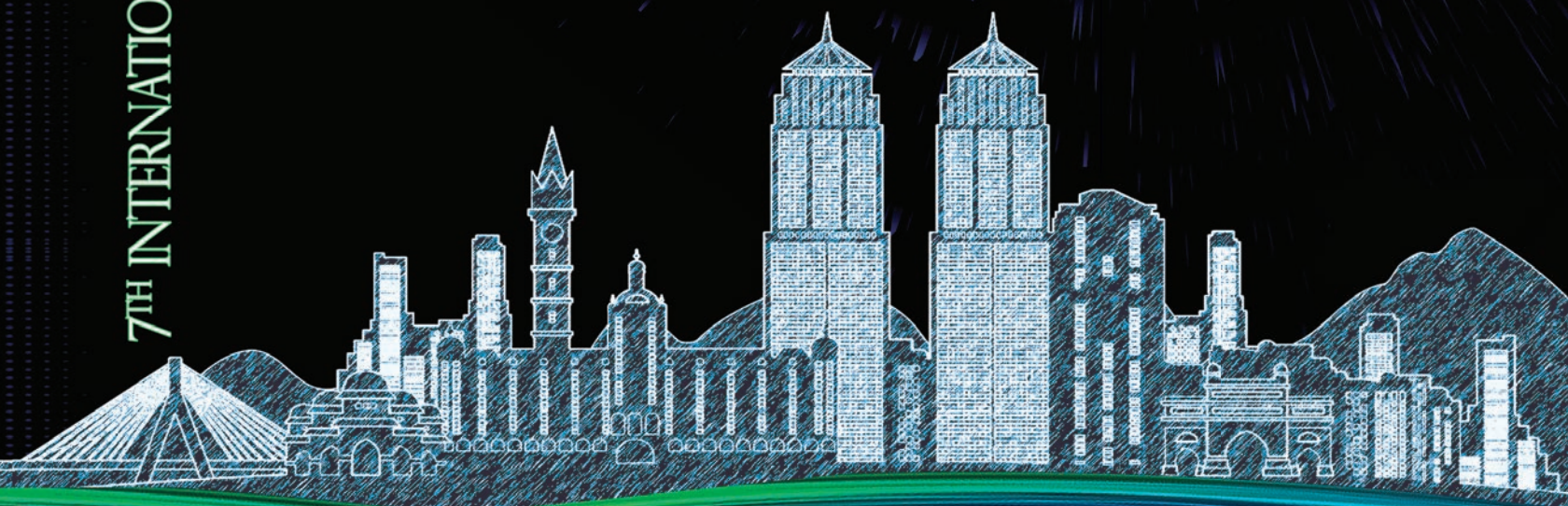
7TH INTERNATIONAL IBAAS CONFERENCE AND EXHIBITION

IBAAS 2018

INDIAN ALUMINIUM INDUSTRY

STATUS, STRATEGIES & WAY FORWARD FOR ACCELERATED GROWTH



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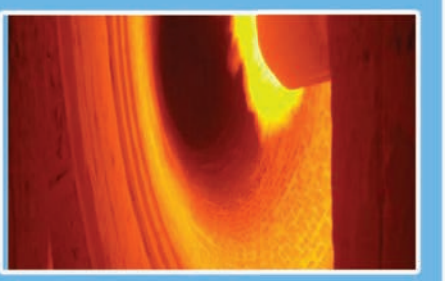

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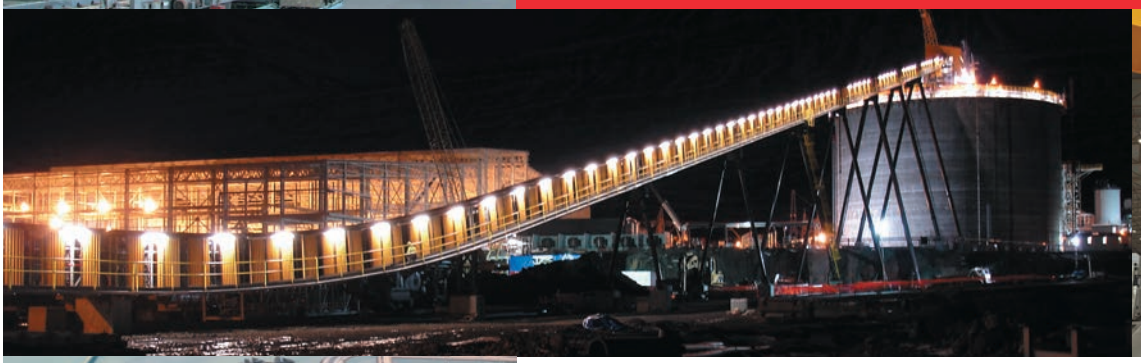

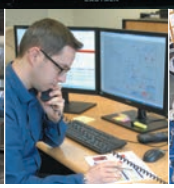

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Welcome Note

On behalf of the organizing committee, it is our pleasure to welcome you in the 7th IBAAS International Conference & Exhibition (IBAAS-2018) on *"Indian Aluminium Industry – Status, Strategies & Way Forward for Accelerated Growth"* being held in Mumbai, India during September 5 -7, 2018 in association with Aluminium Association of India (AAI), The Indian Institute of Metals (IIM), Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC) and Aditya Birla Science and Technology Company Private Limited (ABSTCPL).

About 70 abstracts of technical papers have been received from all over the world for this mega Aluminium event. Several special technical sessions are planned for 7th IBAAS International Conference & Exhibition and these are listed below:

1. **Bauxite-Alumina Session**
2. **Non-Metallurgical Bauxite & Alumina**
3. **Value from Wastes**
4. **Aluminium Smelting Session**
5. **Aluminium Downstream: One full day special session**
6. **Bauxite, Alumina & Aluminium Market**

We welcome you to this mega Aluminium conference in India and are confident that you all will enjoy the stimulating technical sessions and will benefit from this opportunity to interact with bauxite, mining, alumina and aluminium industry leaders, experts and professionals from all over the world.

Best Regards,
Organizing Committee of IBAAS-2018

International Bauxite, Alumina & Aluminium Society (IBAAS)

IBAAS is an organization formed by professionals active in various fields of Aluminium industry, with its roots in India/Asia. The objectives of this society are as follows:

- Provide platform for Bauxite-Alumina-Aluminium industry to interact and network for the common goal and development of this industry.
- Organize annual and bi-annual workshop, symposium and conferences in association with primary Aluminium producers, Engineering, R&D Institutes and local resource companies.
- Promote latest technology and advertise products and equipment.
- Publish papers, monographs and books to highlight latest achievements in the field.
- Facilitate technology transfer and compile a list of experts available in the field.

The Society was established in 2012 and is committed to promote the development of Bauxite, Alumina and Aluminium industry in the World. The Society has since then organized six International events in India, China and Guinea.

IBAAS-2012: First International symposium of IBAAS on the topic "Bauxite, Alumina and Aluminium Industry of Asia – Vision 2020", December 3-5, 2012 in association with JNARDDC (Jawaharlal Nehru Aluminium Research Development & Design Centre) in Nagpur, India with a special emphasize on non-metallurgical bauxites and alumina products.

IBAAS-2013: Second International symposium of IBAAS on the topic "Present Status and Future Prospects of Bauxite-Alumina and Aluminium Industry of the World, with Special Reference to China", November 28-30, 2013 in association with CHALIECO (China Aluminum International Engineering Co., Ltd.) and ANTAIKE (Beijing Antaike Information Development Co., Ltd) in Nanning, Guangxi, China.

IBAAS-2014: Third International symposium of IBAAS on the topic "Technological Improvements & Market Developments in Aluminium Industry with Special Reference to Value Added Products of Bauxite, Alumina and Aluminium" in Visakhapatnam, India during November 27-29, 2014.

IBAAS-2015: Fourth International symposium of IBAAS on the topic "The Development and Future of Aluminium Industry in China - Reality and Dream" was organized in Suzhou, China during November 25-27, 2015 in association with CHALIECO (China Aluminum International Engineering Corporation Limited) and SINR (Suzhou Research Institute for Nonferrous Metals).

IBAAS-2016: The 5th IBAAS symposium on the topic "Aluminium Industry-The Evolving Asia-Pacific Story" was held successfully in Goa India during September 26 – 28, 2016. This International Symposium was jointly organized with The Indian Institute of Metals (IIM) and attracted more than 200 delegates from all over the world. The conference was organized closely in association with Indian Primary Aluminium Producers like HINDALCO, VEDANTA and NALCO.

IBAAS-2017: The sixth International symposium of IBAAS on the topic 'Sustainable Development of Bauxite & Alumina Industry in Guinea' was organized in Conakry, Guinea during September 21-22, 2017 in collaboration with CAMEN Resources. This was the first Bauxite-Alumina conference in Guinea and widely appreciated by participating companies, delegates and Government of Guinea.

The above six International events were highly successful and evoked wide interest of Bauxite-Alumina & Aluminium industry and experts in the IBAAS symposium and conferences. In continuation of above six conferences, this year IBAAS is organizing seventh International conference & exhibition (IBAAS-2018) in Mumbai, India during September 5-7, 2018. For further details please visit the IBAAS website ***http://www.ibaas.info/***

Associated Organizers

The Indian Institute of Metals (IIM) is a premier organization representing materials and metallurgical engineers in India. Founded in 1946 by a group of metallurgists led by Dr. D.P. Antia, IIM is the largest professional organization for metallurgist in India with over 10,000 members from R&D laboratories, academia and industry. The two main objectives of IIM are: promoting and advancing the science and technology of metals and alloys and protecting the interests of metallurgists and metallurgical industry. Website http://www.iim-india.net/

Aluminium Association India (AAI) is a member of International Body of Aluminium Associations, has always projected proactive views focusing on the principal objective of increasing Aluminium production and consumption in the country by the way of promoting Aluminium in the application sectors i.e. Transport, Power, Packaging, Building, Infrastructure, Defence and other strategic applications etc. by the way of Seminars, Round Tables, Workshops, National and International Conferences etc. Website: http://www.aluminium-india.org

Jawaharlal Nehru Aluminium Research Development and Design Centre (JNARDDC) is an autonomous body under ministry of mines, Govt. of India. It is a "center of excellence" set up in 1989 as a joint project by Ministry of Mines, Government of India and United Nations Development program and fully functional since 1996. It was set up with a vision to create a state of the art research institute for the development of technologies and provide services to both primary and secondary aluminium industries with a special emphasis on environmental sustenance, energy and material conservation.

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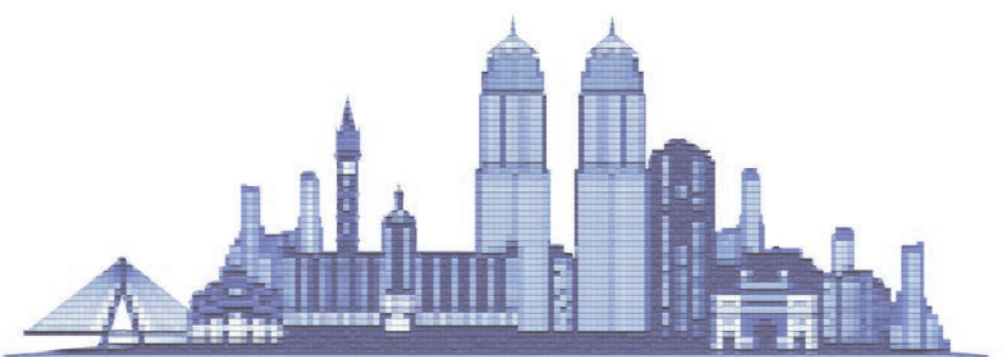

