The Study, Execution and Handover to Operations of a Smelter Potline Extension at EGA Al Taweelah Smelter

Nicole Teeling[1], Olivier Charette[2], Jean-Denis Carrier[3] and Saif Alhashmi[4]
1. Lead Structural Engineer, Hatch
2. Engineering Manager, Hatch
3. Global Director - Aluminium and Alliances, Hatch
4. Director - Special Projects, EGA
Corresponding author: nicole.teeling@hatch.com

Abstract

Over the past decade, operational improvements in reduction cells process control and technology development have allowed reduction potline operators to consider various approaches to increase metal output from their assets. Amongst these approaches, the extension of an existing smelter potline by incorporating additional reduction cells can be an attractive option to maximize the usage of the existing substation equipment. While preparing an extension project, the impact of the additional cells on entire potline operation needs to be studied. A plant assessment must be conducted for all the smelter main areas including carbon plant, gas treatment center, cast house, pot feed system and other services to identify potential bottlenecks and develop strategies to carry out the construction safely and efficiently under brownfield conditions.

Since 2014, Emirates Global Aluminium (EGA) started to plan a potline extension for its Al Taweelah smelter. An integrated team formed by EGA Capital Projects and Hatch conducted a feasibility study to initiate the extension design and define innovative solutions to address the bottlenecks for all the smelter main areas. Following the feasibility study, the project execution phase was initiated in 2019 which included detailed engineering, procurement, construction, and commissioning activities. The extended sections of Potlines 1 and 2 (PL1-2) were completed and successfully energized in April and July 2021 while the extension of Potline 3 (PL3) is now nearing its energization date, with over 3 million lost time incident (LTI)-free manhours completed on the project. This article describes the joint efforts of the integrated team to incorporate an additional 66 pots at the end of the three (3) existing potlines of EGA Al Taweelah site. It provides insight about how the extension sizing was performed, the debottlenecking studies conducted for the main areas, the solutions identified to optimize some facilities, the engineering and construction challenges overcome during the project as well as the successful energization and startup of the new cells.

Keywords: Aluminium reduction technology, Potline extension, Brownfield smelter upgrade, Debottlenecking.

1. Introduction

1.1 General

The potline extension as described in this paper consists of connecting additional reduction cells in series to the existing ones at the opposite end of the rectifier transformers (non-rectifier end). The objective of this modification is to increase the production capacity of each potline in a cost-effective manner, taking advantage of spare capacity which is already built-in the reduction line and other plant areas. Given the capacity in other plant areas and especially in the substation, potline extensions are usually more cost effective than construction of a new potline.

One of the main challenges of the potline extension is that it requires relocating the existing busbar crossover between 2 potrooms to the end of the extension while keeping the busbar energized for the existing potlines. This paper explains how this challenge was overcome in the extension of Potlines 1, 2 & 3 at EGA Al Taweelah.

In planning for this project, the extension size was defined considering the capacity of the existing substation, while simultaneously optimizing and/or limiting the impact on the smelter main areas to maintain the feasibility and cost effectiveness of the project. The addition of new cells will increase the demand on other reduction areas and equipment such as: the gas treatment center, the fluorinated alumina distribution system, the compressed air system, potroom cranes and other operational equipment. It will increase the plant anode requirements, increasing demand on the carbon plant. Increased molten metal output will affect the cast house operations and molten metal transfers.

The tie-in and integration of new pots within the existing smelter systems need to be carefully engineered to minimize the impact on the operating smelter. Shutdown times, production losses and the construction activities need to be planned considering works in brownfield environment, with hazards associated to an operating smelter such as magnetic fields, molten metal, and electrical hazards. The Operations team involvement during the study, construction, and commissioning of such an extension is critical to successful outcomes and needs to be considered throughout the entire project lifecycle.

1.2 EGA Al Taweelah Extension

The EGA Al Taweelah smelter was built in two phases and is made up of Potline 1 and 2 constructed in 2009 and Potline 3 which was constructed shortly after in 2013. The three (3) potlines encompassed 1200 reduction cells prior to the extension. The extension project involves the extension of all 3 potlines, with a total of 26 pots added to potline 1 and 2 respectively and 14 pots incorporated in Potline 3. The 66 new pots will add a total of approximately 78 000 tonnes of hot metal per year.

The extension of Potlines 1 and 2 uses the same proprietary owned technology as the original potline, the DX Technology. The extension of Potline 3 uses DX+ Ultra Technology, which is an upgraded version of Potline 3 original DX+ Technology. For all potlines, the objective is to operate at the same amperage as existing reduction cells to avoid the need for an auxiliary rectifier/ booster.

The additional cells are incorporated at the non-rectifier ends of the existing buildings as shown in Figure 1 and Figure 2. The extensions incorporate 13 pots in each of the two potrooms of Potlines 1 and 2. Since only 14 pots are considered for the extension of potline 3, a single potroom building is considered to incorporate the new cells.

