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Application of Artificial Intelligence in the Aluminium Industry

Integrated Red Mud Pond Management Using Digitalization and Artificial Intelligence

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ABSTRACT

Red mud ponds are among the most safety-critical assets in alumina refineries, with their long-term integrity directly dependent on the interaction of material behavior, water balance, pore pressure development, phreatic line position, bund geometry, and changing operational conditions. Traditional management practices—based on manual instrumentation, periodic inspections, and snapshot-based stability assessments—have been effective for compliance but remain largely reactive. These limitations become increasingly significant under higher rainfall variability, aging infrastructure, and growing regulatory, ESG, and community expectations, where early warning and proactive risk management are essential.

This paper presents a practical digital and AI-enabled framework for red mud pond management that builds on proven geotechnical practices rather than replacing them. Recognizing the poor reliability of online sensors in caustic red mud environments, the approach deliberately retains manual piezometers and inclinometers while digitizing data collection, integration, and visualization through mobile applications and centralized dashboards. Digitized field measurements are spatially integrated to continuously track pore pressure evolution and phreatic line movement across the pond and bund. Using existing design assumptions and historical stability models, these data are converted into a dynamic Factor of Safety (FoS), providing continuous visibility of stability margins and early warning of deterioration well before visible signs of distress. The framework integrates drone-based surface inspection, computer-vision-assisted crack and erosion detection, high-precision DGPS deformation monitoring, AI-driven dust suppression, operational mud inventory assessment, and storm water management for supernatant liquor ponds. All real-time and historical datasets are consolidated into a unified digital platform that functions as a living digital twin of the red mud pond. By enabling predictive analytics, scenario modeling, and structured insight-to-action

decision workflows, the proposed system transforms red mud pond management from a reactive compliance activity into a proactive, predictive, and risk-based governance process, supporting improved safety, regulatory compliance, ESG performance, and long-term operational resilience.

Keywords: ***Red Mud Pond, Digital Twin, Pore Pressure, Phreatic Line, Slope Stability, AI, Dam Safety, Geotechnical Monitoring.***

Transforming Effluent Treatment through Automation, Analytics, and Circular Resource Recovery

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ABSTRACT

Water scarcity poses a critical operational challenge for Hindalco Belagavi, a specialty alumina refinery located in a water-stressed region with no perennial river source and complete dependence on monsoonal rainfall. Ensuring a reliable supply of high-quality water is essential for specialty alumina production, which demands stringent water quality standards. While increasing reuse of treated process water is imperative for sustainability, conventional Effluent Treatment Plant (ETP) operations—based on manual controls, fixed chemical dosing, and periodic intervention—have proven inadequate due to persistently high Total Dissolved Solids (TDS), colour, odour, and biological growth caused by caustic contamination and large-volume storage conditions.

Building on earlier process optimization efforts that successfully eliminated colour and odour through improved coagulant–flocculant systems and controlled biocide application, this paper presents a fully automated, sensor-driven, and AI-enabled ETP framework for specialty alumina operations. The proposed system integrates automated acid dosing for real-time neutralization of process water, dynamic coagulant and flocculant dosing based on online turbidity measurements, and ORP-based biocide control. Machine-learning algorithms analyze historical and real-time data to optimize chemical dosage, minimize consumption, and prevent under- or over-treatment. Automated sludge-level monitoring enables controlled and timely sludge withdrawal, ensuring stable hydraulic and treatment performance.

To achieve complete circularity, the withdrawn sludge is processed through a thermal dryer to achieve greater than 90% solids, enabling its utilization in cement industry co-processing and eliminating dependence on traditional TSDF disposal routes. The

integration of automation, real-time sensing, and AI-based optimization significantly improves treated water quality, enhances system reliability, and reduces freshwater intake, chemical usage, operational variability, and environmental risk. This study demonstrates a scalable and cost-effective pathway for autonomous ETP operation in water-scarce, compliance-intensive industrial environments.

Keywords:* *AI-Enabled Automation, Water Reuse, Sensor-Driven Dosing, Circularity.