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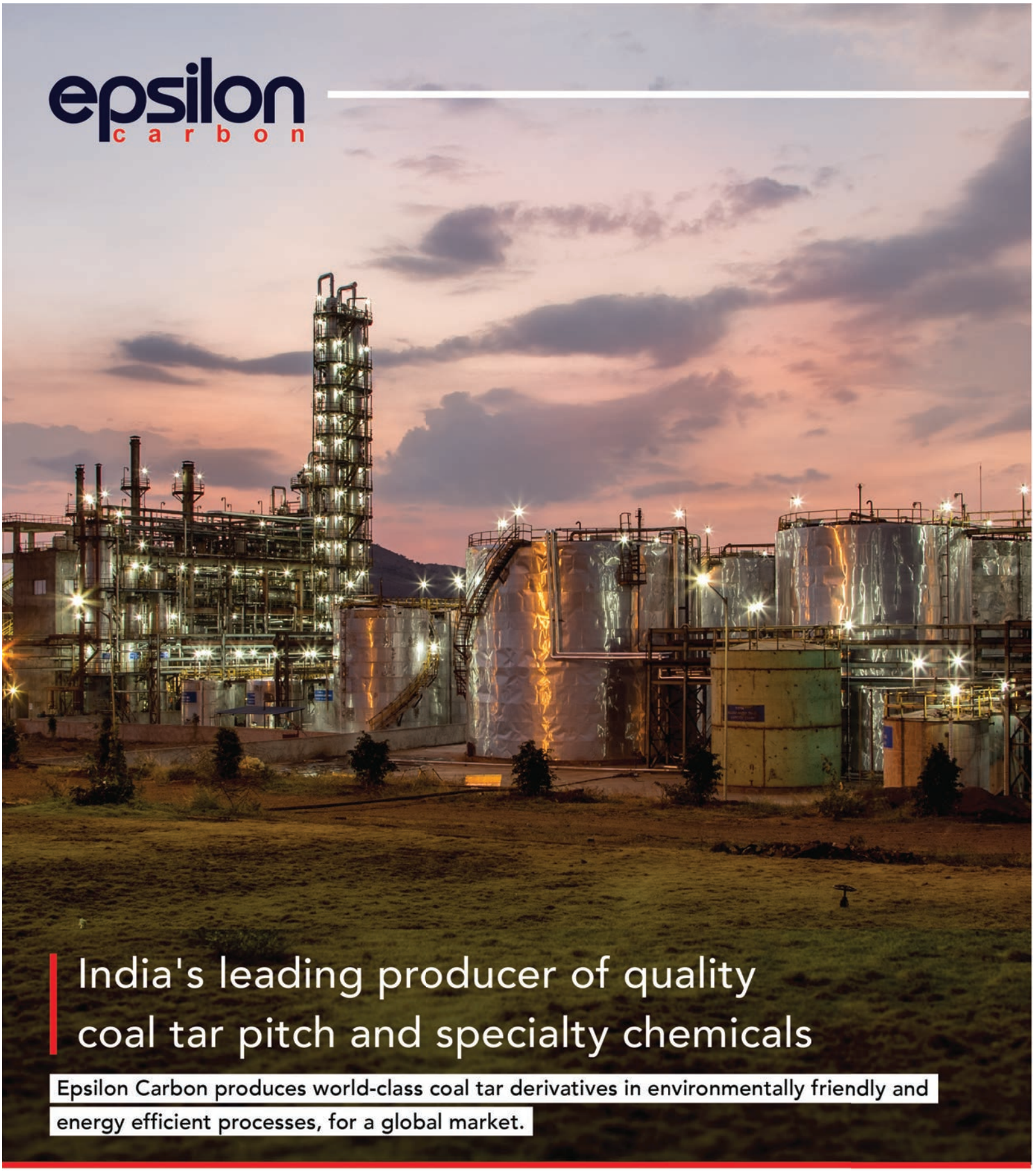

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BAUXITE-ALUMINA

Importance of Assessing Infrastructure and Logistics Requirements at an Early Stage for Development of Bauxite Projects

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Abstract

Bauxite mining projects are **bulk-commodity** projects typically producing between 2 and 15 million tonnes per annum. More recently developed (or proposed) bauxite projects are often found some distance from existing or new refineries and are now being developed as standalone businesses, trading bauxite in the open global market.

This means that for a new bauxite projects to be technically and economically viable, not only does the grade/quality and mineralogy, low stripping ratios, consistent thickness, etc. need to be demonstrated, a project also needs to have feasible **logistics** and **infrastructure solutions** for transporting the bauxite to market. These solutions can be as complex as the mining operation and can require a significant relative proportion of investment capital and subsequent operating expenditure. Utilization of existing infrastructure or shared infrastructure adds an extra level of complexity and/or benefits and opportunities.

A holistic approach to the **technical assessment** of the key areas in a project's development is vitally important at an **early stage**. It is important that the crucial drivers for increasing project definition and addressing key risks are both identified early and progressed to a suitable level to ensure investment, both during study and developmental stages, is spent wisely and provides overall confidence and de-risking of a project.

Key Words: *Bauxite, Bulk-commodity, Logistics, Infrastructure solutions, Technical assessment, Early stage.*

Pathways for Doubling the Resources in Eastern Ghats, India: Lessons from Guinea Success Story

Ajit Sahu[1] & Ashok Nandi[2]
[1]Vedanta Ltd., Bhubaneswar
[2]IBAAS, Nagpur
Email: ajit.Sahu@vedanta.co.in

Abstract

Eastern Ghats Bauxite belt of India, despite various issues, is able to sustain 3[1] large alumina refineries of the country. With growing demand, can India meet its future Bauxite need domestically?[2]

The authors strongly believe that the **bauxite resources** in the Eastern Ghats can be doubled. An apple to apple comparison has been attempted between Guinean and Eastern Ghats (Odisha & AP) bauxites. Guinea's bauxite resource map of 2005 is compared with present day bauxite cadastral (2017), showing significant increase in resources as a result of recent exploration. The

quality and grade of Eastern Ghats Bauxite ore body are, in general, comparable with the Guinean ore, which is presently considered one of the best metallurgical grade bauxite in the world.

Bauxite resources of Odisha & AP is pegged at 2.6 Billion Tonnes. There are 3 ways to increase the resources and reserves:

1) By Making **New Discoveries**,

2) By stepping up **exploration** i.e. preliminary (G4) to detailed exploration (G1), and

3) By Re-estimating resources by adopting **dynamic cut offs**, i.e. economic cut-offs.

Acquisition of new good quality datasets using drones, newer interpretations using machine learnings and spectral analysis by deploying proven technologies (GPR, Sonic/RC drilling) are key to success, including targeting low grade high tonnage resources. It is, therefore, necessary to carry out systematic and detail satellite imagery work including survey by Drones along with ground truth verification to actually prove the presence of metallurgical grade bauxite. It will also be necessary to make few exploratory holes at large grid pattern (say 600 or 1200m grid) to know the potential of these occurrences.

The ecosystem has to be created and policy changes adopted where greenfield exploration is given its due importance so that the pipe line of G4 projects could be kept healthy for further evaluation and auctioning; this will facilitate opening of new mines and new investments in the region. Needless to say, this alone can't give us the success unless social license is secured and best in class mining practices are demonstrated by the industry.

Keywords: *Eastern Ghat Bauxite Belt, Bauxite Resources, New Discoveries, Exploration, Dynamic Cut-off.*

[1] Vedanta, Nalco & Utkal

[2] India produced 20.63 Mt of Bauxite in 2017-18. India grew at +7% GDP and will continue to grow at similar rate. India's aluminium CAGR is pegged at 13% (till 2022). Therefore, India's need for aluminium metal could be 10 Mtpa in 2030 for which India has to sustain production of 60 Mtpa Bauxite. This highlights the need to expand the refinery capacity and to set up of new refineries to meet 20 Mtpa alumina requirement. This will be underpinned by the availability of raw materials, i.e. bauxite, caustic soda, energy, etc.

Flotation as a Novel Method for Beneficiation of Low Grade Bauxites

Sagar S. Pandit and Rajanikant N. Jadhav
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Abstract

Beneficiation of bauxite has acquired a strategic importance globally with the depletion of high grade ores. Low grade bauxites have an **Alumina to Silica (A/S) ratio** of 5-6, as against 10-12 for high grade bauxite. Beneficiation, as a technique, is employed for increasing the A/S using different physical / chemical techniques. One such technique, which is extensively used for beneficiation of copper concentrate, is now being studied for its feasibility in beneficiation of low grade bauxites is **Froth Flotation**.

Froth Flotation is a physico-chemical separation process that utilizes the difference in surface properties of the valuable and gangue materials. Application of froth flotation, in beneficiation of **low grade bauxites**, mainly has its application in reduction of silica content in bauxite and thus leading to the enrichment of its alumina content.
This paper presents an attempt, made for developing a method for reducing the silica content in bauxite through froth flotation technique. The various stages involved in development of method for froth flotation of bauxite viz. selection of flotation media, selection of collector and frother chemicals, optimisation of dosage & scale up process, have been discussed in this paper. Results show ~ 50% **reduction in silica content**, with a recovery of 55% by weight, along with the selected collector and frother chemicals.

Keywords: *Beneficiation, Froth Flotation, Low grade bauxite, Alumina to Silica Ratio, Reduction in Silica Content.*

An Initiative to Beneficiate High Silica Bauxite Ore

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Abstract

The silica content of bauxite plays an important role in the cost of alumina production as this is directly related to caustic soda consumption. Silica in bauxite is mainly found in the form of kaolinite and quartz. In most of the lateritic bauxite deposits of India, 70 to 90% of silica is in the form of kaolinite and is considered as reactive part of silica for low temperature alumina refineries because kaolinite readily reacts with caustic soda during **Bayer's process** and causes loss of both alumina and caustic soda. As good quality bauxite is slowly depleting, bauxites with high silica content are left over in the mines and it has become imperative to bring down this silica content to make alumina production process economically viable. Further high cost of caustic soda does not warrant Indian alumina refineries to use bauxite having more than 4% **reactive silica**.

There are mainly two routes to beneficiate high silica bauxite – first is dry process wherein ore is crushed and dry screened. As in the lateritic bauxite, kaolinite occurs in superfine particles (<10 microns) range, during crushing this mineral gets released from lumps. However, the dry process has limitation and silica cannot be brought down significantly. Second is the wet process, wherein crushing followed by intensive scrubbing releases kaolinite and also a part of goethite from the bauxite and these fines are removed subsequently by screening and classification. The resultant scrubbed bauxite contains significantly lower reactive silica and higher alumina compared to feed. Further scrubbing process not only brings down the silica content but also homogenizes the ore for the refinery with minimum variations.

Recently MBE-CMT has designed, constructed and erected a beneficiation plant to process high silica bauxite ore for one of the leading Indian clients to produce low reactive silica bauxite. The present paper describes salient features of **bauxite beneficiation** process and demonstrates the economics of **silica removal**.

Key Words: *Bauxite beneficiation, Reactive silica, Bayer's process, Silica removal.*

Silica Removal Studies of Gibbisitic Bauxites from Gujarat

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Abstract

Indian non-metallurgical industry is utilizing **low ferric Gujarat bauxites** as a major raw material for ceramic, refractory and abrasive products from several decades. Metallurgical grade bauxite is mainly exported to other Indian states and many countries for alumina refineries. Due to depletion of high grade ores and its non-availability, the lean grade is subjected to beneficiation for removal of silica, calcium and iron bearing minerals. The current investigation emphasises on **upgradation** of bauxites by removal of silica present in various deposits from Gujarat. The detailed **characterization** by chemical and mineralogical analysis is presented along with results of beneficiation studies i.e. washing studies by sizing, screening and scrubbing experiments. Effect of dispersing agent on removal of clay from bauxites are also discussed.

Keywords: *Low ferric Gujarat bauxites, upgradation, characterization.*

Significance of Geo-informatics Technology in Evaluation of Lateritic Bauxite Deposits

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Abstract

India is endowed with 3850 million tonnes of **bauxite** resources and Maharashtra state constitutes about 5% of the total assets. Geomorphologically, the lateritic bauxite deposits of Maharashtra can be classified into high level and low level (coastal). The high-level deposits are located in Kolhapur, Satara and Sangli districts, whereas coastal deposits are concentrated in the districts of Raigad, Ratnagiri, Sindhudurg and Thane. Except in some parts of the coastal areas (ex. Sindhudurg district) where they occur on the Kaladgi group of rocks, the **laterite**-bauxite deposits are mostly developed over the Deccan Trap basalts. The texture, chemico-mineralogy, trace element characteristics of ore depend on minerals present in parent rock. The evaluation studies carried out by JNARDDC show that the bauxite deposits of Maharashtra are small and resources of individual deposits are in the order of 0.5 to 10 million tonnes. The bauxite in high level deposits contains moderate to high alumina, low silica with high titania. Mineralogically, the

low-level bauxite is gibbsitic in nature, while high level deposits contain some amount boehmite and diaspore.

In the present study, a unique approach has been devised with integration of the detailed deposit type information pertaining to the geotechnical information and geospatial data of the sampling location. The chemical, mineralogical, trace element, petrology, morphology, technological studies describe in comprehensive detail the laterite and bauxite deposits. However, when done in isolation without any locational information, it loses its full analysis potential. Hence, the geotechnological data is integrated with the multiple resources information, namely, geology, geomorphology, physiography, soil, slope and the most important component of High Resolution Satellite imageries. This integrated approach provides a new perspective hitherto not available in the area of laterite and bauxite resource analysis for the expanse of the entire state, namely Maharashtra. The blend of geospatial technology and geotechnical data for the individual bauxite and laterite deposits is attempted. The studies have provided a new perspective to the geotechnical evaluation of the bauxite and laterite deposits.