2. Assessment of the Impacts on Reduction Main Facilities

For a project like the extension of EGA Al Taweelah potlines to be successful, the production capacity of all the main smelter facilities needs to be assessed and adapted to support the additional cells while maintain stability and efficiency. The bottlenecks need to be identified and addressed while optimizing the capital expenditure investment.

Assessment of the potline extension impact on the reduction main areas and/or equipment such as potline substation, gas treatment center, potfeed system, and potroom equipment was performed and it was established that facilities would be suitable for the increased capacity, considering the optimized modifications as described in this document.

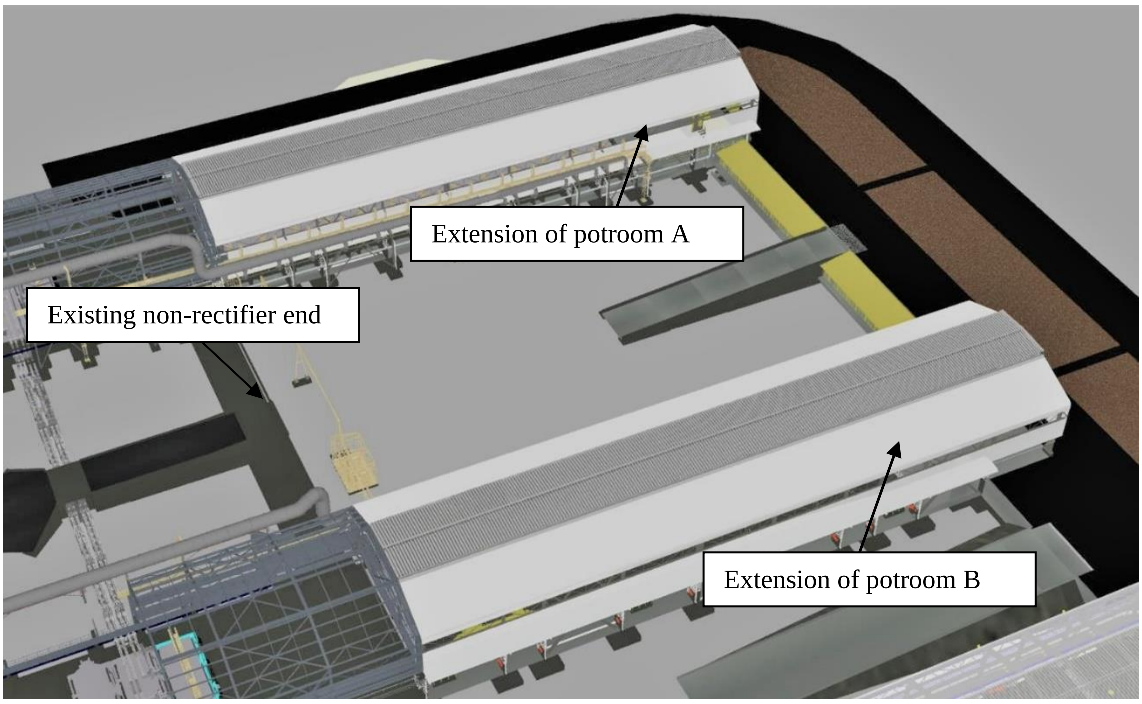

Figure 1. Typical extension of Potlines 1 and 2.

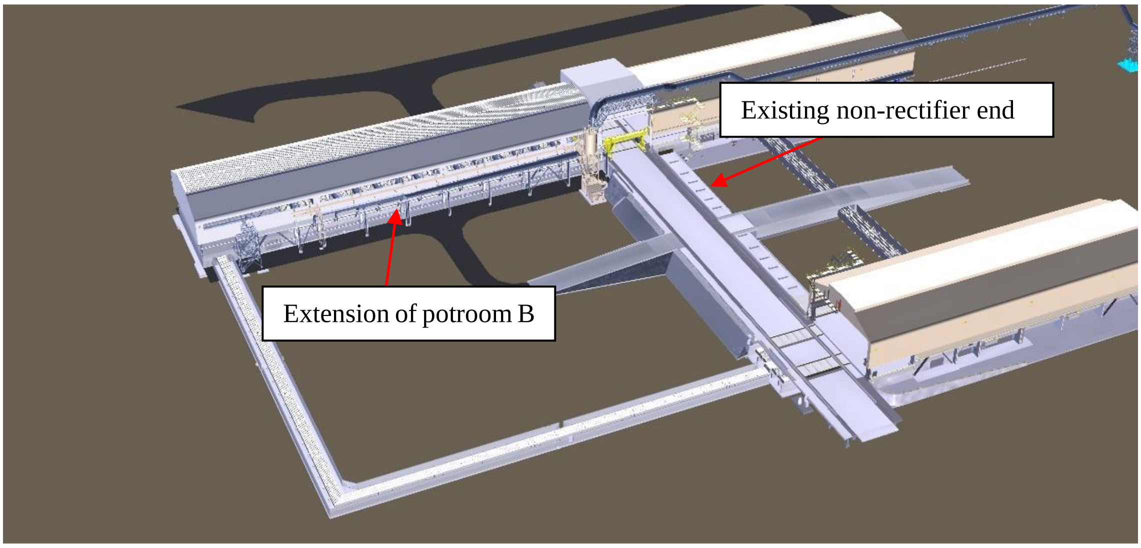

Figure 2. Extension of Potline 3.

