Experience of Potline Restarts in the TRIMET Group

Janik Brenk[1], Roman Düssel[2], Hanno Vogel[3], Matthias Dechent[4], Oliver Marzin[5], Christian Erkes[6], Richard Meier[7], Remi Krachewski[8], Patrice Battistella[9] and Nicolas Pasquier[10]

1. Production Manager Electrolysis
2. Plant Manager
3. Reduction Manager

TRIMET Aluminium SE, Essen, Germany

4. Production Manager Electrolysis
5. Reduction Manager

TRIMET Aluminium SE, Voerde, Germany

6. Production Manager Electrolysis
7. Reduction Manager

TRIMET Aluminium SE, Hamburg, Germany

8. Production Manager Electrolysis
9. Process Foreman
10. Reduction Manager

TRIMET France, Saint-Jean-de-Maurienne, France

Corresponding author: Matthias.Dechent@trimet.de
https://doi.org/10.71659/icsoba2024-al002

Abstract

Due to high expected power prices, TRIMET Aluminium SE started to reduce the production output in its three German electrolysis sites by around 20 % in 2021. After the start of the war in Ukraine and subsequent gas pipeline explosions in 2022, the German smelters curtailed its production and operated at only 30 % of its capacity. The F-Line in Saint-Jean-de-Maurienne was also curtailed in 2022 due to limited energy availability in France.

To restart the idled potlines with a common best practice, as soon as prices and energy availability would allow, a joined meeting was conducted already in the beginning of 2023, to discuss methodologies, equipment, and team organisation. The teams from the four smelters discussed past experiences and shared concerns about safety and limiting factors for restarts, for example liquid bath generation.

The preparation process and its results are presented in this paper as well as experiences of failed tests, and incidents during restart operations. The four smelters started the ramp-up in the first quarter of 2024 and the results from the first months in the restart environment are discussed.

Keywords: Aluminium reduction potline restart, Electrical restart, Restart methodology, Gas restart, Idled potline.

1. Introduction

As early as 2021, the tense situation on the raw material markets forced primary aluminium production to take a serious step - cutting back production. Primary aluminium production at the Essen, Hamburg and Voerde locations was significantly scaled back. Jobs were not affected by this measure because the existence of the locations is beyond question.

Due to the situation on the global gas market, there was also a gas shortage in Germany in 2022 [1]. TRIMET has therefore decided to reduce production even further in order to save gas by reducing the production of the anode baking furnaces. Further adjustments were subsequently made in September 2022 to reduce the German smelters down to 30 % of their capacity. Also, the French smelter decreased its capacity to 80 % around this time due to the still very tense situation on the energy market.

Preparation is essential for the successful restart of any potline. But preparation already starts with the curtailment, if possible. Daviou et al. have discussed the topic of scheduled curtailment in contrast to sudden shutdown due to an outside event and showed promising results with a planned curtailment [2]. The TRIMET smelters developed strategies on their average potlife on which cells would be restarted – or relined during the curtailment phase.

During the curtailment, cells which were marked as restart pots would not be tapped empty, but rather a layer of aluminium was allowed to stay in the cell to protect the cathode surface from oxidation and exfoliation of the cathode carbon surface. In the Essen smelter the standard procedure was to empty the pots as much as possible and leave a thin protective aluminium layer. Most pots had no solid metal plate left.

2. Common Preparation for Restart Methodology

During a common restart preparation process improvement group meeting initiated by the process improvement group leader, several restart methods were discussed and rated with a Pugh matrix approach. Data was gathered and prepared for the meeting by several of the authors of this paper. The restart methods were researched in press releases, publications in conference proceedings and personal communications with contacts at the individual plants.

2.1 Restart and Start Methods from Literature

We are not the first smelters to restart and others have published their experiences in the last years [2-4]. Table 1a and Table 1b show an overview about the published methods available for preheating of new cells and cells designated for restart.

Table 1a. Overview of used preheating methods in literature. [2], [4-17].