Predictive Modelling of Alumina Trihydrate Particle Size Using Machine Learning

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ABSTRACT

As demand for specialty alumina continues to grow, consistent control of alumina trihydrate particle size distribution (PSD) during precipitation has become increasingly critical for meeting customer-specific quality requirements and ensuring stable refinery operation. Many alumina refineries continue to operate ageing precipitation circuits, where any meaningful process adjustment typically requires 15–20 days to manifest in the final product. This delay significantly increases the risk of quality drift, particularly in the formation of excessive fines or coarse material, for different customers. The challenge is further compounded by the need to supply multiple customers with distinct PSD targets, placing strong emphasis on effective production planning, sequencing, and process stability.

Traditional precipitation control relies predominantly on delayed laboratory measurements and operator judgement, limiting the ability to anticipate PSD deviations and intervene in a timely manner. In this study, a data-driven predictive framework is developed to estimate the median particle size (d_{50}) of alumina trihydrate directly from real-time process variables, while remaining anchored in established precipitation chemistry. The model is based on three years of continuous plant operating data, comprising 25,404 hourly observations and 36 key variables related to liquor chemistry, seed characteristics, super saturation, and temperature profiles. A major challenge was the high sparsity of laboratory PSD measurements, with approximately 85–90% missing

data, which was addressed through Bayesian iterative imputation and time-lagged feature construction over 1–24 hour intervals.

Key mechanistic indicators, including super saturation, Tschamper ratios, seed specific surface area, and temperature gradients, were combined with statistical descriptors, with multi collinearity controlled using variance inflation factor analysis. A Light GBM ensemble model delivered the best performance, achieving an R^2 of 0.727, MAE of 3.55 µm, and RMSE of 4.63 µm. With a predictive horizon of approximately 14 days, the framework allows early identification of PSD drift, supporting stable quality delivery, reduced switching losses, and improved customer confidence in specialty alumina supply

Keywords:* *Digital Twin, Process Digitalization, Predictive Analytics, Precipitation Control, Particle Size Distribution, Machine Learning.

AI-Enabled Bauxite Yard Management Using Online Analyzer, Intelligent Stacking–Reclaiming, and Real-Time Laser-Based Volume Control

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ABSTRACT

Efficient bauxite yard management is critical for ensuring consistent feed quality, optimized inventory utilization, and improved downstream process performance in alumina refineries. This paper presents the concept of an AI-based bauxite yard management system integrating an online bauxite analyser, intelligent stacker control, grade-wise segregation, optimized reclamation and blending, and real-time volume monitoring using terrestrial laser scanning (TLS).

This method utilizes an online bauxite analyser installed on the conveyor feeding the stacker to continuously measure key quality parameters such as Al_2O_3, SiO_2, Fe_2O_3, and moisture. These real-time inputs are processed through AI and machine learning algorithms to dynamically determine stacking strategies, enabling grade-wise

segregation and formation of optimized stockpiles. The stacker operation is automatically guided to place material in designated zones based on predicted quality trends and blending requirements.

For reclamation, the system integrates AI-driven reclaimer scheduling and control, ensuring best-blend extraction by combining material from multiple stockpiles and layers to achieve target quality specifications for refinery feed. Historical analyser data, stockpile quality models, and process requirements are used to generate optimal reclaimer paths and reclaim rates, minimizing quality variability and reducing manual intervention.

Additionally, terrestrial laser surveying can be employed for real-time, volume-based yard management. High-resolution 3D stockpile models generated from TLS data provide accurate measurements of stockpile volume, shape, and reclaim progress. These models are continuously synchronized with the AI system, enabling precise inventory tracking, reconciliation, and decision-making in real time.

The integrated solution can enhance operational transparency, quality control, and inventory accuracy, while reducing blending losses, operational delays, and dependency on subjective judgment. The adoption of AI-based bauxite yard management with real-time analysers and laser scanning represents a significant step toward digitalization and smart material handling in the aluminium industry.

