

# Vibroforming and Cooling Sections Revamping of Green Anode Plant Line 2 at EGA Jebel Ali

Christophe Bouché<sup>1</sup> and Vincent Philippaux<sup>2</sup>

1. Carbon technical Director

2. Head of Mechanical Department

Fives Solios, Givors, France

Corresponding author: Christophe.Bouche@fivesgroup.com

## Abstract

In 2014, as part of an amperage creeping project, EGA Jebel Ali Operation (DUBAL) decided to increase anode size up to 1600 mm, and therefore, to upgrade Line 2 anode forming, cooling and handling systems within DUBAL's Green Carbon area. It was also the opportunity to improve the green anode quality and Line 2 availability. Fives Solios was awarded the contract to supply its latest generation of Xelios vibrocompactor and pan cooling conveyor. Firstly, this paper details the challenges related to such revamping project: constrained footprint, interfaces with existing equipment's and extremely short plant shutdown duration to minimize anode production losses. Secondly, the safety, process, mechanical and environmental performances achieved by the upgraded installation are presented and discussed.

**Keywords:** Green anode plant; Xelios; forming; cooling; anode.

## 1 Introduction

Amperage creeping projects are key milestones to improve productivity of aluminum smelters. They are also opportunities to upgrade vibro-compactors to the state-of-the-art in terms of anode quality and equipment availability.

In 2014, as part of an amperage creeping project, EGA Jebel Ali Operation (DUBAL) decided to increase anode size up to 1600 mm, and therefore, to upgrade Line 2 anode forming, cooling and handling systems within DUBAL's Green Carbon area:

- This was a real challenge in terms of constrained footprint, interfaces with existing equipment's and extremely short plant shutdown duration to minimize anode production losses.
- Fives was awarded the contract to supply its most advanced eco-designed vibro-compactor called "Xelios 2.0" and pan cooling conveyor.
- Finally, the safety, process, mechanical and environmental performances achieved by the upgraded installation are presented and discussed.

## 2 The Contract

Green anode plant line 2 at DUBAL has a nominal throughput of 36 tph. Design is based on conventional process associated with kneader and cooler. After the latest revamping in 2005, forming and cooling sections' layout is composed of a single former and a cooling tunnel able to handle up to 30 anodes per hour. For the revamping DUBAL decided to increase anode size up to 1600 mm and to have no taper, no bottom chamfer and no slot at green stage.

The work environment was a brownfield in a plant under production: This was a real challenge in terms of constrained footprint, interfaces with existing pieces of equipment and extremely short plant shutdown duration to minimize anode production losses.

Despite the fact that size of anode was increasing, allocated space to implement the new pieces of equipment remain exactly the same, meaning very constrained in the area of the vibro-compactor. Original design of the paste plant was not based on this type of equipment to form and cool the anodes:

- Height is very limited for a vibro-compactor,
- Footprint for the cooling tunnel is a simple corridor of 60m x 5m confined between buildings.

On time schedule side, Notification to Proceed (NTP) was placed in December 2014. Anode plant Line 2 shutdown was forecast for only 6 weeks and estimated date for the first good anode was December 2015, so just one year after the NTP.

On top of that, DUBAL for the past 10 years established routine procedures and best practices which lead to what can be considered as a benchmark in terms of plant availability and reliability [1], so this revamping was also a real challenge in term of process and performance requirements:

- DUBAL needs for anodes and so for throughput are very high: Design criteria were defined to achieve up to one anode every 118 seconds, to have a total reject rate below 2,5% and to reach availability above 90%.
- Due to specific upstream layout, there was some existing segregation of paste on the paste feeder. The target was therefore to attenuate the effect of segregation as much as possible.
- Anode density target was set to 0.02 kg/dm<sup>3</sup> above existing mean values and height of the anodes has to be with a +/- 5mm tolerance instead of +/-10mm usually.
- Moreover, the available flow and inlet temperature of cooling water were set. Nevertheless, efficiency of anode spraying had to be optimized to reach a skin temperature of 65°C downstream of the cooling tunnel.
- The constraints were similar for the Pitch Fume Treatment System (PFTS): Fan was existing, and spare capacity was very limited. However, quality of ambient air in the vibro-compactor had to be improved.