		Short description of method	Sources
New cell start	**Resistor bake**	Anodes are placed on top of resistive carbon material (graphite or coke), which is placed in patches, strips or as a full bed on top of the cathode. Cell is taken into circuit, at target temperature liquid bath is poured into cell and anodes are lifted.	[5-7]
	Dry start	Similar to resistor bake; however, anodes are lowered and cell is taken into circuit and heated by electric arcing until cryolite is molten and no liquid bath is added during the process. Cell reached temperature above 1000 °C for melting process of cryolite.	[7], [11]
	Gas/ oil preheat	Burners are placed into a cavity on top of cathode surface and below anodes. Anodes are locked with clamp as in process. During startup, liquid bath is poured, then the cell is cut in. Cell usually has higher voltage compared to resistor bake during early operations.	[6-8], [12-13], [17]

Table 1b. Overview of used preheating methods in literature. [2], [4-17].

		Short description of method	Sources
Restart	**Crash start**	Liquid bath is poured into a room temperature cell, cell is taken into circuit	[6-7], [9-10], [14]
	Metal restart	Anodes are placed on metal pad and additionally metal is poured around them; cell is taken into circuit, anodes in metal preheat the cell to a given temperature, then liquid bath is poured, and anodes are lifted	[6], [9-10], [15]
	Resistor bed on metal	Anodes are placed on top of a resistor coke or graphite bed, which is placed on top of a metal plate	[10]
	Resistor bake with metal extraction	Metal pad, if in cell, is removed by excavator. Then, the process of usual new cell resistor bake is conducted. Usually works good with young cells, for older cells, the graphite bed can lead to hot spots due to different heights.	[4-5], [7-10], [12]
	Dry start	Metal is extracted, then process like during new cell dry start.	[8], [12], [16]
	Gas/ fuel preheat with metal extraction	Metal is extracted, then process like during new cell gas preheat.	[12]
	Gas fuel preheat without metal extraction	Metal surface is cleaned, then process like new cell gas preheat.	[2]

2.2 Expected Pot Failures

One of the main concerns of restarting a plant is the failure rate of cells within the first 365 days of operations. As the restart is a great effort and one can assume some exhaustion within the process and production teams, it is very demoralising to see cells tap out, which have been restarted only recently. For the metal planning, unscheduled reduction of operating cells always is a risk, as metal contract might not be sufficiently covered by the production.

The teams in the smelters included a certain number of cells expected to tap out within the first 365 days and extrapolated the expected age structure. The age structure was used to forecast the number of cells to be relined within the next two years for staffing and purchasing of necessary materials. According to Tabereaux, the potlife is reduced due to damages in the lining and cathode with repeated preheating and bath-up. The potlife can be reduced between 100 and 400 days, depending on restart methodology and number of restarts [18]. The smelters used 200 days of potlife loss to estimate the relining budget for the coming years. Additionally, the estimated failure rate of cells – independent of pot age – has been investigated. The published failure rates are mostly between 10 and 20 %.

2.3 Assessment of Methodology

The methods for restart (Table 2) discussed during the joint meeting were analysed and assessed for their risk and chance for success in several categories (Table 3). The most important criteria were operational and workers safety, knowledge of technology and expected failure rate for cells below 1500 days. For the criteria, a three-level point system was used to emphasise the risks.
In a first round, all plants together evaluated the different methods and selected a few methods deemed too risky to test. As the cell technologies for the restart are comparable in cell size, it was

also discussed which knowledge and equipment could be changed. In a second round, each smelter did an assessment on itself to discuss investment projects and potential knowledge needs. The results from the evaluation for the Hamburg smelter can be found in Table 4. The last row of the table shows the result of the risk assessment and was therefore used to select the preferred method. For example, as the shift leaders and management from Hamburg were not experienced with gas restarts, an exchange was organised to visit Voerde during the preparation for the restart to learn about gas preheated restarts.

Table 2. Methods considered for restarting.

				Preheating			
No.	**Start-up method**	**No preheat**	**Metal pad**	**Gas**	**Resistor bed**	**Resistance**	**Liquid bath**
1	Crash start	x					x
2	Metal crash start	x	x				x
3	Anode on metal pad		x			x	x
4	Resistor bed on metal pad		x		x		x
5	Resistor bed no metal pad				x		x
6	Dry start				x		
7	Burner calcination		x	x			x
8	Burner calcination no metal			x			x

Table 3. Criteria for evaluation of considered restart methods.