Keywords: ***AI-Based Yard Management, Online Bauxite Analyzer, Grade-Wise Segregation, Intelligent Stacker Control, Optimized Reclamation, Best Blending Strategy, Terrestrial Laser Scanning (TLS), Real-Time Volume Measurement, Digital Stockpile Management, Alumina Refinery Feed Optimization, Machine Learning in Bulk Material Handling, Smart Mining and Industry 4.0.***

AI-Guided Optimization of Last Growth Tank Temperature in the Precipitation Circuit of Utkal Alumina International Limited (Alumina Refinery)

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ABSTRACT

In the precipitation circuit of an alumina refinery, precise temperature control across tanks is critical for hydrate crystal growth, size distribution, impurity incorporation and process efficiency. Conventional operation of manually controlled inter-stage coolers (ISCs) often governed by fixed SOPs that lack sensitivity to dynamic process and environmental condition, failing to dynamically adjust to ambient fluctuations and radiation losses, thereby causing variability in the final (last growth) tank temperature. The control philosophy is basically a backward feed control.

A common operational constraint is maintaining the last growth tank temperature above 54°C (50% of time), leading to conservative cooling strategies and consequent loss in precipitation productivity. Furthermore, the lag between operator action and measurable impact at the last tank — approximately 7–8 hours — limits effective feedback control.

To address these limitations, this study investigates data-driven strategies to model ambient cooling between the last operational ISC and the last growth tank, reduce temperature control lag by adopting forward feed control to dynamic conditions, enable dynamic target setting for last operational ISC inlet temperatures using predictive models and quantify the resultant gains in precipitation productivity and refinery throughput.

This paper outlines an AI/ML-based framework to optimize last growth tank temperature by modelling ambient cooling and operational behaviour of ISCs across the precipitation train. Using a Random Forest model and a regression-based ambient cooling equation trained on plant data (June 2024–August 2025), the study establishes the link between last operational ISC inlet temperature, ambient temperature, and target last growth tank temperature. The proposed framework enables real-time target setting of ISC inlet temperature to achieve consistent last tank temperature within 54–54.5°C.

Implementation trials demonstrated can have an average improvement of ~0.4 gpl in precipitation productivity (~0.46% throughput increase), by maintaining the target last growth temp, 90% of time. The work demonstrates the potential of intelligent control frameworks in modern alumina refining operations for enhancing process consistency, productivity, and energy efficiency.

Keywords: ***Artificial Intelligence (AI), Machine Learning (Random Forest), Forward Feed Control, Ambient Cooling Modelling, Process Optimization, Temperature Control, Precipitation Productivity, Hydrate Crystal Growth, AI-Driven Process Optimization, Machine Learning, Last Growth Tank Temperature, Inter-Stage Cooler (ISC) Optimization, Refinery Throughput Improvement and Energy efficiency.***

Re-imagining the Aluminium Value Chain through Digitalization

Digital Transformation in a 60-Year-Old Industrial Plant: A Practical Approach

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ABSTRACT

Ageing industrial plants operate within constraints such as legacy equipment, soloed data, and manual processes that limit energy efficiency, reliability, and decision speed. This paper presents a practical, phased digital-transformation model implemented in a 60+ year old aluminium smelter, beginning with the establishment of a secure, real time operational data backbone using the Data Management System. On this foundation, targeted high impact analytical applications were deployed across operations and maintenance. The programme includes a Maintenance Analytics tool that delivers MTTR and MTBF based reliability insights along with spare consumption intelligence, enabling faster decisions and more efficient asset management. Complementary solutions include CBM Analytics for vibration, thermography, air leakage and oil diagnostics; Cooling Water Analytics for chemistry and ΔT control; a Pot Digital Twin that predicts pot temperature and recommends AlF_3 dosing; Anode Cover Analytics to minimize heat loss and guide operator upskilling; VC Analytics to track the transition from open to closed crucibles; and Auto Reports that cascade Macro→Micro insights (Potline→Room→Zone→Pot) to accelerate daily and chronic abnormality resolution. Governance and safety enablers—Cyber secure OT/IT/CCTV, Layered Process Audits, Third Party Inspection compliance, and a unified Digital Landing Page—further strengthened transparency, discipline, and operational control. Collectively, these interventions reduced manual workload, improved energy stewardship, accelerated abnormality detection, and enhanced reliability, offering a replicable blueprint for transforming legacy brownfield plants into data driven "Plants of the Future."

