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Experiences with Alstom's new Alfeed system at Emal

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Abstract

Alstom's new pot feeding system (Alfeed) was successfully installed and commissioned on Emal's 756 pots during 2009-2010.

The Alfeed system consists of 15 km distribution and pot airslides, manufactured in standard sections for maximum ease of installation and use.

Alfeed on Emal is connected to 8 enriched alumina silos, each feeding two sections with 48 pots. Each section is 300 m long. The nominal flow rate to each pot is >200 kg/h, and to each section >10 ton/h.

The main issue encountered during start-up was dusting from the pot's alumina hopper lids. Small puffs of dusty air would leak through a narrow opening, eventually leading to build-ups of alumina on the superstructure. This was resolved through implementation of a clamp to the lid as well as a gasket.

As with all new systems, some challenges were encountered as well as possibilities for optimisation. These are discussed in detail in the paper.

Introduction

When the first pot at Emal was started on 2 December 2009, Alfeed for this first section was already commissioned, and the required pots filled with alumina.

The start up was of course very important for Emal, as they were starting up the world's largest single site Greenfield aluminium smelter, but also for Alstom with start-up of the first commercial installation of Alfeed and start up of the largest GTC that Alstom has so far delivered.

Alfeed is Alstom's pot feeding system and has earlier been presented at TMS [1].

The basic outline of the Alfeed system is shown in Figure 1. Alfeed is based on two different kinds of airslides:

- Horizontal distribution airslide
- Pot feeding airslide

In addition, airslides for alumina transport only is used as and when necessary, depending on the configuration of the smelter.

The fully fluidized horizontal distribution airslide is used to distribute alumina to the entire sections of a potline. This airslide is normally fed with enriched alumina from the upstream enriched alumina silo. The airslide is operated as a fluidized bed, well above minimum fluidization velocity. The distribution airslide also operates as a reservoir of alumina. The level is kept constant by the operation of a rotary feeder, in connection to signals from the airslide level transmitters.

At each pot, alumina is fed from the distribution airslide to the pot airslide. Fluidization air is vented through a cyclone to the gas duct. The fine particles are separated out of the vent air by the cyclone and sent directly to the pot. Alumina is transported to the pot with a flexible hose. A similar hose connects the air chamber of the distribution airslide with the air chamber of the pot airslide.

The pot airslide is a potentially fluidized system that keeps the pot silos filled at all times. When the pot consumes alumina, the pot airslide will automatically top-up the pot's internal silos. A visual indicator on the pot airslide's end indicates if it is filled or not. A GRP airslide section provides electrical insulation.

The fluidisation air source of Alfeed is normal high pressure fans with a fluidisation pressure of approximately 15 kPa. No blowers or compressed air is necessary with the associated energy savings (smaller motors). Compared to systems using compressed air and/or blowers the Alfeed system is a very energy efficient potfeed system.

Airslide components of Alfeed are produced in cooperation with a production partner that has a special factory in Norway. The factory is highly automated and allows for production of airslides with little human interaction. This gives high accuracy in the production of the airslides and especially the flanges. This is highly important for an airslide that is several hundred meters long.

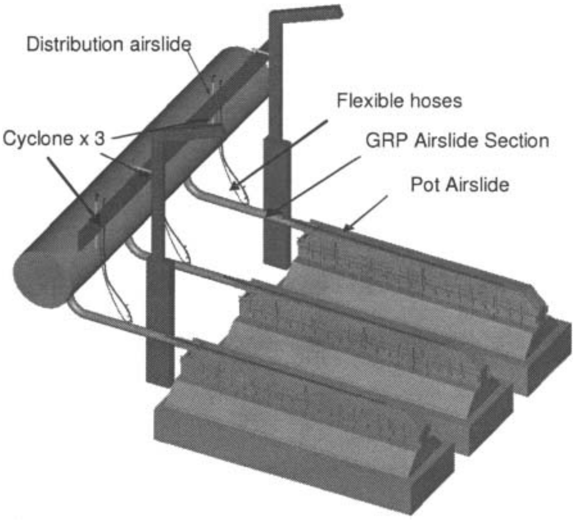

Figure 1 Basic outline of Alfeed system for 3 cells

EMAL

At Emal, Alfeed feeds the 756 reduction pots on Phase 1 of the smelter. There are four GTCs and each GTC is supplying enriched alumina to two silos of 700 ton each. These silos are connected to the Alfeed system.