All the detailed information pertaining to the geological characterization and technological details of the individual bauxite and laterite deposits have been integrated with the geospatial database in RS & GIS environment. This will provide a value-added decision support tool for the users of the laterite and bauxite resources for multiple applications and industrial utilization.

The increasing need of the raw minerals and their management have created a demand to develop a digital database along with the technological information of individual deposits useful for aluminium industries. The attribute information collected for technological characterization of the laterite and bauxite deposits when integrated with the GIS database, in spatial domain will provide a new perspective, vital in the area of bauxite-alumina industry. In the recent periods, information availability has become the strength of nations and this approach helps us to achieve our Country's objective of e-governance based transparent and effective decision making. The advantages of this approach are: transparent system, e-gov compatible, easy & timely updating, online decision making, periodic satellite task/monitoring, centralized information availability, etc.

In current scenario, the aluminium industry is facing shortage of good quality raw ore. The research work can be useful for entrepreneurs working on lateritic bauxite deposits, mine owners, bauxite industry located in Maharashtra and Central India. The database derived from **remote sensing** GIS can be directly used by existing mining, aluminum industry and new entrepreneurs. The study may lead to optimum utilization of bauxite as well as low grade materials such as laterite, low grade bauxite, saprolite which is lying unutilized.

In this paper, geotechnical characteristics of lateritic bauxite deposits of Maharashtra are summarized and role as well as significance of **geo-informatics** technology in the evaluation of lateritic bauxite deposits is highlighted.

***Keyword**: Bauxite, Laterite, deposits evaluation, geo-informatics, remote sensing.*

Evaluation of Technological Alternatives in Bayer Alumina Process

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Abstract

Bayer alumina process is more than a century old process and globally used technology for the manufacture of alumina. Nevertheless, substantial advances based on fundamental understanding of the process paved path for many technological up-gradations in process equipment and design, both in red and white side. The current work evaluates and compares the various technology and equipment developments in the areas of Bayer process specific to digestion and precipitation. The opportunity for key technological development area to improve the Bayer process efficiency is reviewed and presented.

Keywords: *Alumina digester, Precipitator, Scale-up, Design optimization, Efficiency.*

Bayer Process and Challenges in Red Side

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Abstract

Bayer process is used worldwide for the extraction of alumina from the bauxite ore. Although it is a 100 years old process, the problems associated with degrading raw material quality, process mineralogy and waste generation has limited the process efficiency and thus imposed a challenge on attaining the target of maximum extraction and minimum losses. Degrading bauxite quality (i.e. increase in impurities like silica and iron) is one of the major concerns for smooth functioning of the alumina refineries. The high silica content reacts with caustic soda and forms DSP's (**Disilication** products) which coats the surface of alumina phases and leads to the reduction in alumina **extraction** efficiency and increases losses. Similarly, the increase in iron content results in low productivity and also create problem during solid liquid separation. Also, the difficulty of extracting alumina associated in the goethetic and haematitic crystals has resulted in the decrease in extraction efficiency. Utilization of low grade bauxite results in the increase in **red mud** generation in the Bayer's process. Red mud generation varies from 1.5-2.2

tonnes per tonne of alumina production. Redmud being highly alkaline in nature and containing heavy metals imposes another serious challenge for the industry in terms of its storage and utilization in an environmental friendly manner.

The current work focusses to address the various challenges associated with the red side of Bayer's process and their effect on the **sustainability** of the alumina industry in future.

Keywords: *Disilication, Extraction, Red mud, Sustainability.*

Hydrocycloning Technology Contribution to Improved Productivity through Fines Loss Recovery and Seed Classification

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Abstract

Since 1978, AKW Equipment + Process Design, high performance **polyurethane** based **hydrocyclones**, type AKA-VORTEX, have been successfully installed and used into more than 50 **alumina refinery** projects.

With the **alumina industry** returning to growth after a challenging market period, key players have understood that a successful come-back requires first a careful and thorough look into their overall production process, with a focus on productivity improvement:

- by increasing the product discharge, at same input capacity,
- by increasing efficiency through higher recovery rate, and
- by minimizing losses of valuable materials from usual discharge streams.

If the first two productivity improvement levels are already well established, recently, a particular focus was put on the **recovery of fines** which are otherwise lost throughout the various liquor streams of the alumina plant. This aspect on which limited attention had been put on in the last decades, now raises more attention, with AKW Equipment + Process Design offering unique process solutions to make it an opportunity. The recovery principle of such losses, characterized by low alumina content and specific size range (PSD), will be presented on the basis of a selected example.

Keywords: *Polyurethane, Hydrocyclone, Alumina refinery, Alumina industry, Recovery of fines.*

Restart Behavior and Impeller Arrangement for Re-suspension in Settled Slurry Tanks

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Abstract

Worldwide there are various open stirred systems for slurry tanks like precipitators in use which are designed to achieve special grade of homogeneity and mixing quality. This article shows slurry settling behavior in case of agitator failure or emergency shutdown. The theoretical background gives a good overview of the most influencing parameters. Based on this the conditions and possibilities to restart the agitator and resuspend the solid particles will be pointed out.

Keywords: *Slurry tanks, Precipitator, Impeller, Settling, Restart behavior.*

Application of Piston Diaphragm Pumps in the Alumina Industry

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Abstract

Piston diaphragm pumps are widely used in the mining and metallurgical industry for numerous **applications**, such as concentrate pipeline transfer, tailings pipeline transfer, autoclave feed/digester feed. The common denominator of these applications is high concentrate abrasive slurry, high pressure, and low to medium flow rates.
In some instances, the above-mentioned applications are being used in all stages of the production process. One of those cases is the production of alumina through the Bayer process.
This paper describes the use of piston diaphragm pumps and their **advantages** for the transportation of bauxite from the mine or port to the alumina refinery, feeding caustic bauxite slurry into a digester, injection of lime into digesters, and the transportation of the waste product (red mud) from the refinery to the tailings pond.

Keywords: *Piston diaphragm pump, Alumina Industry, Applications, Advantages.*

Combustion Modeling of Tuyere Burner Operation

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Abstract

Industrial burners are a part of the combustion system in calcination and clinkerization process. It is very important to understand the flame and air distribution patterns inside the chambers. This knowhow helps to control the process parameters and gives scope for **optimization**. **Computational fluid dynamics (CFD)** is a numerical simulation tool that helps in understanding the complex flow problems in a better way. The CFD modelling of burner operation is conducted to find the profiles of flow, speed, temperature, flame distribution and other variables inside the chamber under different operating conditions. The numerical model is used to solve the Navier–Stokes equations with the k–ε turbulence scheme.

There are different types of burners used depending on the fuel type, like solid (coal), liquid and gas-phase combustion type. **Tuyere burner** is a non-premixed type of burner where fuel and steam are sprayed separately into the chamber. Predominantly heavy oil (Mazut) is used as fuel in Tuyere burners. This paper explains the combustion simulation of Tuyere burner operation using CFD. This study also focuses on the influence of primary, secondary and tertiary air on the flow characteristics.

Keywords: *Combustion, Optimization, Computational fluid dynamics (CFD), Tuyere Burner.*

Impact of Swirl Flow in Mixing of Oxygen and Fuel for Burners in Rotary Kiln

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Abstract

The rotary kilns are mostly used in cement and alumina industry for carrying out high temperature reactions or phase transformation. In alumina industry, most of the kilns are phased out due to more efficient technology like fluidized bed but still specialty alumina plants are using kilns. High temperature is achieved by burning the fuel, like pet coke, natural gas and other carbon-based fuels. The efficient combustion of fuel will result in maximum amount heat and will, in turn, avoid the utilization of excessive fuel. The current study focuses on optimization of axial and swirl flow using non-premixed combustion model in Ansys fluent. The simulations were carried out for different cases in which split of axial & swirl flow was varied and its effect was studied on mixing pattern, flame length and flue gases after combustion. The optimized air flow

of axial swirl has resulted in stable flame with complete combustion of fuel and reduced greenhouse gases.

Keywords: *Rotary kiln, burner, mixing, swirl flow, combustion of methane, CFD modeling.*

Caustic Soda: An Essential Ingredient in Alumina Production

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Abstract

World **caustic soda** consumption is estimated at 76 million metric tonnes in 2017, with 17% of the market, alumina is the largest single use of caustic soda. By 2022, this share will increase to 19%. The largest consumer of caustic soda and producer of alumna in North East Asia, is China, with about half of the total world production. Global consumption growth rate of 3.1% per year is forecast for caustic soda used for **alumina production** over the next 5 years.

Caustic soda is produced together with chlorine in an electrochemical unit (ECU). Chlorine is mainly used in the production of chemicals and plastics used in durable goods, particularly vinyls (PVC). Caustic soda on the other hand is used in general manufacturing activities. Production and prices are very cyclical for the durable goods industry, which leads to oversupply of caustic soda and downward pressure on price.

Chlorine is usually produced close to where it is required, as it is dangerous and expensive to transport. Caustic soda on the other hand is **easy to transport**, leading to a large amount of inter-regional trade and total imports of 8.9 million metric tonnes in 2017.

Keywords: *Caustic soda, Alumina production, Easy to transport.*

NON-METALLURGICAL BAUXITE-ALUMINA

World Speciality Alumina Market: Overview and Trends

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Abstract

Specialty Alumina market represents less than 10% of the global alumina production. Thanks to its physical and chemical property, **calcined alumina** can be employed in many applications such as refractory, glass, tiles, technical ceramics, and abrasives. Steel, nonferrous metals, aluminium in particular, construction and automotive are the **key drivers** for specialty alumina markets.

All specialty alumina producers are strengthening and improving production quality and focusing on R&D in order to accompany the development of key markets which require finer and pure alumina qualities.

India is a fast-growing market and the massive efforts in housing and infrastructure development will have a major impact on steel, aluminium and construction materials. This means a positive impact on specialty alumina markets such as refractory, polishing and ceramics.

Concerning refractories, a double growth effect is expected on alumina consumption with an increase of volumes but also with a significant improvement on refractory quality driven by a more and more demanding ferrous and nonferrous industries. Ceramic industry is also expected to move fast following the developments in automotive and electronic industries. A growing demand of electronic substrate, mechanical wear parts, spark plugs, will require high quantity of ceramic materials which are mainly imported from Japan, Korea, Taiwan and China, but could be produced locally in short term.

The big and growing housing market is also driving tiles growth, where India is now acting as a world leader. Even if technical requirements are less demanding, cost improvement, efficiency and fashion effect keep the alumina supply as a critical success factor for Indian industry.

Alteo Gardanne facility is the biggest specialty alumina plant in the world offering more than 100 different products, from hydrates to very low soda alumina and is set to play a leading role in India development.

Keywords: *Speciality alumina, Market, Calcined alumina, Key drivers.*

Emerging Alternative High Purity Alumina Production

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Abstract

FYI Resources Ltd is an emerging **high purity alumina** (HPA) producer that is seeking to address rapidly growing demand from an alternative source to the current traditional supply. The alternative processing route derives the target 99.99% purity product from aluminous clay (**kaolin**) and offers considerable industry and commercial advantages such as significantly lower capital and operating costs, time to production and product specification control.

Keywords: *High purity alumina, Kaolin.*

Characteristics that Enable Synthetic High Alumina Aggregate, Tabular Alumina as Optimum Fit for Refractory Applications

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Abstract

High alumina materials are several decades old solution for numerous **refractory applications**. Bauxite and other naturally occurring alumina raw materials served the refractory demands since long. Many changes took place over the past 20 years in terms of naturally occurring raw materials availability and their refractory demands. Use of synthetic high alumina raw materials and refractories has been popular over last couple of decades. These are becoming benchmark products in the industry day by day in several refractory usage, especially in iron and steel industry applications. Refractories using synthetically produced high alumina aggregate, **Tabular Alumina**, outperform natural as well as fused alumina materials because of inherent microstructural and chemical advantages, and benefits associated with homogeneity and consistency. Parameters like uniformity of chemical purity, homogeneity of particle size distribution, closed porosity and high toughness impart superior properties in refractories with better rheology, hot strengths, thermal stability, thermal spalling, abrasion and corrosion resistances. It has been already proven with numerous experimental and live performance data and years of growing and sustained business that synthetically produced high alumina aggregate, tabular alumina excels in various iron and steel applications like castables in blast furnace trough, steel ladle lining, well block and purging plugs, sliding gate and black refractories, resin bonded alumina-carbon bricks, fired high purity alumina and alumina-spinel bricks, neutral ramming mass and so on. In this paper, we studied and explored the roles of synthetic tabular alumina in those applications. It is seen that high alumina refractories using tabular alumina drive the

performances in terms of life, productivity and predictability and made tabular alumina an unavoidable choice as raw material.