Keywords: Legacy Plant Modernization, Industrial Digitalization, Data-Driven Operations, Operational Intelligence, Predictive Maintenance.

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Predicting Keyholes in Additively Manufactured Aluminium using a Multiphase Physics Model of AM PravaH®

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ABSTRACT

This manuscript presents the prediction of melt pool behavior and a more critical aspect of melt pool dynamics, i.e., keyhole formation in pure aluminium. A physics-based approach is used for modeling the pure aluminium welding process at 500 W laser power and 1.2 m/s. The model is an advanced physics-based numerical simulation tool, AM PravaH ®, which has been developed and introduced by Paanduv Applications; it is specifically designed for high-fidelity analysis of Additive Manufacturing processes. The model is highly sensitive to the thermo physical properties, laser characteristics such as emissivity, absorption coefficients, and Fresnel coefficients. The tool aims to predict the defects in additively manufactured parts by a high-fidelity computational fluid dynamics approach involving multi physics coupling in laser-assisted AM processes. It captures the complex interplay of multi physical phenomena, such as a laser heat source for the melting of the solid alloys, particle distribution using Discrete Element Modeling, along with heat, mass transfer, and Marangoni convection for elaborate surface tension effects. The solver's accuracy is deployed by minimizing the assumptions and incorporating a dedicated vapour phase to capture vaporization effects along with the Fresnel reflections, to predict the interfacial optical interactions. Furthermore, the model validation with experimental results is presented here, reinforcing the model's reliability and predictive capability.

Keywords: Aluminium alloys; Additive Manufacturing; LPBF; keyhole.

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Green Aluminium

The Next Cycle of Aluminium Growth and its Carbon Consequences

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ABSTRACT

Since 2000, the global aluminium industry has undergone a profound geographical shift in primary smelting capacity from Western regions to Asia and the Middle East. This relocation has significantly altered the sector's carbon footprint due to differences in regional power-generation mixes.

Between 2000 and 2015, a substantial share of new smelter capacity in China and India was powered predominantly by coal-fired electricity, while new capacity in the Middle East relied largely on natural gas. As a result, industry-wide direct and indirect carbon emissions rose by approximately 200% over this period, equivalent to a compound annual growth rate (CAGR) of 7.5%. Over the same timeframe, global primary aluminium output grew at a slower pace of 6.5% CAGR, underscoring the sector's increasing dependency on fossil fuel–based power and the associated carbon intensification of supply.

Following COP21 and the adoption of the Paris Agreement in 2015, global awareness of climate risks increased markedly, prompting aluminium producers to embark on decarbonisation initiatives. Although China, the Middle East, and several Asian economies continued to add fossil-fuel-powered smelting capacity, the broader industry began implementing carbon-reduction strategies. These included relocating capacity to hydro-rich provinces in China, integrating renewable energy sources into power portfolios, and signing renewable power purchase agreements. Collectively, these efforts contributed to a stabilisation—or plateauing—of sector-wide emissions despite continued production growth.

As the industry enters its next growth cycle, a critical question emerges: Which regions will dominate future smelter additions, and how will their respective power-generation profiles influence the aluminium sector's decarbonisation trajectory? Understanding this dynamic is essential for anticipating whether global emissions will resume an upward.

This paper presents Wood Mackenzie's projections of future aluminium supply growth, assesses the likely energy sources underpinning new capacity, and quantifies the expected impact of these developments on the global decarbonisation pathway for primary aluminium production.

