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15 YEARS OF GTC OPERATION AT ALDEL: LONG-TERM ASSESSMENT OF GTC PERFORMANCE

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Abstract

In 1998, a new Gas Treatment Center (GTC) was taken into operation at the ALDEL Aluminum Smelter located in Delfzijl, the Netherlands. This GTC was designed and built by Danieli Corus (former Hoogovens Technical Services) according to the Pleno IV design. This year, the GTC at ALDEL is operating successfully and reliably for 15 years, which is the reason for looking back at the past performance. In this article, the design and operation as well as the performance and availability of this GTC over the past 15 years will be discussed.

Introduction

With a capacity of 170,000 ton/yr, ALDEL is one of the largest producers of primary aluminum in Western Europe. The majority of this quantity (110,000 tons) is produced in the reduction lines, while another 50,000 tons is produced by the re-melting and recycling of secondary aluminum. The GTC treats the gas of the 304 reduction cells which produce a total gas volume of 1,520,000 Nm^3/hr. Table I summarizes the properties of this gas:

Table I – Potroom Data

Number of Pots	304
Pot Technology	Alusuisse EPT10
Amperage (kA)	146
Gas Flow per Pot (Nm^3/hr)	5,000
Gas Temperature at GTC Inlet (°C)	50 – 80
GTC Inlet Gas Composition (mg/Nm^3)	
Gaseous Fluoride	180 – 270
Particulate Fluoride	90
Total Particulate	360 – 900
CO_2	14,000
CO	800 – 1,200
SO_2	100 – 500
NO_x	10 – 20

GTC Design and Operation

The basis of design for the ALDEL GTC is founded on Danieli Corus (DC) proprietary Pleno IV technology and its successful implementation in numerous applications. Table II summarizes the design of the ALDEL GTC.

Table II: ALDEL GTC Specifications

Number of Baghouses	11
Number of Filter Bags per Baghouse	1336
Filter Bag Length (mm)	6600
Number of Main Exhaust Fans	3 +1
Alumina Consumption (tonnes/hr)	30

Layout

It is generally understood that the gas suction rate from the individual pot cells must be balanced in order to achieve a high gas collection efficiency. Therefore, it is important that the potroom gas collection ducting is designed such that the gas evacuation rates for the individual cells are within a fixed bandwidth [1].

At the ALDEL aluminum smelter, one of the major challenges was to design a well-balanced ducting layout. The reason for this was the complex potline configuration as can be seen in Figure 1.

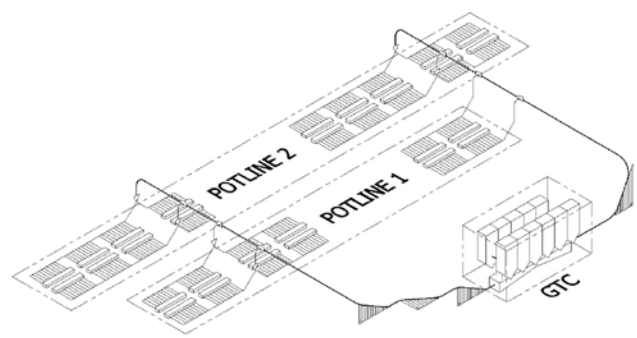

Figure 1: ALDEL Potline Configuration

Exhaust gas from the pots is entering the GTC from two sides, while the configuration of the potline is different on either side. The gas path from the pot farthest away from the GTC is over 700 m, while the gas path from the pot closest to the GTC is only 75 m.

Figure 2: Gas Duct from Potlines to GTC

Balancing the gas flows from each individual pot requires good quality engineering and understanding of the conditions that must be faced over time. From Figure 3 can be seen that the gas flows from the individual pots are balanced relatively well especially considering that the North pots in potline 1 are out of operation causing an unbalance in the GTC flow distribution.

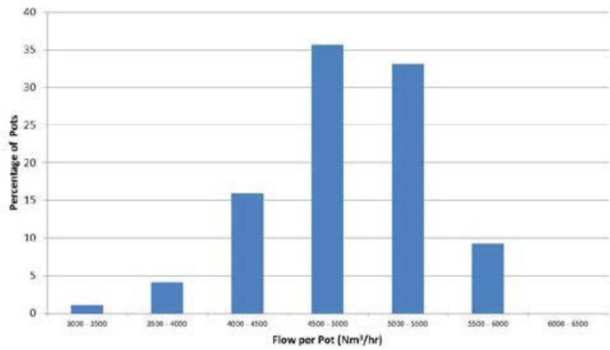

Figure 3: Distribution of Gas Flow from Individual Pots

A common problem is the accumulation of atmolite ($NaAlF_4$) and fine dust inside the exhaust duct and in-leakage of air which lead to a decrease of the gas cleaning capacity of the GTC [1]. This requires extensive cleaning and maintenance effort in order to maintain the GTC at full gas cleaning potential.

