AL13 - Alumina Distribution and Transport System to Pots Retrofitted in EGA Jebel Ali Potlines 5 and 6

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Abstract

EGA Jebel Ali has planned retrofitting of their existing potlines 5 and 6 with a continuous alumina distribution and transport system for secondary alumina to each pot to reduce dependency on cranes, to improve potroom atmosphere for operators and eliminate anomalous emission from fume treatment plants due to crane breakdown. The existing pot super structures in the two potlines are CD20 technology with open-top alumina storage hoppers for crane filling. Crane feeding was replaced on the first 120 pots in February 2023 by a continuous alumina distribution and transport system, which delivers continuous alumina smoothly to each of the pots by the use of low-pressure fluidisation.

This paper reports the main observations, improvements and best-practices implemented to optimise operation of the pot feed system. As the system was integrated into operating potlines, early involvement of stake holders and end-users in the project development and design phase was imperative for successful implementation. The system is designed with continuous feeding as well as sequential draining and re-filling to avoid any potential build-ups of coarse material. This significantly reduces cleaning requirements. The ventilation of the fluidising air for the system is purposedly designed to reduce the variations in material particle distribution along the potrooms, and to reduce the risk of dust carrying over to the fume treatment plants. Furthermore, the low-pressure fluidising air for the system minimises the air load added to the existing gas treatment centers. The continuous feeding of alumina to the pots allows for a constant feed rate to the fume treatment plants, which in turn improve their fluoride scrubbing efficiency. In addition, the constantly filled pots eliminate anode effects experienced due to empty pot storage hoppers. This design is tailor-made for easy and fast disconnection of individual pots in the event of replacing pot-super structures at pot cut-out.

The success of the retrofit of the continuous alumina distribution and transport system for the potlines is seen in reduced dependency on cranes, cleaner potroom atmosphere due to closed pot storage hoppers, and limited operator interaction.

Keywords: EGA Jebel Ali potlines 5 and 6, Operational efficiency, Retrofit of alumina transport system, Potroom atmosphere.

1. Introduction

EGA Jebel Ali has since 2017 evaluated and planned for a retrofit of their existing potlines 5 and 6 with a continuous alumina distribution and transport system to each pot to reduce dependency on cranes for feeding alumina to the pots. The 480 existing pot super structures in the two potlines are EGA CD20 (264 kA) technology with open-top alumina storage hoppers for crane filling.

A new transport and distribution system for alumina directly from each fume treatment plant (FTP) storage silo to the pots will eliminate anomalous emission from FTPs that can occur due to crane unavailability. Any stop in material distribution from the silos will reduce or eliminate storage capacity which in turn will reduce or even stop alumina output from the FTPs and result in increased emissions. A sealed alumina distribution and transport system will also improve potroom atmosphere for operators as the dust generated by crane filling to the open pot hoppers will be eliminated.

2. The Project

The project for the supply and installation of the continuous alumina transport and distribution system for bringing alumina directly from the storage silos to each of the 480 pot storage hoppers in potlines 5 & 6 was agreed upon by EGA and Norwegian Emission Abatement Technologies AS (NEATEC) in December 2021. Commissioning and start-up of the first 120 pots in Potline 5 took place in February 2023 and by June 2023 all the 240 pots in Potline 5 were operational with the new system. The remaining system for Potline 6 is scheduled for start-up by the end of 2023.

The system delivers continuous alumina smoothly from the fume treatment plant storage silos to each of the pots by the use of low-pressure fluidisation. The simplified process diagram for the system for 120 pots can be seen in Figure 1.

