumina feeding system (Pseudo Point Feed). This allowed increased production through higher amperage of >200 kA from the original 150 kA and better current efficiency.

3.2. Development of D18+ Technology

During 2013, the in-house Technology Development team conceived and designed an improved D18 cell (called D18+) that could replace the existing 520 D18 cells with more energy-efficient cells. D18+ cells have the same potpot distance with new magnetically compensated aluminium busbars and anode risers. The pots are longer to accommodate two additional anodes and two cathode blocks. This was achieved by modifying the existing potshell and installing a modern alumina point feeding system [1].

Following a seven-cell pilot project (Figure 1) that demonstrated EGA's expertise in retrofitting older potlines, the D18 cells are currently being replaced with D18+ Technology.

The newer technology offers a reduction in net specific energy consumption to below 13 kWh/kg Al, delivering current efficiency greater than 95 per cent and an increase in production capacity to 2.0 tonnes Al/pot-day. The first 32 new D18+ Technology cells are scheduled for start-up in October 2015.

4. DX, DX+ and DX+ Ultra Technology family

4.1. DX Technology

In 2004, DUBAL independently designed and engineered the DX reduction cell entirely in-house. From 2005 to 2010, DX Technology progressed successfully from initial prototyping through to large scale industrialization. Five DX prototype cells were installed in a dedicated development potroom at DUBAL and started up at 325 kA between September and December 2005.



Figure 1. D18 pot (left) and the first D18+ pot (right) in the demonstration section of DUBAL Potline 1.

The successful and stable performance of these prototype DX cells led to the strategic decision to invest in the construction of a demonstration potline of 40 cells, known as Potline 8, which was commissioned in 2008 at 340 kA, and reached 402 kA in February 2015.

The next significant step in the industrial deployment of DX Technology was construction of EMAL Potlines 1 and 2 with 378 DX cells each, commissioned in December 2013 at 350 kA with a nominal production capacity of 740 000 tonnes per year. These potlines are currently operating at 388 kA and the aim is to increase amperage to 400 kA in 2016, thus increasing the output by almost 15% to 850 000 tonnes per year (nominal capacity). The excellent performance and cell voltage reduction has created an opportunity to add additional 40 cells in Potlines 1 and 2.

In parallel, the increased operating amperage, together with the associated reduction in specific energy consumption, has allowed for four additional DX cells in DUBAL Potline 8, which in turn increased the production capacity of the potline. These four cells are in operation now.



Figure 2. DX cell in EMAL Potline 1.

4.2. DX+ Technology

After successfully implementing DX Technology in EMAL Potline 1 and 2, technology development at DUBAL continued. By August 2009, DUBAL completed the design of a new generation of cells, called DX+. As the name indicates, DX+ technology is an extension of the DX design to higher amperage, resulting in higher metal production per pot-day 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 is larger to accommodate the higher amperage without increasing external voltage drop. While both cells have 36 anodes, the size of the DX+ anode is increased to match the greater potshell dimensions and to maintain the anode current density at higher amperage. Neither DX nor DX+ Technology requires forced potshell cooling or external magnetic compensation.

Five DX+ demonstration cells were started in July and August 2010 in DUBAL's dedicated development potroom (replacing the DX demonstration cells) at 420 kA. Cell amperage was increased in stages with long time operation at 440 kA and 450 kA before the cells were shut-down in January 2014 to allow for installation of the new DX+ Ultra cells [6].

The industrial scale Potline 3 at EMAL, comprising 444 DX+ cells, was started-up between September 2013 and June 2014 at 440 kA to 444 kA, with design capacity of 520 000 tonnes. The potline is currently operating at 455 kA and the aim is to increase amperage to 460 kA in 2016 [7]. The DX+ cell in EMAL Potline 3 is shown in Figure 3.



Figure 3. DX+ cell in EMAL Potline 3.

4.3. DX+ Ultra Technology

Further efforts to develop lower CAPEX and even lower energy, high amperage reduction cells have led to the design of DX+ Ultra Technology. By introducing various voltage drop reduction initiatives that address the key energy consumers in a reduction cell, DX+ Ultra Technology will achieve substantially reduced specific energy consumption than earlier generation cells.

DX+ Ultra cells have the same dimensions as DX+ cells, but incorporate a new cathode design with lower voltage drop, thus saving in OPEX. It also incorporates modified pot-to-pot busbar (saving aluminium weight) and decreased cell-to-cell centreline distance from 6.3 m to 6.0 m, thus saving in CAPEX. The end-result is a best-in-class production per building surface area.

DX+ Ultra cells are designed to operate at the same amperage as DX+, but with specific energy consumption of less than or equal to 12.5 kWh/kg Al in an industrial version cell. In 2014, five DX+ Ultra demonstration cells were built and commissioned in DUBAL's dedicated demonstration potroom, replacing the five DX+ Technology cells. One of the pots has been constructed with a heat recovery system ("HRS") in place and has, since start-up in May 2014, achieved a heat recovery rate of around 200 kW.

