ABSTRACTS

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INTERNATIONAL BAUXITE, ALUMINA AND ALUMINIUM SOCIETY (IBAAS)
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Bauxite - Alumina

Application of NIR Mineral Phase Analysis in Bauxite Ore in the Example of Chalco

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ABSTRACT

This technical paper examines the theory behind near infra-red (NIR) real time analysis for the use in the minerals industry and the practical application of an online chemical analyzer for Bauxite and Coal analysis in the aluminum industry, focusing on improving process control in digestion and optimizing Alumina recovery.
Traditional lab-based analysis methods are often not correctly representing the chemistry of the bulk material fed to the process as sampling techniques cannot keep up with the mass of material. Further the time delay till the samples are analyzed prevent a proactive process control. Hence a real time analysis, which scans the entire bulk of Bauxite or Coal going to the process will allow for real time process control, especially as NIR technology will measure mineral phase composition as well as organics and moisture.
As part of the paper, our installations Chalco are showcased, and online analysis is compared with the lab results. In addition, an outlook to the process control is given.

Keywords: Near Infra-Red (NIR) Analysis, Real-Time Mineral Analysis, Alumina Recovery.

Enhancing Wet Bauxite Handling Without Compromising the Bayer Process

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ABSTRACT

The handling of wet bauxite presents significant operational challenges, including material adhesion, flow difficulties, and equipment clogging. These issues can lead to increased maintenance costs, reduced processing efficiency, and unplanned downtime, negatively impacting overall plant performance. To address these challenges, the use of a handling aid agent can enhance material flow, minimize blockages, and reduce

operational interruptions. However, its application must be carefully assessed to ensure no adverse effects on the Bayer process, particularly during the critical solid/liquid separation phase, where the liquor is separated from the red mud.
An ideal handling aid should improve bauxite transport efficiency while maintaining process integrity throughout all subsequent stages. Factors such as flowability enhancement, moisture control, and chemical compatibility with Bayer digestion conditions must be considered. Thus, SNF has developed a novel range of additives specifically designed to optimize wet bauxite manipulation while preserving process stability. Experimental results demonstrate that the selected agent significantly enhances handling efficiency without affecting grinding process. These findings suggest a viable industrial solution that not only mitigates handling challenges but also ensures long-term operational reliability and Bayer process performance.

Keywords: Wet Bauxite, Clogging, Flowability, Handling Aid.

Overcome the Challenges of Usage of Low-Grade Bauxite with Higher Organic to Produce Speciality Alumina/Hydrate

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ABSTRACT

Bauxite is a critical raw material for alumina refineries to produce alumina/hydrate through a consistent and controlled process. The Belagavi Alumina Refinery, renowned globally for its specialty alumina hydrate production, was originally designed to process high-grade bauxite with a Total Available Alumina (THA) content of 40% and K Silica content of 3%, sourced from captive mines. Following the depletion of these mines, the refinery transitioned to using purchased bauxite, incorporating a blend of 20-30% low-quality bauxite to maintain a minimum feedstock quality of 37-38% THA. Considering the current global challenges in bauxite availability, the Belagavi refinery has increased the proportion of low-grade bauxite (THA 34%, K Silica 4.5%) in its feedstock where quality itself is huge variation within a source and containing higher organic content in some sources which was additional load to design limitation of oxalate destruction unit. This Shift in bauxite feed source has introduced significant increase of TOC in liquor by around 22% from its normal level.
The increased organic loading manifested in higher liquor viscosity, hindered crystal growth, and deterioration in product brightness, whiteness, and soda content. This escalation adversely impacted key downstream operations, particularly hydrate precipitation, and final product quality—parameters that are vital to produce special-grade alumina/hydrate. Higher organic content adverse impact over precipitation yields

and impacting the physical appearance of alumina hydrate in terms of brightness. To mitigate these challenges, extensive trials were conducted at both laboratory and plant scale, employing various chemical additives to enhance process efficiency.
The results of the intervention were encouraging. The organic removal aid effectively reduced liquor viscosity, stabilized precipitation behaviour, and enhanced product quality metrics. Additionally, a noticeable reduction in scaling frequency was observed, contributing to enhanced equipment performance and reduced downtime. These outcomes demonstrated the additive's potential to mitigate the adverse effects of organic accumulation arising from low-grade bauxite processing.
Through these rigorous efforts, the Belagavi refinery is adapting for use of 100% low-grade bauxite, meeting the demand for specialty alumina without compromising product quality. In conclusion, the trial underscores the importance of adaptive process chemistry in maintaining operational efficiency and product quality in the face of fluctuating key raw material characteristics.
This paper details the innovative methodologies and process optimizations developed to enable the effective utilization of low-grade bauxite, ensuring the refinery's operational sustainability and efficiency without compromising end product quality.

Keywords: TOC, THA, Speciality Alumina/Hydrate, Low Grade Bauxite.

De-Ironing of Bauxite Ore Via Chlorination

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ABSTRACT

Calcined bauxite, a critical raw material for the refractories and abrasives markets, is traditionally manufactured from high alumina, low iron bauxite. However, the depletion of high-quality bauxite reserves in India has necessitated the adoption of beneficiation processes to reduce iron and titanium content. Conventional de-ironing methods, such as HCl acid leaching, present significant environmental challenges and economic concerns due to substantial raw material loss.
The Gharda Scientific Research Foundation (GSRF) has developed a novel, sustainable, and economically viable selective chlorination process for de-ironing bauxite ore. This process involves single-step bauxite carbo-chlorination in a fluidized bed reactor, utilizing calcined petroleum coke as a reductant. Laboratory and kilogram-scale experiments demonstrated a conversion efficiency of 93-94% for Fe_2O_3 to $FeCl_3$, over 50% for TiO_2 to $TiCl_4$, and below 10% for Al_2O_3 to $AlCl_3$. The recovery of saleable by-products, $FeCl_3$ and $AlCl_3$, further enhances the economic attractiveness of this method. This paper presents the development and experimental validation of the GSRF process, highlighting its potential to address the current challenges in bauxite beneficiation for non-metallurgical application.

Keywords: Chlorination, Fluidization, De-Ironing, Refractory Grade Bauxite.

Reducing Digestion Steam Consumption with KX Heat Exchangers from Low-Grade Heat from Calcination Stack-Gas

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ABSTRACT

The aluminium industry faces a dual challenge: maintaining long-term competitiveness while aligning with the global imperative to achieve Net Zero emissions by 2050. In this context, Sahl Regen, with the support of Worley and GEA Kestner, presents a novel approach to reducing energy consumption and carbon emissions in alumina production.

It has been proposed elsewhere that Calcination waste vapour can be captured, cleaned, recompressed via mechanical vapour recompression, and recycled to Digestion as useful steam. This would significantly reduce the net steam consumption of the Digestion process. This paper explores a potential alternate approach to Calcination stack gas waste heat recovery, applying KX Heat Exchanger technology to instead recover Calciner low-grade heat indirectly into the Digestion feed liquor or bauxite slurry. This approach of including indirect heat exchange lowers technical risk from compressing dirty calciner vapour with particulates in high-speed machines.

To evaluate the effectiveness and implications of recovering calcination heat into spent liquor or bauxite slurry, a SysCAD process simulation was undertaken to compare the performance of KX heat exchangers integrated into Digestion against a conventional flash tank heat recovery Digestion circuit.

KX heat exchange is an innovative technology solution that draws on established industrial experience and equipment, thus providing a practical pathway to decarbonising industrial operations while maintaining global competitiveness in the alumina supply chain. By integrating advanced heat recovery systems, this solution can significantly reduce refinery net energy and water consumption as well as greenhouse gas emissions. The paper provides technical insights and broader implications for the future of sustainable alumina production.

Keywords: Digestion, Recompression, Calcination, Liquor, Heat Exchange.

Performance Evaluation of Dewatering Aid (DEWA – 369)

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ABSTRACT

Alumina refineries employ slurry filtration, which is the important unit operation used for the separation of solid alumina hydrate from the liquor. In present study, alumina slurry filtration was investigated using a novel dewatering aid developed by Abhitech Energycon Ltd. (AEL). This innovative dewatering aid, DEWA-369, enhances hydrate slurry filtration in the alumina industry. To evaluate its effectiveness, laboratory scale trials were conducted at the Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC), using an industrial hydrate slurry sample provided by AEL. Filtration and hot water washing tests were performed under simulated drum filter washing conditions, and the results were analyzed for moisture content and soda reduction.

The trials demonstrated that DEWA-369 significantly improved filtration efficiency, achieving a 29% reduction in moisture content as compared to that of the blank sample. The optimized dosage was found to be in the range of 75 – 100 grams per ton (GPT). Additionally, it contributed to a 13% reduction in soda content, enhancing product quality.

These findings highlight DEWA-369's potential as an effective solution for improving hydrate slurry filtration, reducing processing costs, and enhancing sustainability in alumina production.

Keywords: Alumina Processing, Dewatering, Filtration, Filter aid, Alumina Slurry.

Modern Efficient Alumina Refinery Digestion Design

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ABSTRACT

Safety, operability, high availability and stability, optimum alumina recovery, capital and energy efficiency are key features in any alumina refinery digestion design. Digestion is a critical part of the Bayer process and must be designed to consider current or future production rate plans.

Worley was recently challenged by the owner of a partially constructed but stalled alumina plant expansion to redesign the digestion plant and deliver an improved refinery-wide design that would set industry benchmark performance and product quality metrics with significantly improved safety, availability, operability and maintainability, energy efficiency, and capital efficiency. The improved Digestion design includes a modified flash vessel bottom feed arrangement with specifically designed internals, targeted changes in valve, equipment, and pressure relief arrangements, as well as redesign of slurry heaters to reduce erosion and blockages.

The result of the design changes will increase heat recovery and a 40 % increase in throughput to the original design from the existing design, as well as a step change in availability, reliability, stability, and safety. The improved heat recovery will contribute to reduction in overall energy consumption and carbon emission in the refinery.

Keywords: Waste Heat Minimization, Availability and Operability, Digestion throughput, Safety, Flash Vessel Internals.

Evaluation of Nalco Water's New Washer RRA Flocculant in Indian Alumina Refinery to Improve Operational Efficiency

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ABSTRACT

This study outlines the strategic transition from long-standing polyacrylamide flocculant 85144 to Nalco 85295RRA in the refinery tail washer circuit of a 2.47 MTPA

alumina plant, driven by the dual challenges of production expansion and anticipated deterioration in bauxite quality. Historically, flocculant 85144 had delivered stable performance; however, with increased throughput targets and evolving ore characteristics—particularly a potential drop in tri-hydrate alumina content and higher mud loads—the need for a more efficient and robust solution became critical. In collaboration with the refinery, Nalco Water developed and proposed the use of 85295RRA, a next-generation flocculant engineered to deliver superior underflow solids concentration, improved soda recovery, and reduced chemical consumption.

Extensive laboratory tests, simulating varied plant conditions, confirmed enhanced solid-liquid separation and compaction with the new flocculant. A subsequent 20 MT plant-scale trial validated these findings, achieving a 2.5% increase in underflow solids concentration, a 25% reduction in flocculant dosage, and a 25% decrease in water usage—translating into annual savings of approximately $241K and an additional mud throughput of 10,560 MT. Importantly, the transition did not impact rake torque or mud rheology, ensuring operational stability.

This work offers a compelling case for process optimization in alumina refineries, demonstrating how tailored chemistry can support higher productivity, lower operating costs, and greater resilience to raw material variability—paving the way for sustainable long-term performance.

Keywords: Robust, Recovery, Compaction, Consumption, Mud Rheology, Operational Cost.

Feasibility Studies for Oxalate Removal System at Renukoot Refinery

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ABSTRACT

Hindalco is the one of the leading manufacturers of value-added products and Super value-added product for non – metallurgical grade alumina in the world. Furthermore, in the year 2019 – 2020 the plant was converted to produce 100% integrated speciality alumina. The quality of product in Bayer's process is of paramount importance in the alumina manufacturing business.

