Auto Retract Technology for Pneumatic Breakers and Feeders in INALUM Cells

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Abstract

In aluminium smelters, such as at INALUM, emergency situations like power outages (blackouts) can cause significant disruptions. One of the critical issues is the shutdown of the compressor plant, which results in a loss of air pressure in the pneumatic system. This can cause pneumatic cylinders to fail, leading to the dropping of the breaker chisel, which can submerge into molten bath. This increases the iron content in the metal and decreases metal purity.

To address this problem, this paper introduces the Auto Retract technology. The system is designed to detect the air pressure drop below 200 kPa and automatically opens a valve on a backup air tank, which allows compressed air to refill the cylinders and restore the breaker chisel to its proper position, locking it safely above the molten bath. This technology not only prevents damage to the pneumatic cylinders but also serves as a stabilizer for air pressure, ensuring the system remains stable even during fluctuations in pressure. By maintaining stable air pressure, the auto retract technology enhances the overall efficiency of the aluminium smelting process, leading to better operational stability and improved aluminium quality.

The Auto Retract technology has been successfully implemented at INALUM in Potline 3, Pot R669 since January 2023. Its application is expected to significantly improve both safety and operational efficiency, particularly during emergency situations such as power blackout.

Keywords: Auto Retract technology, Aluminium smelting technology, Blackout safety, Pneumatic system stability, Operational efficiency.

1. Introduction

In aluminium smelting operations emergency situations like compressor plant shut down due to auxiliary power outage or AC/DC current shut-down (blackout) can lead to significant operational disruptions. One of the most critical challenges during blackout is the shutdown of the compressor plant which results in a sudden loss of air pressure. The loss of pressure in the breakers and feeders leads to dropping of breaker chisels into the bath, where it will remain until the power is restored. This not only affects the safety of the operation but also increases the iron content in the metal, thereby diminishing the overall quality of the aluminium. The need for the reliability of power supply to the aluminium reduction cells is well known [1–5]. Not only in INALUM, power outages also occur in other smelters in the world as shown in Figure 1.

Year of Outage	Smelter and 1st Potline Startup Year	Cause of Failure	Outage Hours	Decrease in Production (Cells Stopped)	Comments
Dec. 18, 2010	Alcoa Fjardaál, Iceland, 2008	Transformer explosion and fire	2.25	0	Total power loss in plant; no cells were shutdown due to the power outage.
Sept. 1, 2010	Century Aluminum, Grundartangi, Iceland, 1998	36 kV breaker for potline 1 failed; power plant did not restart	2	0	One rectifier transformer was under repair at the time; no cells were shutdown due to power outage.
Aug. 9, 2010	Qatalum, Qatar, 2010	Power plant shutdown; did not restart	5	100%, (444 of 706 cells)	Began restarting cells Sept. 2010; estimated completion in 1st quarter 2011.
July 7, 2010	Laterrière, Canada, 1989	2 transformer failures and explosion	>24	50%, (216 of 432 cells)	Began restarting cells August 1, 2008; Sept. 30, 2010, 25,000 t loss production.
Nov. 9, 2008	NZAS, Tiwai Point, NZ, 1971	Transformer failure	>24	33%, (206 of 618 cells)	Gradual restart began mid-May, 2009.
Nov. 2, 2008	Dubal, UAE, 1979	Thermal overload of its power plant	>2	42%, (660 of 1565 cells)	Began restarting cells after 1 month; capacity was restored in 2.5 months.
June 12, 2008	Anglesey, England, 1971	132 kV transformer failure-fire	4	67%, (211 of 316 cells)	1st potline restored in late July; 2nd potline in August 2008; smelter closed Sept. 2010.
May 2008	Keao Aluminium, Zoucheng, China, 2003	No supply of power from grid system	5	0	180 cells (300 kA), power only for automaton and lighting, no cells were shutdown due to power outage.
Jan. 1, 2008	Noranda, U.S., 1968	Broken power transmission lines	>24	75%, (377 of 508 cells)	Restarted Lines 1 & 2; gradual restart in Line 3.
April 16, 2007	Alcoa, TN, U.S., 1969	Broken power transmission lines	4	50%, (164 of 328 cells)	Began restart of Line 1 May 28 and completed June 2007.
July 18, 2003	Alumar, Brazil, 1984	2 rectifier failures	>24	40%, (250 of 710 cells)	Began restart Oct. 13 and competed Nov. 14, 2003
Sept. 14, 2001	Hillside Aluminum, BHP, South Africa, 1995	Temp. lost power from grid; air compressors failed to re-start	5.2 (L1), 6.3 (L2)	21%, (123 of 576 cells)	Air off for 4 hour, gas TC off for 5 hrs, and fume TC off for 9 hrs.
March 10, 2000	Alcoa, Mt. Holly, U.S., 1980	Aluminum bus failure	5	25%, (90 of 360 cells)	Began restart almost immediately.

Figure 1. Power outages (blackout) in aluminium smelter around the world from 2000-2010 [1]. Power outages until May 2018 are given in [2].

To resolve the issue of breaker chisel dropping in the bath, we introduced the Auto Retract technology for pneumatic breakers and prevent their malfunctioning. The system works by automatically triggering a valve connected to a buffer tank and releasing compressed air to the pneumatic cylinders to restore their operational pressure. This action ensures the breaker chisel is returned to its correct position and securely locked above the molten bath instead of falling into the bath.

The implementation of Auto Retract Technology at the INALUM has enhanced operational reliability and safety. The technology prevents damage on pneumatic cylinders and promotes

1. **Improved safety**
   This system makes sure that the breaker chisel retracts and locks safely above the liquid bath for all emergencies including blackout and loss of air pressure.
2. **Reliable backup air supply**
   By reusing air cylinder as a buffer tank, the system provides an economic solution when the main air supply fails.
3. **Automatic response to pressure loss**
   The Auto Retract system is equipped with a pressure switch that detects air pressure drops to below 200 kPa. When triggered, the system automatically releases compressed air from the buffer tank through a valve and then retracts the cylinder and locks the breaker. This avoids the risk of the breaker chisel falling into the bath.
4. **Operational continuity**
   By stabilizing air pressure, the Auto Retract system minimizes operational disruptions and improves the overall efficiency and reliability of cell operation even during unexpected conditions.
5. **Proven reliability**
   The test demonstrated that the system works effectively even when the main air supply is cut off and that it performs in emergency as designed.
6. **Cost-effective and sustainable**
   Reused cylinders as buffer tanks for backup air storage provide a cost-effective solution.

The successful implementation of the Auto Retract system at INALUM enhances operational safety, assures continuity of operations during emergencies, and maintains aluminium purity. This innovation is a vital step forward in improving the resilience and efficiency of INALUM operations.

7. References

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