4.4. Performance of DX, DX+ and DX+ Ultra cells

Table 1 gives the key performance indicators (KPIs) for DX cells in EMAL Potlines 1 and 2, EMAL Potline 3 and DX+ Ultra demonstration cells in DUBAL Eagle Section. DX results are given for the full year 2014, corresponding to the last year of operation of generation one potlining. DX+ results are from 1 January to 30 September 2015, with amperage at 455 kA, including the transition from 450 kA to 455 kA from January to March 2015. The DX+ Ultra results are for five months of established operation at 455 kA.

The KPIs show that the DX, DX+ and DX+ Ultra cells deliver excellent performances, specifically noting high metal output per cell in each technology and low specific energy consumption in DX+ Ultra. Particularly remarkable is the environment performance, with very low equivalent CO₂ PFC emissions. This is achieved with a strong performing Pot Control System (PCS) that was developed entirely in-house.

Table 1. Key performance indicators for DX EMAL Potlines 1 & 2, DX+ EMAL Potline 3 and DX+ Ultra in DUBAL Eagle Demonstration Section.

KPI	Units	DX EMAL Year 2014	DX+ EMAL, 1 Jan. to 30 Sept. 2015	DX+ Ultra 1 May to 30 Sept. 2015
Number of cells		756	444	5
Amperage	kA	380.6	454.4	454.7
Current efficiency	%	94.4	95.0	95.1
Metal production	kg/pot-day	2891	3471	3483
Net cell voltage	V	4.25	4.26	4.10
DC net specific energy cons.	kWh/kg Al	13.42	13.36	12.85
Gross carbon consumption	kg C/t Al	546	555	524
Net carbon consumption	kg C/t Al	415	415	405
Bath temperature	°C	961	960	963
Excess AlF ₃	%	10.1	10.0	10.6
Fe	%	0.045	0.041	0.029
Si	%	0.029	0.025	0.027
AE frequency	No./pot- day	0.050	0.100	0.012
AE duration	seconds	15	11	6
PFC emissions CO ₂ equivalent*	kg/t Al	14	20	1

*Calculated as in [7] using Tier 2 Method of Aluminium Sector Greenhouse Protocol of IAI and Global Warming Potentials as per IPCC Second Assessment Report.

5. Cell modelling, design, engineering and pot control system

During the last ten years, DUBAL Technology Development department has developed in-depth mathematical modelling capability for aluminium electrolysis cells, based on commercial software packages, comprising thermo-electric, magnetohydrodynamic (MHD) and mechanical models of the cells as well as CFD models of gas extraction from cells and potroom ventilation (Figure 4) [8, 9].

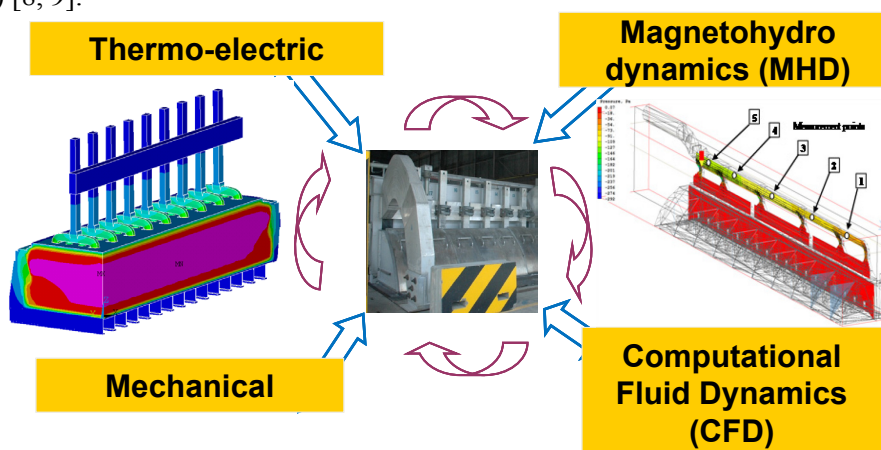


Figure 4. Mathematical models of aluminium electrolysis cells at EGA.

These models are used to design and develop the mechanical structure of potshells and superstructure, thermo-electrical design of the lining, electrical and MHD balance of busbars, electrical resistance optimisation of anode assemblies and cathode collector bar connections to busbars, potroom design for optimised cooling of pots and air circulation for better working environment.

The development team is supported by an in-house engineering team, supported by external engineering resources as required, for developing new pot designs, prototyping and installation and commissioning of the prototype cells,

Over the last several years, DUBAL has developed a new PCS based on standard programmable logic controller (PLC) hardware architecture (Figures 5 and 6) and is successfully used in EMAL [10]. The new PCS is based on standard market PLCs, which give increased human machine interface (HMI) capabilities and assure easy maintenance and future development. It is also installed on the DX+ Ultra demonstration cells, where it is used continually to enhance its performance and functionalities.