### **3 The Project**

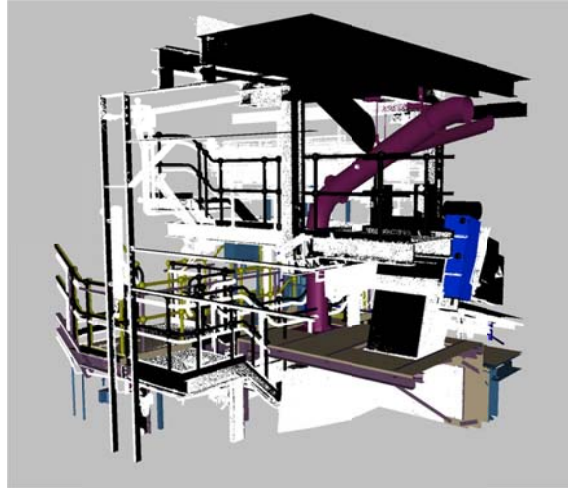
The scope of this brownfield project included:

- Engineering and Fabrication of new pieces of equipment and all modified parts
- Pre-assembly of modules, erection and commissioning
- Structural, civil works, electrical, mechanical, automation and process
- Training

Battery limits were the exit of paste cooler upstream and the roller conveyor for stacking crane downstream.

#### **3.1. “Augmented 3D simulation”**

A main characteristic of a brownfield project is that you should compose with existing plant. Redmarks and site survey were not ensuring enough reliability in our case. So during a shift shutdown, a complete 3D scanning of existing equipment and its environment has been done (Figure 1). With post-treatment it locates existing pipes, structures, cable trays with an accuracy of 3 mm. This image of the existing environment has been inserted in our 3D models.



**Figure 1. Augmented 3D drawings**

### 3.2 Dosing of the paste and mould feeding

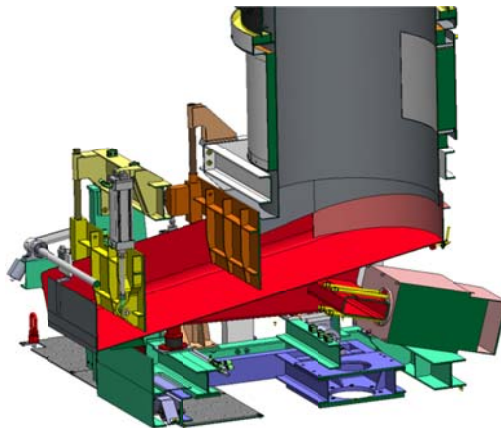
On process side, the first steps are to dose the paste for one anode and to feed the mould. Improvements in this area were focusing on the following topics:

- Decrease the weight deviation via an accurate dosing
- Segregation via a better paste repartition
- Improve Environmental working conditions via a better fume capture during mould paste transfer.

To have a low standard deviation on anode height, the first step is to have a low error on anode weight. This can be achieved via an accurate paste weighing and an efficient dosing system. And it should be adapted to the constraints of carbon area: Short acquisition time to fit with high productivity, robust design to ensure high availability but simple to ease maintenance and reduce cost.

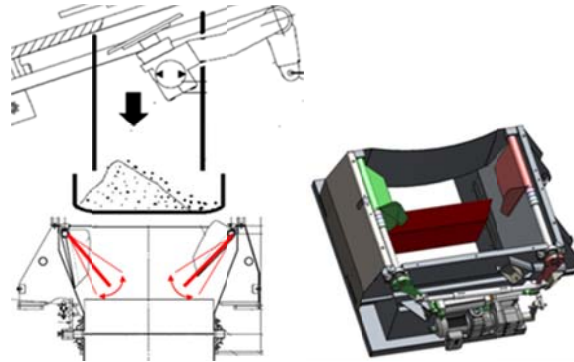
Fives has developed a brand new concept to adapt the height of paste in the vibrating feeder (Figure 2):

- During the filling phase, the layer is thick to have high throughput
- At the end, there is a phase to dose the quantity of paste. Layer of paste is reduced to be more accurate.



**Figure 2. Paste feeder with adjustable gates**

Due to specific upstream layout, there was some segregation of paste on the feeder. To attenuate the effects on green anode, a brand new paste distributor has been designed with the possibility to adjust paste along the length but also along the width of the anode (Figure 3). In order to have the highest flexibility during start up, amplitude and speeds are adjustable.