Keywords: ***Aluminum Smelting, Decarbonization, Carbon Emissions, Energy Mix, Global Supply Shift.***

Green and Low-carbon Aluminium Technologies

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ABSTRACT

In the Aluminum industry there are different challenges like achieving energy consumption, complying with environmental standards, achieving quality demands, and facing the market challenges. Linde's Ox fuel technology helps address these challenges by reducing fuel consumption and emissions in aluminum melting furnaces. Through this technology, in melting furnaces various benefits can be achieved like power saving, refractory saving, operation safety improvement, reducing operation and maintenance costs and increasing yield. Other benefits can be achieved like reduction of fuel consumption up to 35-40%, homogeneous heating in the furnaces, higher thermal efficiency and heat transfer and less Nox emissions due to reduced nitrogen ballast and recirculated flue gases which effectively lowers flame temperature.

Keywords: ***Aluminum Industry, Oxy-Fuel Technology, Linde plc, Energy Efficiency, Fuel Consumption Reduction, Emission Reduction.***

Non-Metallurgical Bauxite–Alumina Applications

Challenges in Designing Equipment for Small Speciality Alumina Refineries

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ABSTRACT

India is seeing a surge in small capacity Specialty Alumina refineries coming up or under advance stage of planning. Specialty alumina production at modest capacities (10,000 – 60,000 tons per year) presents unique engineering challenges. Unlike large-scale alumina refineries, small plants must adapt liquid/solids separation equipment such as Deep Bed® Decanters, Deep Bed® Washers, Disc filters, Pan filters, and Security filters to achieve high product quality, process efficiency, and economic viability. This paper explores the technical, operational, and integration challenges of designing small-scale process equipment, highlighting the trade-offs between scale, efficiency, and flexibility.

***Keywords:* Speciality Alumina, Liquid/Solids separation, Deep Bed®Decanters, Deep Bed®Washers, Disc filters, Pan filters, Security filters.**

Selective Removal of Iron Oxide from Bauxite Ore

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ABSTRACT

The progressive depletion of high-grade bauxite reserves in India has necessitated the development of effective beneficiation technologies to reduce iron and titanium impurities in low-grade ores. Conventional de-ironing techniques, such as hydrochloric acid leaching, suffer from major environmental drawbacks and economic penalties due to excessive alumina loss and reagent consumption.

The Gharda Scientific Research Foundation (GSRF) has developed and successfully demonstrated a novel, sustainable, and economically viable selective chlorination route

for bauxite beneficiation. The process is based on single-step carbo-chlorination of bauxite in a fluidized-bed reactor using calcined petroleum coke as a reductant. Following extensive laboratory & Kg Scale studies, the process was scaled up and validated at the pilot/demonstration-plant level.

Pilot/Demonstration-scale trials achieved selective conversion of iron and titanium oxides while preserving alumina integrity. The process reduced Fe_2O_3 content in beneficiated bauxite to 2.5% ± 0.2%, with approximately 5-7% loss of Al_2O_3. High selectivity was observed, with substantial conversion of iron and titanium oxides to volatile chlorides and minimal chlorination of alumina. The recovery of valuable by-product ferric chloride further improves process economics and resource efficiency.

GSRF process establishes the techno-economic feasibility of the selective chlorination process at pilot/demonstration scale and demonstrates its potential as an environmentally cleaner and industrially viable solution for upgrading low-grade Indian bauxite for non-metallurgical applications.

Keywords:* *Selective Chlorination, Bauxite beneficiation, Carbo-chlorination, Pilot-plant validation.

Sustainable Refractory Engineering: Performance Optimization and Shell Temperature Minimization by Using Dense Bauxite in ASC brick

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ABSTRACT

The growing demand for low-carbon refractory solutions has accelerated the exploration of alternative raw materials to energy-intensive fused corundum. Dense Bauxite offers a promising pathway toward carbon footprint reduction due to its significantly lower calcination energy requirement and reduced associated CO_2 emissions. In our earlier development work, a customized refractory formulation utilizing fused corundum and High Dense Bauxite, balanced with binders and additives, was introduced for hot-metal ladle linings. The modified composition effectively achieved the customer's primary requirement—a measurable reduction in ladle shell temperature, driven by improved thermal insulation characteristics. However, field trials revealed that the overall refractory performance, especially in terms of wear resistance, thermal shock stability, and service life, did not meet operational benchmarks. In response to these performance gaps and upon customer expectations