2.1 Potline Extension Power Requirement

The key factors to assess the potential to extend a potline is the current potline voltage and the installed capacity of the existing substation. One of the key enablers of the project is that EGA has successfully improved its specific energy consumption since the start-up of the smelter, therefore reducing the overall potential delivered by the rectifier-transformers. This new operating potential was carefully considered when establishing the maximum number of pots which could be added, considering the total potline voltage while keeping enough provision to face various operational conditions. For this project, the DC voltage requirements for each potline was calculated and the impact on the Rectifier Transformers (RTs) was assessed with the support of the OEM.

Various assessments of the existing system were conducted jointly with all key stakeholders, and it was established that the additional voltage required for the extension would not put the normal potline operations at risk and that potlines can operate safely within the capacity of the RTs considering the additional cells.

It is important to note that without this pre-condition the potline extension would not have been viable as it would have required the upgrade of existing rectifier-transformers thus significantly increasing the project cost, probably beyond economic viability.

2.2 Gas Treatment Centre

As for existing potlines, the new pots are required to be connected to the Gas Treatment Centre (GTC) to reduce the air emissions and recover the fluoride in the process. During the early stages of the project, a detailed assessment was performed with the original equipment manufacturer (OEM) to assess the extra capacity available for the system and identify potential solutions which would allow the existing equipment to cope with the extension requirements while meeting environmental targets. The solutions were reviewed considering the operational advantages, the cost, and impact on the project overall schedule.

It was found that existing GTC's of potlines 1 and 2 could not accommodate the extension requirements without modification. It was proposed that the performance of the GTC could be improved by introducing forced cooling and heat exchangers unit at the GTC main inlet. Typical extension of the GTC system including the heat transfer unit is shown in Figure 3.

The extension of the GTC system, through the project experience was found to be one of the most challenging components of the whole execution due to all the interfaces with the existing potroom structure, the location of the new ducting and scale of the installation works executed entirely under brownfield conditions.

For Potline 3, the existing GTC units were found capable to accommodate the 14 additional pots of the extension, which made the tie-in to the existing system much simpler, requiring only new ducts to be connected to the existing units and extended to connect the extension.

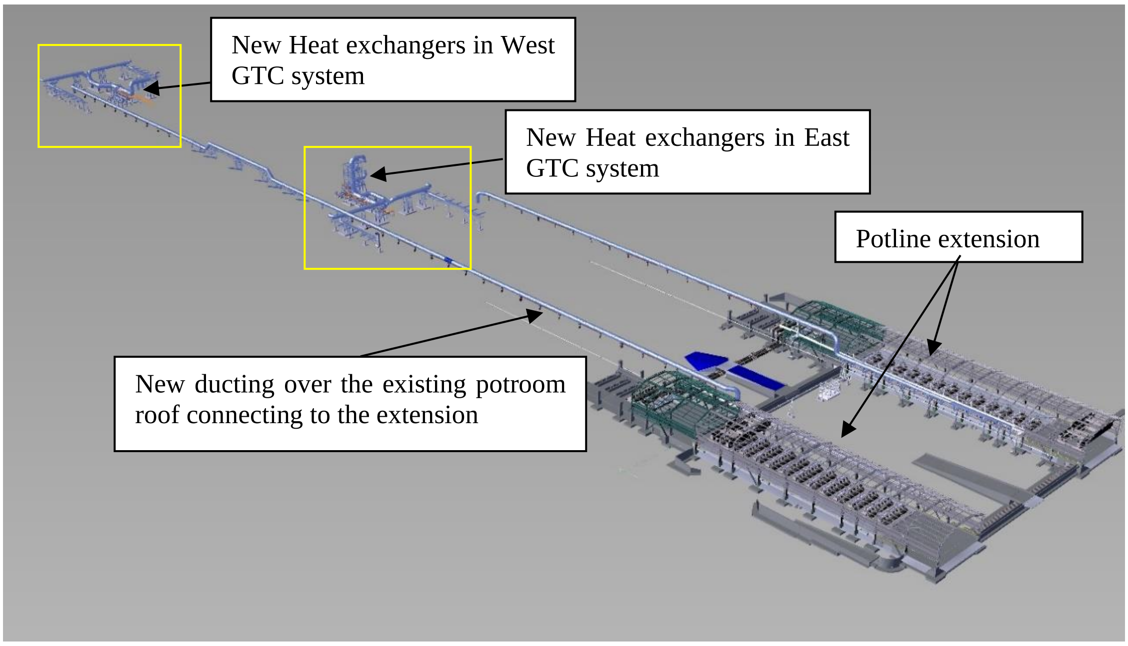

Figure 3. GTC extension and connection to new pots for Potlines 1 and 2.