Keywords: *High Alumina Materials, Refractory Applications, Tabular Alumina.*

Applications and Characteristics of Different Grades of Alumina Tri-Hydrate

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Abstract

The total alumina production in the world is estimated to be about 126 million tonnes in 2017. About 94% of this quantity is what is called 'Metallurgical alumina' being used for making aluminium metal using the Hall-Heroult process. The balance, about 7 million tonnes, is called '**Chemical alumina**'. This consists of "Chemical **Alumina Tri-Hydrate** (ATH)" and "Chemical calcined alumina" roughly in 50:50 proportion.

ATH is classified into various grades based on diverse physical and chemical characteristics namely, 'wet or dry', 'coarse or fine or very fine', 'narrow or broad or very broad' particle size distribution', 'normal or medium or low' soda content and 'normal or high purity with respect to other impurities'. A combination of these characteristics is achieved in specific grades of ATH through properly selected and controlled process steps and conditions.

Applications for Chemical grade ATH are numerous. They range from 'aluminium chemicals like alum, PAC, etc.', 'commercial and industrial carpet applications for imparting flame-retardancy', 'adhesives and sealants used for automotive and building applications like silicone and urethane', 'as flame retardant and smoke suppressant filler in thermoplastics like cable, piping, flexible and rigid PVC products, Flooring etc.', 'Thermoset Composites of unsaturated polyester and epoxy applications like fiberglass reinforced Sheet Molding Compound and Dough Molding Compound, Cast polymer/ solid surface etc.', 'Fire retardant rubber products like wire and cable, silicone rubber etc.'

This paper deals with **different grades** of ATH evaluating the various characteristics required for the various applications.

Keywords: *Chemical alumina, Alumina Tri-Hydrate, Applications, Different grades.*

Alumina, a Versatile Raw Material for Ceramics and Refractory Applications

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Abstract

The excellent high temperature properties of **alumina** (α-Al_2O_3) makes it a preferred raw material for **refractory** and **ceramic applications**. Depending on particle size distribution, crystal size, degree of calcinations and reactivity, this material serves a variety of functions in the refractory formulations such as: (a) Enhancing the end products' refractoriness and overall performance by increasing the alumina content of the formulation through pure raw materials, (b) Improving both room temperature and high temperature mechanical properties and abrasion resistance by improving the particle packing through the addition of fine alumina particles, (c) Forming a high refractoriness material with good thermal shock resistance and resistance to corrosion and chemical attack, when reacting with binders like calcium aluminate cements, (d) Optimizing the packing characteristics leading to reduced water demand and improved flow characteristics, etc. Alumina is also used in a wide range of ceramic applications like technical / industrial ceramics, HT insulators, spark plug, polishing, tiles including glazes, engobes and frits, etc. Alumina offers high mechanical resistance and hardness, as well as surface effects such as matt / gloss finish, depending on the type of alumina used. Additionally, alumina ceramics exhibit very favorable thermal properties providing dimensional stability.

The Chemicals Business of Hindalco produces more than 80 grades of specialty alumina and supplies to different refractory and ceramic industries, throughout the world. It's well equipped R&D facilities work constantly to develop new products and applications to meet the demanding needs of domestic, as well as overseas markets. It also proactively works for the development of futuristic products, like high purity alumina (3N, 4N materials), alumina for environmental applications, etc, in order to stay ahead of the competition.

This paper elaborates all these activities and its engagement with the refractory and ceramic industries.

Keywords: *Alumina, Refractory Applications, Ceramic Applications.*

Production of Pure Sodium Aluminate and Fine Precipitate Alumina Tri-hydrates Through Bicarbonate Process

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Abstract

Process for production of pure **sodium aluminate** in its solid state and fine precipitate **alumina tri-hydrate** (ATH) has been studied in detail using high grade bauxite and metallurgical grade alumina tri-hydrate through **bicarbonate process**. Precipitations of fine and white alumina tri-hydrate of different properties for fire retardant filler applications have been prepared extending the process following **controlled precipitation** techniques.

Results have shown that up to **>99% purity** sodium aluminate at its solid state could be prepared (against conventional process of about 90% purity) following the bicarbonate treatment of alumina tri-hydrate under optimum conditions. Digestion of ATH or high alumina bauxite at 160-180°C is carried out using sodium bicarbonate to form the intermediate product, dawsonite. Solid sodium aluminate has been prepared by drying of dawsonite, formed by reaction of alumina tri-hydrate and sodium bicarbonate at an elevated temperature. Solid sodium aluminate, whose price is determined from its purity, has a potential market for its application in water treatment, construction, paper, etc. The solid sodium aluminate was further leached to precipitate fine special hydrate products of superior purity and desired median particle sizes using controlled precipitation techniques and special seed. Different conditions of precipitation to prepare customized alumina tri-hydrate products for application as a potential fire-retardant filler have been discussed in the paper.

The bicarbonate process appears to be innovative and allows the economic operation of suitable capacity plant aiming to produce value added products from alumina tri-hydrate for its specialized applications. The paper describes the comparative situation of producing sodium aluminate and specialty hydrate products in conventional Bayer process vis-à-vis bicarbonate process.

Keywords: *Sodium Aluminate, Alumina Tri-hydrate, >99% purity, Bi-carbonate Process, Controlled Precipitation.*

Effect of Seed Properties on Liquor Productivity & Product Quality in Precipitation Process for Development of Special Products

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Abstract

For **precipitation** of alumina from the aluminate liquor in an alumina refinery, aluminium hydroxide is used as **seed**. The seed provides surface area for the deposition of alumina from the supersaturated liquor. Hydrated alumina of particular quality and granulometry depends upon the **precipitation parameters** and the quality of the seed used. The paper investigates the effect of altered seed property on liquor productivity and product quality. The **seed properties** were modified by activating it mechanically, thermally and hydrothermally. Detailed characterization of each seed after activation and the product obtained has been studied. The work has revealed that alteration in seed properties changes the parameters for precipitation and the product characteristics. The investigations have led to the development of **new and special products** which can be used for specific applications. Also, boehmite precipitation is one of the important highlights of the work.

Key Words: *Precipitation, Seed, Precipitation parameters, Seed property, New and special products.*

Non-metallurgical Bauxite - Challenges in Indian Refractory Industry

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Abstract

In India, resources of **non-metallurgical bauxite** are limited and constitute around 4% of total reserve. Requirement of non-metallurgical bauxite in India is continuously rising with increasing demand of refractory and high alumina cement.

The non-metallurgical bauxite grades have tighter **specification** and hence **higher-cost products** than metallurgical bauxite.

Raw bauxite is used in refractory industry for manufacture of medium purity high alumina cement which requires low silica and low iron contents. Calcined bauxite used in refractory industries requires high alumina and low iron and TiO_2 contents.

Apart from refractoriness, **calcined bauxite** is also required for manufacturing of proppants and abrasives.

For good quality **calcined bauxite**, India mostly depends on china, but in recent years, there has been considerable concern about the availability of calcined bauxite. This is because of restricted supplies from China. Hence this is **challenge** for Indian refractory industries.

Keywords: *Non-metallurgical bauxite, Specification, Higher cost product, Calcined bauxite, Challenge.*

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Thyssenkrupp

Abstract

Thyssenkrupp Industrial Solutions (tkIS) India's pre-eminent position as an EPC-LST / EPCM / PMC contractor for chemical plants and projects has resulted in lasting relationships with the **Indian chemical industry**. Active in the field of fertilisers, petrochemicals, refineries, caustic soda, low-temperature storages and industrial, tkIS India has made incisive forays in the **metallurgy and minerals sectors**, with plants for some of the major non-ferrous metal players in this segment. Our experience covers alumina refineries, zinc smelters, iron oxide and silica implemented in EPCM and PMC modes.

Working in conjunction with its sister companies in the tk group to ensure fully-integrated services, tkIS India offers the entire range of services from Residual Basic Engineering, Detailed Engineering, Technical Procurement, Inspection, Project Management, Construction and Commissioning Services, and 360° Life Cycle Services for Metallurgy and Mineral projects.

tkIS India's quality consciousness and customer commitment is resulting in repeat orders with mineral majors that are defining the course of the key metal sectors in India.

This paper covers the experience, expertise and value proposition that tkIS India offers players in the metallurgy and minerals space.

Keywords: *Indian chemical industry, Metallurgy and mineral sector.*

Aluminium Chemicals Market – Overview of the Water Treatment, Aluminium Fluoride and Flame Retardant Markets

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Abstract

Non-metallurgical alumina accounts for 6% of global alumina consumption, and 57% or 6 million metric tonnes can be classified as chemical grade **alumina trihydrate (ATH)**. This material is consumed to produce aluminium chemicals, including sulphates and fluorides. Fire retardants, detergent zeolites, catalysts and desiccants, are important direct uses of chemical ATH.

Aluminium sulphate is a very effective coagulant in **water treatment**. The main competitors are ferric chloride and aluminium chlorides. 1.6 million metric tonnes of ATH was consumed in aluminium sulphate production in 2017, and the market is forecast to grow over the next 5 years at 1.7% per year, globally.

Aluminium fluoride production consumed 14% of the world's chemical grade ATH, or just below one million metric tonnes in 2017. About 93% was produced from fluorspar, and the other 7% from fluorosilicic acid. It is primarily used to lower the temperature of the aluminium smelter pot, using 10-25 kg per tonne of aluminium produced. Also used in chemical, ceramic and glass industries.

ATH is the largest **flame retardant filler** in the world by volume, accounting for about 38% of the total global flame retardant demand in 2017. It is cheap, effective and breaks down to low toxicity components in a fire. It can be used in many different products, including plastic cable covers, roof tiles and sealants. The market for mineral flame retardants is forecast to grow at 3.6% per year globally, over the next 5 years.

Keywords: *Non-metallurgical alumina, Alumina trihydrate (ATH), Aluminium sulphate, Water treatment, Aluminium fluoride, Flame retardant filler.*

VALUE FROM WASTES

Dealing With 'Bauxite Residues': Challenges and the Path Ahead

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Abstract

The disposal/storage of the **bauxite residues** is becoming a **major challenge** due to the requirement of large areas of land, difficulties associated with creating stable dumps, leachate management, and air pollution, for alumina refineries. Hence, the need of the hour is to adopt strategies that are unique and would prove to be a game changer in the days to come. In this context, the initiatives taken by M/S HINDALCO Ltd. and their collaboration with the researchers at Indian Institute of Technology Bombay, India, for **bulk utilization** of the bauxite residues is noteworthy. This talk presents a comprehensive picture of the **initiatives** that have been implemented, successfully, and those with a 'potential' to be a panacea for the alumina refineries, in the days to come.

Keywords: *Bauxite residues, Major challenge, Bulk utilization, Initiatives.*

Recovery of Rare Earths and Major Metals from Bauxite Residue (Red Mud)

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Abstract

Bauxite residue generation is a major concern in the aluminum industry due to its alkalinity and generated volumes. However, some of the bauxite residues contain valuable minor metals like **rare earth elements** (REEs). Hence, recovery of REEs with or without other metals from bauxite residue, and utilization of the left-over residue in other applications like building materials can solve the handling and storage problem of bauxite residue. To achieve this, selective recovery of REEs over major elements such as iron was studied first, by direct acid leaching. During **leaching**, either the recovery of REEs was low, or the dissolution of iron was high. The high amount of iron going into solution during leaching poses problems during the extraction of REEs from leach solution. Therefore, iron was removed from bauxite residue in the form of pig iron before leaching by high-temperature **smelting** process. The slag generated during smelting was leached with acids. The selectivity of REEs over iron was improved. However, smelting of bauxite residue requires a high amount of energy due to the presence of high alumina content in bauxite residue, which requires a high amount of flux. Therefore, the removal (and recovery) of

alumina from bauxite residue by sodium carbonate roasting was studied. The sample after alumina removal was smelted without any added flux and it was possible to obtain a clear slag-metal separation. REEs were successfully recovered from slag by acid leaching from alumina-poor slags. An alternative process called sulfation-roasting-leaching was also developed to selectively leach the REEs. In this process, bauxite residue was mixed with water and concentrated H_2SO_4 followed by drying, **roasting** and finally leaching of the roasted product in water. REEs were selectively leached by this process. However, the **scandium** recovery is low. The residue generated in this process could be used in cementitious binders. Preliminary energy and economic analyses show that alkali roasting-smelting-leaching and sulfation-roasting-leaching are promising processes for treatment of bauxite residue.