Due to the well-balanced ducting design at ALDEL, which has been engineered to be able to face the elements over the duration of the life of a cell, very little cleaning and maintenance work is required.

Alumina Handling

Alumina arrives at ALDEL by ship and is transported directly into the big storage silo (30,000 metric tons) by a conveyor. Directly underneath the silo, four volumetric feeders are installed with a capacity of 5 – 15 metric tons/hr each. These volumetric feeders have a dosing accuracy of 1% for extremely precise supply of alumina to the GTC.

Accuracy of the fresh alumina feed rate is essential; this rate should correspond with the amperage trend in the Pot Cells to ensure the amount of alumina fed to the Pot Cells is sufficient. In Figure 4, the relation between the theoretical alumina consumption calculated on the pot amperage (blue) and the alumina supplied by the volumetric feeder (red) is shown on a relative basis. The green line indicates the difference between these two values.

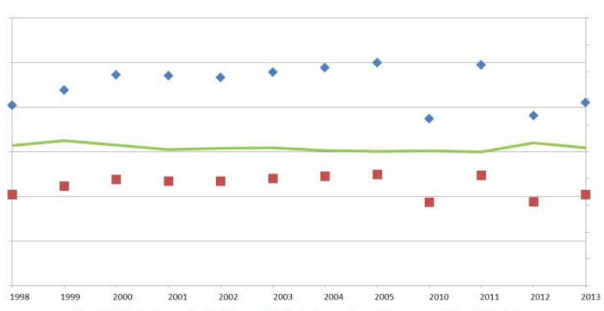

Figure 4: Alumina Feed Rate vs. Amperage

Analysis of the logged data shows that the average alumina dosing accuracy is 0.6%.

From the volumetric feeders, the alumina is transported to the GTC using air gravity conveyors and airlifts. Figure 5 shows the ALDEL GTC with in front the large air gravity conveyor that supplies alumina to the GTC.

Figure 5: ALDEL GTC

Under high performance of the GTC, the material handling system should be capable to transport more alumina than originally designed for. To transport the alumina, the Danieli Corus design uses air gravity conveyors instead of screw conveyors in order to avoid equipment abrasion and capacity limitation. Apart from the low abrasion, also the attrition of the alumina in the alumina handling equipment is very low, which is beneficial to the smelting process [2]. It is known that other conveying systems (e.g. screw conveyors) cause more attrition than air gravity conveyers.

Figure 6 shows the average particle size for Fresh Alumina (FA) and Reacted Alumina (RA).

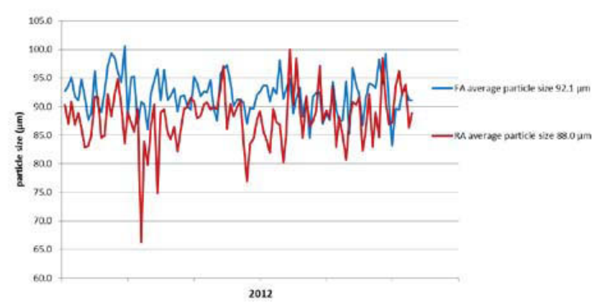

Figure 6: Alumina Attrition

From this figure can be seen that the difference between the FA particle size and the RA particle size is only 4.1 µm, which indicates that the attrition of alumina within the GTC is very low.

Figure 7: Volumetric Feeder

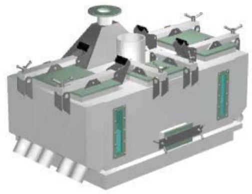

Figure 8: Distribution Box

At ALDEL, the four volumetric feeders and the distribution box that have originally been installed in 1998 are still in use and are in good shape. Only little maintenance has been done during those years.

The heart of the Danieli Corus Pleno IV technology is the patented Vertical Radial Injection (VRI) system. The VRI creates an excellent contact of the alumina particles and the gas, obtaining more than 98% HF removal efficiencies. Air is used to fluidize the alumina inside the VRI and the alumina overflows through the holes as shown in Figure 9.

Figure 9: Vertical Radial Injector

Low Pressure Pulse System

The GTC at ALDEL also uses the Danieli Corus low pressure pulse system. This system has proven itself in the industry as a very efficient method to clean filter bags and promote filter bag life.