2.3 Fluorinated Alumina Supply "Potfeed System"

As with the GTC, the potfeed system capacity to supply fluorinated alumina to the new pots was assessed. Different options were considered to extend the systems which included extension of the existing distribution airslides, a new buffer bin and dense phase potfeed systems to the new pots or a new day silo at the extension with independent potfeed system for the new pots.

After consultation with OEM's and EGA operations teams, it was confirmed that the PL1-2 system could accommodate the new pots through extension of the distribution airslide and addition of a blower for additional fluidization air. This resulted in a straightforward extension of this system.

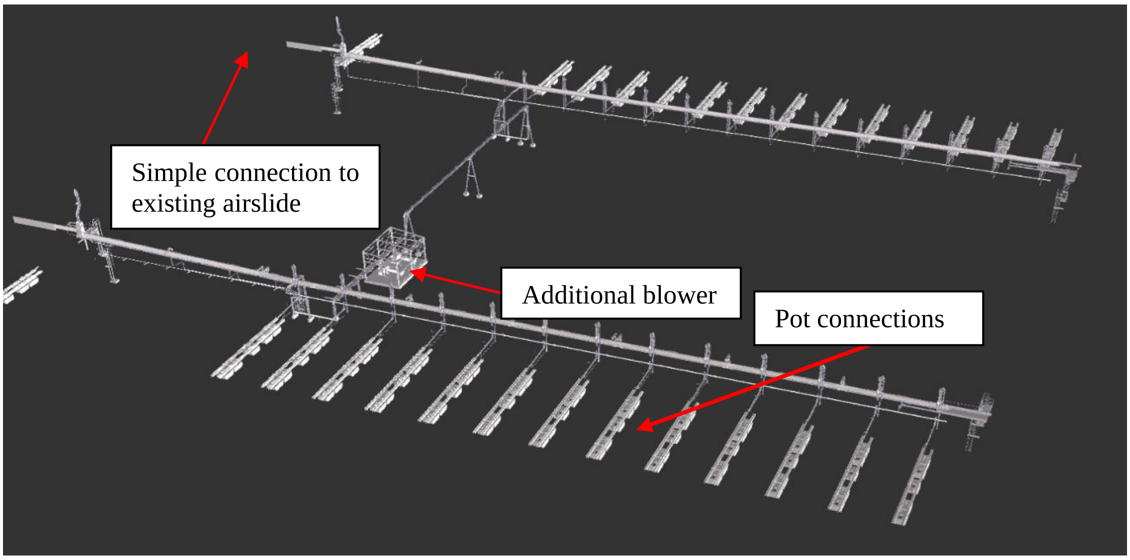

Figure 4. Potfeed system extension for PL1-2.

The potline 3 system however was found insufficient, and a new dense phase system was the optimal approach for an extension of this size. A buffer silo was required for this extension as shown in Figure 5.

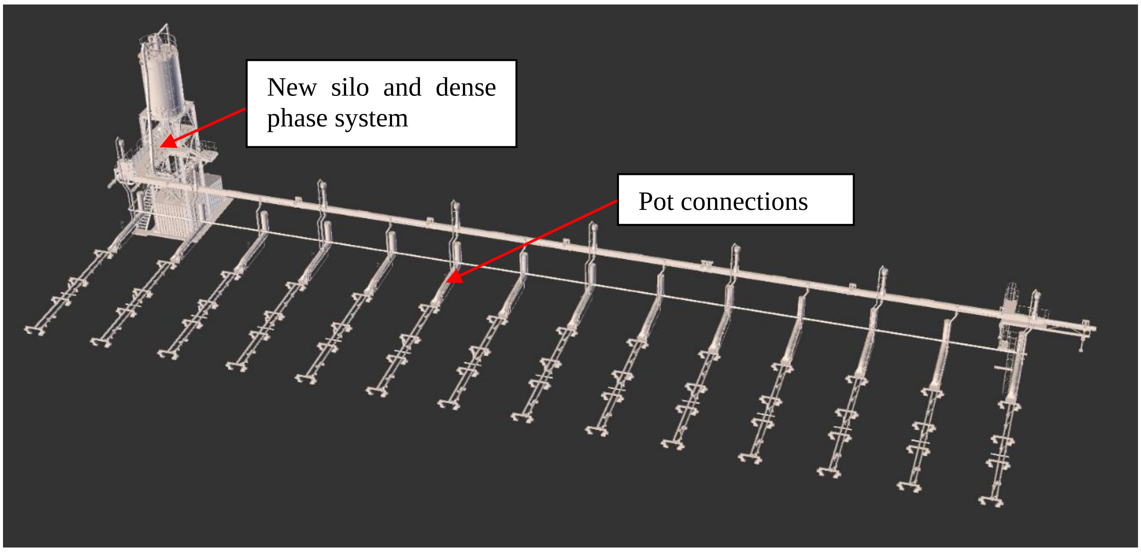

Figure 5. Potfeed system extension for PL3.

