AL38 - Experiences with the REEL Heat Exchangers and HF Sniffers Installed at EGA Al Taweelah

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Abstract

The P100 project at EGA Al Taweelah increased the primary aluminium production of the three potlines by adding 66 cells. This expansion resulted in increased pot gas temperatures and more fluoride evolution from the pots, thus adding extra load to the existing Gas Treatment Centres (GTCs). Each of the three potlines have two GTCs. The eastmost GTCs, where the potroom extensions are located, are the most affected. To mitigate the added load on the east GTCs, REEL's pot gas heat exchangers were installed. In addition, the REEL HF sniffer system was implemented to monitor the HF performance of each of the 32 compartments in the three GTCs. The system helps improve overall emission as any deviation in operation can quickly be narrowed down to a single filter compartment. This paper describes the experiences from the operation of the REEL HEX and HF sniffers after two years of operation.

Keywords: Potline gas treatment centre, Pot exhaust gas cooling, HF monitoring.

1. Introduction

Primary aluminium producers consider different approaches to increase their metal production. Strategies such as increasing the amperage of the reduction line, or adding additional pots, utilising existing capacity [1] are often found more cost effective than construction of new potlines. This paper will review the Gas Treatment Centre (GTC) and how the GTCs were upgraded to meet the goals of the potline expansion project at EGA Al Taweelah in 2021, including operational experience over the last two years.

The main purpose of the GTC is to remove HF (gaseous hydrogen fluoride) from the pot gas and recover the fluoride. Alumina, the raw material for the reduction process, is brought in contact with the fumes. Fluorides are adsorbed on to the surface of the alumina particles. High removal efficiency is important to protect the environment from harmful emission, and to recover fluorides back to the pots. Elevated gas temperatures [2], or suboptimal distribution of gas and alumina flow, are both factors reducing GTC performance.

Adding more pots to an existing potline does necessarily mean more pot gas has to be treated. This is often accompanied with amperage increase, giving elevated pot gas temperatures. The challenge is more gas volume and heat that must be handled by the existing GTC [2]. To handle the pot gas flow during peak summer hours, the GTCs were originally designed with spare capacity allowing for introduction of ambient air to bring down the temperature of the gas flow. This spare capacity in GTCs was used to accommodate for the additional pots by replacing the dilution air with heat exchangers (HEX), cooling the pot gas before entering the GTC.

Alumina flow through the GTC dry scrubbing did increase when adding the pots. Operating the GTC closer to its limits, both with regards to alumina and gas throughout, calls for better process control. The sniffer system is a tool for extractive sampling of HF. It is used to monitor GTC performance in each individual dry scrubbing filter module. Operational issues or abnormalities can be detected early. Operation can then be optimised to maintain the lowest emissions.

To meet strict requirements on emissions and reliability, the HEX was installed to improve process capacity together with the sniffer giving improved process control. The two technologies were combined and successfully implemented as presented in the following.

2. Capacity Increase and the Potline Extensions Project

In the potline extension at Al Taweelah, all 66 new pots were connected to the existing GTCs [1]. Pot gas from new pots were collected with REEL's impulse ducts, a solution which optimises gas flow minimising pressure loss in the potroom duct. In Potline 1, 13 pots were connected to the east inlet of GTC-5311, and 13 pots via an overhead duct to the west inlet of GTC-5311. Likewise in potline 2 and GTC-5321. In potline 3 additional 14 pots were added to GTC-5331, increasing the number of pots from 222 to 236. Pot gas flow specification was unchanged.

Table 1. Al Taweelah potline extension in 2021.

	GTC-5311	GTC-5321	GTC-5331
Pots per GTC before extension	192	192	222
Pots added in 2021 (A + B room)	13 + 13	13 + 13	14
Pots routed via EHEX (East + West)	30 + 30	30 + 30	-

The objective of the potline extension project was to increase production capacity in a cost-effective manner by maximising the utilisation of existing equipment. As described by Teeling et al. [1], debottlenecking studies were conducted for various areas. For the GTCs, upgrades included improvements in primary alumina distribution, secondary alumina conveying capacity, pot gas cooling with EHEX and process optimisation with the HF sniffer. The next sections will explain the implementation and operation of the two latter systems as these were the main contributors.

