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Startup and Tuning of Material Distribution System at Aluminium Smelter in Qatar

JAN PAEPCKE[1], ARNE HILCK[1], JULIAN SOWAH[2], VIVEK SHROFF[2], SANTOSH KUMAR[2], RAHUL JAIN[2]
[1]Claudius Peters Projects GmbH, Schanzenstr. 40, Buxtehude 21614, Germany
[2]Qatalum/ Mesaieed Industrial City/ Qatar

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Abstract

The start of Qatar Aluminium (Qatalum) in 2009 saw the largest aerated distribution system (ADS) at that time.
The Aerated Distribution System was designed to supply secondary alumina from silos to 704 electrolysis pots with a total design output of 585,000 tpa based on fluidized airslide conveyors
In this article the technology of the aerated distribution system is briefly described to show its uniqueness and advantages.
The main focus in the article is set on the experiences during the first operation of the ADS, highlighting challenges and breakthroughs; and how it was possible to optimize the system to be more functional than projected, especially under the Middle Eastern conditions.
The measures that have been taken to achieve this target and the lessons learned are described in the article.
This paper concludes technical features presented on earlier TMS Annual Meetings [1, 2, 3, 5, 6] and compares them with results from practice.

Introduction

The first electrolysis cells at Qatar were started in 2009 and by 2011 the system was running at full production capacity.
The secondary alumina is transported from the four day silos within the Fume Treatment Plants by the Aerated Distribution System (ADS) to the pot superstructures inside two potrooms.
The design for mechanical equipment should always be as simple as possible for a given task. Distribution systems for alumina in the aluminium industry follow fundamental bulk solids transport principles. The key difference sets with the parameters that determine performance of these. This paper compares the different options for these processes and highlights the operational experience with the system. The data collected, challenges met and experience gained from this startup and early years of operation will prove helpful for future installations.

Description of Aerated Distribution System

The Aerated Distribution System (ADS) is designed to convey alumina from the Secondary Alumina Silo at the Fume Treatment Plant to the different cells in the potrooms. Table 1 shows the key data.

	Expected	Achieved
Four Systems, each serving 176 cells, separated into two subsystems, coarse particle separator upfront, operating intermittently		
Capacity of Transport Airslide	50 t/h	More than 50 t/h
Capacity of Cell Airslide	10 t/h	20 t/h
Longest conveying distance	290 m	

Table 1: Key design data

The operating functions are described in [1, 2, 5, 6].

The ADS mainly consists of inclined airslides for the transport of alumina and its operation is divided into two Levels. (See Fig. 1)

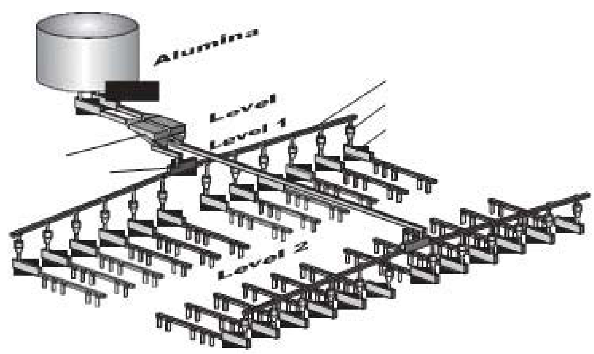

Fig 1: Principle sketch of ADS [1]

Level Control Boxes between the levels allow a controlled material flow in the different airslide levels.
Level 1 starts at the outlet of the day silo at the FTP with a level control box, followed by a coarse particle separator and conveys the alumina to distribution boxes located along the potroom wall. (Fig.2).

Fig 2: Transport Airslide

From the distribution boxes, with an integrated level control system located at the potroom wall, the alumina is transported via the distribution airslides (see Fig. 3) to the buffer silos upfront each pot.

Fig. 3: Distribution Airslide

Level 2 comprises of the level control box underneath the different buffer silos, the insulation airslide and the pot superstructure airslide.
Depending on the available options, the airslide is deaerated to different systems. The main air volume is vented through the pot superstructure to the gas collecting ducts.

The Aerated Distribution System is operated by sequentially controlling airflow from the day silo and at various parts of the system. The different airslides are only operated intermittently, thus saving aeration air and energy.