One of the major requirements of precipitation circuit at Bayer plant is to control impurities during the process of Alumina hydrate precipitation. Impurities like Na_2SO_4, P_2O_5, NaCl, $Na_2C_2O_4$ and other organics tend to build up in the Bayer liquor over the period. Among these, Sodium Oxalate ($Na_2C_2O_4$) is formed in the Bayer liquor majorly due to the degradation of organic carbon, that is entered into the system through Bauxite, or additives used in the process. When this $Na_2C_2O_4$ concentration exceeds the critical concentration limit it starts precipitating along with the product hydrate and thereby

hampering the quality (granulometry and impurities). Hence, it is essential to control the concentration level below its limit to avoid co-precipitation.
Renukoot refinery in recent period observed an increasing trend in Oxalate and therefore, it was a need of the hour to develop a suitable process to control level of oxalate in Bayer liquor. In the first step, the test was conducted to understand the COC level of Oxalate in Bayer liquor. Further, 3 different streams were analyzed to understand the best feasible liquor to be used a feed to the removal system. A series of experiments were designed (DOE) and performed with varying process conditions to arrive at the best condition to achieve highest oxalate productivity and accordingly design the Oxalate removal system at Renukoot refinery.
Oxalate precipitation test showed that oxalate precipitates adequately with a good productivity of 2.2 g/l and 91.7 % purity at the temperature of 50 °C, Residence time of 3 hrs., and seeding at 20 gpl.
Experiments were conducted with varying temperatures and residence. From the series of DOE's conducted, the above conditions were optimized for the process where oxalate removal was observed higher.
This study aimed to provide all the required inputs based on the lab scale fundamental experiments to take up the proposal for setting up the oxalate removal system for Renukoot.

Keywords: Sodium Oxalate, Oxalate Precipitation, Critical Oxalate Concentration, and Design of Experiments.

Optimizing Energy Efficiency in Gas Suspension Calciners through Refractory Enhancements and CFD Analysis

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ABSTRACT

In alumina refineries, calcination plays a pivotal role in converting alumina hydrate into calcined alumina, significantly influencing both product quality and energy consumption. The Gas Suspension Calciner (GSC) is a key unit in this process, accounting for approximately 30–35% of the total energy consumption in a refinery. The primary heat sources to Calciner are heavy furnace oil (HFO) or natural gas (NG, which contribute substantially to the refinery's fuel demand. Consequently, optimizing calciner efficiency is crucial for reducing energy consumption and promoting sustainability.
This study presents design modifications implemented in the Utkal GSC, where a third layer was added to the refractory design, and the thickness was optimized with high-grade refractory material. This novel approach effectively increased the overall refractory thickness, enhancing insulation and reducing heat losses. The impact of these modifications was evaluated through temperature profile analysis, heat loss calculations, and fuel savings estimation. These changes resulted in a reduction in specific energy

consumption (SEC) by 0.30–0.40 kg/T, as well as a decrease in furnace temperature, which ensured stable product quality and a 5–6°C increase in HV03 (Holding vessel) temperature.
However, increasing the refractory thickness reduced the effective volume of the vessel, potentially altering thermal and velocity profiles and affecting process performance. To assess these effects, a Computational Fluid Dynamics (CFD) study was conducted to analyse temperature gradients and flow dynamics. The CFD results validated the feasibility of the design changes, confirming that there are no major effects on operational efficiency, product residence time and hence quality.
This study demonstrates that systematic design modifications and validation, can significantly enhance calcination efficiency, reduce energy consumption, and improve equipment longevity. The findings provide a framework for future optimization efforts, supporting energy conservation and sustainability goals in alumina refineries.

Keywords: ***Gas Suspension Calciner (GSC), Refractory Modification, Energy Optimization, Computational Fluid Dynamics (CFD), Thermal Efficiency.***

Optimization of Sodium Oxalate Removal Using Alternate Bayer Liquors in Low-Temperature Digestion

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ABSTRACT

Low-temperature Bayer digestion refineries often encounter operational challenges due to the accumulation of sodium oxalate in process liquor. This impurity, originating from the degradation of organics present in bauxite and process additives, tends to co-precipitate with product hydrate when its concentration exceeds critical limits, thereby impacting product quality and reducing process efficiency. The conventional approach to oxalate removal involves seeded precipitation using spent liquor under controlled conditions.
To enhance oxalate removal efficiency while maintaining liquor quality, a study was undertaken to investigate the feasibility of using alternate Bayer liquors—such as thick liquor and its blends with spent liquor—for sodium oxalate precipitation. Laboratory-scale experiments were conducted under simulated plant conditions to evaluate the effect of different liquor types and seed dosages on precipitation performance.
The results demonstrated that blending thick liquor with spent liquor improved oxalate precipitation efficiency, with a specific blend ratio yielding the most favourable outcome. The study also emphasized the significance of liquor composition and seed concentration in influencing overall oxalate removal productivity.

These findings indicate that strategic utilization of alternate liquors offers a viable approach to optimizing sodium oxalate removal in the Bayer process, contributing to improved process control, hydrate quality, and refinery performance.

Keywords: Liquor Blending, Sodium Oxalate, Seeded Precipitation, Low-Temperature Digestion.

Enhancing Chemical Extraction and Overall Alumina Recovery through Process Optimization at Hindalco Muri Alumina Refinery

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ABSTRACT

The Bayer's Process remains the cornerstone of alumina production from bauxite, relying on the selective solubility of alumina in caustic soda under temperature and pressure, followed by precipitation and calcination. Hindalco Muri is one of the refineries, which focusses on extraction of Boehmite with the help of High Temperature digestion and pressure decanter.

This paper presents the optimization strategies undertaken to mitigate process deviations and enhance overall efficiency. Key interventions included improving ball mill product granulometry through grinding media optimization, ensuring continuous IBSH operation to increase pre-Desilication slurry density, fine-tuning the Low temperature digester slurry-to-liquor ratio to maintain a stable A/C ratio and changing the flocculent dosing strategy (Feedwell: Feedline:: 70:30) along with optimizing flocculant dozing in Pressure Decanter and change in operational philosophy based on PD inventory to improve underflow solids. These strategies collectively resulted in measurable performance gains, which resulted in enhancement of Ball Mill product granulometry from 60% to 65%, Pre Desilication density improvement from 1.70g/cc to 1.74 g/cc, reduction of Boehmite reversion in PD from 40% to 20%, and chemical extraction increased from 92% to 96%. As a result, the overall alumina recovery surpassed 93%, marking a significant advancement in process efficiency.

Keywords: Alumina Recovery, Chemical Extraction, Reversion, Pre Desilication, Pressure Decanter.

ZLD – Concept to Commissioning – Innovatively Conceived Project

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ABSTRACT

With freshwater scarcity escalating, alternative water sources such as desalination, wastewater recycling, and industrial wastewater recycling bridge the gap for sustainable water sources. While alternative water's use through advance technologies have gained relevance, there are significant gaps in financing projects deploying these concepts.
This presentation through case study shares technological advancements to enhance water security using alternative sources and supporting the UN's Sustainable Development Goals (SDG 6 & SDG 12) for a leader in non-steel Industry. It details use of cutting-edge biological, membrane, and thermal evaporation (option) technologies for water reclamation from complex mine water source using a very innovative Build, Own, Operate & Transfer (BOOT) model.
The project allowed the Industry to focus on their core manufacturing business, saving in upfront capital expenditure, and adopt advanced reclaim technologies, for design, construction and operation of a complex effluent recycle plants. It also allowed it to meet regulatory norms and embrace ESG goals in its operation.

***Keywords**: Alternative Sources, Industrial Wastewater Recycling, Zero Liquid Discharge (ZLD), Build, Own, Operate & Transfer, Sustainable Development Goals (SDGs), ESG.*

Improvement of the Effectiveness of Making Alumina by the Updated ILTD Process: Alumina Refineries in India as Examples

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ABSTRACT

For those who are familiar with alumina production by the Bayer Process it is evident that that the Cost of Production (COP) largely depends on the Available alumina (A.Al) and Reactive silica (R.Si) content of the particular bauxite. The caustic consumption, which is mainly dependent on A.Al and R.Si, constitutes the second largest cost item after the cost of bauxite in the Bayer's process.
In India there are large lateritic bauxite resources with medium available alumina content (THA) and medium to high Reactive SiO_2 content. With the deteriorating bauxite quality, refineries are struggling to keep the alumina production cost at the low level.

The Updated Improved Low Temperature Digestion (ILTD) Process as a novel way to increase the economic and environmental effectiveness of the alumina production is summarized in the paper.
The qualities of real bauxite feedstock's, the production levels, and estimated unit costs were used for three alumina refineries located in the Eastern part of India. The Material and Energy consumptions, the amount and composition of the bauxite residues, the same for the dicalcium silicate (C_2S) by-products were calculated and used to present the improvement in the COP of the Updated ILTD Process compared with the Conventional Low Temperature Digestion (CLTD). The coverage, i.e. difference of the Selling Price and the Cost of Production could be increased by 30, 64 and 77 %, respectively by the Updated ILTD Process. The Investment costs for the upgrade and the approximate Payback periods are estimated for each of the alumina refineries. For the three alumina refineries the Payback periods were found to be 1.9, 2.5 and 3 years, respectively, which are deemed to be fairly good returns of investments. The aluminous laterites that are reasonably considered to be sub-economic materials for the Conventional Bayer Process are suitable for their viable processing with the Updated ILTD Process. In this case the Payback period was found to be fairly low (1.3 years).
However, each of the unit operation that should be upgraded from the Conventional process have been or were on commercial scale operation, a pilot scale demonstration of the Updated ILTD Process as a whole is suggested so that commercialization take place with maximum confidence. It may be noted that the alumina production process on similar line as ILTD process was successfully implemented in the Sumitomo refinery of Japan, which is now closed down.

Keywords: ***Gibbsitic Bauxites, Reduction of Cost of Production, Wastefree Process, Recovery of Soda and Alumina from Desilication Product (DSP), Bauxite Residue with High Iron and Very Low Caustic Content, Updated Improved Low Temperature Digestion (ILTD) Process.***

Boosting Efficiency through In-House Optimization and Plant Strategies in Bayer Precipitation

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ABSTRACT

The precipitation is pivotal to Bayer process defining product quality and yield. Muri refinery, being one of the oldest, achieving higher liquor productivity remains a persistent challenge due to several operational and process inefficiencies. Older design, variations in seed surface area, suboptimal temperature management, reduced residence time, and insufficient slurry flow due to scaling result in lower alumina

recovery rates. The limitations in the precipitation circuit leading to lower liquor productivity have an impact in terms of higher energy consumption, inefficiencies in cooling systems. This directly increases production costs, raising sustainability concerns.
The temperature profile in Bayer precipitation is defined by spent liquor cooling in PHE and water cooling in interstage coolers. The performances of these heat exchangers were evaluated to identify debottlenecks. The scaling and settling of hydrate in tanks are a major concern, reducing the residence time in the circuit significantly. The tank cleaning cycle was methodically planned, thereby reducing the dead volume by half. It improved residence time and thereby productivity. Additionally, ML based predictive model (having predictive accuracy >95%) deployed in PI System is ensuring forecast PSD 40 hours in advance. With visualization and automated alerts, it is facilitating real-time decision-making. It reduced PSD deviations by 50%, minimizing reprocessing and rejects. The ML model, along with pipeline redistribution providing choice of location of coarse seed addition, allowed better control over particle size distribution. The plant team followed a systematic approach, comprising lab experimentation, sustained plant practices and design modifications. This lowered steam consumption in downstream operations enabling sustainable practices in Bayer process. This study includes implementation of different strategies thereby improving liquor productivity consistently from 71-73 gpl to 76-77 gpl.