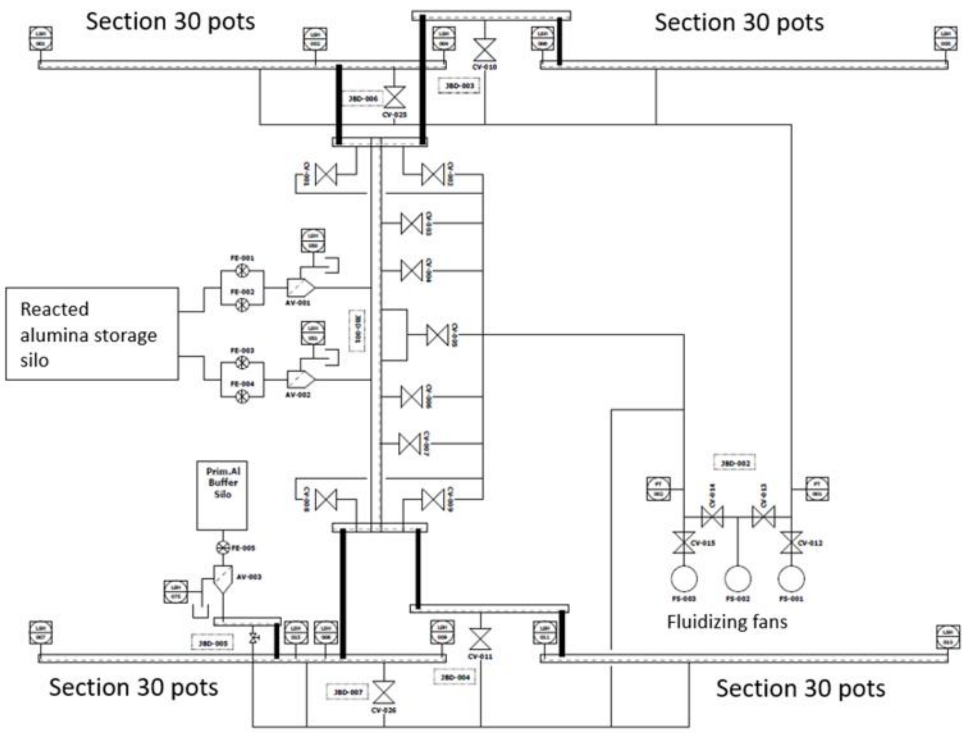

Figure 1. Simplified process diagram.

The key components of the alumina distribution and transport system are:

- Feed system from existing alumina storage silos to each potroom
- Horizontal distribution system to each of the four 30-pot sections in each potroom
- Pot air slide with isolator section to each pot storage hopper
- Dedicated primary feed system to one section of 30 pots.

Alumina is discharged from the existing storage silos through rotary feeders for metering of alumina quantity before the material is filtered through a vibrating sieve (1.6 mm mesh) to remove coarse materials and any foreign objects. The alumina then enters a low pressure fluidised bed transport system that brings the material to each of the horizontal distribution systems along the potroom. This distribution system is split into sections of 30 pots, each designed to handle more than twice the hourly alumina load consumed by the pots, that will act as a reservoir for alumina during normal operation. At each pot, the alumina is fed through a flexible hose connection and an electrical isolator air slide to the pot air slide. From there it is fed to each of the 4 pot storage hoppers through feeding nozzles. The pot air slide will top up the pot storage hoppers only when the pot consumes alumina. The fluidising air to the system is provided by high pressure fans and is ventilated to the FTP potroom ducts though ventilation cyclones. Particles captured are mixed back into the alumina before being fed to the pots.

The alumina level in the distribution system is controlled by high level transmitters and timers, and the system has two main modes of operation:

1. Constant leveling, i.e., maintaining a constant level in the horizontal distribution and transport systems while keeping all pots filled at all times.
2. Exercising, i.e., filling the system up to normal level and then fully emptying the system for 3 hours before refilling. Exercising is done to remove build-ups of coarse material.

The main components of the system (air slides, piping, steel supports and walkways, glass-reinforced plastic (GRP) air slides, electrical panels) were fabricated and assembled in the UAE to ensure strict quality compliance and on-time deliveries. Local fabrication also expedited EGA project team participation on quality inspections of all critical equipment.

3. Design Phase

The inherent limitations of the system design for retrofitting a new alumina transport and distribution system to the existing plant were identified early on by EGA stakeholders during the tender phase and later during design review meetings and Hazard and Operability Study (HAZOP) meetings. This early involvement by the EGA team in the project design phase ensured that the systems were purposedly designed and optimised for installation, operation and maintenance, and that the lessons learned, and improvements were incorporated early on. The outcomes from the design and HAZOP meetings were compiled in action lists that were followed up on a weekly basis.

The project was started on the back end of the COVID-19 pandemic and most of the project interaction between the EGA team and NEATEC during the design phase were managed by online web conference meetings with people participating from multiple locations. This online meeting approach made it easy for all personnel to join in on critical meetings from their own office without having to spend time on physically moving locations.