3. Gas Cooling with Heat Exchangers

In total, 4 REEL External Heat Exchangers (EHEX) are installed. Location is in the courtyard near the east and west inlets of GTC-5311 and GTC-5321. The EHEXs are located upstream the GTCs. Each EHEX is cooling gasses from 30 pots, two EHEX and 60 pots per GTC. It is important to note that the 26 new pots, located at the furthest distance from the GTC, were connected directly to the GTC. While the collecting ductwork for 60 existing pots with a more central location were re-routed via the 2 new EHEX (one on each side of the GTC). An overview is presented in Table 1.

The main benefit of the HEX technology in the EGA Al Taweelah expansion is that acceptable temperatures can be maintained during summer without addition of dilution air. The addition of cooling air is disadvantageous, not only because it is increasing the gas volume, but also because the gasses are diluted before dry scrubbing, thus reducing the efficiency of HF adsorption [3].

Pot gas HEX is also a very relevant technology when it comes to potline amperage increase project. One strategy to maintain cell energy balance while the internal heat generation is increasing, is to reduce the anode cover height [4]. The additional heat is then mostly picked up by the pot exhaust gases. Cooling pot gasses with HEX is an excellent option in such cases.

Figure 1 shows EHEX installation arrangement in Potline 2.

3.1 EHEX Implementation at Al Taweelah

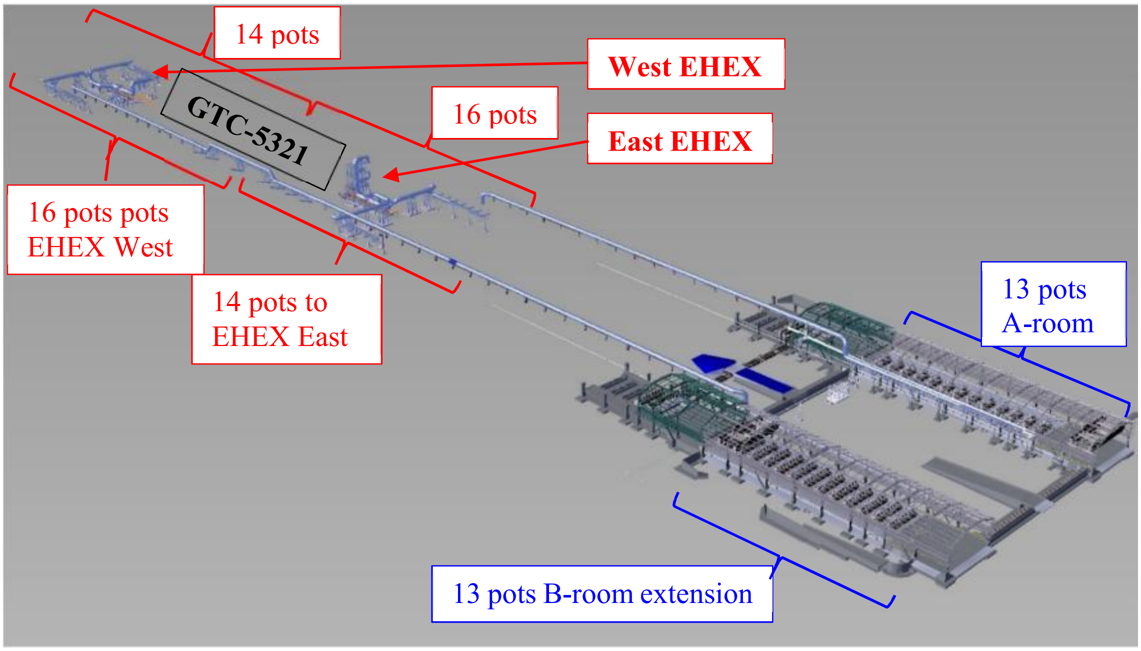

Figure 1. Potline 2 extension and new EHEX ductwork, courtesy to Teeling et al. [1].