The Danieli Corus LP pulse cleaning system uses a low air pressure (0.6 – 0.7 bar) and a high air volumes to remove the alumina from the filter bags. The LP pulse cleaning system has several distinctive advantages with respect to the commonly used HP pulse system [3].

Figure 10: LP Pulse Cleaning System at ALDEL

Due to the pulsing sequence in which non-adjacent filter bags are pulsed at the same time, pulse frequency is reduced and bag life is extended. This can be clearly observed at ALDEL, where the filter bags have a typical lifetime of 7 years and several of them have only been replaced once since the startup of the GTC in 1998. The relatively moderate gas temperatures at Aldel are beneficial to the lifetime of the filterbags, but from experience it is known that the main contribution to the long baglife is the low pressure pulse system.

Table III shows the year in which the filter bags have been replaced for each of the 11 Filter Modules. A number of filter bags have been cleaned instead of replaced, this significantly improves the lifetime of the filterbags.

Table III: Year of replacement of all bags per Filter Module

Filter Module	Filterbags replaced (1st time)	Filterbags replaced (2nd time)	Cleaned
1	2005	2011	
2	2003		2008
3	2006		
4	2003		2009
5	2005		
6	2003		2011
7	2003	2007	
8	2006		
9	2006		
10	2005	2007	
11	2006		2011

In addition to the filterbag replacement of one entire module, individual filter bags are also replaced during operation, for example due to leakage. At ALDEL, the total number of filter bags that need to be replaced per year is reasonably low as can be seen in Figure 11. This figure shows that only 1 – 4 % of the filter bags need to be replaced each year.

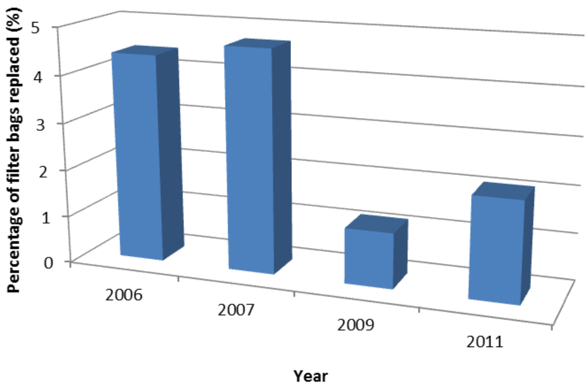

Figure 11: Percentage of filterbags replaced per year

Apart from energy consumption, filter bags represent one of the major operational expenses in the GTC. Taking into account that one ALDEL filter module contains 1336 filter bags, the costs of replacing the filter bags of one entire module are significant. Therefore, a long filter bag life leads to a significant reduction of the overall operational expenses.

On top of this, the low pressure pulse system associated with the Danieli Corus scrubber provides unimpeded access to the filter bags. If miscellaneous bag changes are required, personnel can simply enter the tubesheet level and change the filter bag without having to remove blow pipes. This simplicity means less downtime, which ensures productivity and meets emission requirements. At ALDEL, bag replacement is done extremely efficiently and only takes around 15 minutes per bag.

The GTC at ALDEL also incorporates numerous other distinctive Danieli Corus design features:

- Proven Operational Reliability
  At ALDEL, only 1 operator required during daytime. In night time the potroom operators monitor the GTC operation.

- Designed to Minimize and Control Hard Gray Scale
  Minimum maintenance required on ducting. A provision is made to remove hard scale from the hopper without taking the baghouse out of operation.
  – refer to 'Layout' section.

- Best in class Alumina Handling System
  Air gravity conveying, airlifts and VRI to reduce abrasion and attrition – refer to 'Alumina Handling' section

GTC Performance

Dust Emissions

In Figure 12 below, the average particulate emission in the exit stream from the GTC, from 2001 to 2012 is given.

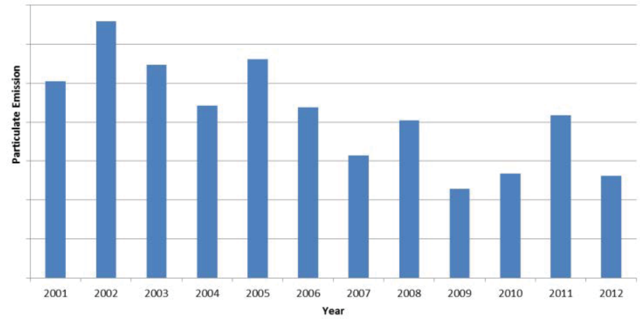

Figure 12: Yearly average particulate emission

The particulate emission limit at ALDEL is 5 mg/Nm^3 and it should be noted that this limit is only exceeded by exception.