Control of the Aerated Distribution System

The control system is automated, requires little attention and can run virtually unmanned with interactive display screens which give a clear representation of the current operation at any time. Operational data are stored and used for planning of maintenance activities and to evaluate material behavior and process changes.
The level indicators in the system allow for a comprehensive depiction of the operation of the ADS system at any one time. (See Fig.4)

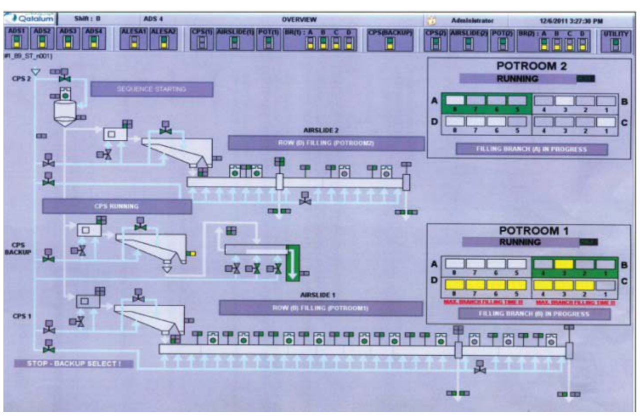

Fig. 4: Operator screen

Since the system is operated intermittently and not continuously, the air consumption is kept very low.

Modular design
The Aerated Distribution System follows a simple modular design. Different parts allow for easy adaption to user requirements. The high degree of standardization results in a consistent quality control, and low inventory requirements for spare parts.

Operation of aerated distribution system
The inclined airslides transport material of varying properties.
The transport velocity for a given material varies depending on the grain size distribution. Coarse particles will be transported with a lower velocity than fine particles. If there is no inclination in the system, the coarse particles might need to be drained out at the front end of a distribution system, as the accumulation might affect the overall transport capacity. The inclined system transports coarser material as well.
While segregation would have no significant relevance to inclined airslide systems, there would be an effect on horizontal airslide systems.
The low velocity of air and material within the airslide chamber coupled with the negative pressure ensures consistency during conveying and reduces the tendency for scaling.

Wear and Maintenance

The intermittent operation function of the Aerated Distribution System enables easy maintenance without disturbing the cell operation. Inspections of internal and external parts and corrective maintenance tasks can be planned with ease.
The evaluation from the first few years of operation in Qatalum has shown little wear on system components and low maintenance requirement compared to other conveying systems.
Also, the observed amount of scale formation over the 3-year period of operation has been low, especially on the internal walls of the airslides. However the level sensors were found to accumulate flaky layers of scales weighing between 5 to 30 grams depending on their location. Cleaning of these sensors is done annually.
Particular attention, estimated at 20mins a week of first line maintenance, is required on the coarse particle separator where material flow is most critical. Routine checks mainly involve the air supply to the system, the coarse particle separator (CPS), deaeration filters units on the airslides and instruments.

Operations During Startup

The secondary alumina, during the first commissioning phase in Qatalum had higher fines (>10% of -45µm grain size), compared to material from a plant being in full operation. This high percentage in alumina fines was due to attrition during the bag coating and recirculation process at the start of the Qatalum Fume Treatment Plant. Though these fine particles are usually flushed out after a few conveying cycles, it was observed to impact the flow pattern during startup of the ADS by reducing the conveying rate of the airslide and the coarse particle separator (CPS).
A higher fraction of fines would increase the tendency for bridging and the angle of repose will change, affecting the material bed height and CPS capacity
A varying material level made it necessary to alter the heights of the sensors in the airslides, creating the need to install adjustable sensors instead of fixed types within the airslides.
A key feature of the airslides is the nozzles for air supply & fluidization which were found to be rather sensitive to particulate materials in the air quality. The flushing of the compressed air piping system from the ADS proved to be essential after installation. Blocked nozzles were a challenge in the first few

years of operations and though they were easy to detect, physical access to the airslides was a setback.

Coarse Particle Separator (CPS): Designed to screen particle sizes above 3mm, the CPS in Qatalum consists of containment with an inclined mesh, a vibrating unit and venting connections. The main startup and operational challenge encountered with the unit was its ability to withstand the rough conditions inside the material stream. Small modifications in the equipment and process as well as an upgrade in components greatly reduced the failure rate and saw an increase alumina flow consistency.
Another key challenge was to control the flow of fluidized alumina from the day silo to match with the capacity of the coarse particle separator. This was usually indicated by the spillage of the CPS with alumina from the silo. This was addressed during the plant operational phase by fine tuning the material discharge rate from the silo, review of air supply to the CPS level control box, in improvements in the vibrating unit. Fig. 5 below shows the outcome of these step changes.