2.4 Potroom Equipment

In the potroom, the Pot Tending Machines (PTM) are specialized cranes performing various operations associated to pot operations. The workload associated to the new pots will impact the availability of PTM and potential requirements of an additional machine need to be assessed. Hatch and EGA team performed time and motion studies to assess the impact the additional pots would have on the current operations of Potlines 1 and 2 which will incorporate 52 new pots in total. It was concluded that the additional pots would increase the utilization of the PTM to its acceptable limit and that the 13-pot extension per room was the maximum number that could be accommodated using the existing PTMs.

For the extension of Potline 3, the 14 additional pots in Potline 3 were not a concern to EGA operations team in terms of capacity, however, the introduction of pots using new DX+ Ultra Technology impacted the tools of the existing PTMs. Modifications were identified due to clashes with the pots and the existing equipment. This is primarily due to the reduced pot to pot spacing of the DX+ Ultra Technology. Any modifications of this equipment require the involvement of the OEM and potline operations team. Any modifications carried out to tend the new pots, needs to be carefully assessed to ensure that existing operations are not affected. The following equipment was found to be affected with an extension using a different technology to the current potline:

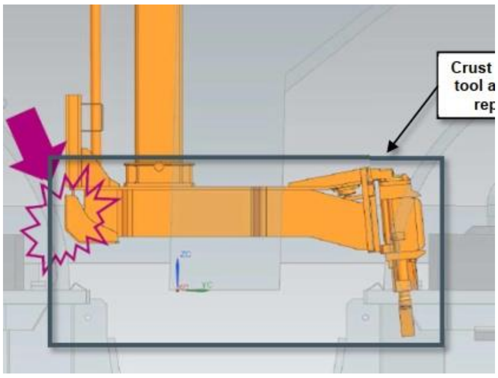

Figure 6. Crust breaking tool interference.

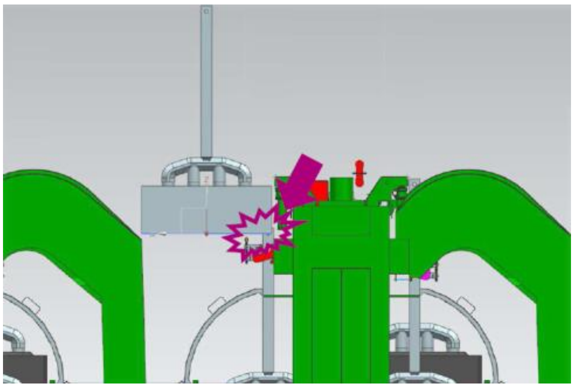

Figure 7. PTM anode extraction interference.

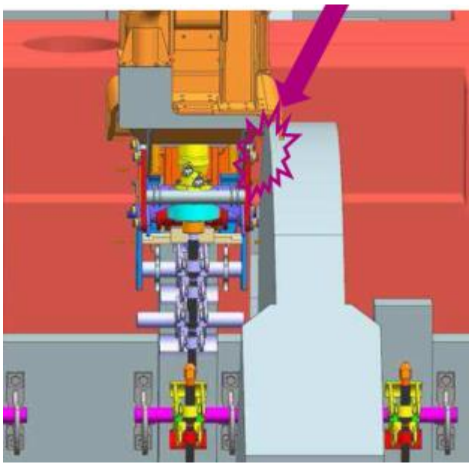

Figure 8. Interference between anode extracting tool and the anode riser.

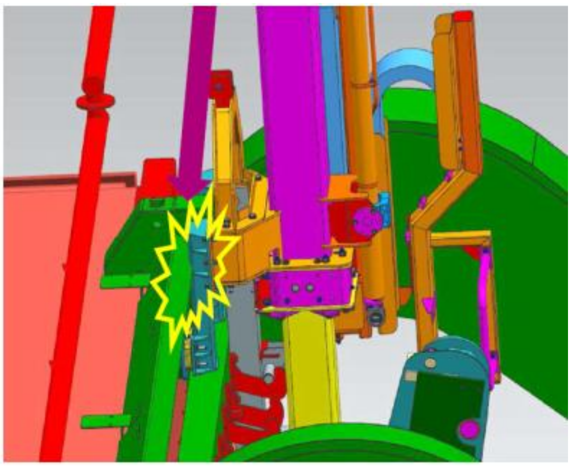

Figure 9. Interference between the shovel and the superstructure.

Rectifications including replacement of the lower arm of the crust breaking tool, replacement of the anode extraction tool and replacement of the bumper support on the shovel are required in this case. Careful planning and coordination with the EGA Operations team was required to successfully implement modifications to ensure that the operating potline was not affected due to unavailability of this equipment during the works.