Keywords: ***Bayer Process, Precipitation, Optimization, Productivity Enhancement, Sustainable practices.***

Promoting Differential Extraction for Sustainable Alumina Industry in India: Strategies for Effective Implementation

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ABSTRACT

Aluminum is an essential material for establishing a sustainable society. The raw material for aluminum production, alumina, must also be sustainable. The alumina industry requires the following three elements for its sustainability:

1. Achieving carbon neutrality,
2. Ensuring the sustainability of the bauxite resource,
3. Addressing environmental issues and promoting effective utilization of red mud.

India's economic growth is remarkable and the growth of its aluminum industry is globally anticipated. In recent years, the quality of bauxite has been declining, necessitating the use of high-silica bauxite from the perspective of resource conservation. Despite having substantial bauxite deposits within the country, India has not yet to utilize them effectively and remains dependent on imported bauxite. To manufacture alumina while addressing industrial challenges using high-silica parts of gibbsitic bauxite found predominantly in Eastern India, the "differential extraction process" is optimal.

However, despite the extensive research conducted on differential extraction, it was industrialized only by Sumitomo. Why is there no else following in their footsteps? This stagnation stems from researchers and engineers hesitating to pursue development due to doubts about the process being "industrially viable," despite understanding its advantages.

The author experienced the industrialization of this process, solving numerous challenges encountered from development to actual operation and achieving commercial plant operations for over seven years. While the Sumitomo process had a low liquor-productivity problem, it could be resolved by introducing sweetening digestion. Additionally, this process was implemented with an annual capacity of 200,000 tons, raising questions about how to scale up for today's large alumina plants.

This report first presents case studies illustrating the potential advantages of applying the differential extraction process to gibbsitic bauxite in Eastern India. Using this process, even low-grade bauxite with Av-alumina (AA) < 40%, R-SiO_2 (RS) > 5%, and an RS/AA ratio between 0.12 and 0.14 can achieve desilication soda-loss of only 50-60 k-NaOH per ton of Al_2O_3 roughly half the soda consumption of conventional processes. More than 70w% of the resulting red mud would be nearly soda-free, making it safer to store and easier to utilize effectively. The remaining less than 30w%, while high in soda content, could allow for efficient soda recovery or to be used for specialized applications.

Next, the author will discuss the challenges encountered during the industrialization and how they were addressed. The discussion will focus on what needs to be elucidated through experimental methods to achieve industrialization, and what specific challenges must be overcome. Finally, an example of a process flow sheet will be presented. Through this, the paper aims to demonstrate how the application of differential extraction can offer solutions to issues such as the utilization of high-silica bauxite resources, the environmental problem of red mud, and energy challenges related to decarbonization. With the current period of industrial expansion, now is the ideal opportunity to introduce and implement new technologies to drive further growth. Through this report, the author hopes to encourage Indian engineers and researchers to confidently engage in the development of this process.

Keywords: Industrially Viable, Differential Extraction, Recovery, Desilication.

Process Optimization for Enhanced Effluent Quality in a Conventional ETP

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Abstract

The Belagavi Alumina Refinery, located in a water scarce region, previously relied on conventional water-based sprinkling for dust suppression over red mud storage areas. The treated effluent from the refinery's 400 m^3/h Effluent Treatment Plant (ETP), which processes a mix of process wastewater and red mud runoff, was effectively reused for this purpose. However, a recent shift to chemical dust suppressants significantly reduced the demand for treated water, resulting in prolonged storage. This led to issues such as algal growth, green discoloration, foul odour, and elevated Total Dissolved Solids (TDS) levels due to excessive sodium hypochlorite dosing. As a result, the quality of treated water deteriorated, making it unsuitable for reuse in plant operations due to increased suspended solids, unpleasant odour, and discoloration.

To address these challenges, a phased non-CAPEX intervention strategy was implemented. Sodium hypochlorite was replaced with a selective biocide, effectively controlling algal growth while improving odour and reducing TDS accumulation. Subsequently, a new coagulant flocculant combination, Tacelene Chem 4571 and Tacelene Chem 4326, was introduced. Optimal dosages were determined at 15 ppm and 0.6 ppm respectively, resulting in over 90 percent turbidity reduction and an 85 percent decrease in Total Suspended Solids (TSS) during plant trials.

These chemical interventions significantly improved the quality of treated water, enabling its reuse for multiple operational applications and reducing dependence on fresh water. This case study demonstrates that targeted chemical optimization can successfully revitalize conventional treatment systems without capital investments, offering a scalable model for water intensive industries operating under resource constraints.

Keywords: Effluent Treatment, Biocide, Turbidity, TDS, Chemical Optimization

Boosting Security Filtration Flux with Specialty Chemical Aid while Ensuring PGL Quality Compliance

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ABSTRACT

Security filtration operations in an alumina refinery play a crucial role in impurity control and in maintaining steady plant production volumes by ensuring adequate liquor filtration flux. Hydrate production can be significantly disrupted if security filters underperform, either due to suboptimal process conditions or the challenging rheology of bauxite. For older refineries with vintage Kelly filtration technology, this challenge becomes more prominent, making process optimization essential to sustain liquor filtration flux without compromising strict impurity control related to red mud content in pregnant liquor (PGL).

Hindalco's Belagavi Alumina Refinery, with a legacy of more than 55 years, operates with aging mud clarification and security filtration systems. The complexity is further increased with the use of bauxite ores sourced from various mines, each with different geological characteristics. As a fully integrated specialty alumina and hydrate production facility, the Belagavi unit manufactures high-end value-added products and super value-added products under very stringent quality norms. In recent years, the refinery has been operating entirely on domestic bauxite, which has comparatively lower alumina content and highly variable processability. This has posed a major challenge for processing in an older refinery setup, especially in the areas of mud clarification and security filtration.

With an increase in domestic bauxite charge of varying quality and characteristics, Kelly liquor filtration has become a significant bottleneck in maintaining the required hydrate production volume, due to a notable drop in liquor filtration flux as well as in the quality norms of PGL. This paper outlines how the plant team engaged in extensive brainstorming to develop and implement various process control and optimization strategies to increase the liquor filtration flux and improve the PGL quality control. After multiple laboratory trials, a specialty chemical aid was successfully introduced to enhance the liquor filtration rate. This allowed the refinery to maintain steady hydrate production volumes while meeting strict quality standards, even under challenging raw material conditions.

Keywords: Security Filtration, Process Optimization, PGL, Chemical Aid.

Development of a New Crystal Growth Modifier for Controlling Particle Size Distribution in High Solid Hydrate Precipitation Circuit

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ABSTRACT

Crystal Growth Modifier (CGM) plays a major role in Particle Size Distribution (PSD) control in High Solid Alumina tri-hydrate precipitation circuit is very critical as it impacts final Product Alumina fines (particles of size less than 45 microns). Nucleation crisis is a challenging phenomenon in high solid precipitation circuit as it affects in over Coarsening of circuit. Over-coarsening can result in very high nucleation (both primary & secondary) and thus finer circuit. To avoid this a CGM was developed which was used to grow Ultrafine particles at a faster rate into its next fraction than normal which can subsequently shorten the finer phase of the precipitation cycle and thus final Product quality remains unaffected. A detailed study was conducted in both Lab scale and Plant scale with different dosing of Crystal Growth Modifier to analyse the impact of particle size distribution of hydrate particles at different phases of precipitation circuit in both agglomeration and Growth conditions.

Keywords: Precipitation, Particle Size Distribution, Ultrafine, Crystal Growth, Modifier, Agglomeration

Reimagining Bauxite Mining: Making the Most of Low-Grade Reserves

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ABSTRACT

The aluminium industry's attention is increasingly turning to low-grade bauxite deposits as high-grade bauxite supplies are being depleted. With the depletion of high-grade sources, the growing demand for aluminium worldwide, and the growing emphasis on environmental responsibility, the sustainable use of low-grade bauxite is becoming more and more significant. Low-grade bauxite has always been regarded as inappropriate for classic alumina extraction procedures like the Bayer technique due to its high silica and low alumina concentration. However, there is increased interest in

the beneficiation and alternate uses of low-grade bauxite due to the rising demand for aluminium and the depletion of high-grade bauxite reserves. This study examines several methods for efficiently using low-grade bauxite, such as thermal activation, chemical leaching, physical beneficiation, and usage in non-metallurgical processes such adsorbents, cement, and refractories. There are encouraging opportunities to turn this neglected resource into a lucrative raw material thanks to recent developments in mineral processing technologies and the creation of economical, ecologically friendly techniques. In order to support resource conservation and sustainable development in the aluminium industry, the study highlights the possible financial and environmental advantages of using low-grade bauxite.

Keywords: Mining, Bauxite, Low-Grade Bauxite, Physical Beneficiation & Bayer Technique.

Carbon Footprint Reduction in Alumina Calciners

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ABSTRACT

As the creators of the most advanced alumina calciner systems in the industry, we value staying at the forefront of research and development. Our engineers analysed every aspect of our Gas Suspension Calciner (GCS) system and discovered opportunities to address energy efficiency, economy of scale.
Building on a world-class design, we made numerous enhancements to improve performance while reducing costs. Our recent developments are a direct result of our customers' desire to maximize throughput, cost efficiency, and alumina quality. The following improvements bring our customers better control and consistent results without a premium price. Improved cyclone design, Better refractory, Smarter digital interface, Lower building height.
And in keeping with our Mission Zero goals, our latest technological and digital solutions help customers move towards greener processes by reducing thermal energy and power consumption as well as CO_2 emissions.
After research and development of Hydrogen firing in Alumina calciners, now into to real time projects to meet our goals of mission zero.

Keywords: Alumina, calciners, thermal energy consumption

Effect Of Temperature on Bauxite Dissolution and Silica Precipitation for East Coast Bauxite

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ABSTRACT

The impact of temperature on the dissolution of bauxite and the precipitation of silica is a critical factor in optimizing the extraction process of alumina from bauxite ores. This study specifically examines the effects of temperature on these processes for East Coast bauxite, a significant source of bauxite in certain regions. Bauxite processing, particularly through the Bayer process, involves the dissolution of bauxite in a sodium hydroxide solution. The dissolution kinetics of bauxite and the precipitation behaviour of silica can be influenced by various parameters, with temperature being one of the most crucial factors that governs both the rate and efficiency of these processes.

In this study, laboratory experiments were conducted to investigate the dissolution rates of East Coast bauxite under varying temperature conditions. The bauxite samples, rich in alumina and silica, were treated with a sodium hydroxide solution at temperatures ranging from 100°C to 160°C. The experiments focused on understanding the temperature-dependent dissolution of bauxite, the solubility of alumina, and the subsequent precipitation of silica. Key variables, such as time, pH, and concentration of sodium hydroxide, were carefully controlled to isolate the temperature effect.

The results of the dissolution experiments demonstrated a clear positive correlation between temperature and the dissolution rate of bauxite. As the temperature increased, the rate of alumina dissolution accelerated, leading to higher yields of alumina. However, a significant observation was that temperature also influenced the behaviour of silica, a key impurity in the process. Silica precipitation was observed to increase with temperature, but the morphology and particle size of the silica varied with changes in temperature. Higher temperatures not only enhanced the rate of silica precipitation but also affected its form, leading to the formation of larger, more amorphous silica particles, which could complicate downstream separation processes. The precipitation of silica at higher temperatures also led to increased losses of alumina due to silica contamination, affecting the overall efficiency of the alumina extraction.

Furthermore, the study explored the optimal temperature range for minimizing silica precipitation while maximizing alumina dissolution. The results indicated that there is an optimal temperature window where bauxite dissolution is efficient, but silica precipitation is minimized, ensuring a higher alumina yield and lower impurity levels.