The following lessons learned and key limitations were identified by EGA team and stake holders as critical for the project and for the system design:

1. Completion of the system on time with zero lost time incidents (LTI)

2. The system should be based on alumina transport by fluidised bed
3. Limited head-room for installation of system on existing pots
4. System shall be designed to avoid over-filling and spillage experienced on other systems at EGA plants
5. Control of thermal expansion of system along potrooms to ensure correct elevation and to ensure proper alumina flow in system
6. Sealing of pot storage hoppers to avoid dust generation inside potrooms
7. Minimum flow to each pot of 178 kg/h.
8. Maximum flow for 30 pots for emergency re-filling of pots 45 tonnes per hour
9. Maximum allowable added load for dust and ventilation air to existing fume treatment plants
10. Maximum allowable power consumption due to existing constraints on local 400 V distribution board (DB) panels.

The critical issues identified by EGA for the system design were addressed early on in the project, and solutions were presented and discussed.

3.1 Spillage and Hose Disconnection

One of EGA´s main system requirements was to avoid spillage due to overfilling and alumina feed hose disconnection. Overfilling was controlled by introducing level sensors at feed points and installing automatic control valves for the fluidising of the air slides that would stop the flow of alumina if overfilling were detected. The risk of feed hoses disconnecting was removed by serrated pipe connections and sturdy hose clamps; the connection in the potroom were secured by an additional easy to remove wire clamp (Figure 2).

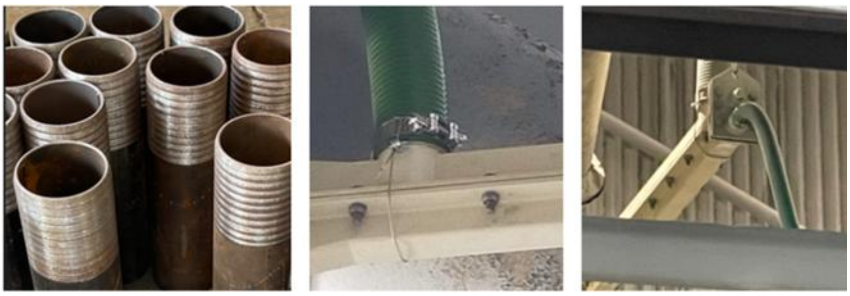

Figure 2. Serrated hose connections and securing wires for flexibles.

3.2 Thermal Expansion

During operation, the fluidizing air within the system can reach up to 80 ºC. Thermal expansion of the steel air slides could change the incline of the system thus causing reduction in flow or even conditions with no-flow. EGA has experienced this on some of their existing systems. In order to avoid problems associated with thermal expansion, NEATEC added a fixed anchor point on the air slides and designed the length of each support to ensure a slight downward slope on the air slides also after start-up of the system. Verification after start-up of the system shows a slight downward slope.

3.3 Pot Air slide Design and Pot Cover Sealing

The existing CD20 pot superstructure was designed for crane feeding with open top storage hoppers and removable covers for access to crust breaker and feeder pneumatic cylinders. The design of the new pot air slide had to consider height limitations due to anode jacking frames and crane movement, whereas the sealing of the pot covers had to facilitate access for maintenance of pneumatic cylinders inside the pot storage hoppers.

The pot air slide was lowered on top of the superstructure and tested with an anode jacking frame to ensure no interference, and the pot covers were modified with sealing gaskets and easily removable fixing clamps to allow for maintenance access (Figure 3).

Figure 3. Pot cover gaskets and sealing.

3.4 Ventilation of Pot Air Slide

The fluidising air from the pot air slide is discharged into the pot storage hoppers when alumina is fed to the hoppers. After sealing the pot covers, the hoppers became over-pressurised and the fluidising air had to be removed to avoid dust leaks from the pot covers. As the FTP gas duct is extracting the hot gas from the pots it was decided to install 2 vertical ventilation pipes connecting the pot storage hoppers with the suction plenum above the anodes in the pot. This solution allowed for any potential alumina dust in the ventilation air to remain in the pot (Figure 4).