for both enhanced lining durability and further shell-temperature minimization, the present work focuses on transitioning to an optimized Alumina–Silicon Carbide–Carbon (ASC) brick system incorporating a refined balance of fused corundum and High Dense Bauxite. The revised formulation strategically increases the proportion of engineered bauxite fractions and introduces a controlled SiC-C matrix to improve slag resistance, thermal conductivity tuning, and microstructural bonding. This fine-tuned recipe not only strengthens the thermomechanical performance of the lining but also continues to displace a higher percentage of energy-intensive fused corundum, thereby reducing CO_2 emissions. Comprehensive evaluation through thermal profiling, microstructural analysis, and operational trials indicates that the optimized ASC design enhances hot-face stability, limits heat transfer to the shell, and significantly improves campaign life compared to the earlier corundum-dominant mix. The study demonstrates that carbon-optimized refractory engineering—leveraging High Dense Bauxite as a sustainable raw material—can deliver both environmental benefits and superior functional performance. This work thus positions optimized ASC refractories as a viable next-generation solution for steel plants aiming to balance energy efficiency, reduced thermal losses, and sustainability-driven material selection.

Keywords: ***High Dense Bauxite (HDB), Carbon Footprint Reduction, Thermal Efficiency, Microstructural Optimization***

Aluminium Smelting

Special Session

Cathodes for Energy Management and Pot-Life Extension

Cathodes for Energy Management and Pot Life Extension

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ABSTRACT

Aluminium Smelting is very high energy intensive process and shell life and energy consumption are the key cost driver for the modern aluminium shell. In the modern aluminium production, optimizing energy consumption is a critical and continuous operational priority due to its substantial influence on overall production cost and environmental impact. Among multiple factors affecting efficiency and energy consumption, Cathode plays a vital role in entire pot life in determining efficiency. The global aluminium industry is trying to reduce its carbon footprint, in line with climate change policy, and great strides are being made in the use of hydropower, solar, and geothermal electricity, as opposed to fossil-fuel powered electricity.

This paper discusses the critical role of prebaked carbon cathodes in enhancing energy efficiency and extending pot-life in aluminium smelting operations. In high-amperage Hall–Heroult cells, cathode performance directly affects current distribution, metal flow, heat balance, and overall specific energy consumption. Cathode wear mechanisms—including sodium penetration, graphitization, and sidewall erosion—contribute to increased voltage losses and premature end-of-life for pots. Modern cathode technologies aim to mitigate these degradation pathways while improving operational stability.

Advances in cathode formulations, such as optimized anthracite–graphite blends, improved pitch quality, and nanomaterial-reinforced carbon composites, have demonstrated reductions in cathode voltage drop (CVD), better resistance to chemical attack, and improved thermal shock tolerance. Additionally, ramming paste

innovations with low reactivity and optimized permeability support a more stable cell bottom profile. Controlled cathode block microstructure enhances sodium resistance, reducing swelling and limiting metal pad instabilities that can elevate energy consumption.

Energy management strategies increasingly emphasize cathode design alignment with targeted heat balance. High-density blocks and improved insulation layouts reduce heat losses while maintaining adequate freeze thickness. These measures support lower operating voltages and reduce anode effects. Extending pot-life, often from 2,000–2,500 days to more than 3,000 days, is achieved through optimized current loads, stable cell bottoms, and predictive monitoring of cathode wear using thermal imaging and impedance-based diagnostics. Longer pot-life significantly reduces shutdown frequency, refractory replacement costs, and overall energy per tonne of aluminium produced.

In conclusion, cathodes are a pivotal lever for energy efficiency and long-term stability in modern smelting plants. Continued development in materials engineering, digital monitoring, and pot control systems will further enable lower specific DC energy consumption and improved asset life, supporting operational excellence and sustainability goals across the aluminium industry.

Keywords: Cathode Voltage Drop, Sodium penetration, graphitization, energy efficiency, sustainability.