Beyond this optimal range, excessive silica precipitation reduced the purity of the alumina, thereby diminishing the economic efficiency of the process.

This research provides valuable insights into the role of temperature in enhancing the dissolution of bauxite and controlling silica precipitation during the Bayer process for East Coast bauxite. The findings underscore the importance of temperature control in optimizing processing conditions to achieve better alumina recovery while minimizing impurities. The study also contributes to the broader understanding of how temperature can be strategically managed in industrial-scale bauxite refining operations, with implications for improving the sustainability and cost-effectiveness of alumina production from East Coast bauxite ores.

Keywords: East Coast bauxite, Bayer process, Alumina extraction, Bauxite dissolution, Silica precipitation, Temperature effect

Energy Savings, Flow Improvement and Erosion Control of Gas Suspension Calciner in Alumina Refinery using Computational Fluid Dynamics Analysis

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ABSTRACT

Energy saving in gas suspension calciner (GSC) for the alumina extraction system via fluid flow and erosion control mechanisms have been studied using computational fluid dynamic analysis with experimental validations. CFD analysis predicted the velocity, pressure, and temperature distribution of air/gas within the cyclones and ducts from the FD fan outlet to the ESP inlet. The single-phase flow approach has been used for this CFD analysis of GSC. For the CFD analysis, the material flow was not considered directly; however, the porous medium approach has been used to model the pressure drop by material flow across the ducts and cyclones based on the pressure values obtained from the site condition. The optimum design modifications have been found out from the modified designs to improve the flow and erosion control of cyclones and riser ducts for the gas suspension calciner. The pressure drop value has been reduced by up to ~2.5% from the forced draft fans (FD Fan) outlet to the electrostatic precipitators (ESP) inlet. The power saving of the GSC system has been found ~2% while using the proposed design.

Keywords: power saving, erosion control, gas suspension calciner, computational fluid dynamics, flow control.

Standardization of Raw Material and Transparency of Pricing through E-commerce - The Way to the Future.

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ABSTRACT

This paper titled "Standardization of Raw Material and Transparency of Pricing through E-commerce
The Way to the Future" explores the critical challenges and emerging trends in the raw material category, with a specific focus on the refractory industry. This paper delves into the transformative potential of standardization and transparency facilitated by e-commerce platforms.

In the contemporary industrial landscape, the procurement of raw materials presents multifaceted challenges ranging from inconsistent quality standards to opaque pricing mechanisms. Such challenges not only impede operational efficiency but also hinder strategic decision-making processes. Through an in-depth analysis of the current scenario, this paper underscores the urgent need for standardization in raw material procurement and pricing transparency.

Drawing insights from the refractory industry, which is highly reliant on specialized raw materials, the paper elucidates how standardization can mitigate the risks associated with variable product quality and performance. By establishing uniform specifications and benchmarks, standardization fosters consistency across the supply chain, enabling manufacturers to optimize production processes and enhance product reliability.

Furthermore, the paper advocates for the adoption of e-commerce platforms as a catalyst for transparency in pricing mechanisms. Traditional procurement channels often lack transparency, leading to price discrepancies and negotiation challenges. Leveraging the digital infrastructure of e- commerce, organizations can promote fair pricing practices and provide stakeholders with real-time access to market-driven pricing data.

Through case studies and industry insights, this paper highlights the transformative impact of standardization and pricing transparency on the refractory industry's competitiveness and sustainability. By embracing these principles, manufacturers can streamline procurement operations, mitigate supply chain risks, and foster collaborative partnerships across the value chain.

In conclusion, "Standardization of Raw Material and Transparency of Pricing through E-commerce - The Way to the Future" offers actionable recommendations for industry stakeholders to navigate the evolving landscape of raw material procurement and achieve sustainable growth in an increasingly competitive marketplace.

Keywords: Standardization of Value Chain, Bauxite, Transparency, E-Commerce.

Non- Metallurgical Bauxite - Alumina

Sustainable Upgrading of Bauxite and Valorisation of Bauxite Tailings

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ABSTRACT

The world production of bauxite is reported in 2022 with 400 mill. t/a. More than half of it is coming from Australia and Guinea. A lot of other Bauxite reserves need an upgrading to meet the requirements regarding the main ingredients of Al2O3 and SiO2, to make it suitable for the Alumina refinery extraction process. Therefore, upgrading by washing and classification processes could be the solution to disintegrate and to separate unwanted impurities.
Due to the typical composition in the PSD (particle size distribution) of such Bauxite deposits the valuable fractions need to be identified and the specifically liberated and separated. The main tasks for the upgrading are the designing of the process route, selection and sizing of suitable equipment and the overall plant layout.
Additionally, the valorisation of tailings, from existing old washing plants, could be considered to recover valuable fractions in the sense of sustainable usage. Due to unavailability or improper classification processes old bauxite washing plants focus mainly on coarse fractions > 4 mm. Whereas by specific investigations in existing old tailings dams it could be found that still a remarkable amount reflects the required quality standards. The task therefore is to define the referring cut size and to design the resulting process route. Based on Practical case studies by realized plants referring enhanced results will be shown.

Keywords: Upgrading, Tailings Valorisation, Quality Demand.

Brown Fused Alumina - Strength and Stability in Every Grain

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ABSTRACT

Brown Fused Alumina (BFA) stands as a cornerstone of modern industrial materials, renowned for its exceptional hardness (Mohs 9), thermal resistance (melting point ~2,250 °C), and chemical inertness. Synthesized through the high-temperature reduction of calcined bauxite in electric arc furnaces, BFA primarily consists of Aluminum Oxide (Al_2O_3) in concentrations ranging from 94–97%, along with controlled amounts of Titanium Dioxide (TiO_2), Iron Oxide (Fe_2O_3), and Silicon Dioxide

(SiO_2). These compositional attributes contribute to its superior mechanical strength, thermal shock resistance, and wear performance, making BFA indispensable across various sectors including abrasives, refractories, surface conditioning, and anti-skid systems.

A defining hallmark of BFA is its grain size distribution, which directly influences its functional performance. Coarser macro-grits (F4–F220) are employed in grinding wheels and heavy-duty abrasives, while finer micro-grits (F240–F1200) support high-precision applications such as micro-machining, semiconductor polishing, and aerospace surface treatments. The grain structure enhances both cutting efficiency and thermal stability, underscoring BFA's reliability even in the most demanding operating environments.

The production process integrates carefully selected high-alumina bauxite, carbonaceous reductants (e.g., coke), and iron filings, ensuring thermal efficiency and impurity segregation during high-temperature fusion. Recent advances focus on energy optimization and environmental stewardship, incorporating technologies like waste heat recovery systems, high-efficiency heat exchangers, and Organic Rankine Cycles (ORCs) to minimize energy consumption and reduce carbon footprint. Further innovations in dust management, slag optimization, and automated sorting technologies ensure higher material purity and yield consistency.

Despite its high energy demands, BFA is favoured for its recyclability, chemical stability, and long service life, aligning well with modern sustainability targets. The material exhibits resistance to corrosion, erosion, and mechanical degradation, making it an ideal candidate for refractory linings, precision machining tools, ceramic binders, and transportation-grade anti-skid coatings.

The global BFA market, valued at USD 1.56 billion in 2023, is projected to reach USD 2.07 billion by 2030, driven by expanding industrial applications, advances in production technology, and increasing demand for high-performance abrasives. Asia-Pacific remains the dominant region due to its robust manufacturing base, while North America and Europe are witnessing growing interest from the automotive, aerospace, and electronics sectors. Concurrently, stricter environmental regulations are reshaping production practices, necessitating greener alternatives and more efficient processes.

This paper delves into the mineralogical composition, microstructural advantages, manufacturing innovations, and global market trajectory of Brown Fused Alumina, emphasizing how "strength and stability in every grain" encapsulates its enduring value across modern industries.

Keywords: High Alumina Bauxite, Bauxite Fusion, Grain Size, Abrasives, Refractory, Ceramic Binders, Anti-Skid Coatings.

Mullite: *A Versatile Choice for Refractory Application*

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ABSTRACT

Mullite is high-performance refractory raw material renowned for its exceptional thermal stability, good shock resistance, abrasion resistance, chemical resistance and excellent properties such as low density, superior strength, low conductivity, low thermal expansion, and good fracture toughness. Therefore, Mullite is a versatile choice for refractory and ceramic application.

The mineral Mullite is an alumina (Al_2O_3) and silica (SiO_2) compound extensively used in traditional and as well as technical applications. The mineral Mullite has $3Al_2O_3{\cdot}2SiO_2$ as its stoichiometric composition, found very rare in natural rocks. Mullite is becoming an essential material because of its suitability for optical, electronic, and high-temperature structural applications. While calcined bauxite is widely used in refractory applications, its high-temperature properties can be limiting. For high-performance applications in steel, glass, and cement industries, Mullite is often the preferred material for refractory manufacturers.

Classical Mullite ceramics are broadly used for porcelain, pottery, whitewares, cement manufacturing, glass production, refractories, kiln slabs, lining for high-temperature reactors, *etc*. The industry relies on synthetic Mullite which are achieved by melting or 'calcining' various alumino-silicates such as kaolin, clays, rarely Andalusite or fine silica and alumina to high temperatures. One of the best natural sources of Mullite is kaolin (as Kaolinic clays). It is ideal for the production of refractories such as fired or unfired bricks, Castables and plastic mixes. Sintered Mullite and fused Mullite are primarily used for the production of refractories and the casting of steel and titanium alloys. Mullite melting point is too high; hence, it uses high-temperature exposed parts and has adequate strength and creep resistance at elevated temperatures. In Mullite, creep resistance, bending strength and are affected by the presence of quartz or glass in grain boundaries, but in the absence of glass into grain boundary, Mullite ceramics shows excellent strength at room temperatures and up to 1400˚C.

This paper details the manufacturing processes, properties, and applications of Mullite in both refractory and ceramic contexts.

Keywords: Alumina, Versatile, Creep Resistance, Kaolin, Strength, Refractories.

Low-Viscosity Hydrate Composites: *Advancements and Applications in Multifunctional Materials*

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ABSTRACT

Low viscosity aluminium trihydrate (ATH) which is prepared by apposite blending of coarse and milled hydrate. Compared to standard ATH, this has several advantages, especially for applications where mechanical properties, processing efficiency, and flowability are crucial in nature. It exhibits a range of unique properties that make them suitable for various multifunctional applications like flame retardant, composites, paints, adhesives etc. Their optimized rheology enhances workability and dispersion, leading to improved material performance. Besides, the combining coarse and milled ATH provides

a calculated method for enhancing a material's processing, mechanical, and thermal qualities. However, while low viscosity ATH is highly beneficial for flame retardancy, coatings, plastics, and composites, challenges like settling, storage volume, and potential cost increases should be considered when selecting it for an application.
This study investigates the effects of varying ratios of coarse and milled ATH on the overall performance of the material, dispersion in polymer matrices, and particle packing efficiency. Experimental analysis reveals that a controlled blend (e.g. fine 80% and coarse 20%) enhances flame retardancy, improves surface finish, and balances mechanical strength with processability. The study further explores that loading low viscosity can be raised from normal hydrate loading of 65 % to 115 % maximum in the polymer matrix and even at higher loading, the viscosity of the polymer doesn't change much (e.g. reduction of viscosity says ~35-40% occurred when 150 phr of blended ATH was loaded in lieu of normal ATH into polymer matrix specifically unsaturated polyester resins). Furthermore, blended ATH can enhance sustainability in multiple ways, especially in manufacturing, energy consumption, material efficiency, and environmental impact.