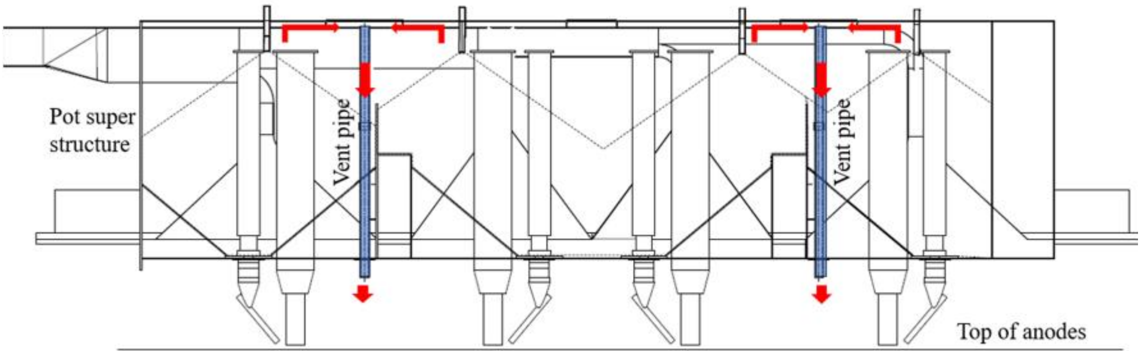

Figure 4. Pot super structure with storage hopper ventilation.

4. Fabrication

All equipment supplied for the project were sourced from pre-approved companies with a proven track record for safety, quality and on-time deliveries. Air slide system fabrication was given particular attention as maintaining standards for flanges and connections were paramount to get a sealed system.

The majority of the equipment for the project were sourced and fabricated in UAE. Local supply and fabrication enabled close interaction with the EGA team for verification of deliveries and inspections at the local suppliers.

Equipment fabricated locally:

- All fluidised bed air slides (8 km) and piping (9 km)
- Support structures and walkways
- GRP molded insulation air slide (1.1 km), Figure 5
- Electrical panels, cables and cable support systems
- Rotary feeders (Figure 6).

Figure 5. GRP Insulation air slide molding in UAE.

Figure 6. Rotary feeder and air slide fabrication in UAE

Equipment that could not be sourced locally in the UAE was procured from reputed international companies in Norway, UK and Germany. Final inspections and testing were carried out before shipping for fans and vibrating sieves to ensure quality and that final performance and capacities were according to specifications (Figure 7).

Figure 7. Fluidising fan and vibration sieve testing in UK and Germany

5. Installation

The EGA Jebel Ali potlines 5& 6 (Figure 8) consist of four (4) potrooms, each with 120 pots in groups of 30 pots. The material handling and pot gas treatment for each of the potlines are split into two (2) gas treatment plants each, treating pot gas from 120 pots and each with a dedicated storage silo for alumina to feed 120 pots.

Figure 8. EGA Jebel Ali Potlines 5 & 6.

The EGA JA potlines 5 & 6 are operating at full capacity with daily activities for pot operations, hot metal movements as well as general maintenance operations. It was paramount that the installation of the new systems adhered to the strict constraints for vehicle movement for transport of material and personnel to the installation locations and that the installation activities did not restrict pot operation and metal production. A detailed traffic movement plan was prepared early at the start of the site activities, and updated during the project, to ensure that all parties were aware of and adhered to the constraints for movement on the plant. An on-site EGA coordinator had the daily coordination with EGA operations and NEATEC site organisation to organise available work areas and to liaise with the operations team for all interface points.

EHS campaigns were regularly carried out to ensure that constant focus on safety was kept during the installation period. This was particularly important as many tasks were repetitive.

Installing equipment on operating equipment limited the possibility to completely shut down existing systems for extended periods of time for modification. This also resulted in modification of pot covers and installation of pot air slide on operational pots. EGA provided a dedicated construction crane to be used by NEATEC for the installation activity inside the potrooms. It was agreed, on a daily basis, in which potroom section the work could be carried out to avoid interfering with the normal day-to-day potroom activities. However, all work inside the potrooms required special attention to vehicle and crane movement, and had to strictly adhere to the safety precautions for work in earth free zones in the potroom.

The EGA JA permit to work system were applied to all work at the construction site. A detailed Method Statement Risk Assessment (MSRA) was prepared for the various work tasks and submitted to the EGA team for review and approval prior to applying for a work permit. As of June 2023, a total of 91 MRSA's had been issued in the project, a majority of which were submitted for renewal every 30 days. Up to 12 different permits were simultaneously active for carrying out installation activities in several different work areas with different EGA area owners.

The majority of the installation work is done in work areas with higher temperatures than ambient (due to heat generated from live pots) and the construction workers were provided cool rooms close to the work areas to mitigate heat stress. During summer period the mandatory UAE mid-day break was implemented as the temperature inside the potrooms could spike to +50-60 °C in the various work areas.

Figure 9 shows lifting of horizontal distribution and transport air slide.

Figure 9. Lifting of horizontal distribution and transport air slide.