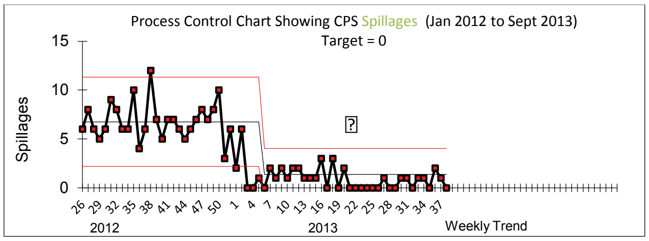

Fig. 5: Spillage rate

Operational Data Evaluation

As mentioned above, the operational data of the system are stored and are analyzed to aid day to day maintenance and process planning.
A more detailed investigation of the data is ongoing and the first results will be presented in the near future.
The evaluation of data from the operation can give a more in-depth view on the Aerated Distribution System. The latest data will then be presented at the coming TMS meeting.

a) Evaluation of duration of aeration will give a view on the capacity and stability of the system.
b) The particle size distribution at different locations of one branch will be analyzed to verify the absence of segregation.
c) The physical properties of the material at different positions of the system will be analyzed.

Lessons learned

At present the performance of the Qatalum ADS system is optimal and stable compared to the early phases after startup. Emphasis is placed on the joint efforts by the Qatalum operations team and technology providers (Norsk Hydro and Claudius Peters).

From silo to Coarse Particle Separator
With this design, a stable flow from the silo is crucial for high operational uptime of the coarse particle separator and the entire distribution system. By installing a modified vibrator unit the coarse particle separator was adapted to cope with flow variations. For future installations more focus will be given to the control of material flow from the silo going into the system.

Air supply
By adjusting the air pressure the aeration air volume may be adjusted as well. The operation shows that the material might need significantly less air volume for the conveying than expected, thus the possibility to reduce overall air consumption without compromising capacity.

Deaeration Filter
Usually the system should be solely deaerated to the main vent network but may not be practical due to the plant layout (as seen in Qatalum). In this case pressure filters are installed at vantage points to function at venting units. These units have proven to be suitable for this task.

Another key finding was the effect of overall venting on material flow within the CPS. In the design, the venting line for excess air is connected to a shared filter unit mounted on the silo and this was found to influence flow patterns especially during maintenance activities in the Fume Treatment Plant, ageing of filter bags or during process changes. Fig. 6 shows a trend of suction measurements taken on a day shift with maintenance and regular operations of the Fume Treatment Plant. Variations in the venting (negative pressure) ranged between -1000Pa to 0Pa. The lesson learned was to minimize stoppages or at least ensure well-coordinated maintenance shutdowns. Connection to the main fume duct has been seen to be the best way to ensure constant negative pressure.

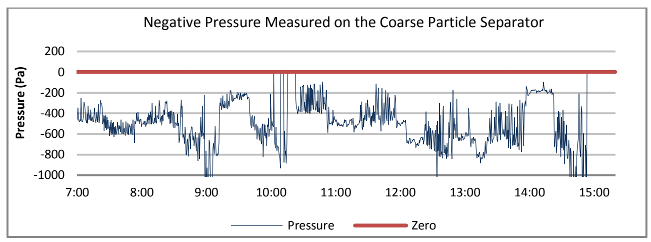

Fig. 6: Chart showing unstable negative pressure readings

Adjustable Sensors
The ability to adjust the depths of the level sensors into the material stream in the airslides was found to be a good advantage when determining the flow. This is most essential to startup and future optimization of material volume in the airslides. Feedback on the user interface screens immediately shows where to troubleshoot.

Comparison of different options

There are different design options for a material distribution system.

a) Pipe conveying with valves to all receiving points
b) Horizontal airslides
c) Inclined airslides

While with a horizontal airslide the coarse material fractions will be found more likely in the first part of the system (Fig. 6) the inclined airslide will have a more even material distribution over the entire conveying length.