3. Carbon Plant

New pots as well as increases in amperage will result in increased demand for rodded anodes for the potlines. The production capacity of the Carbon Plant was assessed, and debottlenecking studies undertaken to increase the production in these facilities. These include the paste plant, the rodding shop, and the anode baking furnace. During the extension at EGA Al Taweelah, EGA and Hatch assessed various areas of concern and found that the lack of redundancies within the current Rodding Shop could have significant effects on production output of rodded anodes. Debottlenecking studies were carried out and improvements implemented during the smelter extension to improve the existing plant throughput economically.

4. Casthouse

The total metal production from the reduction area is increased by 6 % through the potline extension. Based on an assessment of the current capacity of the casthouse, the increased production from the extension was a concern. An automated sow casting system will be implemented to increase the facility casting capacity.

5. Building Layout, Design and Construction Considerations

The layout and design of the building extensions was carefully studied to simplify the design, construction and reduce the capital cost of the project as much as possible.

For Potlines 1 and 2 the building extensions are connected as an expansion joint at the end of the existing four potroom buildings as shown in Figure 10. The extension of Potline 1 is identical to Potline 2.

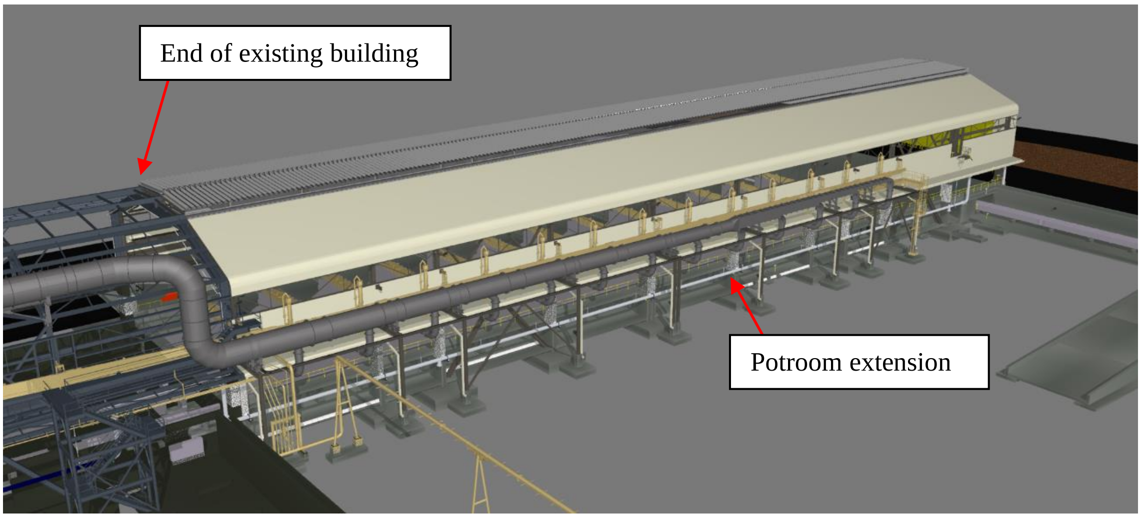

Figure 10. Potline 1 and 2 extension building layouts.

This approach would reduce the required demolitions of the existing building- the existing end passage area would need to be almost completely demolished to convert it to meet the requirements of the electrical isolation philosophy of the building. The approach therefore simplifies the construction while minimizing the effect on the operations of the live smelter. It also enables the construction of the new buildings to be carried in a 'greenfield' area with lesser impact from the magnetic fields which are very high at the end of the potlines. The existing busbar crossover and crane maintenance bay are relocated to the end of the new extension and the busbars are connected similar to a passageway linkage through the existing end passage to the extension section. To support the new linkage busbars, new supports are required to be constructed while the temporary bypass is in operation, which required innovative construction methods to reduce durations as much as possible.

For Potline 3, the 14 new pots are housed in a single potroom, potroom 3B. A single building was chosen for this extension to simplify the design, construction works and improve project economics since only a single area is considered. The building extension is located across the existing transfer gantry passage and the busbar arrangement to connect the new pots is complex in this area. Hatch busbar experts and the EGA technology team collaborated to design a feasible arrangement, while limiting the losses across this area. Busbars are installed in tunnels to pass under the transfer gantry. Given the space restrictions, this area was complex during design and construction phases.

At the end of the new 3B building, a connection to the existing potroom 3A is required through a 200 m long busbar crossover – material for this was reused from the demolitions of the crossovers of the other potlines, reducing the capital cost. The existing transfer gantry will be used to tend the pots in the extension and will remain in place. The use of the existing gantry will reduce the capital investment in providing a raising girder for the extension. This extension is shown in the Figure 11.