***Keywords**: Bauxite Residue, Leaching, Rare-earth elements, Roasting, Scandium, Smelting.*

Neutralization and Utilization of Bauxite Residue

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Abstract

Bayer process is widely used for extraction of alumina from bauxite. About 1 tonne of alumina is produced from 3 tonnes of bauxite. This process results in generation of huge quantity of **bauxite residue (BR)** known as Red Mud (RM). Depending on the raw material processed, 1-2.5 tonnes of red mud is generated per tonne of alumina produced. The red mud is highly **alkaline** in nature with a pH in the range of 10.5-12.5. Presently, it is allowed to store the RM at alkaline pH, but in future, it may not be allowed due to high pH. There remains issue of leachate coming out of RM disposal area and has **environmental issue** due to alkaline in nature with high fluoride content.

There is bound and free soda in RM and high pH is due to free soda content which can be neutralized with mineral acid for secondary utilization/ environmental friendly disposal of RM. Application of HCl for **neutralization** of BR revealed fixation of fluoride on neutralised BR without leaching of any other metal. Concentration of fluoride in filtrate remained less than 2 ppm which might be >50 ppm in case of alkaline RM. Neutralization also resulted in better filterability characteristics of BR. This neutralised low soda content BR can be used in Cement manufacturing. The neutralised filtrate can be recycled back to chlor-alkali industry for recovery of salt.

***Keywords:** Bauxite residue (BR), Alkaline, Environmental issue, Neutralization.*

Pre-concentration & Extraction of Strategic Rare Earths from Indian Red Mud

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Abstract

Red mud is a process waste composed of un-dissolved bauxite phases during the caustic digestion in Bayer process. It is alkaline and consists of very fine particles (d_{50} <20 μm). **Rare earth elements (REE)** are enriched in the bauxite residue which could be a potential resource for extraction of REEs (Sc, La, Ce). Large amounts of iron in the leach solution create problems for further recovery processes as iron and scandium have a few common chemical characteristics. Therefore, it is advisable to remove iron as much as possible from the mud through physical beneficiation.

In the present study, characterization and various techniques of physical beneficiation, such as sieving/screening, hydro-cyclone, multi-gravity separator (MGS) have been exploited. The **selective leaching** with different mineral acids (HCl, HNO_3 & H_2SO_4) for the **extraction** of REEs has been discussed. Various experimental parameters (i.e. Roasting, acid conc., solid/liquid ratio, leaching time and temperature) were studied in detail.

It was observed that leaching of Sc, La and Ce with 2-3M H_2SO_4 mixture at 95-100°C under optimized condition resulted in maximum leaching efficiencies (81-90%) with minimum dissolution of iron (<8.5%).

***Keywords**: Red Mud, Pre-concentration, REEs, Selective leaching, Extraction.*

Comparative Evaluation of Indian Alumina Refineries wrt Technology, Bauxite and Residue Disposal Systems

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Abstract

There are six alumina refineries operating presently in India. The total annual production capacity of these operating refineries is about 7.3 million tonnes. Three refineries are more than 40 years old. While one refinery is about 30 years old, the remaining two are less than 10 years old. Some of these are under further expansion. The **bauxite** source for each of these refineries is different and the bauxite quality differs from one another – from low silica gibbsitic to high silica gibbsitic with moderately high boehmite to what is traditionally called boehmitic. Consequently, the digestion technology used in these refineries is different and unique to the bauxite being processed.

The **bauxite residue** being generated in these refineries differ in characteristics from one another. The original residue disposal system designed and operated in these refineries were in

line technologies available and needed in those days. However, in line modern requirements and strict environmental considerations, the disposal systems have been redefined even in the "old" refineries.

In line with World commitments and targets, alternative uses for the bauxite residue are being explored by all these refineries.

This paper does a comparative evaluation of all the operating **Indian alumina refineries** with respect to Technology being used, bauxite quality and the current **residue disposal** systems being used by them.

Keywords: *Bauxite, Bauxite residue, Indian alumina refineries, Residue disposal.*

SPL: Turning Waste into Value

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Abstract

Historically, the aluminum industry has faced a lot of challenges in efficient management of its hazardous waste products, one of them being Spent PotLining (SPL). SPL is a solid waste discharged from the aluminum smelter at a rate of ~1-1.5 MTPA. Because of exorbitantly high treatment costs, SPL is usually stored in specially constructed sites. However, the presence of toxic and corrosive components such as F, CN, Na, Al in SPL, poses an environmental threat as they may contaminate the earth's crust and underground water. Dastur Innovation Labs, in collaboration with Process Metallurgy Research Labs, is working extensively to understand the chemistry of SPL to extract value out of these wastes. Due to its C and F content, SPL can potentially act as: (a) a flux in the nonferrous industry, (b) an alternate to coal in ironmaking blast furnaces, and (c) a carbon injection source in the EAF. The applicability of these ideas has been explored using both process simulation and small-scale experiments, which show promising results.

Keywords: *Spent Potlining (SPL), Aluminium waste, Recycling, Carbon source, Fuel injection, and Flux.*

Recovery of Metal Values from Aluminium Dross: A Review

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Abstract

Global aluminum industry produces approximately three to four million tonnes of **aluminium dross** every year. Aluminum dross is generated from both primary and secondary aluminium production. Dross is classified according to metal content. White dross contains higher aluminum content and is generated at primary and secondary source (smelter & re-melting units, 15-70% aluminium content) whereas black dross is generated during aluminum recycling (aluminum recycling sector, 12-20% aluminium content).

Metal loss as dross in primary and secondary aluminium industry is approximately 0.5-3.5%, which is one of the significant concerns of aluminium producers and re-melters. Additionally, the pressure to reduce the costs due to global over-capacities, environmental awareness and stringent regulations limiting the aluminium produces and re-melters to gate away with current practices for dross processing and disposal. A few decades ago around 30% of aluminum recovery of the dross weight was standard acceptable criteria, which is not accepted today, as with current technologies over 65% of aluminum on dross weight can be achievable.

This paper reviews the various **dross processing technologies** and two industrial trial case studies. The first case study is about the mechanical processing of dross to get dross granules with aluminium content > 85% of the dross weight for further processing and second case study is of hot/cold dross processing with rotary dross furnace under inert atmosphere for aluminium recovery >60% of the dross weight.

Keywords: *Aluminium dross, Metal loss, Dross processing technologies.*

Pyro-hydrometallurgical Process for the Recovery of Alumina from Waste Aluminium Dross

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Abstract

Disposal and recycling of **aluminium dross** produced during aluminium production and melting is a worldwide problem. Most of the dross after recovering possible metal is disposed by storing at a landfill sites with exceptional care, not to have any possible leaching to soil. This is due to the fact it may result in leaching of toxic metal ions into ground water causing serious **pollution problems** in case of its contact directly to the soil or its exposed to rain. In addition, when aluminium dross encounters water it emits harmful gases such as NH_3, CH_4, PH_3, H_2S, H_2, etc. In India, a rough estimate shows that over 50,000 tons of aluminium dross is generated every year and some of it is used for making crackers, impure chemicals using the metal part in it and most of it is stock piled due to environment constraint and unavailability of suitable technologies to process the same. Further, for sustainable development, replacement of primary resources with secondary resources has also become essential. There is a need of a suitable technology for

the processing of aluminium dross for recovering of metal part after which to recover the alumina content so that the dross can be utilized as a secondary resource of alumina mitigating the environmental threats caused by its piling.

In this work, aluminium dross of particle size less than 150 µm containing about 65% Al_2O_3 and 5-6% Al metal (after removal of possible metal content) was subjected to **pyro-hydrothermal process**, i.e., soda roasting at a temperature of 800°C for an hour and then leached in 2% (w/v) NaOH solution at a temperature of 70°C for 2 h to solubilise the alumina content. It has been observed that, all the aluminium values present in the dross can be leached out completely. The leached liquor was then subjected to lime treatment for removal of co-dissolved silica and then carbonisation of the pure sodium aluminate liquor was carried out for precipitation of aluminium hydroxide. The alumina tri-hydrate produced can be a source for calcined alumina also. The overall **recovery** of alumina from dross has been found to be over 90%. A process flowsheet has been developed for the recovery of alumina from dross.

Key Words: *Aluminium dross, Pollution problem, Pyro-hydrometallurgical Process, Recovery.*

Recovering Fluorine Value from Spent Pot Lining in the Form of Cryolite

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Abstract

Spent pot-lining (SPL) is a hazardous waste generated at the end-of-life of carbon cathodes in aluminium smelting electrolysis cells or pots. It contains around 10-12% **total fluorine**, 4-6% CaF_2, 25-30% Al_2O_3, 15-20% Na_2O and 8-9% SiO_2. Removal of fluoride is very important due to hazardous nature of the material. The **extraction** of fluoride from SPL is carried out by three stage leaching process first. Acid and non-ferric alum is added to extract fluoride in the form of cryolite. In leaching process alkaline solution is produced which is neutralized with H_2SO_4 for maintaining pH at 7. For completion of the reaction, sufficient holding time is provided. Particle thickening is done in a **cryolite** thickener by adding flocculent and the thickened product is then filtered in a drum filter. The filter cake is dried on a jacketed screw conveyor and recycled to the smelter plant for use as bath material. The cryolite so recovered contained about 46-50% total fluorine, 0.2-0.3% CaF_2, 8-10% Al_2O_3, 0.5-0.8% Na_2O and 0.1-0.2% SiO_2. The details of the process and the key learnings from the operations will be discussed in the paper.

Keywords: *Spent pot-lining (SPL), Total fluorine, Extraction, Cryolite.*

Advanced Technologies for Zero Liquid Discharge (ZLD)

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Abstract

The major challenge faced by the industry is **fluoride treatment and disposal**, which can be managed through the innovative ion exchange process. Total water management approach to **recycle waste water** in alumina industry through advanced, cost-effective technologies ensures total water reclaim, **zero effluent discharge** and lowest ecological foot print.

Keywords: *Fluoride treatment and disposal, Recycle waste water, and Zero effluent discharge.*

R&D Activities at JNARDDC for Utilization of Aluminium Industry Wastes

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Abstract

Aluminium it is the most abundant metal in earth crust about 8%, it is largest growing nonferrous metal since 1960 followed by Cu, steel, lead and tin and it is 2nd largest metal in use and largest non-ferrous industry in world. Aluminium metal is said to be a metal of future, it is also called strategic and green metal due to its light weight and easy recycling nature.

The main pioneers in aluminium production from bauxite were Bayer and Hall-Héroult without whom the commercial aluminium production would not have been possible. During the production of aluminium from bauxite the main processes are mining of bauxite, refining of bauxite to alumina and smelting of alumina to aluminium. During each process lot of wastes are generated. Some of them are hazardous and some are non-hazardous. For example, the major waste generated during refining process called Redmud, till date Central Polution Control Board (CPCB) did not declare redmud and Fly ash as hazardous wastes, whereas wastes generated during smelting process are fly ash, SPL (spent pot lining) and Dross. SPL and Dross are declared as hazardous waste from aluminium industry by CPCB under class A & B respectively. It is estimated that, the redmud generation in India is about 7-8 million tonnes/annum, Fly ash generation from captive power plants is 8-9 million tonnes/annum, SPL generation is 1-1.5 lakh tonnes/annum and aluminium dross (powder) is about 20000 tonnes/annum.

To manage these wastes, JNARDDC is carrying out various R&D activities toward the minimization of waste, reuse and utilization of waste to value and zero waste generation concepts. Some of the processes and products developed by JNARDDC from these wastes are (i) Hard bricks from redmud, (ii) Artificial ceramic stone chips from redmud, (iii) Light weight foam

bricks from redmud (iv) Glass-Ceramics tile from redmud, (v) Recovery of carbon and caustic from SPL, and (vi) Alum and castables from dross as well as geo-polymer mix designs suitable for preparing building materials suitable for flooring, wall construction, interior decoration, fire resistant applications, road construction, etc.