There is a pressure loss, due to friction, and temperature drop, due to convection to the ambient air, along the length of ductwork from pot to GTC. The relative long transfer duct from the new extension pots provides ample cooling as opposed to the pots closest to the GTC, where the duct is short, and the gas is hotter. Therefore, the pots closest to the GTC were connected to the EHEX maximising the potential for heat transfer.

Furthermore, the pots located in the extensions end of the potroom with longest ductwork has correspondingly more pressure loss than the more centrally located pots. This means that there is a differential pressure available at the more central pots that otherwise is throttled (lost) in the pot outlet damper. Around ⅓ of the pots, the most central ones, were connected to the EHEX to take benefit of this potential. The outcome is that the six induced draft fans could be kept unmodified running at approximately same operation point as before the extension project.

3.2 EHEX Process Results

The EHEX is a shell-and-tube heat exchanger where pot gas passes on the tube side and water circulates in the shell side. Heat from the pot gasses inside the tubes is transferred to the water on the outside. Pumps are circulating the cooling water in a closed loop. Heat is rejected to ambient in an industrial dry air cooler (chiller) with fans.

There are large knife gate dampers up- and downstream of the HEX allowing for maintenance access. During such interventions, a third damper opens, and pot gas flows through an alternative path known as the bypass duct. The system is designed to ensure pot draft during all events.

Figure 2 shows the EHEX on the floor, with cooling station to the right. A mixer (vertical duct) brings the cooler gasses from the 30 pots connected to the EHEX back in to the GTC east inlet (overhead duct). Effective temperature reduction in the total mixture entering the GTC inlet is typically 7-8 °C. This cooling does not only give benefit by reducing the volumetric gas flow to the GTC inlet and protect the bags from high temperatures, but it also gives a significant reduction in HF emissions [2]. The pot gas cooling is appreciated when operating with GTC inlet temperatures in the 120-130 °C range mid-summer.

Figure 2. EHEX at Al Taweelah PL 1 East (5311-800). Fumes are collected from nearby pots, cooled, and a mixer (vertical structure) brings it in to the GTC inlet duct (on top).

Each of the 4 EHEX units has a duty of typically 3.0 MW. The EHEX is effectively cooling the gases by 24-32 °C, see Figure 3. The units' ability to cool is as expected [5] and have not reduced notably during the operating season.