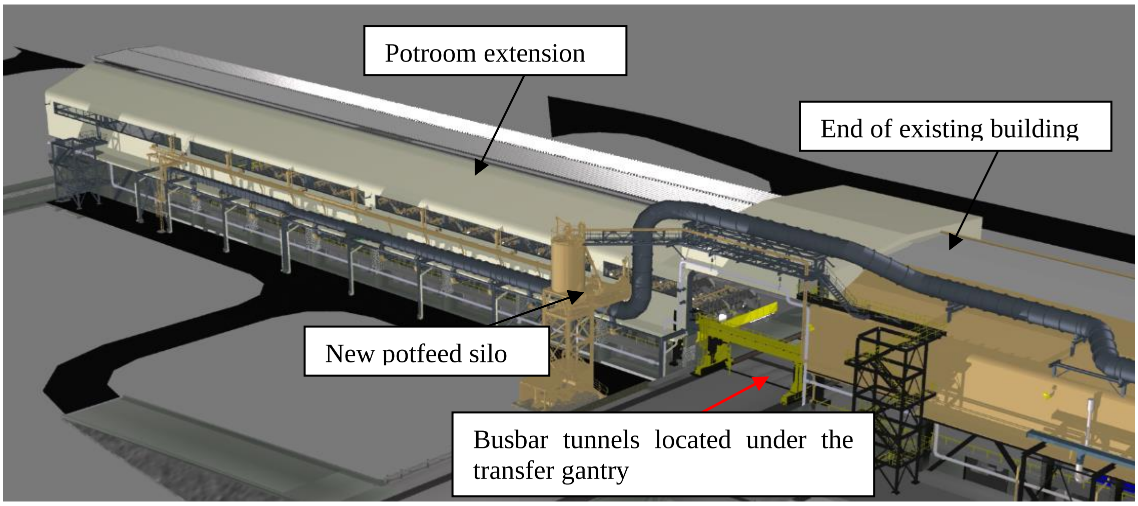

Figure 11. Potline 3 extension building layout.

6. Tie-In Works

As with most brownfields projects, one of the most challenging elements of an extension project are the tie ins to existing systems. For a potline extension, these works have a high level of risk to personnel working near the live areas, as well as risks to the operating systems, in particular the busbar tie ins which could risk the entire potline. In addition to the busbars, the tie ins which proved most challenging for the extension of the potlines at EGA were the structural building tie ins.

6.1 Building Tie-Ins

The complexity in the building tie-ins arises from the availability and accuracy of as built information, limitations on 3D scanning equipment in the magnetic field and access to survey areas such as the existing basement and crane rails during earlier phases of the study.

The existing buildings have incurred settlements over time and these need to be considered in the new design. A particular area of concern in this regard is the continuity of crane rails of the potroom, where maximum vertical and horizontal misalignments are required to be within the range of 10-20 mm. Adjustments for any discrepancy between the new and the existing buildings can be complex and result in realignments and shimming of the existing crane rails of the potline to match the tie-ins to the extension which will impact the operating potroom. An allowance for the study of this critical tie-in needs to be carried out early in the project to mitigate issues during the rail extensions. Levels on the operating floor also need to be considered due to the settlements which may occur.

If ground improvements are required, the proximity and effect on the existing buildings needs to be considered when determining the foundation location and type for the extension. These ground improvement works cannot be easily carried out near the existing buildings, or they could risk damage to the adjacent structures.

6.2 Busbar Tie-Ins

To connect the existing pots to the new extension, remove the existing busbar crossover and carry out the demolition and modification works in the existing east end passage, a temporary crossover was required for each potline. For these works the project team utilized and adapted existing temporary crossover busbar from a previous EGA project. The same temporary crossover was relocated to each of the buildings so that the usage of this crossover was optimized. The construction was sequenced in a way to optimally facilitate this approach.

The temporary crossover was connected using bolted connections to the anode risers of the 3rd last pot of the existing building. 3 pots were considered in bypass for each potroom for the duration of these shutdown works. The construction to execute the tie in works was carried out 24 h a day 7 days a week to reduce the metal loss from these 6 pots as much as possible. This was seen as a critical part of the project and was carefully and successfully executed by the project team and operations, and the potline restored.

While the temporary crossover was in operation the existing permanent busbar crossover was removed and new linkage busbars were installed to connect the new pots to the existing pots in the existing potroom basements. The construction to execute the tie in works including installation of new busbar supports, as well as installation and welding of new busbars required innovative construction solutions to reduce the shutdown duration as much as possible. These busbars designed by EGA's technology team are shown in Figure 13 and Figure 14.

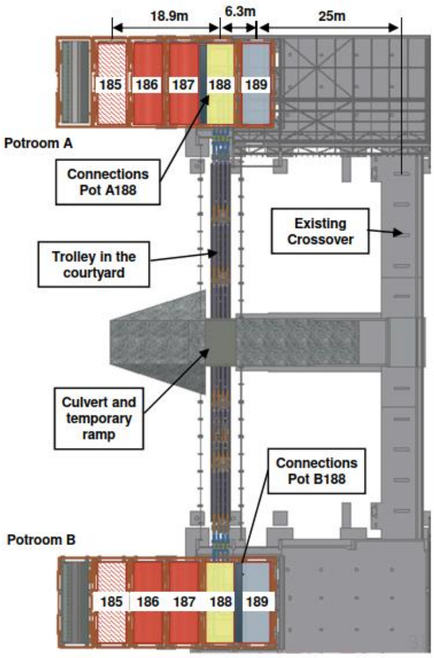

Figure 12. Temporary busbar connections.