Continuous Developments/Improvements in Cathode Lining of Low Amperage Pots (Hirakud Smelter) to Improve Pot Life and Energy Efficiency

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ABSTRACT

Hirakud Smelter (HKD), a unit of Hindalco Industries Limited and part of the Aditya Birla Group (ABG), is one of India's oldest aluminium smelting facilities. Established in 1959, the Hirakud Aluminium Plant is an integrated smelting complex that employs GAMI Technology for aluminium production. In 2009, half of the existing Soderberg potline was successfully converted to a prebake system. This conversion, while beneficial, also brought inherent challenges associated with retrofitting an older potline to modern prebake technology. The smelter utilizes the Hall–Héroult Electrolysis Process to extract aluminium from alumina. Since aluminium production is a

continuous operation, overall productivity is closely linked to the number of operating pots. Over the years, Hirakud has significantly enhanced its performance in terms of energy efficiency and pot life through strategic modifications, particularly in cathode lining design. The combined impact of these initiatives has been substantial. Pot performance is now comparable to that of modern high-amperage smelters in terms of energy efficiency. Most notably, pot life has increased from an average of 1000 days to approximately 1800 days, marking a major operational milestone. This document aims to provide a detailed overview of the comprehensive improvements undertaken at the Hirakud Smelter, with particular emphasis on innovations in cathode and collector bar design, which have been pivotal in achieving the enhanced performance metrics.

Keywords: Cathode, Collector bar, Pot life, Lining materials, Energy Efficiency, Ramming.

General Smelter Papers

Improvement in Anode Quality by Collaboration & In-house Process Optimization

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ABSTRACT

The Carbon Division at the ADITYA Plant plays a critical role in aluminium production by manufacturing high-quality anodes required for the electrolysis process in the pot-room. These anodes are not only utilized in the ADITYA Smelter but are also supplied to the HIRAKUD Smelter, ensuring a reliable and consistent supply across both operations.

To enhance operational efficiency and ensure superior anode performance, several initiatives have been implemented focused on optimization of parameters and improving overall anode quality.

At the ADITYA Plant, the anode manufacturing process encompasses the entire raw material and process chain—from the receipt of Calcined Petroleum Coke (CP Coke) to the final forming and baking of the anode blocks. Recognizing the critical impact of grain size distribution on anode quality and pot-room efficiency, a series of strategic initiatives have been undertaken.

Key among these is close collaboration with the raw material suppliers to optimize incoming CP Coke Sizing. Also design of experiments to optimize the parameters at anode forming stage. These proactive approaches ensured that the final anodes are of high quality and meet the stringent pot-room quality standards which has led to significant power savings.

Keywords: Carbon, Anodes initiatives, Coke Sizing.

From Reactive to Predictive: Data-Driven Reliability Enhancement of Rectifier

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ABSTRACT

Hirakud Smelter (HKD), a unit of Hindalco Industries Limited is a part of Aditya Birla Group (ABG). Hirakud Aluminium is an integrated aluminum smelting complex which uses ABB PEC controller Technology for high power Rectifiers, and one of the oldest Smelter in India established in the year-1959.

This project establishes an analytics-driven reliability framework for rectifier cooling systems, shifting from reactive troubleshooting to a predictive, data-centric model.

The initiative began after frequent nuisance tripping caused by intermittent analog signal disturbances. Analysis revealed limitations in the existing monitoring approach—single sensor dependency, instantaneous protection logic, and standard SCADA trends, which cannot capture millisecond-level signal spikes or transient instability. Although hardware corrections and sensor redundancy reduced immediate tripping, long-term reliability required deeper system visibility and advanced analytics.

cooling-system instrumentation—including DM water temperatures, pressure, conductivity, transformer temperatures, pump status, Heat exchange Delta T/Delta P, Rectifier Cubical temperature and other analog signals was digitally integrated into a unified automation platform, enabling end-to-end monitoring of thermal performance across rectifier units.

A weightage-based Cooling System Health Score (0–100) was developed to convert multi-parameter data into a single actionable reliability indicator, allowing operators to quickly identify degrading conditions and pinpoint mechanical, electrical, or sensor-related issues.

