Light Metals 2013 *Edited by: Barry Sadler*
TMS (The Minerals, Metals & Materials Society), 2013

NEW GREEN ANODE PLANT AT EMAL START-UP & OPERATION IN THE FIRST TWO YEARS

Raja Javed Akhtar [1], Rudolf Gemein [2], Manfred Beilstein [2]

[1] EMAL - Emirates Aluminium PJSC, Al Taweelah, Abu Dhabi, U.A.E.
[2] Outotec GmbH, D-51147 Cologne, Germany

Keywords: Green Anode Plant, Anode Plant, Green Anodes, Vibrocompactor,

Abstract

EMAL – Emirates Aluminium PJSC, a strategic joint venture between aluminium producer Dubai Aluminium Company Limited, Dubai, UAE and Mubadala Development Company PJSC, Abu Dhabi, UAE, awarded the contract for the supply of a green anode plant and butt crushing facility for the 750,000 tpy EMAL – Emirates Aluminium Smelter project located in the Khalifa Port & Industrial Zone at Al Taweelah, halfway between Abu Dhabi and Dubai, to Outotec GmbH, of Cologne, Germany, in July 2007.

Outotec's scope of delivery covered the engineering, supply and installation on EPC basis of the new green anode plant with two anode production lines, each rated at 50 t/h capacity, along with a crushing plant for recycled carbon materials.

It is the first time, that a 100 tph capacity green anode plant was built in one step, utilising continuous mixing and vibro-compacting technologies.

Innovative technologies, such as RTO (regenerative thermal oxidisation) for pitch fume treatment, vertical mill for fines production and green reject paste cooling and recycling have been employed.

This paper describes the EMAL Green Anode Plant, its pre-operational testing, start-up, early operation and the production results in the first year.

Introduction

The EMAL smelter in its 1st Phase is designed for a nominal annual capacity of 750,000 t with two potlines with a total of 756 pots of DUBAL "DX" smelting technology. Due to this smelting capacity the rating of the green anode plant comes to approximately 460,000 tpy good green anodes. At a three shift per day operation, 20 shifts per week, 48 production weeks per year, this coverts to an hourly capacity of approx. 75 t/h green paste production, when allowing a nominal 85% plant availability and 4% max. reject paste and green reject anodes.
Since commercially available and proven paste mixing equipment in a single line was limited to approx. 60 t/h at the time of the design of the EMAL green anode plant, it was necessary to install two paste production lines. However, instead of assigning 50% of the total required 75 t/h paste production to each line, EMAL decided to have two lines installed, each of 50 t/h paste production, which was near or at the limit of proven paste production equipment in a single line.
Thus in terms of production capacity, the green anode plant at EMAL is the biggest of its kind recently built in the aluminium industry.

EMAL Green Anode Plant – Process Design

The Green Anode Plant at EMAL employs a process design, which was jointly developed between R&D Carbon of Sierre, Switzerland, and the Outotec - Cologne office in Germany.
The individual features are proven process unit operations, however the combination of all makes up a modern, efficient, and flexible green anode plant technology.

In summary the special features are the following:
- Strictly separate processing of coke and carbon scrap to avoid carbon scrap entering the fine grinding system
- Preparation of one "recycled" fraction by controlled blending of crushed butts and crushed green scrap
- Incoming coke through cone crusher
- Vertical mill for continuous operation during paste production
- Four fractions:
  - Recycled
  - Coarse coke
  - Fine coke
  - Mill dust at 4,000 BLAINE
- Small overflow bins for coke fractions
- Incoming coke control by level control of mill feed bin
- Direct green reject paste cooling and reprocessing, to avoid intermediate storage and handling by vehicles
- RTO for Pitch fume treatment

Fig. 1: Green Anode Plant at EMAL

The **"Recycled Fraction"** is prepared in a separate screening and crushing plant for baked and green carbon scrap material, as arriving from the rodding shop, baking furnaces and green anode plant. The plant has a primary crusher and secondary crushing circuit with screen, and silos to store the crushed products. The blending of the crushed products is accomplished downstream of the storage silos, and one controlled blend, called “recycled fraction” is sent to the green anode plant.

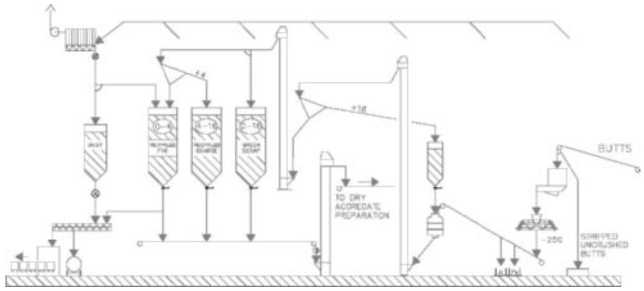

Fig. 2: “Recycled” Processing

The **incoming calcined petroleum** coke is handled separate from carbon scraps, and first crushed in a cone crusher, with automatic gap adjustment. The crusher product is sent to a screen, for separation of the coke fractions of the dry aggregate. The fractions are chuted to small overflow bins, and any surplus material is sent to the mill feed bins.