Keywords: ***Aluminium Trihydrate (ATH), Blending, Flame Retardant, Viscosity and Sustainability.***

Bauxite Residue

Anthropogenic Soils through CCU of the Red Mud

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ABSTRACT

Red Mud (RM), a by-product generated from the aluminum refineries, comprises oxides of silica, aluminum, and iron oxides. Due to the usage of caustic soda, in Bayer's process, RM exhibits pH ranging between 11-13. The particles of RM are extremely fine and hence exhibit very high specific surface area. The higher alkalinity and extremely fine particles of RM pose significant challenges to its handling, transportation, and storage, which requires huge areas of the land, apart from its adverse environmental and geoenvironmental impacts. One of the pathways to come out of this situation would be to purge carbon dioxide and flue gases coming out of the stacks, a process known as carbon capture and utilization, CCU, which results in neutralization and/or mineralization of RM. It is our hypothesis that this state of RM can be treated as *anthropogenic soil* and its different utilization schemes should be thought of. This exercise would champion the *Net-Zero* efforts and support the circular economy and fulfilment of the SDGs, as well. With this in view, and to better understand the CCU potential of RM before conducting laboratory and real-life experiments, it is essential to simulate the entire process, by employing Monte Carlo (MC) simulations and Molecular Dynamics (MD) by imposing different operational conditions (viz., pressure and temperature). In this talk, details of the efforts initiated at Environmental Geotechnology Laboratory, Dept. of Civil Engg., IIT Bombay, will be presented and discussed.

Keywords- ***Red mud, Carbon Capture and Utilization, Neutralization, Mineralization, Net-Zero, Circular Economy, SDGs, Anthropogenic Soils, Molecular Dynamics, Monte Carlo Simulation.***

Red to Green: Ecological Restoration of Bauxite Residue Disposal Area at Hindalco Muri

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ABSTRACT

The "Red to Green" initiative at Hindalco's Muri Refinery demonstrates a pioneering example of industrial land rehabilitation through ecological restoration of a 41-acre bauxite residue disposal site (RMP3). Formerly a barren and lifeless expanse, the site has been transformed into a thriving green ecosystem, reflecting Hindalco's commitment to sustainability, biodiversity enhancement, and responsible industrial stewardship.

The project leveraged integrated land contouring techniques—benching and sloping—to control erosion and support stable vegetation. A combination of native flora plantation and Miyawaki afforestation was employed to accelerate vegetation density and improve ecological resilience. Irrigation was established using treated wastewater from the on-site Sewage Treatment Plant (STP), distributed via drip irrigation and sprinkler systems. This minimized dependence on freshwater sources and exemplified circular water use.

Significantly, no external topsoil was imported. Instead, land rejuvenation was accomplished through targeted application of organic soil amendments such as gypsum, vermicompost, fly ash, and mycorrhiza. These inputs enhanced soil fertility and microbial activity. The use of coir mats on sloped areas further stabilized the terrain, reduced runoff, and retained soil moisture.

Outcomes include a marked reduction in airborne dust pollution from Red Mud Pond, the emergence of self-sustaining vegetation and a notable increase in local biodiversity, with observations of various bird, insect and small mammal species.

Within the restored area, approximately 3 to 4 acres have been developed into a designated bio-park, serving both ecological and recreational functions.

This project stands as a scalable model for eco-restoration of industrial waste land, delivering measurable environmental, aesthetic, and social benefits without reliance on resource-intensive inputs. It reinforces the viability of cost-effective, nature-based solutions in achieving long-term land-use sustainability in the aluminium and mining sector.

Keywords: Industrial Land Rehabilitation, Afforestation, Sustainable Irrigation, Soil Amendment, Biodiversity Enhancement

Innovative R&D for Red Mud Utilization at Hindalco: Circular Economy, Product Development and Ecological Rehabilitation

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ABSTRACT

Red mud, a highly alkaline by-product of the Bayer process in alumina refining, presents significant challenges in terms of handling, storage and long-term environmental impact. Recognising the criticality of addressing this issue, Hindalco

Industries Ltd. has adopted a research-driven and partnership-based approach to red mud utilization, focusing on scalable, sustainable, and circular economy-aligned solutions.

This paper presents Hindalco's advanced Research and Development (R&D) initiatives in red mud utilization, with a focus on material innovation, ecological rehabilitation and industrial symbiosis. A flagship area of R&D includes the development of polymer composites using red mud and plastic waste in collaboration with IIT Bombay. These efforts aim to convert waste into value-added construction products such as paver blocks, tiles and bricks. Another significant collaboration with Carbon8 Systems (UK) and Greenwich University focuses on producing construction-grade aggregates from bauxite residue through carbonation, enabling long-term carbon sequestration and low-cost flue gas usage.

Hindalco is also progressing in eco-restoration of legacy red mud ponds, including large- scale projects such as the "Red to Green" programme at Muri and Renukoot. These involve slope stabilisation, plantation over degraded dump areas, and enhancing green belt coverage, in partnership with TERI, IITs, CBRI, and other leading agencies. The rehabilitation of the 46.7-acre RMP-1 site in Belagavi and the enrichment of an additional 28.3 acres stand as examples of transforming industrial residue zones into green assets.

In the domain of land and material improvement, Hindalco is conducting field trials on reclaiming low-lying lands using red mud and phosphogypsum in collaboration with IIT Bombay, IIFCO, and AMNS. Another key area is the in-situ neutralization of red mud in residue disposal areas (RDA), showing promising results in pH reduction and unlocking future reuse options.

Emerging collaborations are also exploring the chemical transformation of red mud into ALFERROCK, a fire-retardant construction material (with Proferro GmbH), as well as the use of red mud in sound barriers for highway infrastructure (with BambooCrete and Xynteo). Furthermore, trials on converting FGD waste into fertilizer-grade gypsum and composite plaster (CBRI Roorkee) exemplify Hindalco's integrated waste valorization strategy.

Through a multidisciplinary and multi-agency approach, Hindalco's R&D pipeline is positioning red mud as a versatile secondary resource, supporting India's broader goals of industrial decarbonization, resource efficiency, and sustainable development.

Keywords: Red Mud, Circular Economy, Composite Materials, Ecological Rehabilitation, Carbon Sequestration, Sound Barriers, Sustainability.

Aluminium Smelting

Improving Carbon Anode Quality and Performance through Process and Equipment Modifications

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ABSTRACT

Carbon anodes for aluminum production are made using calcined petroleum coke and coal tar pitch. These materials are byproducts of crude oil refineries and steel plant coke ovens. Due to changes in the sources of feed stocks, and the operations of refineries and coke ovens, the quality of coke and pitch available for anode production has changed. The adverse changes in the quality of raw materials have posed challenges for carbon plants in producing anodes that meet the quality requirements of electrolysis cells. This paper discusses strategies to overcome the impacts of coke and pitch quality changes, and how to improve the anode quality and, performance in electrolysis cells. The strategies include blending of coke, reducing segregation of coke particles entering paste plant, high temperature paste mixing, vacuum vibrocompaction, combustion of pitch volatiles during anode baking, providing slots in the anodes, to name a few. The results achieved have been indicated.

Keywords: ***C.P. Coke, C.T. Pitch, Dry Aggregate, Baking Furnace, Electrical Resistivity, Anode Slots.***

Enhanced Anode performance in Aluminium Smelter through In-house Process Upgrades

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ABSTRACT

The production of aluminium from alumina through the Hall-Héroult process requires carbon anodes as a key input. These anodes are primarily composed of calcined petroleum coke and coal tar pitch, along with reusable anode butts. Anode production involves three critical stages: green anode manufacturing, anode baking, and anode rodding. This paper presents a comprehensive study of enhancing anode performance in Potroom by implementing a series of in-house process upgrades. The research was conducted at Hindalco Industries Ltd, unit-Renukoot, where significant improvements were observed in both the quality and Performance of the anodes used in the smelting process. This study highlights the necessity of high-quality anodes for efficient aluminium production. The performance of anodes directly impacts the purity of the aluminium produced and efficiency parameters of the smelting process.

To address the challenges associated with anode performance, a series of process upgrades were implemented. These upgrades were focused on various aspects of anode production, including raw material selection, green anode quality, anode baking quality, and Anode Rodding Operation practices. Each upgrade aimed at addressing specific issues identified in the existing process and optimizing the overall anode quality.
The in-house process upgrades implemented at Hindalco Industries Ltd Renukoot Smelter have significantly enhanced quality of anodes as well as the performance of anodes in the Potroom. The study underscores the importance of continuous process optimization and quality control in achieving superior anode performance and overall efficiency in aluminium production.

Keywords: Anode Performance, Aluminium Smelter, Process Upgrades, Quality Control, Efficiency Parameter.

Influence of Anode Layout and Cathode Rodding Design on Aluminium Reduction Cell Performance

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ABSTRACT

The efficiency and operational stability of aluminium reduction cells are highly dependent on the internal electrical and magnetohydrodynamic (MHD) behaviour, which in turn are significantly influenced by the anode layout and cathode rodding design. This study presents a comprehensive computational investigation how anode layout by varying side channel gap and the length of the cast-iron joint between the cathode and collector bar impact current distribution and magnetohydrodynamic (MHD) stability in an aluminium reduction cell. The aim is to identify design configurations that minimize horizontal current components, which are primary contributors to MHD instabilities affecting cell performance. A series of 3D computational simulations were conducted to evaluate three anode footprint positions: (i) fully inside the cathode, (ii) aligned with the cathode edge, and (iii) extending beyond the cathode. For each case, variations in the cast-iron joint length were introduced to assess their effect on electrical and MHD behaviour. Electrical modelling was used to map horizontal current patterns across the cell, followed by MHD simulations to quantify interfacial wave amplitudes and assess overall cell stability.
The results show that horizontal current is highest in the metal when the anode shadow lies inside the cathode and vice-versa, whereas reducing cast iron joint length reduces the horizontal current (maximum and average values) across the cell width. MHD simulations further reveal that the lowest interfacial wave amplitudes occur with the anode footprint lies inside the cathode edge and with reduced length of cast iron joint. These findings contribute to identifying optimal cathode assembly and anode layout

design to enhance cell stability and improve the overall performance of aluminium reduction cells.

Keywords: ***Aluminium Smelting, Anode Layout, Cast-Iron Joint, Horizontal Current and MHD Stability.***

Sustenance of Low Amperage Potlines Under Frequent Power Disturbances

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ABSTRACT

The Hall–Héroult process, central to primary aluminium production, is a highly energy-intensive process. For smooth operation of aluminium reduction cells, it is necessary to maintain bath temp of 960ºC. To achieve this temperature, heat energy is supplied to resistive cryolite heating. Stable and continuous supply of electric current plays an important role in maintaining desired thermal state inside the Pot. Even a small interruption in power supply can lead to decrease in bath temperature. Such power outage, if persists for long time, can lead to severe effects such as freezing of bath around anodes, increased ledge thickness, cooling of cathode blocks, muck formation due to inefficient Alumina dissolution, freezing of metal etc. The operational stability of Potlines, particularly low-amperage lines (~70 kA), is therefore strongly sensitive to the frequency, intensity and duration of power disturbances.

This study presents a detailed analysis of 63 recorded power interruptions across 11 Potlines comprising 2138 pots between May to August 2025. A comprehensive analysis of power outage on thermal behaviour of pots is studied through computational modelling and real time measurements. Based on findings from this analysis mitigative actions such as maintaining proper bath chemistry and ACD. Results demonstrate that rapid normalization protocols and targeted operational adjustments can reduce pot failure rates during high-disturbance periods. The findings reinforce the necessity for aluminium smelters to implement comprehensive outage preparedness frameworks, incorporating real-time monitoring and predictive failure modeling. Ensuring power continuity is not merely operationally advantageous but is a fundamental prerequisite for maintaining the thermal and chemical stability of aluminium electrolysis reduction cells.

Keywords: ***Aluminium Electrolysis, Hall–Héroult Process, Power Interruption, Potline Stability, Low-Amperage Smelter, Pot Recovery, Thermal Balance***

Improvement in Anode Quality by Stage Wise Iron Recovery

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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 potroom. 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 reducing impurities 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 impurity control on anode performance and potroom efficiency, a series of strategic initiatives have been undertaken.