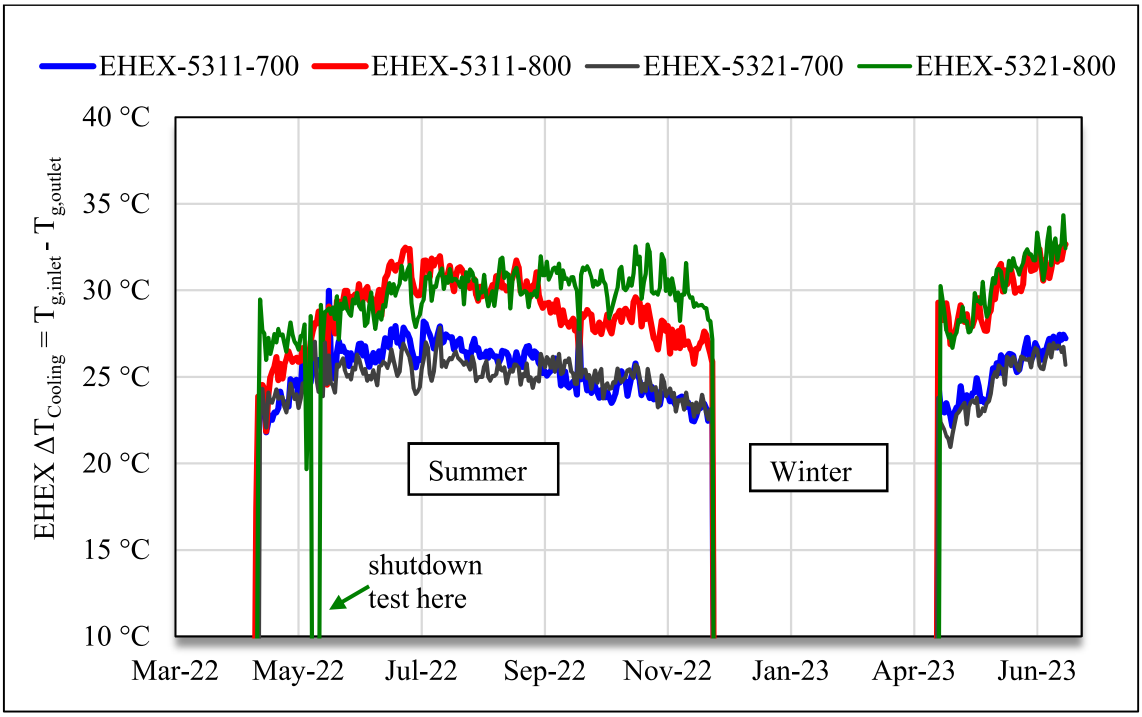

Figure 3. Operation over the last year, cooling is shown as the temperature difference between gas inlet and outlet.

The EHEX system is normally shut down for maintenance every winter. Tasks to be scheduled includes internal inspection, cleaning inside tubes, and topping up the water circuit. During the first cleaning 2021/2022 it was sufficient to use compressed air. Deposits consisted only of loose alumina. It is seen that hard grey scale (HGS) is forming in the inlet between tubes. This layer will not only protect the steel from erosion but also naturally improve the flow entering each tube.

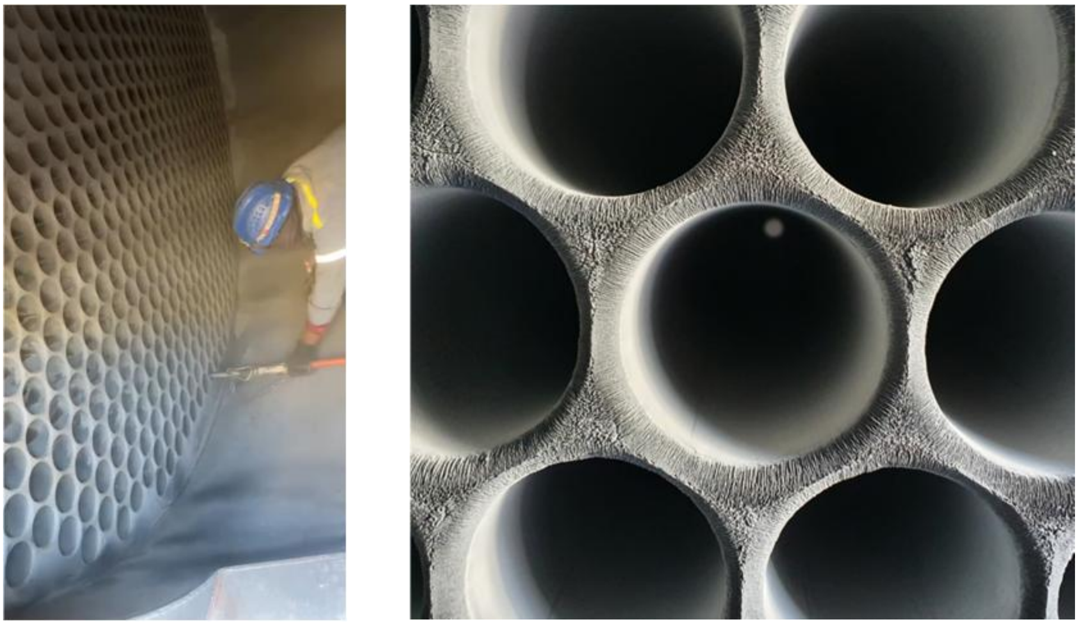

Figure 4 - Cleaning with compressed air lance (left) and tubes (right) photo from inlet side