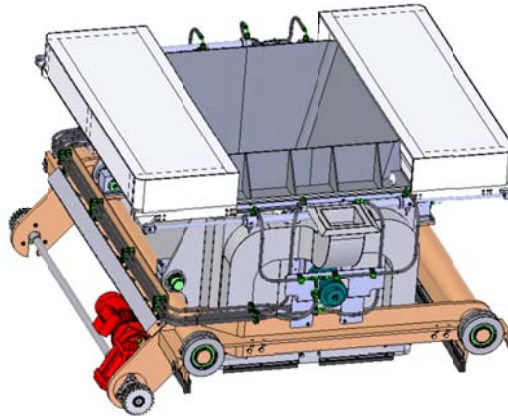


**Figure 3. Paste distributor**

Most of pitch fumes are emitted during transfer of paste from equipment to the other. Vibrating feeder and filling operations of hoppers and moulds were identified as the main sources of emissions to be treated [2].

Designs improvements are based on following constraints:

- Pitch fume collection should be efficient also during transfer of paste from hopper to mould (Figure 4). So Air suction should be higher to 2,000 m<sup>3</sup>/h.
- Flows and pressure drops of the network were recalculated to fit with such specific operations where fumes emissions are important.
- Fume collection have to be closer to emission points.
- Air flow to be treated should not increase as the PFTS filter remained unchanged. Gaps between equipment should be limited to improve suction efficiency



**Figure 4. Eco-designed Transfer hopper with top cover and fume collector**

### 3.3 Advanced Former: Xelios 2.0

Led by the continuous quest for performance, Fives continues to develop this new generation of vibro-compactor [2][3]. The target is to increase its availability, performance, and quality of delivered anodes.

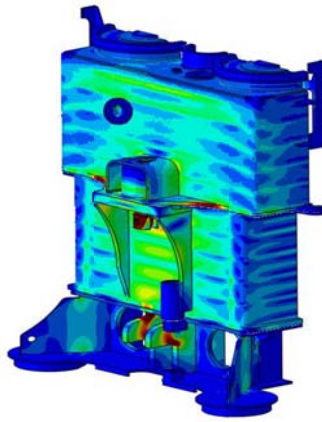
- Quick change between anode format
- Availability: long life design & space out maintenance requirement

- Height deviation with Dynpac

One of the specificity of DUBAL, is that they are operating 4 different size of anodes. So changeover has to be quick but also safe. Fives engineered a tailor-made solution to allow changing format of anodes within a shift taking into account safety and restricted space available.

Previous generation of compactor was designed to work with lower energy of compaction. Xelios allows transmitting 30% more energy.

Mould and hood are now designed based on double wall principle to increase mechanical inertia. The upgraded quality of welding joints and their improved location out of stressed areas (Figure 5), allow to transmit that increased energy and to reach the expected fatigue life higher than 1 billion cycles (which corresponds to 22Hz x 55'' vibration time x 30 anodes x 6000 hrs x 5 years).



**Figure 5. Xelios FEM calculations showing stress areas**

Xelios for DUBAL is equipped with the advanced function “Dynpac” (Figure 6). Integrated sensors allow measuring the actual anode height during compaction. Based on that, the vibration time is shortened or extended and weight set point for next anode is calculated.