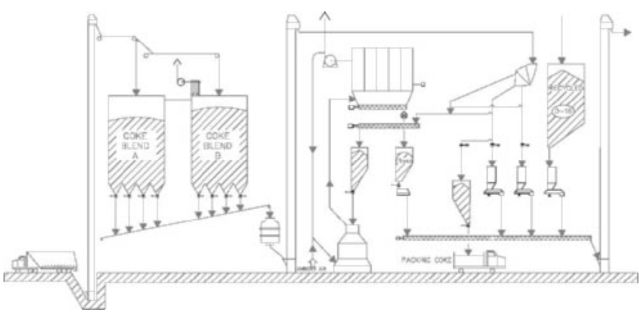

Fig. 3: Dry Aggregate Preparation & Proportioning

A **vertical mill** is employed in each paste production line for generation of the mill dust fraction. The vertical mill offers a number of distinct process advantages against the conventional ball mill, which is mostly used in green anode production. The advantages are:

System Advantages …

- low noise level < 85 dBA
  →no noise insulation of building required
- compact design
  →less area, less civil work and steel structure required
- raw coke size up to 100 mm grindable
  → less crushing required
- all dedusting points can be connected to the mill filter
  →no filter dust silo with filter is required

Lower operation cost due to…

- use of highly wear resistant grinding elements
  →no maintenance required during lifetime
- less installed power
  → less power consumption during operation
- optimum continuous process
  →constant grain size distribution (const. BLAINE no.)
  →sized acc. to plant capacity, no need to stop due to oversize

Advantages for Anodes in Primary Aluminium Smelting

- use of wear resistant grinding elements
  →approx. 95% less iron in fines from grinding elements

Fig. 4: Vertical Mill for Coke Grinding at EMAL

The **“hot” section of the green anode plant** at EMAL is of conventional and proven design, with equipment items already installed and in operation at other plants earlier, at the rated capacity of 50 t/h.

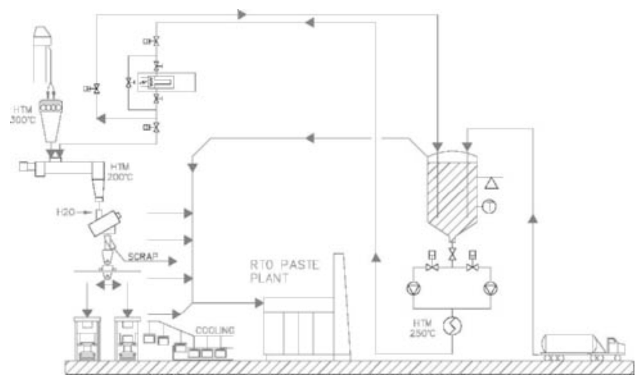

Fig. 5: Paste Mixing, Anode Forming & Cooling

Each line of the Green Anode Plant at EMAL has the following equipment arranged in series:

- dry aggregate proportioning by “loss-in-weight” feeders & liquid pitch proportioning by Coriolis flow meter
- four screw “holoflite” dry aggregate preheater
- continuous kneader
- intensive paste re-mixer/cooler
- twin table anode vibrocompactor with vacuum system and pre-stressed cover weight
- Power & free type pallet conveyor for submersion cooling of the green anode blocks.

Commissioning & Start-up of the Green Anode Plant

1st Feb. 2010:	Start of POV (pre-operational verification)
April 2010:	POV of Line 1 and the common systems finished and start of commissioning
15th April 2010:	First Good Anode produced on Line 1
30th May 2010:	POV of Line 2 finished and start of commissioning
2nd June 2010:	First Good Anode produced on Line 2
Mid July 2010:	Ramp-up of production of the complete plant finished
22nd October 2010	Stabilization period ended after 3 months
19th Nov. 2010	end of Performance Test of both Lines in simultaneous operation
20th Nov. 2010	4-weeks Performance Test of Line 2 finished
7th Dec. 2010	4-weeks Performance Test of Line 1 finished.