Each silo, supplies two sections (approximately 300 m each) of the potline. The distribution airslide for each section is located on the outside of the potroom.

The pot airslide is fed from the distribution airslide and will in turn feed one reduction pot with 5 pot hoppers. These hoppers are filled from a spout from the pot airslide. Feed shutoff happens when the alumina level reaches the end of the spout and chokes the flow.

In addition there are approximately 100 meters of transport airslides per plant. The transport airslides transport alumina from the enriched alumina silo to the distribution airslide. Totally there is approximately 15 km of airslides installed at Emal.

Erection

The distribution airslides were pre-assembled in the lay-down area. Six distribution airslides were bolted together, including two cyclones. The pre-assembled distribution airslide were then trucked the short distance to site and erected.

Figure 2. Lifting and erection of distribution airslide

With 1200 meters of distribution airslides per plant and airslide sections of 2 meters each, (i.e. 600 joints per potroom) it can easily be understood that some of the airslide flange joints had issues. To mitigate this risk rigorous quality control of the assembly was implemented. The flanges were torque checked at assembly, then prior to erection and also re-checked during pre operation and verification and commissioning. This minimised the amount of joint issues, though some occurred. Most of them have however only been air leaks, as opposed to more serious alumina leaks.

To minimize possible leaks from airslide joints, changes to the airslide flanges and gaskets design will be implemented into future Alfeed systems.

The pot airslides were mainly erected during superstructure fabrication, though some also were installed on site. Flexible hoses transport alumina from the distribution airslide to the pot airslide.

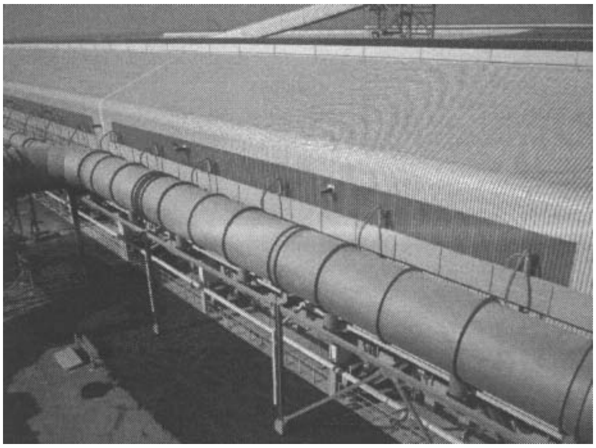

Figure 3 – Alfeed installed

During start up the length of the PVC hoses from the distribution airslide cyclones to the pot airslide expanded. When installed they were at ambient temperature and un-loaded. As alumina is hydroscopic, it was decided to wait until the last possible moment before priming the system with alumina. When the PVC hoses were filled with alumina, they stretched, and this resulted in sagging hoses at some pots. The reasons for sagging is slack from the installation, but also stretching and expansion of the hoses when exposed to alumina above ambient temperature. Hoses with problems were then adjusted after start-up. Discussions with the supplier of the hoses have identified possible improvements. The flexibility of hoses to penetrate the complex building walls is a major advantage of the Alfeed system, though some improvements of the hose layout were necessary during the commissioning on site.

Issues Encountered

Dust from the pot hopper lid – Finding a solution

The main issue encountered during start-up was dusting from the hoppers of the pot. The openings of the pot hopper were closed with a metal lid. The lid had an opening for the alumina feed pipe with a very small gap between the pipe and the lid (< 1mm). Small puffs of dusty air from the refilling of the hopper would flow out of these openings. Over time, alumina accumulated on top of the superstructure.

There are several possible reasons for this accumulation. These include thermal rise of the air/dust and blocked vent openings from the hopper towards the pot. Regardless of the reason, accumulation of alumina dust on the superstructure is not desirable and a solution therefore had to be found.