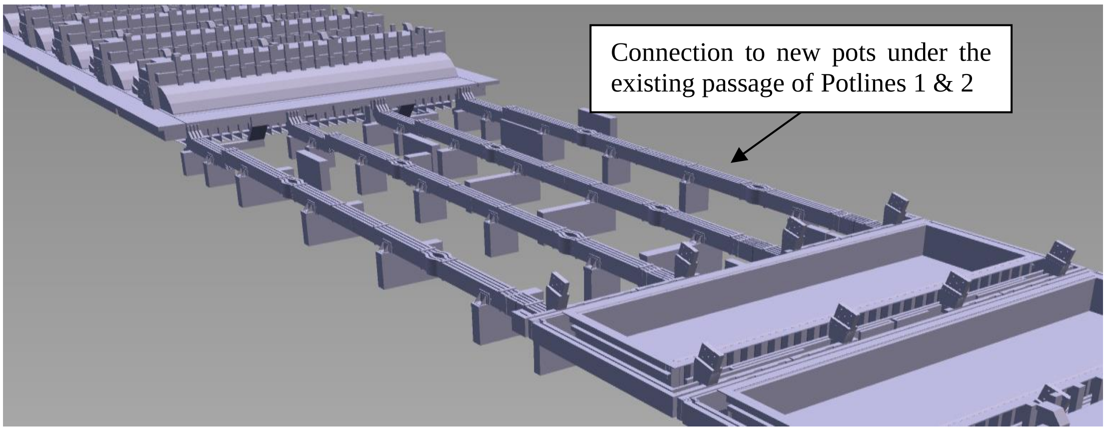

Figure 13. Permanent busbar connections Potlines 1 and 2.

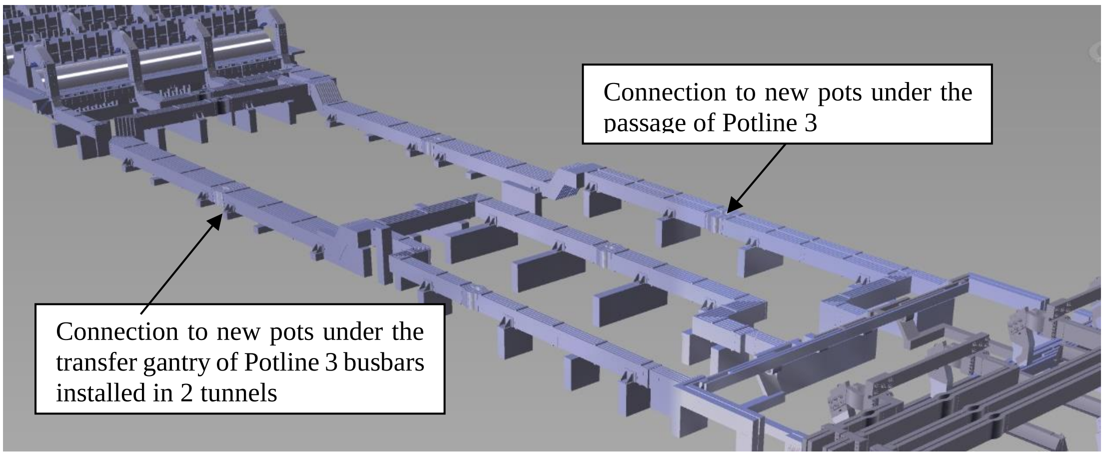

Figure 14. Permanent busbar connections Potline 3.

7. Conclusions

The extension of potline buildings to incorporate additional cells can be a very successful approach to increase the output of an aluminium smelter by taking advantage of existing assets. Innovative solutions to maximize the number of pots which can be incorporated in the shortest possible duration at the lowest possible capital cost while ensuring the safety everyone, will determine the overall success of the project.

The extension at EGA Al Taweelah encompasses the joint effort of an Integrated EGA and Hatch project team to study all the affected areas of the plant and provide engineering solutions to improve bottlenecks, reduce shut down durations, optimize the use of the available power, upgrade the existing GTCs and add flexibility to incorporate new technology to the extension. All of this was carried out while ensuring that safety is incorporated at every stage. The project has been a joint effort between the Project team, EGA Operations and EGA Technology teams who have contributed through every stage to the success of the project.

Most importantly, the integrated team of EGA and Hatch has demonstrated that this type of complex project can be delivered safely for both workers and process and ultimately deliver a strong return on investment for the owner.