Key among these is the installation of magnetic separators at carefully selected points along the value chain. These locations were strategically defined based on material flow and impurity risk analysis to effectively eliminate metallic and ferromagnetic contaminants from the process stream. This proactive approach ensures that the final anodes are of high purity and meet the stringent quality standards.

Keywords: Carbon, Anodes, Initiatives, Magnetic Seperators.

Laboratory Testing of Silicon Carbide Sidelining Materials for Corrosion Resistance

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ABSTRACT

In Aluminium industry the laboratory corrosion testing of Si_3N_4-SiC side lining is a sort of a check-in control of material before the use at aluminium smelter.

The damage of N-SiC side lining of the reduction cells due to corrosion sometimes may be the cause of shut down or at least of local repair of the reduction cell. The quality of Si_3N_4-SiC side lining is critical and is one of the key factors affecting the service lifetime of reduction cells.

There are several variants of laboratory corrosion test of Si_3N_4-SiC material for the use in aluminium reduction cell.

SINTEF corrosion test is the most popular. Si_3N_4-SiC rods are exposed to molten aluminium and cryolite in the laboratory reduction cell.
In another test Si_3N_4-SiC samples are samples are pre-oxidized in a steam and then subjected for some period of time to the molten cryolite (without electrolysis). Certain companies prefer this kind of testing.
The corrosion test of Luoyang Institute for Refractory Research (LIRR) may be considered as a continuation of SINTEF test, the atmosphere of carbon oxide is taken into account. Si_3N_4-SiC rods contact with aluminium and cryolite during the reduction process.
Recently a new kind of testing had appeared. This kind of test takes into account the change of the level of the bath in the reduction cell. Si_3N_4-SiC rods are dipped in molten cryolite and are lifted from cryolite to air according to certain regime during the whole period of the testing time.
The experiments on corrosion resistance were made according to corrosion test, where the rods are dipped in molten cryolite and are lifted from cryolite to air.
The investigation of the corrosion resistance of industrial Si_3N_4-SiC side lining was made together with the investigation of the microstructure of corroded materials (SEM) and the analysis of the phase transformations (XRD) during corrosion. Different parts of corroded samples (above the level of cryolite, in the corrosion zone and below the level of cryolite) corrode in a different way.
The results of lab corrosion testing are compared with the analysis of porosity and the microstructure of Si_3N_4-SiC side lining after the service in industrial reduction cells.

Keywords: Lab Corrosion Testing, Silicon Carbide, Silicon Nitride, Side lining.

Mitigating Challenges in Anode Baking Furnace to Accommodate Longer Anodes

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ABSTRACT

Mahan Aluminium have AP 36 potline, designed for 360 kA operation. In recent past it had raised the amperage up to 376 kA to cater the rise in demand for aluminium. Such increase in amperage leads to rise in anode current density from 0.893 Amp/cm^2 to 0.933 Amp/cm^2. The anode consumption rate in the pot also increased from 1135 to 1184 kg/pot/day, which had adverse impact on anode butt height as well as operation time i.e.,

number of shifts. Consequently, the anode height was increased from 650 mm to 685 mm which helped the pot-room operate with the same shift schedule. To mitigate the challenge of increased current density, Anode length is increased by 30 mm. This paper discusses the equipment retrofitting as well as process modifications done in Anode Baking Furnace to accommodate these longer anodes. To ensure smooth handling of longer anodes from central conveyers to the pit of ABF, Furnace Tending Assembly crane was raised up by 200 mm. Operational and mechanical adoptions to carry out this retrofitting are discussed in detail. Due to increase in anode's length its mass also increases. This leads to the release of higher mass of pitch volatiles in preheating sections and higher fuel consumption in heating sections of ABF. To take care of these aspects, draft settings were tuned accordingly. An experiment was performed to check the impact of increase in anode length on baking level of top layer anodes. Procedure and findings from this experiment are also discussed.

Keywords: Anode Baking, Aluminium Smelting, Amperage Creep, Anode Current Density, Longer Anode, Furnace Tending Assembly.

Considerations in the Design of the Preheating Screw of Green Anode Plants of Aluminium Smelters for a Sustainable Operation and Maintenance.

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ABSTRACT

The preheating screw raises the temperature of proportioned dry aggregate to a suitable temperature to ensure the optimum mixing of the dry aggregates and liquid pitch. The preheating screw generates steam by action of high temperature thermic fluid (HTM). The steam needs to be extracted by an independent circuit in place of present practice of extraction by proportioning dedusting system. The up-stream generates dusts and is being handled by the proportioning dust collector. The preheating screw down- stream process generates dust, pitch fume and vapour, which are being handled by dedicated pitch vapour treatment (PVT) system. The above steam of the preheating screw should not enter proportioning dedusting system. The pitch fume and vapour should not enter into preheating screw. This entry can be minimised by installation of a plug screw after preheating screw in the plants where it is not designed. The feeding chute of dry aggregates should not be compromised because of upstream equipment improper layout. The poor feeding arrangement causes the wear-out of the flights of the preheating screws. This leads to leakage of the heating medium. Sometimes it is unsafe as it causes fire. These issues were experienced in operation of different Green Anode Paste plants at different locations with different supplier of preheating screws. The possible solutions like independent steam extraction system, plug screw and the improved feeding chute are presented in this paper.

Keywords: Dry aggregates, Thermic Fluid, Steam, Extraction System, Feeding Chute, Rotary Joints, Screw Feeder, Plug Screw.

Amperage Increase at Vedanta Aluminium Smelter GP Prebake Technology Potlines

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ABSTRACT

Vedanta Aluminium's Jharsuguda Smelter, one of the largest aluminium production facilities globally, operates six potlines based on GP Prebake Technology, encompassing 1922 reduction cells. The smelter has achieved a significant milestone by successfully increasing the operating current from 340 kA to 350 kA across the SEZ potlines. This amperage creep has resulted in an overall production uplift up to 1829 KTPA in 2024, registering a 2.7% increase in metal output.

Achieving such a substantial performance gain required a multi-faceted approach that integrated indigenous technological developments, process excellence, and advanced predictive facilities.

The current increase was enabled through a combination of in-house innovations in control systems, optimized pot lining configurations, and advanced process monitoring strategies. These efforts allowed for improved thermal and magnetic stability of electrolysis cells under elevated amperage conditions. The deployment of a proprietary pot control technology contributed to precise process regulation and current efficiency retention, while refined lining designs ensured structural resilience and extended pot life. Modeling and simulation of pot dynamics played a crucial role in pre-empting operational challenges, minimizing energy losses, and ensuring smooth transition to higher current regimes. Throughout the creep program, Vedanta maintained current efficiency above 94.5%, underscoring the robustness of its technical strategy.

This achievement demonstrates Vedanta's capability to drive sustainable performance improvements through self-reliant technology development and data-driven decision making. It also reflects the potential for further current creep in GP Prebake Technology potlines without compromising cell life or operational stability.

Keywords: GP Prebake Technology, amperage creep, aluminium smelting, process optimization, predictive modeling

Production & Performance of Slotted Anodes: An In-depth Analysis

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ABSTRACT

The use of slotted anodes has become an established practice among aluminium producers, particularly for smelter technologies that require large anode sizes. The introduction of slots serves a dual purpose: firstly, it reduces thermal stresses within the anodes, consequently lowering the risk of cracking; and secondly, it facilitates the escape of gas bubbles from the anode's bottom surface. This dual effect not only enhances pot stability but also contributes to a reduction in cell voltage drop, which is critical for efficient smelting operations.

In recent years, the application of slotted anodes has expanded beyond large anodes and is now common in smelters utilising mid-sized anodes as well. This shift reflects an industry-wide recognition of the technology's advantages. The principal benefits of using slotted anodes are a measurable reduction in cell resistance and a marked improvement in cell stability—both of which are essential for optimising energy consumption and ensuring consistent production quality.

The effectiveness of slotted anodes is closely linked to the depth and shape of the slots. "Full-life slots", which maintain their effectiveness throughout the anode's operational lifespan, are crucial for ensuring sustained performance. The geometry of the slots also plays a significant role, as it determines the direction of gas escape and influences the distribution of gas bubbles. By optimising slot shape, further improvements in pot management can be achieved, such as enhanced bath circulation and reduced localised wear on the anode surface.

From an economic perspective, slotted anodes enable smelters to save between 0.11 and 0.17 kWh per kilo of aluminium produced. This energy saving translates into substantial cost reductions over time, given the scale of modern smelting operations. Furthermore, if the energy conserved is redirected towards additional production, a smelter can achieve an increase in output ranging from 1.1% to 1.7%. This not only boosts overall efficiency but also provides a significant potential for additional income, reinforcing the financial case for adopting this technology.

T.T. Tomorrow Technology stands as a world-global leader in the field of slotted anode technology, distinguished by extensive expertise in the manufacture of slotting equipment. The company's commitment to in-house research and development, coupled with vast experience in designing and producing dedicated machinery for anode slotting and handling, has culminated in the creation of the latest generation of

automatic slot-cutting machines. These advancements have set new benchmarks for precision, reliability, and operational efficiency in anode slotting.

To summarize it, slotted anode technology represents a significant advancement in aluminium smelting, offering tangible benefits in terms of performance, energy efficiency, and cost savings. As the industry continues to evolve, ongoing innovation and research will likely yield even greater improvements in anode design and production techniques

Keywords: Energy optimization, Slotted anodes, Production improvements, and Lowering carbon footprints.

Auto Cast Slab Casting

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ABSTRACT

Precimeter offers products and technology that help their customers to have hands free casting solutions through their level sensors, flow control actuators, metal level control system and integration.

Through the product and integration support, the customer can achieve process automation, optimize initial fill rate, achieve adjustable metal level, high precision level control and improved metal distribution.

This solution will not only benefit to the customer to have a constant quality in every cast, but it will also help in getting flow control, metal level analysis and thus improvement into the same.

Automatic level and flow control including all above features is a powerful tool providing quality improvement, increased productivity, raw material savings and improved safety

The presentation covers the successful case of Granges, Finspang, which has achieved significant sustainability strides for personnel, environment, and production by implementing Precimeter solutions for more than fifteen years.

Keywords: Hands-free Casting solution, Process automation, Quality improvement, and Productivity.

Raising the Standards of Metal Cleanliness in the Casthouse

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ABSTRACT

In an industry where product integrity and downstream performance begin at the casthouse, achieving exceptional metal cleanliness is no longer optional, it's essential.

This presentation will unveil an integrated approach that empowers aluminum producers to control inclusions, optimize fluxing practices, and validate cleanliness with confidence.

Through a combination of innovative processes such as RFI (Rotary Flux Injection) in the furnace or FFD (Flux Feeder for Degasser) in the degasser, we'll show how strategic interventions during metal treatment can dramatically reduce variability and elevate quality.

The recent introduction of AluClean coupled with the use of Batscan®, a revolutionised inclusions measurement technique, attendees will gain insights into our proven methods to decrease alkalis and inclusions helping to meet the most demanding cleanliness requirements by reducing while enhancing operational efficiency.

Whether your focus is metal quality, casting productivity, or customer satisfaction, this session will provide the know-how to make cleanliness a competitive advantage.