Also the average monthly particulate emission for 2012 is plotted as can be found in Figure 13. From this figure can be seen the particulate emission is reasonably constant and increases with ambient temperature as expected, reaching an annual high during the summer months.

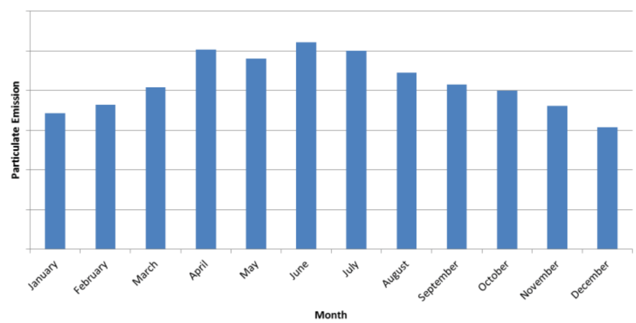

Figure 13: Monthly average particulate emission

Fluoride Emissions

In Figure 14 below, the average fluoride emission from 2002 to 2012 is given.

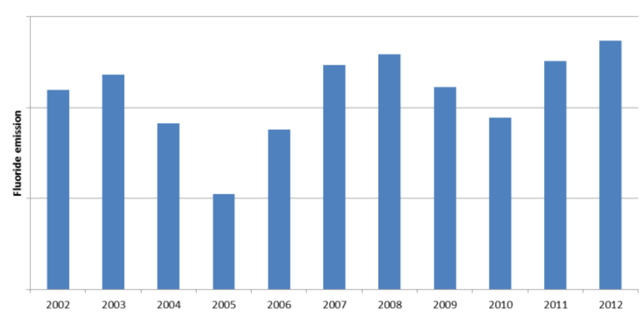

Figure 14: Yearly average fluoride emission

The fluoride emission limit at ALDEL is 0.5 mg/Nm^3, which is once again only exceeded by exception. The scrubbing efficiency is over 99.8%.

Also the average monthly fluoride emission over these years is plotted as can be found in Figure 15. From this figure can be seen the fluoride emission is reasonably constant and increases with temperature as expected.

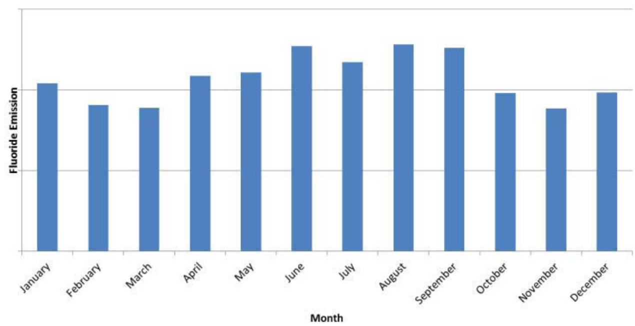

Figure 15: Monthly average fluoride emission

Conclusion

After 15 years of operation, the Gas Treatment Center at ALDEL Aluminium Smelter is still operating successfully and reliably. The GTC is in good condition and only little maintenance work was required over the years.

Due to the properly designed inlet ducting network, there is no accumulation of scale and the pot evacuation rates are balanced reasonably well. Also the alumina handling equipment requires little maintenance due to the use of an air gravity conveying system. The originally installed equipment is still in use and has not been replaced since 1998.

The filterbags at ALDEL have a typical lifetime of more than 7 years as of the low pressure pulse cleaning system used. This leads to a significant reduction in operational costs.

In addition, the potline also benefits from the good GTC performance due to very low abrasion levels of the reacted alumina and the extremely accurate fresh alumina dosing.

The GTC performs well on the emission of fluorides as well as particulates. The emission levels are relatively constant and are below the imposed emission limits.

References

[1] Stephen J. Lindsay, *Effective Techniques to Control Fluoride Emissions*, TMS Light Metals 2007, p 199.

[2] Stephen J. Lindsay, *Attrition of Alumina in Smelter Handling and Scrubber Systems*, TMS Light Metals 2011, p 163.

[3] P. Verbraak, P. Klut, T. Turco, E. Dupon, E. Engel, *Compact Design for Gas Treatment Centers* TMS 2013 142nd Annual Meeting & Exhibition, 3 – 7 March, San Antonio TX, USA