The EHEX has operated reliably the two first seasons. The gas bypass duct arrangement allows the units to be taken offline for trouble free maintenance. The pot gas has neither caused any troublesome scaling nor noticeable erosion. The four EHEXs gives a valuable reduction in inlet temperature in the two GTCs it has been installed.

4. Extractive Sampling with HF Sniffer System

The HF sniffer system is installed in all 3 GTCs having additional pots connected. This is to give tighter process control when operating with higher gas load and alumina throughput. Online measurement of HF is normally done with a stack mounted instrument. The GTCs have 32 individual dry-scrubbing filter-modules. A slight problem in one module may not be recognized if all the others are performing well.

The sniffer system extracts samples from the clean-gas side of each filter module. HF concentration is then analysed with a single laser instrument. This is a benefit as the instrument is relative expensive and, requires regular maintenance and calibration [6].

The picture in Figure 5 is from the filter top penthouse. Each module has a selector valve (two valves seen in the left of the picture) and piping brings the sample to the centralised analyser unit (right hand side of picture). Sampling line size and materials are selected to resist the high temperature and corrosive gas, have good response and avoiding dust accumulation inside, and to minimise internal adsorption and desorption hysteresis between each sample. The sampling station has an approximately one-meter-long measuring cell (cuvette) where the Tunable Diode Laser Absorption Spectroscopy (TDLAS) instrument is mounted across. Flow is ensured by a small sampling blower machine.

Figure 5. Sniffer system installation at GTC filter top level (inside penthouse).

During normal operation the sniffer will sample through all filter modules. Sequence is timed to account for the gas travel time from sampling point to analyser. In between sequences, the sampling pipes are purged with compressed air. There are also pressure and vacuum leak test routines. The collected data is used to verify the health of individual filter modules. It helps identifying the cause of emissions spikes; the operator would know which filter module is at fault and can direct maintenance crew to the correct location.

Figure 6 shows EGAs dashboard. Each column represents one filter module, hopper No 1-32 from left to right, and sampling history is shown row-wise for the last 24 hours. The color scale from blue (low) to red (high) adapts to the recorded levels. The laser instrument was calibrated from supplier. The purpose of the system is not to measure emissions in absolute senses, it is rather to study the relative difference between the filter modules. The goal is all to perform equally well.

The capability of the HF monitoring system has previously been demonstrated by purposely blocking injection of primary alumina to a filter module [6]. During commissioning of the sniffer system, it was recognised one filter module had ten times higher HF emissions than the rest. A quick inspection revealed that a 10 mm size particle partially blocked the feeding slot inside the primary alumina distribution airslide, see Figure 7. Restoring normal alumina supply to this filter module solved the problem and demonstrated the value of the sniffer system.

Significant progress in the development of dry scrubbing technology was made when online instruments started to appear in GTC stacks in the 1990s [7]. Installation of multipoint monitoring devices in GTCs is expected to give further progress. The full potential is yet to be explored.