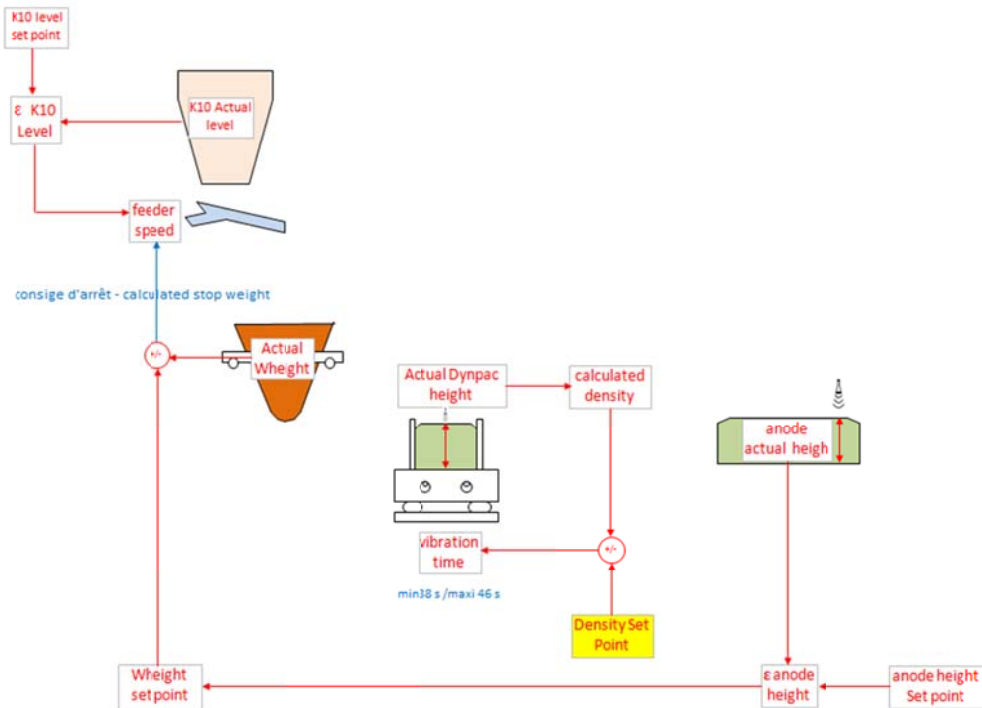


Figure 6. "Dynpac" principle

### 3.4 Vacuum implementation

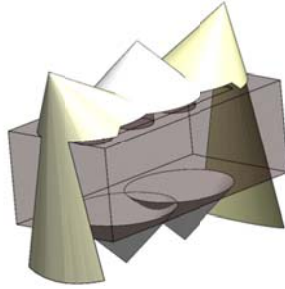
To achieve high throughput and density, high tech components and technologies are required. On the hydraulic side, proportional components allow high speed and softer stop and start in order to shorten cycle times and reduce mechanical stresses.

Vacuum technology has been also implemented to allow higher temperature of forming and consequently higher density. Dedicated set points allow the most efficient cycle time. Air cooled rotary vanes pumps are used for the vacuum system.

Spraying the holes' formers with oil is required. A new design integrates its spraying nozzles on the pusher to spray in the mould in a closed area to avoid oil spillage.

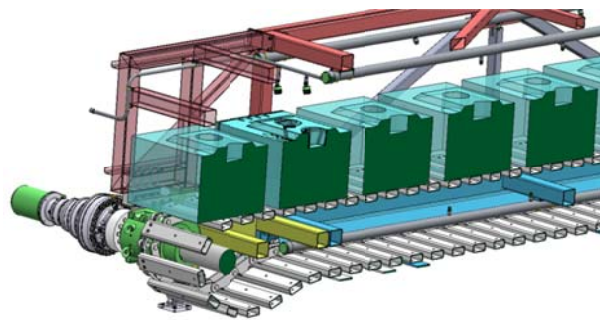
### 3.5 Pan cooling conveyor

DUBAL anodes are big. Their weight can go above 1300 kg and their width is 815 mm. Anode cooling water source was existing and available flow was limited to 180 m<sup>3</sup>/h. A study was carried out with dedicated tests and calculations (Figure 7) to simulate and improve cooling efficiency, to cope with this very low water flow and still maintaining an anode skin temperature of 65°C at any time downstream the cooling tunnel.



**Figure 7. Spray pattern for anode cooling**

Footprint for the cooling system being very limited, the cooling tunnel is based on pan cooling conveyor (Figure 9).



**Figure 9. Pan cooling conveyor**

### **3.6 New Instrumentation Concept**

Sensor breakages represent a significant portion of the non-availability of the equipment: i.e. loose connection or wrong wiring during replacement. To improve reliability of instrumentation new sensors were better adapted to the environment and by choosing the right location:

- I/O modules implemented directly on the machine with keyed quick connect system are IP 69
- Status of the components are viewable via LED lights

These choices allow also minimizing shutdown duration: Workshop wiring with maximum pre-tests and field network are the keys to ensure efficient pre-commissioning of the equipment

Program was also fully tested at engineering stage in order to ensure the fastest production ramp up.

## **4 Results**

Anode plant Line 2 shutdown started exactly as scheduled end of October 2015, ten months after NTP.

## 5 Site Project organization

Six weeks' shutdown was considered as a very tough challenge. Project organization for site activities was set to achieve it

Therefore, Fives Solios works needed to be carefully planned, organized and coordinated on a "daily basis" with DUBAL operations and maintenance teams. The schedule was detailed at a level showing all major tasks on an hourly basis with the manpower required.

All works performed during Line 2 shutdown have been carried out on a continuous basis (around the clock schedule 24hr per day, seven (7) days per week).

HSE aspects were well integrated in the preparation of the project and Fives took the responsibility for HSE management during construction and commissioning. Resources on site reach a maximum of 117 persons. Direct man hours hit 50000 hours without any LTI.