Keywords: *Aluminium Industrial Rejects; SPL, Red mud, Laterite, Dross, Heat Treatment, Geopolymer, Building Materials*

ALUMINIUM SMELTER

Ensuring Availability of Aluminium Smelters Through Island Operation Capability

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Abstract

Aluminium smelters, which are supplied by **captive power plants,** can maintain their production even when disconnected from the external grid, a.k.a. **islanded** operation, provided that the captive plant can control frequency and voltage in a stable manner. This will prevent **blackout** of the plant in case of sudden disconnection or grid collapse and can also be used pre-emptively to avoid disturbances when e.g. a thunderstorm is anticipated. Increasing the **availability** in this manner can save large sums of money.

Solvina has developed a unique method for optimising and verifying the frequency control capability of power plants. The method is called Simulated Island Operation and allows for testing the island operation capability of each unit in a safe manner and without risking a blackout since the generator always stays connected to the grid during the test. The method uses a real time simulator that is connected to the speed governor of the turbine and sends a simulated frequency signal to the frequency input of the governor. The speed controller will then act as if the unit is actually running in island operation. The governor can be tuned during the test for best frequency stability. If the simulated frequency becomes unstable due to the power plant response, then the simulation is simply stopped, and the governor returns to normal operation. At the same time, it is a complete test since it requires the same action of the steam valve and other equipment as in real islanded operation. The capability of the boiler to keep the steam pressure stable in islanded operation is tested at the same time. Governor tuning will optimise the capability of the power plant to maintain production despite sudden load changes in the islanded grid, such as rectifier or generator tripping. It also maximises the amount of grid export that is safe to maintain up until sudden islanding occurs. Depending on the type of power plant, the test may also include voltage control tests and tests that verify the ability of the tested unit to share the load with other units.

Vedanta Aluminium in Jharsuguda will serve as an example of this work. Solvina devised necessary governor changes which allowed them to be tuned. A number of tests, including simulated island operation tests, were performed on 13 units, one at a time. Each governor was tuned each for optimum frequency response and load sharing, making any combination of units possible to run islanded. A number of control issues, for example bypass control interfering with the turbine control, were identified and addressed. After tuning, sudden load changes of around 10% of the installed capacity could be handled without causing excessive frequency deviation or other problems. This, in combination with an already installed load and production shedding system, will make the power plant able to maintain production after a sudden disconnection from the external grid in a variety of operating conditions.

Keywords: *Captive Power Plant, islanded operation, blackout, Availability.*

Perform, Achieve and Trade (PAT) Way to Energy Efficiency in Aluminium Smelters

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Abstract

Primary aluminium is produced through electrolysis of alumina dissolved in molten cryolite bath. Production of primary molten aluminium is **energy intensive process** and a lot of work has been carried out all over the word in last 3-4 decades to reduce the energy consumption in aluminium electrolysis process. In India, around 3 million tonnes of primary aluminium is produced annually in five smelter plants situated at Angul, Jharsuguda, Renukoot, Hirakud, and Bargawan. The aluminium industries are upgrading themselves by adapting state-of-art technologies, which are more energy efficient and sustainable in a highly competitive market. These initiatives are further accelerated and motivated by an innovative incentivization scheme, called **Perform, Achieve and Trade (PAT)** of Govt. of India. Currently, the scheme is under implementation, and a movement towards **energy efficiency** is envisaged as a result that will ultimately lead towards production of low carbon aluminium for the society. JNARDDC has been actively involved in determining the normalization norms of PAT scheme for bringing all the smelters on one platform for evaluation. Based on the normalization relations and techniques under this scheme, reductions in specific energy saving targets are assigned to aluminium smelter for PAT cycle.

Keywords: *Energy intensive process, Incentivization scheme, Energy efficiency.*

Sustainable Pot Performance Through Operational Excellence

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Abstract

An aluminum smelter is one of the distinct processes, in which a series of electrolytic cells is supplied by an extensive rectifier unit. In this industry, the complexities like simulation of parameters (noise, alumina quantity, bath temperature, alf3 content, voltage, etc.), operator's working abilities and identification of risks need proper strategies and rational approach to attain consistent and **stable pot operations**. Reducing energy consumption with sustained current efficiency is a challenging task for any smelter. Analysis has been conducted to characterize the behavior of the pots in various combinations of parameters and the optimum concoction is thus obtained. In this project, advanced approach (Pot categorization, Section-wise Teaming, Daily performance scoring, Rewards & recognitions) has been developed for achieving **operational excellence** along with **optimized process parameters**. The experiment has been carried out in two Pot lines (608 Pots) and resulted in gain of 379 units per tonne of DC energy with current

efficiency above 94.5% for about 6 months. This paper describes the methodology and outcome of **categorization scheme** along with its successful implementation.

Keywords: *Stable pot operation, Operational excellence, Optimized process parameters, Categorization scheme.*

Energy Saving Through FTP Optimization

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Abstract

Fume treatment plant (FTP) is key process of **aluminium smelting** in terms of stable pot operation, Alf3 consumption, HF emission and environmentally friendly workplace. FTP also contributes to significant energy consumption with the operation of blowers and air slide fans. Normally FTP process is optimized to improve the gas collection efficiency for effective fluoride scrubbing without changing Blower & fan operation. As per GAMI design, our FTP operates with the utilization of two hopper blowers and three air slide fans. Team has come up with innovative idea of modifying **process air circuit** requirement. This improvement project covers optimizing the air pressure requirement of FTP operation without any operational difficulties such as fluidization, fines generation, fluoride enrichment and consistent feeding to pots. This project has resulted in energy saving of 4 kWhr/MT Al and thereby having potential of substantial cost reduction per annum. This paper will discuss in detail about the improvements carried out in FTP and consistent **energy saving** over period of six months.

Keywords: *Fume treatment plant (FTP), Aluminium smelting, Process air circuit, Energy saving.*

Networking and Centralized Monitoring Station of Pot Tending Assembly

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Abstract

Availability and reliability of **Pot Tending Machine or Assembly (PTM or PTA)** is one of the key deciding factors of potline performance. In the earlier generation design, without maintenance bay and gantry system, the reliability of PTA plays a very vital role in on-time completion of operational activities like anode change, beam raising, pot preparation, etc. As the PTAs are not a stationary equipment, even **predictive maintenance** is very difficult. The objective of this paper is to demonstrate centralized monitoring station of PTA which is featured by **wireless communication** and networking of all PTAs. The networking is designed with wireless modules installed in individual PTMs, Unshielded Twisted Pair (UTP) cable, fiber optic link and various converter switches. All PTAs are connected to a centralized monitoring station where online simulation of

every tool and its operation are visualized via **SCADA** server, real time access of PLC programing via engineering server, data backup, real time motor current, temperature **trends** and fault logging via historian server and automatic messaging system for fault generation. The implementation of this concept shows reduction in **Mean Time To Repair (MTTR)**, manpower optimization, betterment in predictive maintenance and steady improvement in availability and reliability of PTAs.

Keywords: *Pot Tending Assembly PTA, Predictive maintenance, SCADA, MTTR, Trends, Wireless communication.*

Prevention of Riser Short Circuit Joint Damage in Aluminum Smelter

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Abstract

Open Circuit is a critical issue in aluminum smelter industry. During relining when pot is stopped through short circuit joint, **voltage drop** exists across the contact surface due to contact resistance. This voltage drop generates joule heating and may be critical if it crosses the safety limit. So, periodic measurements are done by process control teams, by measuring manually with multivolt meter, now we have developed a system that monitors the short circuit joint voltage drop of all the **risers** for both tap end and duct end side and it communicates with the device to display it on a screen continuously. If the drop crosses the first safety limit, LED indicator blinks and buzzer sounds for the corresponding riser to alert the operator. If it crosses the **critical limit**, hooter arrangement shoots up in the section and a notification message is sent to emergency contact group to rectify the issue within time. The device has short circuit joint **voltage drop acquisition system**, so that we can analyze the data whenever we require. Install it just after pot is bypassed and remove it before pot is started. The single device can take care of all the five risers and ensures no open circuit during pot relining.

Keywords: *Riser, Contact Resistance, Voltage Drop, Pot Cutout, Aluminum Smelter, Heating.*

Prevention of Pot Leakage from Collector Bar Through Data Analysis in Aluminum Smelter

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Abstract

The behavior of **increasing iron** (Fe) from **pot** metal and collector bar **temperatures** were studied for running pots on shift basis. The data were analyzed with statistical process control tools and corrective actions were taken to prevent the pots from **leakages**. Later the pots were tracked and depending on the situation the pots were stopped proactively. Subsequently during the pot digging, the locations were marked and observations were captured. The study included 10 tap-out pots, 20 pots of collector bar cut and 20 pots of increasing the iron from different sources, mainly from collector bars. The increment of temperature was widely captured and basing on all the pots under the study was used to determine if the source of iron were collector bars or anode stubs or breakers.

Key Words: *Increasing iron, Temperature, Pot, Leakage.*

Investigation of Lining Materials for Enhancing the Cell life

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Abstract

Over the years, aluminum industry has been investing substantial capital to reduce the energy consumption and improve the **cell/pot life**. The cell life enhancement depends on various factors, like cell lining design, material selection, operational activities & start-up procedure. Lining design must ensure that appropriate temperature gradient is present in lining materials to maintain cell thermal balance. The melt freezing isotherm too far down the **refractory/insulation layer** adversely affects the cell thermal balance during the course of cell operation. The depth of electrolytic melt penetration in the cell lining depends on the endurance of refractory lining towards the chemical attack. Ideally, the melt penetration through the cathode blocks causes mineralogical transformation of the refractory layer, which forms a highly viscous layer that acts as a barrier for further melt penetration. However, the chemistry of transformed phases depends on the choice of refractory material. Any mineralogical transformation results in the enhanced heat loss through the cell bottom lining, which increases the tendency of cold cathode resulting in thermal imbalance, that lead to deterioration of cell performance and higher energy consumption. The role of refractory layer, thus, becomes vital in protecting the insulation layer from chemical attack by bath.

This study outlines the **material selection criteria** for cell lining depending upon the degradation mechanism and its impact on pot thermal balance. A detailed pot autopsy of a high amperage side-

by-side cell was carried out, which indicates the performance of dry-barrier mix as a bottom refractory layer in cell lining. This study attempts to describe the degradation of dry-barrier mix layer that eventually leads to cell thermal imbalance, which is in conformance with the literature.

Keywords: *Cell/pot life, Refractory/insulation layer, Material selection criteria.*

Macro-Models for Efficient Aluminium Smelting Process Control

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Abstract

Aluminium is produced through electrowinning process in aluminium reduction cell. For efficient **cell operation**, it needs to run in an optimal operating window under a pseudo equilibrium state. Disturbance in the pot parameters might shift the pot out of optimal operating window resulting in higher energy consumption. **Mathematical models** are beneficial in identifying this optimal operating window of the cell. Based on the fundamental physics and empirical correlations, models for mass/material balance, enthalpy/energy balance, voltage balance, heat balance with flux distribution, ledge thickness and resistance-based feeding, were developed. These models capture multi-physics through individual models to meticulously replicate the actual pot conditions, and are useful in evaluating various pot conditions, e.g. the impact of anode change thermal balance, dissolution of alumina and sludge on pot performance, changes in raw materials and their impact on the gaseous evolution, heat flux distribution and ledge thickness etc. Macro-models perform quick calculations to identify the impact of various input parameters and advice suitable measures through a graphical user interface (GUI), for bringing the pot back into the optimal operating window for **efficient cell performance**.

Keywords: *Cell operation, Mathematical models, Efficient cell performance.*

Operating High Amperage Cells During Varying & Reduced Amperage Scenarios

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Abstract

Reliable power supply is essential for achieving higher energy efficiency of aluminium smelter. However, the **power outage** situations and varying amperages cannot be avoided and smelters are bound to operate in such circumstances. Mahan smelter is built with AP36 cell technology operating currently at about 365 kA. This smelter has faced over 50 zero current situation from the time of inception till date and also encountered several **varying and reduced amperage scenarios** due to several challenges faced at the power supply end. To operate at such conditions, extra voltage in inter-electrode gap is required in order to manage the pot thermal balance. Since, Mahan smelter utilizes **forced cooling network (FCN)** for extracting the heat from the sidewall at designed cell amperage, this gave an opportunity to reduce the FCN flow rate and operate the cell with lesser requirement of extra voltage. Computer simulations were also performed to identify the right parameters at reduced amperage for attaining the **thermal balance** of cell. This paper would detail about the steps taken with respect to modulation of **sidewall heat transfer** through FCN flow rate and other process parameters to ensure thermal balance at reduced and varying amperages.