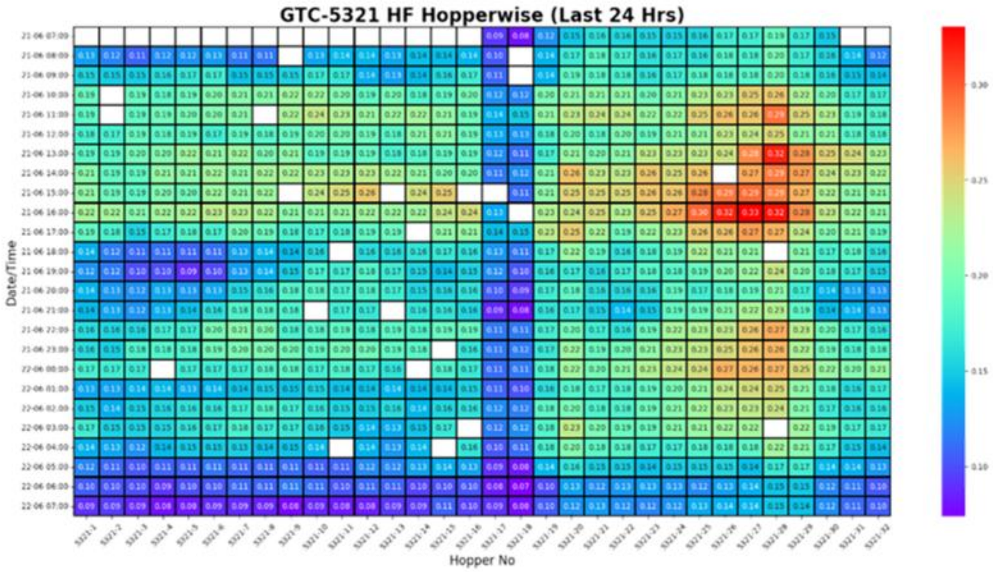

Figure 6. EGAs sniffer system dashboard (for illustration only).

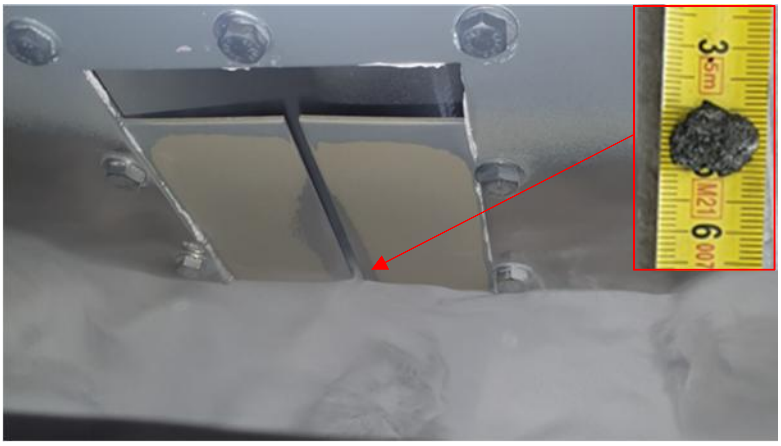

Figure 7 - Example of HF sniffer identifying blockage in primary alumina supply

A further advantage of extractive sampling is that the gas can easily be analysed for other species such as SO_2. Alumina has higher affinity towards HF than SO_2 [7]. Desorption of SO_2 from the surface of alumina particles could therefore be used as a leading indicator for increase in HF.

5. Conclusions

The Al Taweelah potline extension in 2021 was successful in utilising capacity of existing equipment. The additional pots caused an increase in gas flow to the affected GTCs. Installation of EHEX pot gas coolers enabled the use of spare GTC capacity, originally allocated for dilution air, to accommodate the new extension pots. Pot gas flow from all existing pots were maintained at the same level as before. The main induced draft fans were also kept unchanged. The four EHEX has operated reliably for two seasons without noticeable fouling or scaling from the pot gas.

The sniffer ensures efficient HF monitoring from all GTC dry scrubbing modules and is effective in reducing response time to rectify malfunctions. This can significantly reduce the number of exceedances in the HF emissions due to otherwise undetected faults in the equipment or distribution system for gas and alumina. In short, the sniffer enables operation closer to the limit.

The potline extension debottlenecking strategy has proven successful. REEL's HF sniffer, and combined with EHEX gas cooling, made it possible for the GTCs to handle the increased pot gas load while maintaining performance with regards to HF emission control.

6. References

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