Criteria	**Level 1**	**Level 3**	**Level 9**
Safety	Controlled risk	Not completely controlled	Not controlled
Equipment	is on site	low cost available	high cost not available
Bath quantity	no bath	50%	100%
Knowledge of technology	on site	Trimet group	no experience
Maximum Start-up rate	high	mid	low
Exp. Pot failure rate < 1500 days	< 10 %	< 20 %	> 20 %
Amount of people	low	mid	high
relining peak after restart	no	small	big

Table 4. Evaluation scheme for Hamburg smelter.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Safety	9	3	3	1	1	1	3	1
Equipment	1	1	1	1	1	1	3	3
Bath quantity	9	9	9	9	9	1	3	3
Knowledge of technology	9	9	9	3	1	9	3	3
Maximum Start-up rate	3	3	1	3	3	3	3	3
Exp. Pot failure rate < 1500 days	9	9	9	3	3	3	1	1
Amount of people	3	3	3	3	3	3	3	3
Relining peak after restart	9	9	9	3	3	3	1	1
Average	**6.5**	**5.75**	**5.5**	**3.25**	**3.0**	**3.0**	**2.5**	**2.25**

2.4 Full Load Regulation and its Limitations of the Restart

Certain limits regarding start-up speed and the maximum number of pots to be started result from the so-called full load hour regulation. This is a regulation that applies in Germany, which states that large consumers of electrical energy are exempt from certain portions of the grid fees if they reach at least x full load hours. The assumption for the regulation is that large, stable energy consumers are the foundation of a grid extension. The amount of full load hours is calculated as follows:

$$\frac{Electricity\ consumption\ for\ the\ entire\ calendar\ year\ [GWh]}{Peak\ load\ [MW]} = Full\ load\ hours\ [h]$$

The theoretical maximum achievable number of full load hours is therefore 8 760 hours, assuming that the peak load is drawn every hour of the year. The grid charge exemption levels are therefore set at 8 000, 7 500 and 7 000 full-load hours, each with a significant increase in grid charges. The minimum target for all German TRIMET plants was therefore not to fall below 7 000 full load hours, aiming to achieve 7 500 full load hours. This in turn leads to a limit on the maximum number of cells that can be switched on. In simple terms, it can be said that the later the start-up is started or the slower the pots are put into operation, the sooner the respective limit of full-load hours is undershot.

3. Restart Experiences

On January 2nd, 2024, the line bypass in Voerde, which was set during the shutdown period to avoid unnecessary resistance losses due to switched-off pots, was opened. This was followed by the start of the first gas burners to preheat the first cells on the same day. Consequently, the first pot of the TRIMET restart cycle was started in Voerde on January 3$^{rd.}$ Saint-Jean-de-Maurienne followed January 16th, then Hamburg on March 1st and finally Essen on April 2nd. The following section briefly explains the different experiences of the individual TRIMET plants.

3.1 TRIMET Aluminium Voerde (TAV) Restart

The Voerde plant was the one with the shortest preparation time, as there were only three weeks between the decision to ramp up and the actual ramp-up in Voerde. However, everything was of course already prepared for a ramp-up, as it was already assumed that the line would be completely ramped up again during the shutdown. Only the time was not yet fixed.

The Voerde smelter was shut down in two stages. Once in autumn and a second time in autumn 2022. Each time, a bypass of the busbar system was set in such a way that as few switched-off pots as possible were within the electrical circuit of the line to minimise resistance losses. The installation of a bypass takes about one week. During the transfer time, the complete line with all busbar losses consumes energy. To reduce the necessary time during position change and the energy consumption, a second bypass was purchased and installed. This means that when the line is restarted, only the bypass in use needs to be opened and it is possible to switch to the new, already closed bypass, which is located behind it in the switched-off area, during an approximately one hour switching period.

Fortunately, Voerde had plenty of experience with restart pots, as the side riser conversion meant that pots had to be switched off and restarted for the conversion. Shutting down the line favoured the side riser conversion, as it was now much easier to work on the busbar system in the shutdown area, especially for welding. However, starting up many retrofitted pots at once also brought its own challenges, as these brought with them greatly altered magnetohydrodynamics. In particular, the heat balance in the corners changed significantly.