Keywords: *Power outage, Varying and reduced amperage scenarios, Forced cooling network (FCN), Thermal balance, Sidewall heat transfer*

Quick Revival and Restart of Potine-2

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Abstract

Revival of Pot after stoppage and its turnaround time is crucial for aluminum smelter in reaching desired hot metal volume. In case of many **pot stoppages** due to power failure, busbar damage, etc, it calls for different approach to restore the business. At Vedanta, we have stopped almost 200 pots in Potline-2 during April, 2017 due to thermite reaction. **Cross functional team** had been formed to review the condition and came up with the different approach for quick restart of the pots onsite which is the biggest challenging task. This approach includes the **effective utilization** of **Pot Tending Machine (PTM)** in running potline, material planning & availability, pot structure repairing, busbar repairing with competent manpower resources. The key features of this approach are parallel deployment, advance planning of material & equipment, and stringent safety & quality inspection at each stages of revival process. The result is quick revival of all pots within span of 9

months bringing the entire potline in full production by January, 2018. This paper discusses in detail about the approach on repair types, relining practices, quality inspection along with problems faced during this process and their solution.

Keywords: *Pot stoppages, Cross functional team, Pot tending machine (PTM), Effective utilization.*

Effect of Power Failure in Graphitized Line Pots

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Abstract

Aluminium smelting requires uninterrupted power supply. Therefore, all types of power interruptions will affect the operation of aluminium cells. Such situations can occur without warning and a power failure of more than a few hours may severely damage pot line. Time is an important factor during power outage. Total losses for half an hour due to emergency or minor repairs are no problem. Stop for two to four hours are manageable while five hours or more, causes large problems with loss of cell life.

Unplanned Total Power failure (TPF) for more than 4 hrs, can be catastrophic. Cell temperature quickly reaches ~800-820°C within 4 hrs of power outage and can cause **forced shutdown** of cells. This paper investigates the after effect of power resumption in graphitized pots where massive **clad damages** occur, and pots will have to be forcibly stopped to avoid open circuit condition. Few new pots with median age of 338.5 (26-607) days lost in this disaster. All parameters show aberrant behavior. Shrinkage of electrolyte causes bath height to reduce by 30-50%, thereby increasing the bath resistivity, which in turn increases average volts/pot and so overall line voltage. Instability and anode effect (AE) also increases by 50-200%. It is difficult to push current in line in such type of situation. This paper presents:

(1) Understanding the effect of power outage on pot behavior.
(2) Actions to re-establish the full pot control after power interruption.

And finally, (1) It is very much important to keep in mind that a rapid and correct adjustment of energy is fundamental to accelerate the process of line recovery**.** It is also learnt that (2) In order to re-establish operation of line after prolonged shutdown, it is recommended to cut out pots according to the voltage needs**.**

Keywords: *Forced shutdown, Clad damages.*

Global and Domestic Supply Scenario for Coal Tar Pitch

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Abstract

As India has bountiful bauxite reserves and mining potential, there is a constant rise in the production and mining of bauxite. On the other hand, apparent consumption of bauxite is growing at a double digit CAGR (Compound Annual Growth Rate) in last few years. To meet this demand, Indian players are constantly increasing their production capacities to cater primarily to the domestic markets and to export the surplus stock. **Coal tar pitch (CTP)** is a critical binder material for **anode** production required in aluminium smelting through Hall Heroult method of electrolysis. **Coal Tar** (a by product of **coke oven**) is the only available source to produce CTP. CTP remains in high demand and supply is estimated to be tight in foreseen future. China remains the only practical alternative apart from domestic coal tar distillers to source CTP by smelters. However, in China, factors like closure of plants due to environmental concerns, use of coal tar in value added products with much better margins like **carbon black**, needle coke and battery materials will consume a substantial part of coal tar. This coal tar shortage for making CTP in combination with growing Chinese domestic aluminium industry will substantially reduce the CTP available for export. In India also, few Carbon black plants are slated to come on stream in next 3 years based on coal tar feedstock which will negatively impact coal tar available for CTP. With a combination of all these factors we predict CTP supply to be tight in next few years.

Keywords: *Coal Tar, Coal Tar Pitch, Carbon Black, Aluminium, Anode, Coke Oven.*

Coal Tar Pitch: It's Effect on Quality and Cost of Aluminium Production

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Abstract

Coal tar pitch is the main raw material used as a binder for anode manufacturing to be used in electrolytic pots for production of aluminium. Characteristics of pitch binder affect the **paste plant operation** and **anode performance** during electrolysis.

Generally, the coal tar pitches are favoured for the **anode manufacture** for their high **binding quality**. During mixing, the pitch coats the filler coke particles and thus plasticizes the originally dry powder, so that it can be formed to particular sizes of required shape.

During the subsequent heat treatment during baking, the pitch carbonizes and forms a coke that bridges the filler particles. The baking process is necessary to provide strong and dense anodes with electrical and thermal conductance suitable for the application in the electrolysis cell.

Rheological behaviour of the carbon paste has a major impact on anode manufacturing and performance. Characteristics of this behaviour are complex and difficult to characterize by a single parameter. An appropriate characteristic of pitch and a good control of coke aggregate size distributions are required for anode manufacturing and performance.

Paste fluidity behaviour is sensitive to pitch binder property variability and has a major impact on anode performance. Detachment of pieces of baked anodes in the pot cell can be identified as being major factor affecting cell performance. Stability of pitch binder characteristics can be pointed out as one of the most important parameters that affect anode performance.

Many smelters have been facing major problems in controlling the fluidity of paste and frequency of thermal shock for prebaked anodes. Detail Investigations on these problems have shown that the pitch binder characteristics have significant impact on paste and anode performance.

Quality of coal tar pitch plays an important role in manufacturing quality anodes for consistent life in pot lines, so also efficient operation of pot line both qualitatively and quantitatively.

Key Words: *Coal tar pitch, Paste plant operation, Anode performance, Anode manufacture, Binding quality.*

Calderys's Experience of Aluminium Non-wetting Castables: Conversion of Aluminium Melting Holding Furnace Refractory Design from Brick to Monolithic Lining

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Abstract

Aluminium has very **high oxygen affinity** compared to most of the metals. Hence, molten aluminium reacts with almost all refractories resulting in faster **corrosion** of refractory lining in aluminium melting holding furnaces. Moreover, refractories in metal contact area are subjected to severe mechanical and thermal shock along with corrosion by alkali, cryolite, alloying elements and flux used for dross removal. **Brick lining** has its own limitation due to higher number of joints, design limitation, less resistance to alkali and molten aluminium. Hence, brick lining of aluminium melting holding furnaces has been fully replaced with Monolithic lining and refractory design. Calderys is pioneer of in-house development of **non-wetting castables** for molten aluminium contact and has successfully developed monolithic design for aluminium melting holding furnaces in place of brick lining.

Monolithic refractory design has been successfully implemented in number of furnaces. This has helped to improve service life and also has increased furnace availability by reducing corundum build ups and less maintenance requirements.

Keywords: *High oxygen affinity, Corrosion, Brick lining, Non-wetting castables, Improve service life.*

Value Addition by Dastur as Owner's Engineer – GARMCO Cast House Expansion Project in Bahrain

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Abstract

Gulf Aluminium Rolling Mill (GARMCO) located at North Sitra Industrial Area (Kingdom of Bahrain) has successfully completed USD55 million **expansion projects** to enhance the production capacity of the unit by 120 KTPA of **rolling slab**. With this expansion, GARMCO strategically became a regional leader in **aluminium recycling facility** as well as established themselves as a sustainable supply chain creator by recycling a wide range of post-consumed material to high quality rolling slabs.

Fives Solios was appointed as EPC contractor of this expansion project and Dastur Engineering International, GmbH in association with M.N. Dastur and Company (P) Ltd. was involved in this prestigious project as Owner's Consultant. Commissioning the plant within 22 months was a challenge and GRAMCO, Dastur, Fives Solios and other associates joined hands to take-up the challenge and completed the project within stipulated time and target cost. The first cast was successfully taken on 3rd August 2017 – right on schedule.

This paper is intended to describe in brief the success story of timely completion of this prestigious project through **efficient project management** and controls. The innovative engineering ideas and out of the box solutions had made the difficult tasks easier that saved considerable amount of time. The systematic monitoring and control of activities at the grass-root level and proactive actions had also made it possible to arrest cost overrun.

Keywords: *Expansion projects, Rolling slab, Aluminium recycling facility, Efficient project management.*

Hydraulic Lifting: A Change Agent in High Power Transformer Safety for Internal Inspection

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Abstract

Power is considered a raw material for aluminium smelting process since it is power intensive and power sensitive as well. To supply **uninterrupted power** to the aluminium smelting pots, a robust and highly reliable power system is a must requirement. Nowadays, the biggest threat to any smelter is power reliability. Stoppages of aluminium smelters are caused by power system failure and **transformers** and **rectifier system** play vital role in this. So, in order to maintain good health of the transformers and rectifier system, timely maintenance, overhauling and internal inspection should be done.

Although not new, overhauling and maintenance of transformer with complete **lifting** of top cover at site in running system is very difficult and involves lot of safety hazards. Recently at Vedanta, Jharsuguda unit, we have done the internal inspection of all the high capacity transformers as recommended by Original Equipment Manufacturer (OEM) by opening the top cover of transformer. The task was started with the help of 150 tonne crane by clearing passage bay with the removal of LA structures and removal of other accessories of transformers, like oil pipes, conservator tanks, etc. The process was much time consuming and also very unsafe for placement of 150 tonne crane in the area where 220kv overhead high voltage conductors pass and chances of caving of cable trenches were high. So, the necessity of safe and easier way to do the task has led to the idea for lifting the **top cover of transformer** with **hydraulic jacking** arrangement. The new method of lifting the top cover of transformer through a hydraulic cylinder system has saved all kind of dismantling work (like LA, conservator tanks, pipe lines and placement of crane) and reduced the turnaround time of transformer internal inspection by 33% and safety aspect of the job has improved to a lot.

This is the first of its kind application in any power transformer in the world.

Keywords: *Uninterrupted power, Transformers, Rectifier system, Hydraulic jacking, Lifting, Top cover of transformer.*

Thermo Chemical Reduction of Aluminium Chloride

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Abstract

Aluminium Chloride ($AlCl_3$) is highly reactive and corrosive. It is classified as Lewis Acid and will always share a pair of electrons. If positively charged ions are introduced in the system containing AlCl3, then it would be possible to reduce $AlCl_3$, without resorting to electrolysis. For a reductant, **dry ammonia** (NH_3) is to be converted to NH_4^+ ions. For this, it is proposed to use Alpha (α) radiations. **Alpha (α) particles** are nothing but Helium (He) nucleus, having two protons (+) and two neutrons. These α-particles can convert dry ammonia (NH_3) in to NH_4^+ ions.

The NH_4^+ ions thus produced are passed in to a Reaction Chamber holding molten aluminium at 1000°K. Also, aluminium chloride vapour produced by carbo-chlorination of Bauxite is injected in the reaction. Since NH4+ ions & AlCl3 are in gaseous form, they will require a medium to react with each other. The reaction is proposed to be carried out in the medium of **molten aluminium** & molten salt bath of LiCl & NaCl (similar to the ones used in electrolysis of $AlCl_3$) at a temperature of 1000°K. The reaction occurring in the reaction chamber can be given as:

$$AlCl_3 + 3NH_4^+ \text{--------} \rightarrow \text{At 1000°K (in molten Al)} \text{--------} \rightarrow Al_{(l)} + \{NH_4Cl\}_{(g)}$$

Thus, the process uses medium of molten aluminium to produce aluminium/molten salt bath. The use of molten aluminium or molten salt bath also ensures a more +ve ΔS for the reaction as $\Delta S_{(total)} = \Delta S_{(system)} + \Delta S_{(surrounding)}$).

Aluminium metal that is formed would be in molten state and will obviously increase the volume of the bath of molten aluminium in the reactor. Ammonium chloride being in vapor state would leave the reactor. Aluminium is only tapped periodically from the reactor, thus always maintaining the medium of molten aluminium and the salt bath in the reactor. This would make the process continuous.

Keywords: *Aluminium Chloride ($AlCl_3$), Dry ammonia, α-particles, Molten aluminium.*

ALUMINIUM DOWNSTREAM

Circular Economy with Aluminium as the Front Runner

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Abstract

The global focus on **circular economy** represents a unique opportunity to bring aluminium to the forefront, as a material ideal for the new real resource efficient economy.

When old used **scrap** is collected, we start a process whereby aluminium can be re-used endlessly. Thus, the dependency of primary aluminium imports is reduced in many regions of the world dependent on this metal, and save energy and resources, in general.