All the development work is supported by an in-house team of approximately 45 engineers, modelling experts, software developers and technicians. The team includes experts with international experience gathered over many years as well as new local engineers who have been appointed to maintain the momentum of developing new technologies. The team has project management capabilities to package the technology for transferring the same to external clients.



Figure 5. Integrated pot control panel (IPCP) for two cells in EMAL Potline 3.

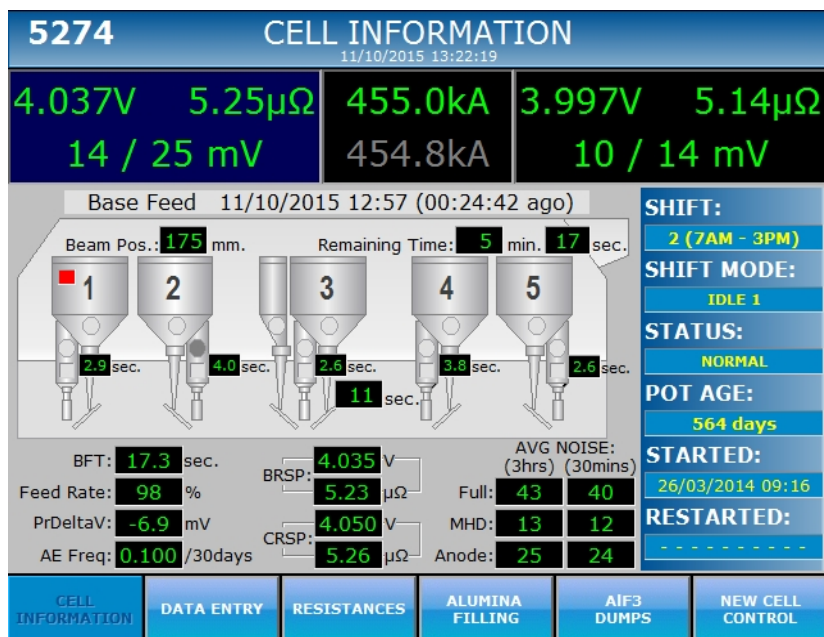


Figure 6. HMI of the PLC Pot Control System in DUBAL DX+ Ultra cell.

6. Suggestion Scheme – Continuous improvement through innovation

The EGA Suggestion Scheme was introduced at DUBAL in May 1981 with the intention of involving non-supervisory employees across the organisation. Today, this highly successful programme is widely recognised regionally and internationally. It has become an integral part of the company's continual improvement process. By involving employees in the decision-making process in areas that affect their jobs, EGA aspires to give employees more control over how they perform their day to day jobs, which leads to greater motivation and commitment and to significant improvements in areas like Productivity, Environment, Health & Safety, Quality, Process, and many other areas.

EGA and its employees have won several awards locally and internationally over the last several years. Just to illustrate:

- Metal Bulletin Global Awards for Aluminium Excellence (2013)
- Gulf Aluminium Council Awards for Environment, Health and Safety (2012)
- Mohammed bin Rashid Al Maktoum Business Awards (2008)
- KAIZEN Awards (2011, 2012, 2013 and 2014)
- Deutsches Institut für Betriebswirtschaft– Best International Idea (2012, 2013)
- Ideas.Arabia awards (2008-2015)
- Ideas.America awards (2006-2008, 2010-2015)
- Ideas UK awards (1997, 1999, 2001, 2005-2012)
- DuPont Safety Awards (2011)
- Institute of Occupational Safety and Health award in Construction category (2011)
- Royal Society for Prevention of Accidents - for Occupational Health and Safety (2013,-2014)
- Vittorio de Nora prize for Environmental Improvements in Metallurgical Industries (2014)
- American Society for Quality (“ASQ”) International Team Excellence Awards – Gold Award (2014)

6. Technical papers in various industry forums

During the last 15 years, EGA has been sharing its know-how and innovation with the industry and has published approximately 100 technical papers at various industrial forums such as ARABAL, Australasian Aluminium Smelting Technology Conferences, ICSOBA, International Conference on Aluminium (INCAL), TMS, and so on.

7. Intellectual property

EGA gives high priority to IP and respects rights embedded in patents. EGA has a robust mechanism to monitor patent applications to ensure non-infringement of third party IPs. It also has an active programme for developing a patent portfolio supporting its technology licensing.

8. What next? – DZ cell technology

Moving forward, EGA is already working on a new cell technology concept that relies on building a high amperage technology (above 600 kA) with even lower energy consumption (<12 kWh/kg Al), which will compete extremely well against other technologies.

9. Conclusion

EGA is committed to continue developing energy-efficient, environmentally responsible, low CAPEX and high performance reduction cells for its own facilities and future licensing. In addition, the business aims to establish EGA as best-in-class operator of carbon facilities that will compliment EGA reduction technologies. This will be achieved by maintaining best-in-class research and development facilities supported by highly skilled and experienced development team as well as innovation contributed by employees across all levels of the organisation.

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