Another major challenge in Voerde was that the entire line was converted to TRIMET's own new process control system called 'METRICS' just months before the start-up [19]. And even though this represents an enormous improvement in process control, it is initially a change that had to be managed at the same time as the ramp-up.

The biggest challenge for the restart in Voerde was undoubtedly the low staffing levels and the large number of vacancies, particularly in the potline operation of the electrolysis plant. Even though TRIMET did not let anyone go during the shutdown, vacant positions, which were mainly due to retirements and internal job changes, were not filled. As a result, around a quarter of the positions in potline operations had to be filled at the start of the ramp-up. While this was hardly noticeable at the start of the ramp-up process, it is quite clear that recruitment and training was not as fast as pots were being started up. The workload for staff increased significantly after the first month, also due to diversification of customers with three customers receiving liquid metal transports (two of them over public roads) and sows casting.

In the beginning of the restart phase, cells were only preheated with a gas burner. However, as the number of cells which had to be restarted increased due to temporarily shut off cells, electrical preheating was tested for new cells. After initial problems with the height of the ramming paste seal on the side, which was limiting the minimum ACD, the first cells were successfully started and a combination of electrical and gas preheating was to free up gas burner capacity in order to supply burners to the Hamburg plant.

3.2 TRIMET FRANCE - Saint-Jean-de-Maurienne Restart

The F Line consists of 60 AP18 pots operating at 200 kA. During the 18 months of potline curtailment, 13 pots were refurbished and 47 were prepared for restarting on metal. A project group was launched to organise all relevant activities and improvement projects.

The main objective of the project was to be completed without any major accidents or incidents. Risk analyses and operating procedures were drawn up with the safety correspondent, the CHSCT (committee for hygiene, safety and working conditions), the project managers and certain operators who were assigned to the various tasks. All these preparations enabled us to approach the restart and all the related activities well prepared, while remaining vigilant on the most delicate points. The restart teams had the opportunity to take part in a day of theoretical training, with role-playing exercises, reading of operating procedures, checking of equipment used during start-up, and practical training by attending a pot start-up. They were asked to use a new risk prevention tool (the pre-job briefing) on a daily basis, enabling them to start their shift with 5 simple questions and thus begin the activity with a clear idea of the tasks to be carried out throughout the day. At the end of the day, the teams had the same ritual (the debriefing) and took a moment to share the work that had gone well, as well as the points that needed to be improved in order to carry out the tasks safely, but also to link them up more smoothly. As the test was successful throughout the restart phase, the tool is now being rolled out across TRIMET France.

For preheating of the cell, an oil-based burner system was used, as no gas network is installed. The system was tested several times on a test pot, the aim being to get to grips with the equipment and find out how long it would take to reach the required temperature. The burners were placed at each end of the pot to preheat the metal sheet and the anodes for around twenty hours to achieve an even temperature across the entire surface of the pot. After the first cell was preheated too long and the metal pad was liquid, the process was improved to ensure proper preheating.

This restart was instructive in several respects. For example, the impact on the bath feeder pots was underestimated. 60 of the 120 pots in the G potline were feeder pots, and throughout the restart phase they were subjected to significantly higher power and liquid levels. This led to wear on the side ledges, weakening the sides of the shells, and a significant rise in silicon levels throughout the potline.

3.3 TRIMET Aluminium Hamburg (THH) Restart

The Hamburg smelter was restarted completely in 2007 [8], [12] after being curtailed and out of operation for one year by its former owners [20]. Back then, 190 cells were restarted. These were restarted depending on cathode condition either electrically with graphite resistor bed or with gas burners, which were borrowed from TAE. In the light of the financial crisis in 2008, 180 cells were shut down after a short operating period.