Keywords: ***Inclusions measurement solutions, Metal cleaniness, Rotary Flux injection, and Batscan.***

Aluminium Downstream

An Effective Interaction of Grain Refinement by TiBAl, TiCAl and modification by AlSr for Eutectic Modification in Aluminium Foundry Alloys

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ABSTRACT

The present paper explores the application of Al base master alloy containing Sr, Ti and B in simultaneous refinement of coarse columnar α-Al dendrites to fine equiaxed α-Al dendrites and modification refines the morphology of primary and eutectic Si crystals of Al alloy. Ti has a high growth restriction factor (GRF) which correspondingly decreases the grain size without undergoing fading phenomena. A master alloy consisting essentially of, in weight percent: 4-20% Sr, 0.2-5% Ti, up to 1% B, the balance being Al and impurities to improve the casting and mechanical properties. Moreover, the SrAl4 intermetallic particle size is reduced which, intern, improves ductility and dissolution time. This is due to the presence of more efficient nucleating particles {(Al, Ti) B2, Al3Ti and commonly formed SrB6 and AlTiBSr particles of the two master alloys in the combined addition}. The presence of Sr does not influence grain refinement and similarly the presence of a grain refiner does not influence the modification of eutectic Si. Titanium boron aluminium (TiBA1) is widely used for the grain refinement of Al alloys and has proved very effective. However, there are some aluminium alloys which are difficult to grain refine with TiBA1. Among these are Al-Li alloys containing Zirconium in which grain size control is particularly difficult. The microstructure of TiCAl contains a dispersion of TiA13 and TiC. The TiC is typically present as evenly dispersed small particles (0.5 to 3 microns). The phase volume of TiC in an alloy containing 1 wt%C is just under twice that occupied by TiB2 in an alloy with 1wt%B. TiAl3 is present as fine needles. TiCAl shows less test to test variation as a grain refiner for 8090 alloy than does TiBA1. TiCAl at 0.4wt% addition rate can provide grain refining of 8090 alloy to a grain size of about 200 microns.
With the addition of 0.2-0.5% of TiBAl in LM series of Aluminum alloys enhances the hardness by 10% and the ultimate tensile strength also achieves a significant improvement of 39%. With the addition of AlSr master alloy there is a significant reduction in the porosities in Al foundry alloy by modification in the eutectic Si phase from long needle structure to fine fibers.

Keywords: Grain Refinement, Modification, Boron, Titanium, Carbo, Strontium, Growth Restriction Factor, Micro Structure, Mechanical Properties

Optimized Production Planning in Primary Aluminium Cast Houses through Machine Learning-Driven Order Sequencing

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ABSTRACT

In a typical primary Aluminium cast house, a range of products is manufactured, including round billets, wire rods, standard ingots, Properzi ingots, horizontally cast T-bars, and rolling ingots, etc. Each of these products possesses distinct characteristics such as specific dimensions, designated production stations, tailored process steps, unique alloy codes, and varied processing times. These variations significantly influence production planning, scheduling, and resource allocation.
Customer orders generally include details like the customer's name, product type, specifications, dimensions, quantities, chemical composition, alloy code, shipping details, and dispatch date. In most cast houses, production planning is usually carried out manually by assigning customer orders to various production stations. This process is not only time-consuming but also relies heavily on the experience and expertise of the planner, often resulting in suboptimal plans.
To address these challenges, a method for automating the sequencing of orders across different production stations is proposed. This method accounts for various properties and constraints, such as minimizing mould and alloy changeovers while ensuring dispatch dates are met. Machine learning/ AI is leveraged to achieve these objectives quickly and enhance production efficiency. Same methodology can be used in many other metallurgical production processes and in smaller production setups.

Keywords: Production Planning, Automatic Production Sequencing, Machine Learning, Primary Aluminium Cast House, Optimization.

Production of Aluminium Alloy Powders through the Gas-Atomization Process: A Numerical Simulation Study

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ABSTRACT

Gas atomization is widely used to produce aluminium alloy powders. In this method, a high-velocity inert gas impinges on a molten metal stream to break it into droplets. The droplets further cool and solidify to form powders. The production of aluminium alloy powders using the gas atomization technique has been investigated using experimental and analytical methods. The experimental methods are very costly, and analytical

methods do not give detailed information about the process. The numerical simulation technique can be a better choice to overcome these limitations. However, limited studies are available on the numerical investigation of the gas atomization process to produce aluminium alloy powders. Therefore, the present work aims to study the production of aluminium alloy powders through the gas atomization process by conducting numerical simulations. The nitrogen has been employed as an atomizing gas. The gas flow field has been obtained from the simulations. The obtained gas field has been employed further to simulate the breakup of aluminium melt stream into droplets for powder formation. The droplet breakup is modelled using the Discrete Phase Model (DPM) coupled with droplet breakup models. The simulations were carried out using Ansys Fluent® software, where the governing equations were solved using the Computational Fluid Dynamics (CFD) method. The final particle size distribution is obtained from the simulations and compared with the published literature. Based on the simulations, it was found that the gas flow field is supersonic, which affects the droplet breakup. The present work will help produce a digital twin for the gas atomization process to produce aluminium alloy powders in various industries. The digital twin can further be employed for design and process optimization with reduced cost, time, and effort.

Keywords: Aluminium Alloy Powders, Gas Atomization, Discrete Phase Model, Numerical Simulation, Computational Fluid Dynamics, Digital Twin.

Evaluation of 5000, 6000 and 7000 series aluminium alloys for enhanced metal air battery performance

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ABSTRACT

Aluminium-air batteries (AABs) are attracting significant attention as high-energy-density power sources, theoretically surpassing conventional lithium-ion batteries, making them perfect candidates for applications ranging from off-grid installations to electric vehicles. However, the practical realisation of AABs is hindered by inherent challenges associated with several technology bottlenecks. While issues such as the cell stability, susceptibility of reactions to passivation and composition of reaction products are solved by optimising the cell design including anode-cathode-electrolyte combination, the primary performance inhibitor is the higher hydrogen evolution reactions in aqueous electrolytes, cost of high purity aluminium anode, metal utilisation rates, all of which directly contributes either to material loss through corrosion or increases the cost of power and energy density per kg of the anode. Aluminium alloy

series, such as 5000 series, 6000 series, 7000 series, containing specific elements, such as silicon, zinc, magnesium, or copper in a certain ratio, have emerged as a highly effective solution to suppress hydrogen evolution and corrosion; however, they have not been widely researched. The choice of a suitable alloy in terms of performance and cost will lead to substantially improved anode utilisation, higher and more stable operating voltages, enhanced discharge capacity & energy density, paving the way for higher battery performance at an affordable cost per unit energy generated. Among the chosen alloys we report here the lowest hydrogen evolution rate of 0.37 ml/cm²/min in 6082 alloy system with an energy density of 3500Wh/Kg. The cost of using this alloy system is beneficial because it costs INR 375/Kg in comparison to 4N7 aluminium which costs INR 6800/Kg for a similar energy density of 3540 Wh/Kg at an hydrogen evolution rate of 0.13 ml/cm²/min. The cost to benefit ratio is highest when 6082 alloy is used as an anode in AAB.

Keywords: Aluminium Alloy, Anode, AAB, Hydrogen evolution reaction, Cost-to-benefit

Systematic analysis of corrosion resistance and creep behaviour of additively manufactured and heat-treated AlSi10Mg alloys

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ABSTRACT

Additive manufacturing through the selective laser melting (SLM) technique has assisted the fabrication of complex aluminum alloy components with precision, thereby minimizing waste generation. AlSi10Mg, a hypoeutectic Al-Si alloy, is widely used due to its excellent mechanical performance and corrosion resistance. This study aims to assess the influence of two different heat treatments (solutionizing followed by artificial aging) on the evolution of phase, microstructure, mechanical properties, creep resistance, and corrosion behaviour of additively manufactured AlSi10Mg alloys prepared under an optimized processing condition of 350 W laser power, 1600 mm/s scan speed, 0.04 mm layer thickness, and 0.08 mm hatch spacing. Detailed microstructural analysis revealed modification in the structure from a fine, cellular eutectic Si network (in as-built condition) to coarser Si precipitates (in heat-treated samples). The mechanical characterization indicated that T6-like heat treated sample demonstrated excellent creep resistance with enhanced ductility despite slight reduction in hardness. The corrosion test revealed an improved corrosion resistance in heat-treated sample, particularly for

T6-like condition. This establishes that additive manufacturing followed by optimized heat treatment leads to formation of dense, defect-free components with superior combination of microstructure and mechanical properties.

Keywords: Heat treatment; phase; microstructure; creep; mechanical; corrosion

Additive Manufacturing of Al-based alloys – A Review

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ABSTRACT

Additive manufacturing (AM) has emerged as a transformative technique for the fabrication of complex geometries while enabling precise control over material properties. The resulting microstructures exhibit significant deviations from their conventionally processed counterparts, thereby presenting opportunities for targeted microstructural manipulation through post- processing heat treatments. Despite the widespread industrial utilization of Al-based alloys – attributable to their low density and exceptional strength-to-weight ratio—their adaptation for AM has remained relatively constrained. This is primarily due to metallurgical challenges associated with rapid cooling rates and directional solidification. Current research has predominantly centered on castable and weldable AlSiMg-based alloys, which, despite their processability, exhibit limitations in high-performance structural applications. Concurrently, efforts have been directed toward the development of AM-specific AlMgSc alloys derived from the 5xxx series, tailored to enhance printability and mechanical performance. High-strength wrought Al alloys, on the other hand, have historically demonstrated incompatibility with AM due to their susceptibility to microstructural instabilities under rapid solidification conditions. Nevertheless, recent investigations indicate substantial potential in overcoming these material constraints. This presentation provides a comprehensive review of the current state of AM for Al-based alloys, with an emphasis on microstructural evolution and its correlation with mechanical performance. Furthermore, prevailing metallurgical theories concerning defect formation during AM processing are examined, alongside emerging strategies aimed at refining microstructural characteristics. The discussion concludes with an exploration of remaining challenges and prospective advancements in the AM of high-strength Al alloys.

Keywords: Additive Manufacturing, Aluminium Alloys, Rapid Solidification, Microstructure, Mechanical Properties, Defect Formation, Powder Bed Fusion, Post-processing, Metallurgy

Treatment & Recovery Process for Scrap Vehicles and Aluminium

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ABSTRACT

Panizzolo S.r.l. is an Italian company with more than 30 years of experience, is a manufacturer of machinery and turnkey plants for the treatment of metal waste. Panizzolo provides scrap recycling solutions with the capacity up to 30 Tons / Hour requirement.

Panizzolo scrap recycling solutions have adopted an approach of analyzing the type of scrap, segregation, shredding, reducing the size of the scrap, separation of difference material of scrap and getting the required ferrous and non-ferrour scrap segregated from the received scrap material.

Scrap recycling by Panizzolo includes pre-shredding, crushing, segregation, sieving, X-ray analysis and separation of various types of scrap in to difference end outputs in order to take every type of scrap towards different process requirement.

In the scenario today of increasing demands and requiement of going towards circular economy, Panizzolo scrap recycling solutions help our customers to recover more than 80% aluminium from the scrap, re-melt it and use it for production of aluminium primary / secondary products. Panizzolo is committed to quality product and solution supply towards green and circular economy.

Keywords: Scrap recycling solutions, Circular economy, and Metal recovery through recycling.

Decarbonization and Sustainability

Decarbonization of Aluminium: Emerging Industry Trends

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ABSTRACT

The aluminium industry, responsible for approximately 2% of global carbon emissions, is at the forefront of efforts to reduce greenhouse gas emissions. This paper begins by discussing the sources of emissions—mines, refineries, and smelters—followed by an exploration of the pathways adopted to curb emissions in these sub-segments. These include green technology adoption, renewable energy integration, and the development of circular economies, as well as the shortcomings and limitations of the decarbonisation quest.

The paper highlights key facts, such as the share of emissions originating from bauxite mining and how miners have invested in expanding their fleets of electric vehicles, replacing diesel-powered equipment to reduce emissions. It discusses the challenges of scalability and how such solutions may not be suitable for all miners.

The paper also addresses emissions from alumina refineries and how companies in this space are adopting green technologies to reduce carbon emissions. It will include case studies from Australia, Brazil, and Ireland.