The majority of the equipment is installed in elevated positions that required the use of multiple cranes and man-lifts. Equipment installed along the potrooms required cantilever supports to be fixed to existing structure by bolted connection and cladding to be cut and re-sealed. The flexible hoses for material and air connection to the pot air slide penetrates the potroom wall cladding through purpose-made mounted brackets to allow for hose replacement in the future. Special attention had to be given to the length of the alumina feed hoses to avoid excess length that could cause flow restriction and alumina blockage. Air slides and piping were pre-assembled in larger sections prior to being lifted into position.

Figure 10 shows installed Alumina distribution and transport system.

Figure 10. Installed alumina distribution and transport system.

6. Observations and Issues

6.1 Alumina Flow Capacities

Alumina feed rate to each pot was one of the critical parameters for system performance. During testing the nominal feed rate per pot was recorded to be 500 kg/h. This is more than double the required feed rate for the CD20 pots of 178 kg/h. This gives added safety for refilling pots after stoppages.

6.2 Alumina Segregation

Alumina particle segregation was measured by samples taken from all discharge nozzles in the first 5 and the last 5 pots in one 30 pot section. The result showed less than 4.4 % difference in the –325 mesh (-45 µm) particles from the start of the transport system to the end pots (Figure 11).

Mesh	Micron	Inches
4	4760	0.185
6	3360	0.131
8	2380	0.093
12	1680	0.065
16	1190	0.046
20	840	0.0328
30	590	0.0232
40	420	0.0164
50	297	0.0116
60	250	0.0097
70	210	0.0082
80	177	0.0069
100	149	0.0058
140	105	0.0041
200	74	0.0029
230	62	0.0023
270	53	0.0021
325	44	0.0017
400	37	0.0015
625	20	0.0008
1250	10	0.0004
2500	5	0.0002

Sample size Distribution (%)					
Sample ID Pot #	+100 mesh	+200 mesh	+325 mesh	-325 mesh	
61	1.6	58.9	87.4	12.6	
62	1.6	59.1	87.4	12.6	
63	1.6	61.3	88.8	11.2	
64	1.8	58.4	86.2	13.8	Average
65	1.8	61.7	88.7	11.3	12.3
86	2.2	63.8	89.7	10.3	
87	2	63.3	89.2	10.8	
88	2.2	64.9	90.2	9.8	
89	2.2	64	89.8	10.2	Average
90	2.4	65.3	90.6	9.4	10.1
		Average	max	12.3%	
			min	10.1%	
			difference	2.2%	
		Real sample	max	13.8%	
			min	9.4%	
			difference	4.4%	

Figure 11. Alumina size distribution, samples for plant 5A.

This low difference for the -325 mesh particle sizes between the 5 first and the 5 last pots in a 30-pot section is attributed to the ventilation design of the air slide system. Dedusting cyclones on the horizontal distribution and transport air slides mix any captured alumina from the ventilation air back into the main distribution system. Each pot is thereby fed an even composition and mix of alumina, and the system avoid excessive accumulation of fine particulates (-325 mesh) in the first pots connected to the start of the air slide system in one section.

6.3 Start-up Sequence and Silo Management

The first 120 pots were started by filling all pots at the same time. This resulted in a rapid drop in silo storage level and introduction of segregated fines from the silos to the pots. After minor operational disturbances, the situation stabilised as soon as the silo level was maintained above the critical level. To avoid this issue, a sequential start-up was implemented for the second plant (120 pots) where only 30 pots would be filled by the new system at a time, ensuring stable silo storage levels. This start-up procedure proved to work well, and no operational issues were experienced on the second plant start-up for the 120 pots.

7. Conclusions

The implementation of the NEATEC alumina distribution and transport system to feed alumina from main storage silos in the court yards to pot storage hoppers in potlines 5 & 6 at EGA JA illustrate how close cooperation between client and contractor can achieve a safe early project completion. The unparalleled speed with which the system was designed and installed on an operating potline would not be possible without the continuous open dialogue, interaction and problem-solving approach from all participants in the project.

The system has been installed and retrofitted onto existing live pots. It is performing according to specification and is delivering continuously 180 kg/h to each pot in normal operation with the capacity to fill pots at much higher feed rates during the exercising mode of operation. The new systems have completely removed the dependency on the cranes for alumina filling to the individual pots, thus eliminating the risk of higher emissions from the fume treatment plants due to crane being unavailable for material withdrawal from storage silos. In addition, the potline environment has greatly improved with lower dust generation due to sealed pot covers.

The observations recorded during the start-up phase were addressed and the system has been operating smoothly from the start-up in February 2023.