In 2018 cells were shut down due to high problems with anodes [21] to save the cells still in operation. These cells were only restarted with electrical heating. Several cells failed shortly after restarting, as the graphite bed was uneven and provoked the formation of spikes. The graphite was partially stuck underneath the anodes used during preheating. As this experience was costly, the decision was taken to restart as many cells as possible with a gas preheating system, borrowed from one of the other plants or purchased on the market. The uneven cathode surface or existing metal plate precludes electrical startup of these pots. New relined pots in Hamburg are electrically preheated using a graphite bed (1 – 4 mm grain size), on which the anodes are placed.

To ensure a smooth restart of potline 1 in the Hamburg smelter several topics were addressed in advance. Investments were made in new equipment, such as new crucibles for bath transfer und new forklifts. To ensure proper safety precautions, risk assessments were carried out in advance for each work step. This helped identify risks for the employees before work began. Precautionary measures for a safe start were carried out by the electrolysis staff, although these tasks do not fall within their normal duties. For example, the superstructures of each pot were dismantled to remove bath material from the cathode or the metal plate in preparation for the restart. Additionally, the cylinders of the crust breaker were replaced after a long period of inactivity. The replacement was done to reduce the risk of failures during startup and stabilisation period of a cell. Failed feeding due to equipment failure can be prevented.

Furthermore, a large amount of liquid bath is required to start a potline. To meet this challenge, the electrolysis team discussed several methods of bath generation. Ultimately, a test was conducted where the alumina hopper was divided using a partition plate. Anode cover material (50% alumina + 50% crushed bath) was placed in one of the compartments using the crane. The material was added to the pot during normal feeding, similar to a dedicated feeder for crushed bath implemented elsewhere [22]. To avoid anode effects and sludge, the feed rate and the voltage of the pot slightly increased. This procedure made it possible to produce approximately 350 kg of liquid bath per pot and day, which could then be used to start new pots through bath transfer. At the Hamburg smelter, 50 pots were equipped with these partition plates to meet the bath demand of 92 pots which had to be started during restart of Potline 1.

During a first test with a gas restart cell, the residual metal pad, left in the cell to protect the cathode from oxidation, was fully molten, as the preheating target temperature was set to 900 °C. Before liquid bath addition, the anodes were lowered to reduce the necessary volume of bath. However, the lowered anodes led to the phenomenon that the bath pushed the molten metal to the tap end side of the cell. After cutting the cell in, the voltage of the cell did not go higher than 3 V. As the crew on site was stressed out and the temperature was dropping, the decision was taken to shut down the cell after only 90 minutes in operation. Later in the debrief, the possibility of shorting was discussed. An autopsy afterwards revealed metal instead of bath right below the

anodes on the tap end side. Learning from this mistake, the preheating final temperature was decreased to 620 °C to insure a preheated, but mostly frozen metal plate. The reduction in temperature also allowed for a faster startup. A second restart of the cell was successful and helped to regain confidence into the restarting capabilities of the potroom staff.
On March 1st, 2024, the first two cells were started with electrical preheating, while an already preheated cell with gas burners was bath-uped.

3.4 TRIMET Aluminium Essen (TAE) Restart

Potline 3 of the Essen smelter was shut down in a series of about 20 pots at a time with installing crossovers to reduce power consumption and because the number of shunts was limited as well. The metal was tapped out as much as possible. Subsequently, the pots were selected by age and prior problems for restart. The cut-off age was selected to be 1900 days, with an average normal pot life of about 2200 days. Still, some pots had a history of high iron content, bad cathode current distribution or even tab-out events, which were also not selected for restart. Immediately the relining works began to replace these pots. The restart pots were left in the potline and cleaned from solid bath by a small excavator.

Extensive repairs, maintenance, and optimizations of the superstructure and feeding equipment were undertaken. The current free time was especially used in Potline 3 to install a new bus bar extension for magnetic compensation of all pots.

The standard calcination in Essen works by two gas burners in the corners of the cell over a period of 3 days. In potline 1 tests were conducted of restarting pots with two days of calcination. When removing the metal left in the pot, most of the bath could be excavated. The restart by two-day calcination worked quite well. This method was adopted for some more restarts as training for the electrolysis team. For ramping up the potline the calcination time was also set to two days. This requires more burners. Essen had four burner pairs available for beginning the ramp-up, meaning that the maximum speed would be 14 restart pots per week. New relined cells made up about 30 % of potline 3, hence reducing the speed ramping up due to the longer calcination time.