Sealing the opening with silicon could be an option, but this would mean less access to the pot hopper and Emal were concerned that complete sealing of the pot could have detrimental effect to the pot operation. It was decided to test the solution to see if complete sealing had unfavourable effects to the pot. No such effect was seen, but sealing the pot hopper lid with silicon was not a good solution to the dusting issue as the access would be limited in the future.

Just using a gasket was not enough, as air could escape if no compression was applied to the lid/gasket. The chosen solution was the combination of a gasket together with a clamp on the lid. Some of the important points to the design of the clamp was that it should be easy to remove and that the gasket should not be damaged by the harsh environment on the pot. The temperature on the pot can be 50-80°C and with the difficult environment on the pot with HF gas and heat, a gasket material of Viton was chosen for the pots.

When the samples arrived on site for test they did not meet the specified dimension. They had been cut at cold temperatures in Europe and when heated to operational temperature they expanded leaving a loose seal between the feed pipe and the gasket. The supplier was asked to test the next set at operational temperatures to see if the gaskets fit. This way the correct square hole size was determined and Viton gaskets with the right dimensions started arriving to site.

Another source of dust accumulation on the pot was spillage from filling the AlF_3 hopper of the pot with crane. Emal have implemented measures to eliminate this spillage.

Figure 4 : Photo of pot with dusting. Dust is accumulating around the inlet to the pot hopper, but also around the ALF3 fill point.

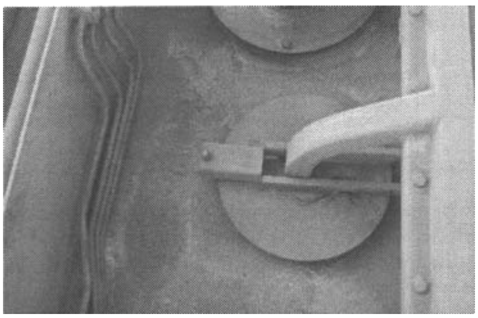

Figure 5: Photo of pot with lid, gasket and bracket. No leakage of air/dust can be seen.

Dust from the hopper – Installation of the solution

In the time period from detection of the problem, discovery of a reliable solution and all the way until the gaskets and brackets were delivered, a large number of pots were in operation. Start up of Emal happened at quick pace, and a number of pots were started each day.

When the time came for installation, many pots were in operation. The top of the pot superstructure is a hazardous place, with lots of trip points, possibility of crane movement, no hand rails and hot surfaces in addition to superstructure control equipment. Ambient temperatures (for the workers) on the top of the pot were 50-60°C. A fall restraint system had to be invented, and a rotation scheme for the workers set up so the workers would have time to recuperate and get re-hydrated. The pot would first be manually cleaned by non-magnetic hand shovel, then swept clean and then the gasket and clamp would be installed. More than 80 people were mobilized to do the work.

The fall restraint system designed by Alstom is now adopted by Emal when they work on the pot superstructure.

Insufficient filling of pot hoppers

During a short period after start-up, occasional hang-ups in filling of some few pot hoppers happened. No apparent reason for it could be found, although we suspect that cohesive materials from the plants test and start up period have a major role.

Distribution Airslide Gaskets

By an unfortunate installation mistake by the erection company, one of the distribution airslide gaskets was installed upside down without anyone noticing this. The design of the airslides and gasket made it possible and it was immediately decided to make changes so that such installation failure could in the future be detected. Gaskets now have "ears" to mark middle points.