For smelting—the most power-intensive segment of the aluminium value chain—the paper explores the opportunities and challenges producers face in their efforts to incorporate renewable energy into their operations. It discusses examples of smelters from regions such as Oceania and Europe that have agreed to source green energy or are working on enhancing smelter technologies to allow greater flexibility in power load variations.

Finally, the paper examines the benefits of circular economies and the difficulties the industry encounters in fully incorporating scrap into production flows. Some of these challenges are rooted in technical limitations, while others arise from traditional business models that have historically kept primary and secondary value chains separate.

Overall, this paper delves into the intricacies of the aluminium industry's efforts to reduce carbon emissions, examining the challenges and opportunities that lie ahead in the pursuit of a more sustainable future.

Keywords: Decarbonization, Circular Economies, Power-Intensive, Green Technology.

GRIPS Framework: Operationalising Sustainability through Green Readiness

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ABSTRACT

In today's industrial landscape, aluminium extrusion manufacturers face growing pressure to embed environmental, social, and governance (ESG) principles into their operations. Yet for many mid-sized plants, meaningful implementation is hindered by unstructured systems, limited digital infrastructure, and reactive management styles.
This paper introduces the GRIPS Framework, a practical model developed at Bhoruka Extrusions to evaluate and accelerate Green Readiness and Implementation Potential. GRIPS comprise five pillars: Governance of Process Discipline, Resource Flow Efficiency, Information Visibility, Partner Transparency, and Sustainability Culture. These pillars align operational systems, ESG goals, and cultural practices into a unified approach for sustainable transformation.
Unlike models reliant on technology or external certification, GRIPS reflect Bhoruka's real-world progress, structured policies, resource optimization, employee engagement, and partner collaboration — all reoriented toward measurable sustainability outcomes. It enables assessment of maturity across key areas and offers clear guidance on improvement priorities.
GRIPS provide a structured lens to view, measure, and integrate sustainability into daily operations. It fosters alignment across governance, resource use, and culture, embedding sustainability into core business functions and value creation. Presented here as both a case study and a replicable model, GRIPS offer aluminium manufacturers a practical, outcome-driven roadmap, grounded in what they already do, but approached smarter, cleaner, and more consciously.

Keywords: ***Sustainability, ESG, Aluminium Extrusion, Operational Systems, GRIPS Framework.***

Reducing Carbon Footprint in Aluminium Extrusion Industry

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The aluminium extrusion industry, an important part of infrastructure, transportation, and renewable energy sectors, is also a major source of carbon emissions due to its energy-heavy processes. These emissions, mainly from burning fossil fuels and electricity use, have harmful effects on the environment and contribute to global warming.

This paper explains the main areas where carbon emissions happen during aluminium extrusion and suggests practical ways to reduce them. It looks into common issues like furnace heating, fuel usage, and inefficient energy practices. The paper also discusses possible solutions such as using renewable energy, improving energy efficiency, recycling aluminium, and adopting better production methods. Basic cost details of these improvements are also included.
By taking a broad view of the industry, this paper aims to offer useful ideas that can help aluminium extrusion companies lower their carbon footprint and move toward eco-friendlier and sustainable operations—aiming to support manufacturers in aligning with global sustainability goals while ensuring business continuity.

Keywords: Carbon Emissions, Energy Efficiency, Renewable Energy, Sustainability, Emission Reduction, Green Manufacturing, Industrial Decarbonisation.

Primary Aluminium Industry offers both Challenges and Opportunities for Global Sustainable Solutions

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Manufacturing of Primary Aluminium starts from Bauxite to Alumina and subsequent electrolytic reduction of Alumina to metallic Aluminium brings challenges which can be converted into opportunities to build a strong Circular Economy. About 4-5 tons of bauxites processed to obtain about 2 tons of Alumina from which about 1 MTton of Aluminium metal can be made. Approximately 1.3 tons of Red Mud is generated per ton of Alumina. Also 175 Million tons of Red Mud are generated globally which is perhaps the biggest sustainability issue with an estimated accumulation of 4 billion tons. Reduction of Alumina in Electrolytic Cell by use of coal based Electrical energy is one among top three CO_2 emitters in the world. Alumina refinery can be considered as secondary source of Ga and also Rare earths like Scandium, Neodymium from Red Mud which are big opportunities. Also electrolytic reduction for Alumina to produce Aluminium gives rise to wastes with high quality Graphite which is an important mineral for decarbonization. This paper will discuss in more detail on how the challenges can be overcome with proper technology, scientific force and strategic economic actions to build a strong Circular economy based Business Model.

Keywords: Rare Earth, Red Mud, Critical Mineral, Sustainability.

Sustainable Mining: Importance of ESG in Bauxite Mines- An Overview

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ABSTRACT

The Mining industry has long been associated with environment challenges, community relations and the risks pertaining to investors. The mining industry, particularly bauxite mining, is increasingly under pressure to align with sustainable development goals due to its significant environmental and social footprint. In order to ensure responsible mining activities, environmental, social, and governance (ESG) frameworks have become essential instruments. ESG has changed from being a trendy term to becoming a key factor in determining the survival and destiny of mining companies. This study examines how ESG may support sustainable bauxite mining, highlighting the importance of ethical governance, community involvement, environmental stewardship, future proofing operations and talent attraction and retention. Key focus areas include land rehabilitation, biodiversity conservation, water and air quality management, community engagement, labour rights, and transparency in operations. It looks at how integrating ESG effectively might improve social license to operate, reduce ecological degradation, and promote long-term economic viability. The best approaches and difficulties in implementing ESG are highlighted by case studies from top bauxite-producing regions. In order to achieve sustainability, the study emphasizes the significance of open reporting, stakeholder participation, and regulatory compliance. In the end, the study shows that ESG-driven tactics are essential for guaranteeing the future of bauxite mining in a world that is changing quickly, in addition to reducing risks and increasing operational effectiveness.

Keywords: ***Mining, Bauxite, ESG (Environment, Social & Governance), Sustainability, SDG (Sustainable Development Goals) & ESG Risk.***

Recovered SPL Graphite as a Potential Hybrid Cathode Material in High-Performance Aluminium-Air Batteries

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ABSTRACT

Graphite, a well-known material for manufacturing batteries and electric vehicles, is used as electrodes because of its novel thermal, electrical and mechanical properties. The global market size of graphite in 2024 was 12.2 billion USD, and the projected market will be approximately 17.8 billion USD by 2030 at a growing CAGR of 6.7%. However, the present market for battery-grade graphite is plagued with supply chain bottlenecks, variability in the quality of synthetic graphite, and elevated cost of synthetic graphite. The Government of India has identified graphite as one of the "Critical minerals" due to its high future supply risk, with special reference to the critical role of graphite in energy storage technologies. The concern for battery-grade graphite is global, and it is essential for the exploration of alternative sources of graphite to satisfy the present market demand. The spent pot liner (SPL) can be a viable source of electrode-grade graphite as it contains a substantial amount of graphite (40-50%). In this work, we utilised SPL to detoxify it and recover high-purity graphite and further exfoliated it partially, to prepare a hybrid graphite-graphene mixed material for use as a cathode in the aluminium-air battery (AAB). The purity and structural integrity of the recovered graphite were analysed using Inductively coupled plasma-optical emission spectroscopy (ICP-OES), fixed carbon analysis, Raman spectroscopy and X-ray diffraction. The performance of this material as a cathode was measured by galvanostatic charge-discharge (GCD) techniques. An energy density and capacity density of about 1800 $WhKg^{-1}$ and 1300 $mAhg^{-1}$ respectively were achieved with a working potential of about 1.3 V per cell. The higher stability and working potential of this cathode prepared from the hybrid cathode sourced from SPL surpasses that of synthetic graphite, owing to higher active catalytic sites for ORR. The reported performance of this recovered graphite from SPL makes it an ideal cathode material for AAB batteries and holistic utilisation of the waste material.

Keywords: SPL, Graphite recovery, Graphene, Aluminium-air battery and Cathode.

Aluminium Industry 4.0

Digital Prescription Modelling for Smart Steam Optimization in Evaporator Circuit of Alumina Refinery

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ABSTRACT

The rise of Industry 4.0 has accelerated the integration of advanced digital technologies into industrial operations, enabling smarter decision-making, optimized resource utilization, and greater control over complex processes. In alumina refineries, the adoption of machine learning (ML) and real-time analytics is driving significant gains in productivity, energy efficiency, process safety, and environmental performance.

This study presents the successful implementation of a machine learning-based steam prescription model at evaporator circuit of alumina refinery utilizing the Bayer process to extract alumina from bauxite. Among the critical stages, evaporation circuit plays a key role in the plant's operational economics. A key parameter here is the thick liquor concentration and steam economy, which must be strictly controlled. Steam economy determines the economics of unit hence its critical parameter that needs to be controlled. Variations in thick liquor concentration can lead to cascading issues such as poor alumina recovery, mismanagement of liquor volumes, and operational disturbances in upstream and downstream units. Traditionally, these parameters are monitored via laboratory analysis of thick liquor concentration with few hours lag often resulting in retrospective and suboptimal process adjustments.

To address these challenges, a machine learning solution based on the Extreme Gradient Boosting (XGBoost) algorithm was implemented to predict key process parameters such as thick liquor concentration and steam economy with over 90% accuracy using live Distributed Control System (DCS) data. Unlike conventional models that require periodic retraining and often lose relevance under changing operational conditions, this model is trained in real time, enabling it to continuously adapt to variations in process behaviour and operational scaling without manual intervention. Beyond prediction, the solution incorporates a prescriptive layer that dynamically recommends optimal steam input based on current process conditions. These recommendations are further validated through embedded rule-based logic to ensure operational safety and compliance with plant standards. Both predictive and prescriptive outputs are displayed in a web-based graphical user interface (GUI) integrated with PI Aveva, updated at five-minute intervals, providing operators with actionable insights for proactive decision-making. This approach significantly enhanced process agility, reduced dependency on delayed laboratory data, and supported consistent quality and energy efficiency. Most importantly, it exemplifies the application of artificial intelligence and autonomous control strategies to build resilient, self-optimizing refinery operations.

Keywords: Industry 4.0, Prescriptive Analytics, Machine Learning (ML), Steam Optimization, Bayer Process, Evaporation Circuit.

A machine learning Model for Aluminium Pot Longevity: Sustainable and Cost-Efficient Operations

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ABSTRACT

Maximizing the lifespan of aluminium reduction cells or pots is critical for improving operational efficiency and reducing costs in Aluminium industries. Traditional preventive maintenance often results in premature shutdowns, thereby limiting cell utilization effectively. In this study, a Machine Learning (ML) based model is developed to predict the Remaining Useful Life (RUL) of aluminium reduction cells. For the model development, plant historical data and smelting process knowledge was used to create a Threat Index, that quantifies discrete degradation events such as power outages and impurity spikes. This threat index was used along with other process data, while integrating a similarity and survival-based models to predict the RUL. This ML model development also had utilised certain core algorithms like Principal Component Analysis, Random Forest Regression, and Cox Proportional Hazards modelling for accurate model prediction. The model was trained on data from more than 300 pots and validated on 14 pots shutdown data, achieving a mean absolute error of just about 11 days. This model has its utility in extending the cell / pot life, resulting in lowering cell lining cost per year and better-informed decision for pot shutdown, with critical pot being shut first. It would also benefit in reducing the generation of spent pot lining (SPL), a hazardous waste, thereby enhancing process sustainability and cost effectiveness. This paper demonstrates a significant advancement toward machine learning based real-time health monitoring of aluminium smelting pots, while also offering pointers for developing solutions for prognostics in other high-risk industrial processes.

Keywords: Aluminium Reduction Cells, Spent Pot Lining, Remaining Useful Pot Life, Machine Learning, Predictive Maintenance.