Before starting the ramp-up process, all pots were carefully cleaned again by a small excavator, removing more bath and loose metal pads. Some young pots looked almost as newly relined cells. Shortly before restarting, all functions of the feeding system and crust brakers as well as signal quality were checked. The pots were prepared as usual for calcination. Anodes were placed in the pot and covered. Checking the final condition of the pots and preparing them for calcination was done by two experienced pot room supervisors. The decision was made to work with the regular shift teams to restart the pots, because this process is trained very well. Also, the shift leaders and foremen know best how to handle the new pots and are also needed in their team for leading the staff. This is why these experts were not removed from their team to create a special restart team.

The biggest challenge is always producing the right amount of liquid bath. Potline 1 consists of 120 pots. For the ramp-up start 40 cells were selected as bath collecting pots with a higher bath level. 20 of these pots were fed with solid bath to produce an excess liquid bath. Because of this high amount of special bath pots, there was no shortage of liquid bath but a surplus, leading to a high number of stub attacks and subsequently higher iron content in the metal. The number of bath generation pots could be reduced quickly to zero after four weeks. Also, the number of bath collecting pots could be gradually reduced as enough liquid bath was available for restarting pots. Restarting with an average rate of about 12 pots per week, it was sufficient in the end to have 20 bath storage pots at a time. These pots were switched from potline 1 to potline 3 for shorter distances for the bath transfer when enough pots ran well in potline 3.

As in Essen nearly all of the operations are carried out using vehicles, special attention needs to be drawn on the maintenance of these vehicles. To assure that the vehicles can be maintained with one rest day at least once per week without any pot startups was established.

In summary, the ramp-up of potline 3 was successful by this method without any restart-related injuries and an early pot failure rate of restart pot of less than 1 %. The experience gained from 15 cells restarted in potline 1 in order to gather insights was successful.

4. Lessons Learned during Restart

With the four smelters amid an ongoing restart during writing these pages, we can already hint on the following lessons we have learned during restart.

- For a cell with a metal pad, keep a distance between metal plate and underside of anodes to allow for waves of bath and metal to equalize, if the metal is already molten.
- Increase capabilities for liquid bath production in a safe manner.
- Expect cells to fail: Communicate the estimated failure rate within the potroom team and management to set expectations.
- Use the experience from other smelters, if possible. Every smelter had at least one start and will have experienced premature failures and restarts of at least a couple of cells.
- If possible, allow for up to six months to find the necessary personnel and train them.
- Expect metal quality to deteriorate: Fe from stub wash on bath pots, Si from insulation material like mineral wool (which include up to 30 % Si).
- Expect anode failure due to uneven preheating. Especially the removal of anodes with failed bi-clads can become a operational and health and safety issue, if no proper equipment can be used. Cells with 10 % or more anodes with failed clades are very difficult to operate.
- ACD is important during the first eight hours. If one finds anodes without current and anode current distribution is off, increase ACD and add metal, if temperature is deemed too high.
- Expect high temperatures in restarted cells, as sometimes shorting occurs within the cells. Failure of refractory material or cathodes can increase the temperature or reduce the ability to lose heat over the shell, leading to red walls.
- The restart begins during scheduled shutdown, as this action enable certain restart technologies by leaving a metal pad.
- Keeping staff constantly informed about the progress of the work and the refurbishment of the pots, to prepare them for the restart.
- Respect and team spirit by involving staff in restoring the potlines and preparing for the restart of the pots and promoting positive results and the desire to succeed together.

5. Conclusions

The restart of four fully or partially curtailed potlines by the TRIMET team was successfully conducted during the first months of 2024. Additionally, we learned several valuable lessons that **are** shared in this paper. As the restart will continue in 2025, a full recap of the results and data on failure rates, cathode life loss and further results from potlines idled for three or more years will be available by the end of 2025.