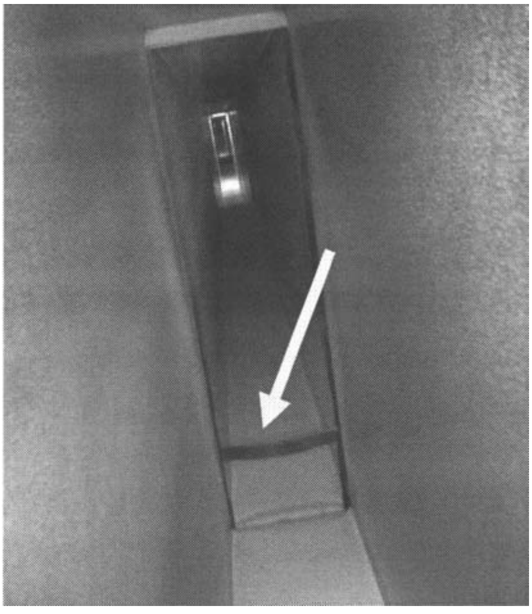

Figure 6: Gasket that is installed upside down

The mistake was detected after start up of the pot line. Alumina leaked into the air compartment, and transport of alumina to the pots stopped. This was one of the most serious incidents, as it threatened the aluminium production. Alstom, Emal maintenance crew and the erection company worked through the night to clean up the distribution airslide to ensure no interruption to the pots.

Alumina level control

The level of the distribution airslide is controlled by signals from several level tuning forks. The first edition of the logic of the control software of the level resulted in an on-off type of feed control. See figure 7. This worked, but was not an optimal way of filling and controlling the level of the airslide.

Although the logic of the level control in the control system worked, it was not optimal. The step-down functions for the rotary feed speed of the alumina feeder into the distribution system, was interfering with the start stop function. This led the system to stop instead of stepping down. The result was that the system would run at max speed, then stop for about the same amount of time, then start up and run at full speed again. The issue was looked at several times, without really understanding how to correct.

Finally during the commissioning of the last plant it was decided to start from scratch. Two level transmitters with solid rods were purchased and installed on one plant in order to be able to understand the levels in the system. A sequence/ logic was then written that incorporated both start, stop, speed increase and speed decrease, into one common entity in the control system.

The logic was such that it assumed that it should run at nominal speed and would step up or down upon input from the level sensor. The step size (step up or step down) was diminished the further away from the nominal the feed-rate, allowing for a tapering off of the increase or decrease in filling rate.

The new sequence ran very well during the tests, see Figure 8. It was tested on the plant with the level transmitters where one could follow the level of fill in the airslide in %. At the end of the test period the new sequence was implemented on all plants. The sequence currently runs so well that Alstom got some complaints from the operators. The operators were happy not have to intervene with the system due to under fill, but they missed seeing the high level indicators on. They later told us that they would regularly provoke a manual overfeed of the system to make sure the system was full.

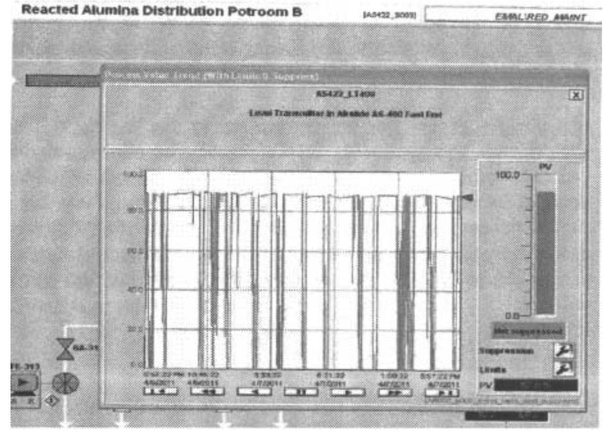

Figure 7 On/Off behaviour of alumina feeders

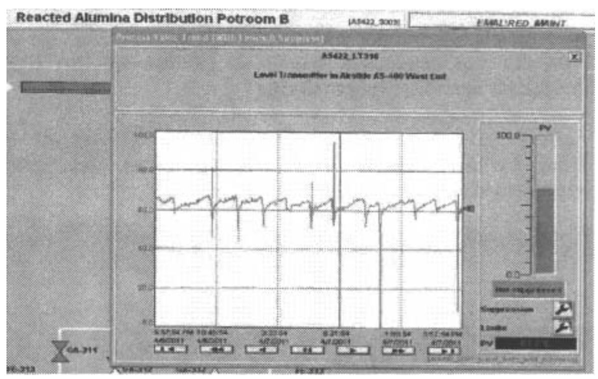

Figure 8 Continuous / varying feed rate from alumina feeders

Influence on alumina quality

For performance tests, samples of alumina were taken at the inlet of the Alfeed (i.e. from the silo) and from the point feeder of the cell. The samples from the silo showed little variation in particle size as seen in Table 1.