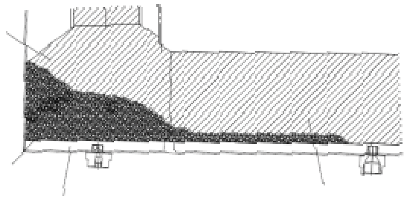

Fig. 6: Collecting of coarse particles [6]

Compared to this a pipe conveying will have high velocities and higher pressure drops in conveying distance, resulting in scaling or material attrition.
If there is no inclination in the system, the coarse particles might need to be drained out at the front end of a distribution system, as the accumulation of coarse particles in the front end might affect the overall transport capacity.
While segregation would have no significant relevance to inclined airslide systems, there would be an effect on horizontal airslide systems [7].
Inside the material chamber of the Aerated Distribution System there is a low to slightly negative pressure. The material is exchanged frequently and there are no high velocities alongside the walls. Therefore the tendency to scaling is very low. Inside the system no scaling is taking place.

Evaluation table
In Table 2 the different options of the basic design are compared.

		Version A	Version B	Version C
Description		Pipe conveying with separate valves	Horizontal airslide	Inclined airslide
Installation cost				
	Supporting Structure	Only piping small size	Horizontal easy to install, but high demand deaeration	Inclined airslide not easy to install
	Mechanical Equipment	Minor but a lot of valves	Same as inclined	
	Installation	Very easy	Easy	Easy
	Electrical Equipment	Lot of valves	Fewer to no valves	Few valves
Operation Cost				
	Air Consumption	High	Very high	Low
	Air Pressure	High	Low	Low
	Wear Parts	Very high demand	Low demand	Low demand
Operation				
	Scaling	Very high	Possible	Very Low
	Segregation	Low	Possible	Low
	Attrition	High	Low	Low
	Control of operation	Reasonable	Low	Very good
	Monitoring of operation	Reasonable	Low	Good

Table 2: Different Options for Material Distribution

Compared to a horizontal airslide or a horizontal pipe the inclined airslide installation might have a higher installation cost, but there are other benefits of the system.

Summary and Outlook

The Aerated Distribution System (ADS) at Qatalum has been in operation since 2009 and has seen significant process stability.
The Material Distribution System was started as scheduled and is still running under full production capacity. Through key findings and improvements made by the end user (Qatalum) and by joint coordination with the technology providers, the systems' performance has met expectations and operational needs.
In comparison to other material distribution systems, the ADS is found to require less maintenance and less human intervention.
A collection of more data and investigation is still ongoing to map the long term performance of the system and its interaction with other process parameters and will be presented in future.

References

[1] Karlsen, M., Dyroy, A., Nagell, B., Enstad, G.G., Hilgraf, P.: New Aerated Distribution (ADS) and Anti Segregation (ASS) Systems for Alumina. TMS Annual Meeting 2002, Seattle, USA, 2002 February 17-21. P.5. A. (02-1000-8).

[2] Wolf, A., Hilgraf, P., Altmann-Rinck, M.: A New Alumina Distribution and Feeding System for Aluminium Reduction Cells. TMS Annual Meeting & Exhibition 2007, Orlando, Florida/USA, 2007, February 25 - March 01, Collected Proceedings: Light Metals - Alumina Reduction, pp. 223 – 228.

[3] Wolf, A., Hilgraf, P.: FLUIDCON - a new pneumatic conveying system for alumina. TMS Annual Meeting 2005, San Antonio TX, USA, 2005 March 13-17. P.5. A. (02-1000-8).

[4] Hilgraf, P.: FLUIDCON - a new pneumatic conveying system for fine-grained bulk materials. CEMENT INTERNATIONAL 2 (2004) No. 6, pp. 74 - 87.

[5] Wolf, A.; Hilgraf, P.; Hilck, A.; Marshalko, S.: Operational Experience with a brownfield expansion project in Sayanogorsk, Russia, TMS Annual Meeting & Exhibition 2007, Orlando, Florida/USA, 2007, February 25 - March 01, Collected Proceedings: Light Metals - Alumina Reduction, pp. 223–228

[6] Paepcke, J; Hilck, A.: Marshalko, S.: Operational Experience of Advanced Alumina Handling Technology in a Russian Smelter, TMS Annual Meeting & Exhibition 2013, San Antonio, TX, 2013, Collected Proceedings: Light Metals - Alumina Reduction, pp. 753-759

[7] Hilck, A.. Karlsen, M., Dyroy, A.: Segregation Effects during Transport and Storage; Presentation at ICSOBA 2012, Belem.