Integration with OSI-PI Historian added a high-resolution analytics layer, where Event Frames automatically detect spikes, drift, and abnormal stability patterns, generating early predictive alerts and enabling faster root-cause diagnosis.

This integrated framework—IOT based sensor digitization, health scoring, and historian analytics—has delivered zero nuisance tripping, improved rectifier availability, faster diagnostics, and more stable operating current, while creating a scalable digital reliability model for rectifier operations.

Keywords: Predict, Detect, Diagnose, Prevent, Stabilize.

Special Session

Value Recovery from Aluminium and Power Plant Wastes

Sustainable Recycling of Raw Materials and By- Products of Smelters with Reference to Carbon, and Carbon Dust for Operation of Greener Aluminium Smelters

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ABSTRACT

The Aluminium smelters consume raw materials like fresh alumina, petroleum coke, pitch, aluminium fluoride, and calcium fluoride. Petroleum coke and pitch are used for the manufacturing of carbon anode, and cathode blocks. The fresh Alumina, Aluminium Fluoride, and Calcium Fluoride are used for electrolysis operation to manufacture prime metal Aluminium. The other inputs are miscellaneous cathode sealing materials, miscellaneous lining materials, new cast iron, additives, refractory bricks, alloying elements and electric power. The smelters generate bath, spent anodes, coke particles, spent pot linings, spent cathode bars, cast house dross, rejected cast iron, lining scrap, iron scrap, miscellaneous scrap and spent refractory materials in solid form including the prime metal Aluminium. The prebaked Aluminium smelters technology has attempted to recycle the bath, spent anodes, spent pot linings, spent cathode bars, cast house dross, rejected cast iron, lining scrap, and iron scrap through different units within the smelter or through outside agency. The smelter emits carbon monoxide, carbon dioxide, sulphur dioxide, gaseous fluorine, fluorine dust, gaseous tar, recycled carbon dust, and clean air. The spent refractory materials composition is complex to segregate to reuse as refractory input material and is uneconomical.

Although the present practice of recycling spent anodes is most effective and highly economical for the operational cost of smelters, there is lots of carbon dust within the smelters. This loss draws attention of management to review periodically. The paper proposes few innovative steps to capture the carbon loss in solid and in gaseous forms. The carbon particles will not be allowed to stockpiled on ground to avoid the contamination of sand and iron. The various steps in handling and storage will improve the reuse of the carbon particles and dust. The carbon concentration is very less to process and capture. It is uneconomical to collect although the pots generate carbon in

large quantity of exhaust gases. This carbon is smaller as compared to loss of carbon particles and dust within smelter carbon area.

Keywords:* *Raw materials, bath, spent anode, spent cathode, dross, carbon particle, carbon dust, iron, silica.

Aluminium Alloys – Sustainable and Smart Engineering Solutions

A Compressible Multiphase Volume of Fluid Model for Aluminum Powder Production using Inert Gas Atomization

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ABSTRACT

A new compressible multiphase model is developed by Paanduv Applications for producing aluminum metal powders using an inert gas atomization process. This process is known to produce metal powders with high purity and sphericity under the influence of a supersonic gas jet to break apart the molten liquid into droplets and its subsequent solidification into spherical metal powder particles. The model executes the compressible flow of gas at Mach number 4. High-quality metal powders exhibit excellent physical properties such as composition, controlled particle size, flowability, and high purity, along with metallurgical behavior. The metallurgical behavior is attributed to the solidification rate during the atomization process, which depends on the undercooling rates achieved by the metal droplets before solidification, which in turn depends on the particle size. The supersonic gas atomization process is widely used across the industry for metal powder manufacturing. The size of the metal droplets depends upon the atomizer configuration. CFD can help understand the effect of different nozzle designs and other process parameters on the atomization of metal droplets. The compressible VOF method is used for capturing the discontinuities, including shock waves and interfaces.

Keywords: Metal powder, Atomization, Compressible flows, Mach number