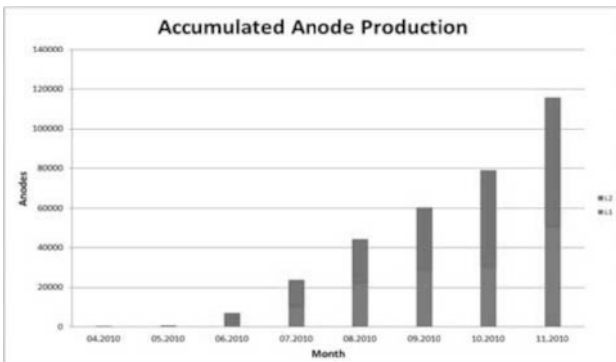

Fig. 6: Ramp-up of Anode Production of Line 1 & 2

Fig. 6 shows the accumulated anode quantities produced by the paste lines 1 & 2 during the production ramp and stabilization period until the performance guarantee tests, and Fig. 7 shows the rejected anode percentages during this period.

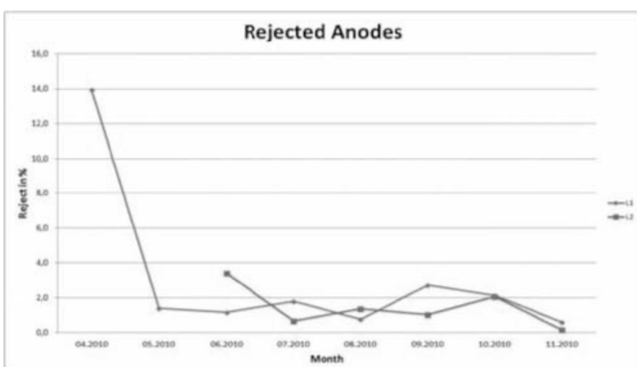

Fig. 7: Reject Anode percentage during the ramp-up period

The reliability and performance guarantee tests for the Line 2 were performed in Oct./Nov. 2010, and the equivalent tests for Line 1 in Nov./Dec. 2010. During the overlapping period a combined performance guarantee test was performed with both lines in operation.
As an example, the performance figures achieved for Line 2 were as follows:

Reliability Test Line 2
23.10.2010 19:00 – 20.11.2010 19:00

Paste output total:	27,782	tons
Generated green scrap & rejects:	334.1	tons
	1.2	%
Average anode weight:	1155	kg
Standard deviation:	3.4	kg
Average anode height:	654	mm
Standard deviation:	1.0	mm
Average green apparent density:	1.640	kg/dm³
Standard deviation:	0.005	kg/dm³

Performance Test Line 2
28.10.2010 07:00 - 04.11.2010 07:00

Paste output total:	7,916	tons
Generated green scrap & rejects:	62	tons
	0.8	%
Average anode weight:	1155	kg
Standard deviation:	2.8	kg
Average anode height:	654	mm
Standard deviation:	0.8	mm
Average green apparent density:	1.641	kg/dm³
Standard deviation:	0.004	kg/dm³

The performance figures achieved during the combined test for both Lines in operation were as follows:

Combined Performance Test	**Line 1**	**Line 2**	
Paste output total:	2,415	2,453	tons
Generated green scrap & rejects:	34.5	15,0	tons
	1.4	0.6	%
Average anode weight:	1154	1154	kg
Standard deviation:	2.6	3.4	kg
Average anode height:	654	654	mm
Standard deviation:	0.8	0.9	mm
Average green apparent density:	1.639	1.638	kg/dm³
Standard deviation:	0.004	0.004	kg/dm³

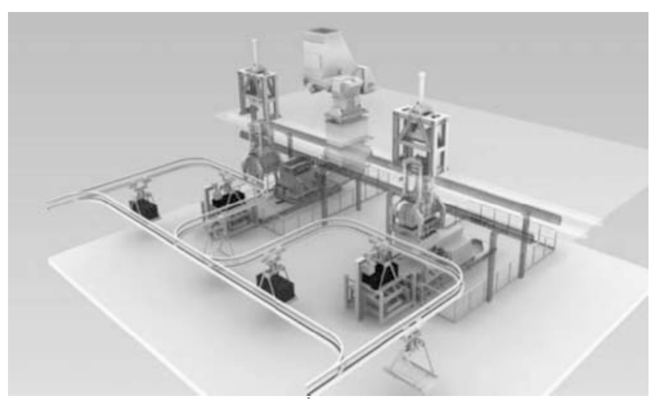

Fig. 8: Vibrocompactors in one production line

Operation in the first 2 Years after Commissioning & Ramp-up

Below is a synopsis of the two year steady state operation of the EMAL paste plant based on productivity, product quality, and operational consistency of both production lines.