Table 1: Alumina Particle size at outlet of silos

From silo	< 150 μm (100 mesh)	< 75 μm (200 mesh)	< 45μm (325 mesh)
Average silo 1	93,6 %	40,2 %	16,6 %
Standard deviation silo 1	0,4	1,1	1,9
Average silo 2	93,8 %	41,4 %	16,8 %
Standard deviation silo 2	0,5	2,6	3,3

The samples from the silo are compared to samples taken from the point feeder of the pots. The particle size results are shown in Table 2. They indicate that the material at the pot is actually coarser at the point feeder than at the silo outlet (which is remarkable) However due to the long time delay (residence time in the pot hopper), these results do not necessary reflect the same alumina quality that is fed to the pot hopper at the time when the samples were taken. No conclusion about the particle size and influence can thus be drawn.

Further testing is planned to verify impact on alumina

Table 2: Particle size distribution of alumina samples taken at pots

	< 150 μm (100 mesh)	< 75 μm (200 mesh)	< 45μm (325 mesh)
Sample 1	96,1 %	35,2 %	6,6 %
Sample 2	94,8 %	37,3 %	11,3 %
Sample 3	96 %	34,1 %	3,6 %
Sample 4	93,9 %	38,9 %	13,3 %
Sample 5	92,6 %	52,9 %	27,4 %
Sample 6	94,4 %	36,9 %	10,6 %
Sample 7	94,3 %	39,4 %	13,4 %
Sample 8	94,5 %	38,7 %	12,5 %

Results from a demo installation showed that the fraction of alumina below 45 μm was 15.5% at the pots and 14.6% in the airslide. Consequently segregation or attrition from silo to pot was not seen.

Capacity

Capacity measurements of the airslide

Potfeeding systems are a main artery for aluminium smelters, and provide the essential raw material for the production. The Alfeed must deliver enough material and do so reliably, if not the smelter will stop.

The Alfeed system has since it was commissioned delivered continuously more than 200 kg/h per pot (or > 10 ton/h per smelter section), which is the normal consumption of alumina.

The maximum capacity of the distribution airslide was tested as part of performance testing. In-situ measurements of this is difficult due to the design and layout of the systems, however all silo outlets are equipped with volumetric rotary feeders. The amount of fed material can thus be determined from the rotational speed of these feeders. All feeders have a set range in tons/hour based on revolutions per minute and bulk density.

The maximum filling rate was determined in the following way

1. Shut down the alumina distribution system for a given time
2. Monitor and log the consumption of alumina by the pots connected to this leg of the alumina distribution system
3. Re-start the alumina distribution system and record the time required for the pot hoppers and distribution air slide to refill.
4. Flow rate of alumina into the system can then be calculated by knowing the volumetric feed and time to fill.

The measurements showed that on average more than 400 kg/h per pot was delivered to the pots during the time required for refilling. This is well above the specified values.

The filling rate to each pot superstructure was estimated during the initial commissioning. The volume of the pot hoppers was estimated and the time required filling the pot hoppers recorded. The filling rate to each pot superstructure was estimated to approximately 5-7 tons/hr. This is considerably higher compared to the required filling rate. Emergency refilling of one empty pot is done in 1-2 hours.

Conclusion

Alstom's pot feeding system is installed on Emal and feed enriched alumina to all the plant's 756 pots. The system is working according to the specifications, delivering more than 200 kg/h to each pot in normal operation. During filling of single pots, considerably higher filling rates are achieved. Also much more alumina has been fed to the system during performance tests than what was specified.

The main issue encountered after start up was dusting from the pots. This was solved by installing gaskets and brackets. This required considerable engineering effort on site and at head office, and also a lot of work from the installation crew who had to clean operating superstructures, and then install the gaskets and brackets. HSE was vital and there were no incidents during this work. After the gaskets and brackets were installed, Alfeed have operated without problems.