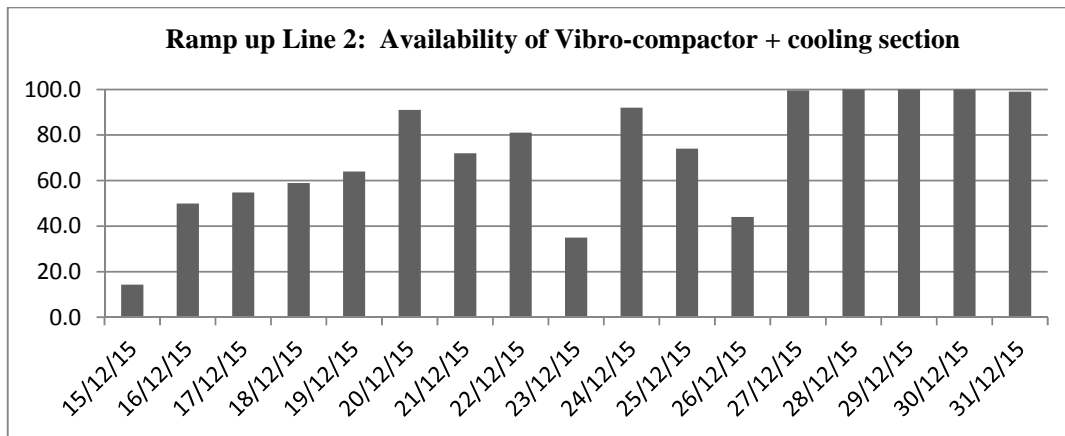
As shown in Table 1, first anode was produced mid of December 2015.

**Table 1. Main milestones achieved**

| <b>DUBAL Line 2: Main Milestones achieved</b>                      | <b>Date</b> |
|--|-------------|
| Contract award   | 14/12/2014  |
| Main shutdown (Day 1)  | 25/10/2015  |
| First anode  | 15/12/2015  |
| Performance achieved<br>(including one month of availability test) | 12/04/2016  |

As shown in Figure 10, ramp-up was satisfactory:

- On December 16<sup>th</sup>, density increase target (+2 points) was reached
- Nominal production capacity of 36 tph was achieved on December 18<sup>th</sup>
- Within 2 weeks, availability of line 2 including vibro-compactor and cooling section reaches 100%



**Figure 10. Line 2 Ramp-up: availability of vibro-compactor and cooling section**

All performances shown in Table 2 have been obtained very quickly and have been demonstrated less than 4 months after startup, including one month of availability test. Today there is no deficiency and punch list is closed. Installation is under monitoring.

**Table 2. Performances achieved on Line 2**

| <b>DUBAL Line 2</b>                         | <b>Typical production before shutdown 4 months in 2015</b> | <b>Achieved production after shutdown 4 months in 2016</b> |
|---|--|--|
| Anode weight (kg)                           | 1276   | 1294   |
| Anode Height (mm)                           | 650,2  | 650,0  |
| $\sigma$ height (mm)                        | 2,1  | 1,4  |
| Anode density (kg/dm <sup>3</sup> )         | 1,633  | 1,654  |
| $\sigma$ density (kg/dm <sup>3</sup> )      | 0,006  | 0,005  |
| Availability of Vibro + cooling section (%) | 94,4   | 98,8   |
| Availability of line 2 (%)                  | 90,0   | 93,5   |

On side of product performances, other benefits have been also achieved as reduced noise level in the vibro-compactor area and improvement on fume captures. It allows to keep the area open and so to ease the access.

## **6 Conclusion**

For Fives, this contract was the opportunity to confirm its turnkey know-how for brownfield projects. Its most advanced eco-designed vibro-compactor “Xelios 2.0” and pan cooling conveyor demonstrated also state-of-the-art performances.

This project is also a success thanks to DUBAL. Running a plant with an uptime above 93% is demanding and required skilled people. Their teams are highly professional and were able to handle immediately this new installation.

## **7 References**

1. B. Ndjom, M.S. Malik & Al, Journey towards world-class operational effectiveness at Dubal paste plant, *Light Metals 2016*, 985-990.
2. V. Philippaux & Al, Xelios Vibro-compactors: Performance & reliability, *Light Metals 2015*, 1103-1107.
3. C. Bouche & Al, 60 tph single line green anode plant commissioned at Qatalum, *Light Metals 2012*, 1153-1157.