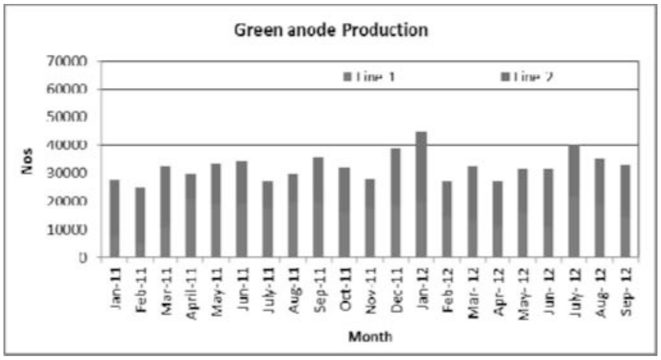

Fig. 9: Green Anode Production of Line 1 & 2

Fig. 9 shows the anode quantities produced by the paste lines 1 & 2 over a period of 2 years. The production is in line with planned requirement with spare capacity still available. Fig. 10 shows the rejected anode percentage for both lines during this period, well within the acceptable limits.

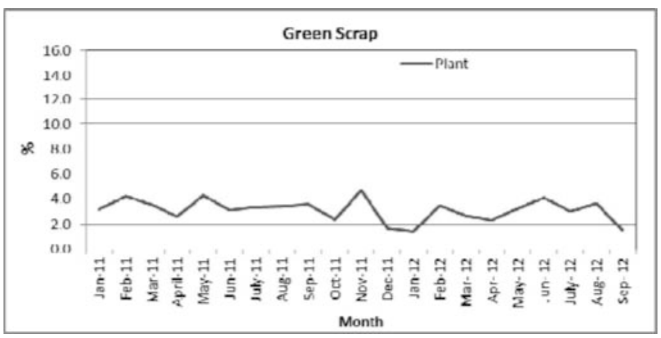

Fig. 10: Green Scrap Generation

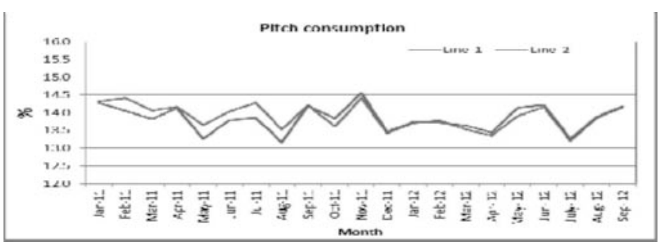

Fig. 11: Pitch Consumption

Fig. 11 and 12 shows consistency of anode manufacturing parameters viz. green apparent density and binder addition with deviations within permissible range which are primarily pertaining to raw material quality variations.

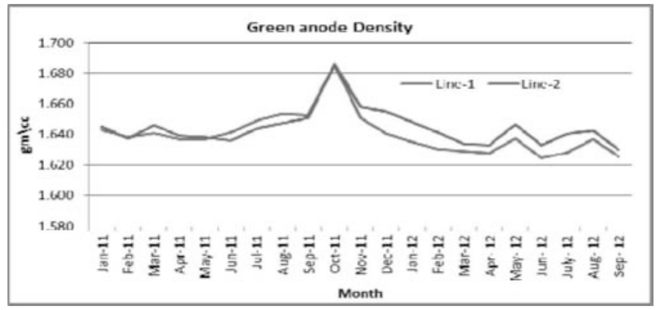

Fig. 12: Green Anode Density

Given the fact of the maiden use of Vertical Mills in fines production for carbon anode manufacturing, the consistency of the Blaine number as depicted below in Fig 13 marks the success of this technological advancement. The fines production with consistent Blaine number and minimal standard deviation is a key to the consistency of product quality at EMAL.

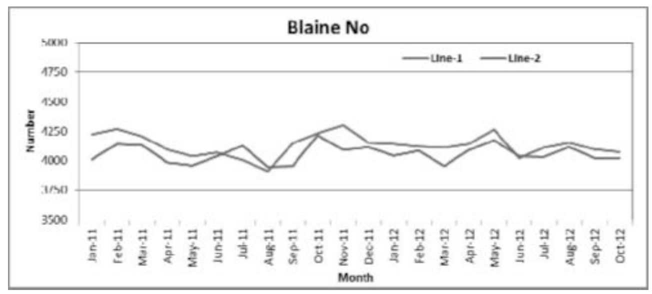

Fig. 13: Blaine No.

Conclusion

It was the first time for the industry, that a 100 t/h green anode production plant was commissioned and ramped up to full production in one step.
This task brought major challenges for all parties involved, and required a joint effort and close collaboration by the teams of Emal Operations, Emal Project, Emals's EPCM Contractor and Outotec.
By eventually providing a high quality product with high consistency, the Green Anode Plant at Emal contributes to the great success of the EMAL Smelter Phase 1.

Acknowledgement

The authors gratefully thank the management of EMAL –Emirates Aluminium PJSC for the permission to publish this paper.

References:

Thore Möller, Fines Production for Anode Manufacturing; Light Metals 2005; page 653 – 658
Matthias Hagen, New requirements and Solutions for the Fume Treatment at Paste Mixing and Anode Baking Plants, Light Metals 2006, page 615 – 619.