6. References

1. N. N, Aktuelle Lage der Gasversorgung in Deutschland, *Bundesnetzagentur,*https://www.bundesnetzagentur.de/DE/Gasversorgung/aktuelle_gasversorgung/start.html (Accessed on: April 15, 2024)

2. María Carolina Daviou et al., Dissimilar Results in Restarting Two Different Potlines, *Light Metals* 2023, 791–796. doi: 10.1007/978-3-031-22532-1_105.
3. Daniel Whitfield et al., Restart of AP30 Cells at Boyne Smelters, *Light Metals* 2024, 537–544. doi: 10.1007/978-3-031-50308-5_69.
4. Ana Carolina Guedes et al., Restart of Albras' Potline 2—Improving Performance and Changing Paradigms, *Light Metals* 2023, 797–807. doi: 10.1007/978-3-031-22532-1_106.
5. Abdalla Alzarooni et al., DX+ Ultra Industrial Version: Preheat Start Up and Early Operation, *Light Metals* 2018, 721–729. doi: 10.1007/978-3-319-72284-9_93.
6. Ketil Å. Rye, Cell Preheat/Start-up and Early Operation, Essential Readings in Light Metals 2016, 718–722. doi: 10.1007/978-3-319-48156-2_107.
7. Michel Reverdy and Vinko Potocnik, A Historical Review of Aluminum Reduction Cell Start-Up and Early Operation, *Light Metals* 2022, 991–997. doi: 10.1007/978-3-030-92529-1_129.
8. Till Reek, Jörg Prepeneit, and David Eisma, Successful dry restart of the hamburg smelter, *Light Metals* 2008, 461–466.
9. Mikhail Lukin and Richard Jeltsch, Reduction Cell Restart Method Influence on Cell Life Evolution, *Light Metals* 2013, 719–724. doi: 10.1007/978-3-319-65136-1_123.
10. Mikhail Lukin and John Johnsson, Prebake Potline Restart after Power Supply Interruption, *Light Metals* 2012, 733–737. doi: 10.1007/978-3-319-48179-1_126.
11. Robert Cayouette and Francois Laplante, Dry cell start-up of an electrolytic cell for aluminum production, WO 2012/174641 A1, filed May 18, 2012, granted Dec. 27, 2012.
12. Till Reek, The Hamburg Smelter-A Study of the Cathode Performance, *Light Metals* 2009, 347–352.
13. Carlos Zangiacomi et al., Preheating study of smelting cells, *Light Metals* 2005, 333–336.
14. Agnello Borim et al., Line 2 restart process at Alumar–Brasil, *Light Metals* 2005, 337–340.
15. Albert Mulder et al., Simultaneous Preheating and Fast Restart of 50 Aluminium Reduction Cells in an Idled Potline, *Essential Readings in Light Metals* 2016, 729–734. doi: 10.1007/978-3-319-48156-2_109.
16. Kayron F. Lalonde et al., Start of an Aluminum Reduction Cell without Liquid Bath, *Light Metals* 2013, 725–728. doi: 10.1007/978-3-319-65136-1_124.
17. W. B. Rickards et al., Thermal Bake-Out of Reduction Cell Cathodes — Advantages and Problem Areas, *Essential Readings in Light Metals* 2016, 694–698. doi: 10.1007/978-3-319-48156-2_103.
18. Alton T. Tabereaux, Loss in Cathode Life Resulting from the Shutdown and Restart of Potlines at Aluminum Smelters, Essential Readings in Light Metals 2016, 723–728. doi: 10.1007/978-3-319-48156-2_108.
19. Sylvain Fardeau et al., Development, test, and deployment of the METRICS control system, *Proceedings of the 42nd ICSOBA Conference, 28-30 October 2024*, Lyon, France, *TRAVAUX* 53.
20. N. N, Comeback eines Industriebetriebs, Manager Magazin. https://www.manager-magazin.de/unternehmen/artikel/a-439729.html (Accessed on: April 15, 2024)
21. Matthias Dechent, An Anode Crisis - The Pitfalls of an Anode Length Increase, *Proceedings of the 41st ICSOBA Conference*, 5-9 November 2023, Dubai, UAE. Paper AL17, *TRAVAUX* 52, 1375–1385.
22. Claude Vanvoren et al., AP 50: The Pechiney 500 kA Cell, *Essential Readings in Light Metals* 2016, 462–467. doi: 10.1007/978-3-319-48156-2_66.