To reach a truly circular economy, we must ensure to maximize the collection of all available aluminium, which will help us to phase out landfilling of recyclable materials. Next, we should develop and stimulate the innovation of new recycling friendly aluminium alloys, and also help encourage investments in gradually more efficient collection systems. We should continue to develop new sorting and treatment technologies to maximize the physical return of old scrap to the recycling furnace. According to International Aluminium Institute, 90% of all aluminium has been produced since 1972. Therefore, aluminium is still a young metal with unlimited opportunities for product and application development, and a large number of lives yet to live. For many applications, aluminium is still in its **first life cycle**.

Key Words: *Circular economy, Scrap, First life cycle.*

European and German Aluminium and Extrusion Market

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Abstract

The presentation will give an overview about the development of the European **Aluminium** Industry:

- Extrusion market
- Requirement trends
- Import / Export
- Perspectives
- Introduction of WKW group.

The aluminium **extrusion industry** in Germany and Europe is on course for further growth. Germany continues to be one of the largest production locations within the European aluminium extrusion industry and produces about 580.000 tonnes annually; its capacity utilization is around 90 per cent. Total demand in Germany is some one million tonnes a year, which is a third of European demand. Although Germany's import of extruded products, mostly commodities, has increased, Germany has compensated for that with higher exports. The good level of business

activity in the extrusion sector is being supported by the development of premium profile applications with enhanced user benefits, specialisation in niche markets with a high degree of product differentiation, and more products being offered along the whole value-creation chain.

Europe produced 3.4 million tonnes of extrusions in 2017. They are used in industry, the building sector and other markets. The transport and transportation sector are of particular importance where industrial applications are concerned.

Forecasts for the global economy have improved slightly in recent months. The **growth expectations** in the European industrial sector and building and construction industry can be described as solid.

Key Words: *Aluminium, Extrusion industry, Growth expectations.*

Aluminium Rolled Products Market Outlook

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Abstract

Globally, 40% of the total **aluminium semi's** demand is in the form of **rolled products**. The highest demand is in the form of can stock and foil stock, followed by demand from the transport sector. While the growing beverage industry is expected to support can stock demand, global adoption of emission and safety norms will support demand from the transport sector. As acceptance and production of electric vehicles increases, this can provide further upside to the demand of rolled products in the transport sector. In contrast to the global scenario, however, demand in the form of rolled product in India is only 15% of total aluminium consumption. In this paper we will discuss the demand outlook of rolled products both in the global markets as well as domestic market and the **demand drivers** for them.

Keywords: *Aluminium semi, Rolled products, Demand drivers.*

Alloy Ingot Development and stabilization

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Abstract

Aluminum Alloy Ingots (A356.2) are used in automotive industries for wheels, aerospace castings, structural parts, automotive suspension components because of its enhanced properties like high strength, ductility, thermal conductivity, good corrosion resistance and good fatigue properties. The domestic market of A356.2/LM25 was 191 KTPA in FY2016-17. Qatalum is the market leader in this segment, followed by Alba, Press metal and Dubal. Vedanta, BALCO is the first smelter to produced A356.2 Alloy Ingot in India.

The main aim of this paper is to demonstrate the **development** and stabilization of A356.2 Alloy Ingot at BALCO, present **market** capture across India and scope of Balco globally as a primary producer of A356.2 Alloy Ingot.

Key Words: *Alumina alloy ingot (A356.2), Development, Market.*

The Future of Aluminium Fuel Tankers in India

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Abstract

The **transportation sector** across the world is currently facing the huge task of **light weighting vehicles** and decreasing the carbon footprint. Tankers used for bulk haulage are no exception to this trend. Fuel tankers are used to carry petrol (gasoline), diesel, chemicals and other dense products such as lube oil, cooking oil and powder products like cement, sugar and alumina. Aluminium, the ideal material for light weighting, has extensively replaced steel in the US and Europe, for most of these applications. The practice of using **aluminium tankers** to transport hydrocarbon fuels is well established in the developed world, and is now gaining acceptance in countries like Malaysia, Indonesia, China, and the Middle East countries. As for as India is concerned, the usage of aluminium tanker is quite limited as the industry and faces several hurdles. This paper deals with **benefits** that the aluminium tankers can offer in bulk haulage of hydrocarbon fuels, the various **constraints** that hinder the shift to aluminium tankers in India and the steps needed to bring this important **development** to fruition.

Key Words: *Transportation sector, Light weighing vehicles, Aluminium tankers, Benefits, Constraints, Developments.*

Application of Praxair's OPTIVIEW™ Image Analysis System in Aluminium Tilting Rotary Furnace for Energy and Productivity Optimization

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Abstract

Secondary aluminium smelting in **tilting rotary furnaces** (TRFs) can produce highly variable carbon monoxide (CO) and volatile organic compounds (VOC) emissions due to rapidly changing operating conditions. The energy available from oils, grease and paints contained in some types of scrap with a high degree of fuel value may be lost and dramatically impacts productivity, if the combustion stoichiometry is not properly controlled.

Praxair's innovative **OPTIVIEW™ Image Analysis System** presented an effective solution for Al TRFs. This technology dynamically controls the combustion in the furnace by modulating the burner firing rate and supplemental oxygen injection using real time off gas flame image information. The system has been successfully in operation at Aluminio la Estrella's in Spain for almost two years. Updated operating data analysis validated the improvements on energy efficiency, productivity and emission control.

Key Words: *Tilting Rotary Furnace, OPTIVIEW™ Image Analysis System.*

Energy Efficient HTLS Conductors

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Abstract

Increased energy consumption in industrial and commercial sectors has significantly increased the loading of power transmission lines. But with the existing lines of ACSR/AAAC conductor, it is difficult to increase the current carrying capacity since the maximum operating temperature is limited up to 75-85°C. Also, operating more than aforesaid temperature will results to deviation in sag/ground clearance due to loss in conductor strength. In order to meet the power demand, there are two major ways to increase the capacity i,e. by using **high temperature low sag conductors** and by new transmission line. To construct new lines, the deal with Right of Way (ROW) will be challenging because of increased population density, growth of infrastructures, increasing environmental concerns and cost. So, replacement of existing conductor with high performance

conductor will be of suitable solution to increase the power capacity. This paper focuses on the study of various conductor solutions such as ACSS, STACIR & ACFR to address the energy demand.

Key word: *High Temperature Low sag (HTLS) conductor.*

Controlling Inverse Segregation in Wagstaff Hot Top Airslip Casting

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Abstract

Inverse segregation in aluminium cast billets is a type of segregation which occurs due to **rapid cooling** and associated stresses. Higher intensity of inverse segregation results in generation of thicker **scalp** from billets while extrusion and **chemical inhomogeneity** developed, which in turn results in reduced strengths, toughness, resistance to creep deformation and poorer corrosion resistance. Recommended value of inverse segregation from Wagstaff hot top casting technology is around ~200 microns. This paper chalks out the impact of high inverse segregation on extrusion part of billet and the methods implied in minimizing its value. Analysis and study of the impact of various casting parameters like water flow rate, water temperature, casting speed, etc., are the key attributes of this paper. This experimental study has not only helped us to establish the optimum parameters for billet casting but also resulted in lesser scalp generation and improved chemical homogeneity (by reduced inverse segregation of billet).

Keywords: *Inverse segregation, Airslip casting, Rapid cooling, Chemical inhomogeneity, Scalp*

Surface Quality Improvement by Improving Response in Hydraulic Circuit in Cold Mill

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Abstract

This paper aims to address '**Skidding mark**' is one of the critical surface defects of the high end aluminum rolling products. Skidding mark is a rolling metal condition wherein a line mark perpendicular to the rolling direction gets created on the surface and repeats at a distance equal to a work roll circumference. The surface has the appearance of a series of scratches in the rolling direction, normally on one side of the sheet but can be on both the sides as well. These generally occur from the skidding phenomenon between the work roll (WR) and the back-up rolls during the different rolling conditions. There can be multiple roll skids and there can be a broken surface on the rolls, which ultimately get transferred on the aluminum sheet. These looks like narrow line, typically 3 mm (1/8 inch) to 12 mm (1/2 inch) wide, consisting of scratch or scuff marks in the rolling

direction. In most cases they are located at the outermost edges of the sheet, however, if severe enough, will be present across the entire width.

A skid mark results when a work and back-up roll surface speed is relative to one another. To avoid the **relative velocity** between backup roll and work roll, sufficient amount of bending/ balancing pressure should be available, especially when roll gap is in open condition and WR is rotating. This type of occurrence can happen during close gap tail out and in case of any emergency stop.

To avoid this it has to be ensured that: (1) Bending circuit **response** should be on the range of ms range whenever it requires, (2) Bending pressure is being controlled with fast enough actuating servo valve and with the help of PI controllers, and (3) The response of the bending should be dependent on the response of PI controller, Servo valve actuation and accumulator pressure at bending circuit.

This paper explains the phenomenon and the actions against each of the above with elaborate illustration.

Keywords: *Skidding mark, Relative velocity, Response.*

Advanced Technologies and Production Facilities for Manufacture of Thin Walled Aluminium Sand Castings for Aerospace and Defence Applications

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Abstract

With the exponential **growth in aerospace civil sector and defence**, the requirement of aircraft for civil and military is many folds. Efforts are underway to reduce weight of the aircraft and increase the passenger capacity while reducing the fuel consumption.

More and more **aluminium alloy** aircraft components and castings are used in aircraft structures, aero engines due to its light weight and specific strength. Complex thin walled aluminium sand castings such as housings, covers are used in hydraulic and electrical systems. The wall thickness of these castings measures a mere 1.5 to 2.0 mm.

The presentation with the above topic will showcase various aluminium alloys, advanced casting technologies and the production facilities available in the country. The presentation also covers quality requirement of the castings.

Keywords: *Growth in aerospace civil sector and defence, Aluminium alloy.*

Aluminium Recycling

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Abstract

With **explosive growth** being witnessed in the country, there is a growing importance of **aluminium recycling** due to higher consumption. Factors to consider are as follows:

1. Conservation of resources,
2. Conservation of energy,
3. Reduction in pollutants, and
4. Lower environmental hazards.

These factors have given secondary aluminium a higher intrinsic value in the industry. **Technological improvements** over the last few decades have helped recyclers derive **higher value** from **scrap**.

a. Scrap processing technology has allowed for improved material management and automate our production process.

b. Melting technology has traditionally been for ingots, with the increased importance of recycling, it has evolved to cater to scrap.

c. With increased demand of different alloys by many different industries, Liquid Metal supply is the latest in "Just-In-Time" metal supply.

Keywords: *Explosive growth, Aluminium recycling, Technological improvements, Higher Value, and Scrap.*

Round Top Charge Aluminium Melting Technology

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Abstract

When Andritz Metals Inc. first introduced **Round Top Charge** melting technology to the Aluminum Industry this furnace was a unique configuration. Today this geometrical configuration is the "standard" configuration for high productivity cast-houses in the USA and China.

The object of the paper is to introduce the Round Top Charge concept to the Indian Aluminum Industry and outline the reasons for its wide acceptance as the "go to" furnace configuration for modern high productivity aluminum cast houses.

By contrasting conventional rectangular furnace designs with the Round Top Charge philosophy the paper will explain the significance that **furnace geometry** and **loading geometry** has on:

- Productivity
- Energy Consumption
- Equipment service life.

Keywords: *Round Top Charge, Furnace geometry, Loading geometry.*

Growing Use of Aluminium in Metro Rail and Transport Industry

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Abstract

India currently makes its way with barely 300 applications of aluminium compared to the developed countries with over 3000 applications. Aluminium usage in India is growing and the upstream industry players are also investing in capacity expansion. Output is set to rise from 3.3 million tonnes in FY 2015-16 to 5.3 metric tonnes in FY 2020-21, as predicted by various industry experts. In addition, government measures like 'Make in India', Smart cities, Housing for all, rural electrification, freights corridors, etc. are factors that offer great opportunity for companies of all sizes.

Growing import of primary from China can be considered as a huge opportunity for value-addition and to expand product portfolio, especially for the downstream players. US is one among them who strategically shifted to value-added products after being held back by growing imports from China. Alcoa is one of the classic examples who started a separate downstream company called Arconic, catering to potential sectors like automotive, aerospace and packaging.

BFPL will be looking to become the strongest downstream player in the aluminium space in India with a clear strategy in the aluminium chain and remains optimistic on the usage of aluminium products in various segments. The growing acceptability of aluminium coupled with the push of the Indian economy towards 'manufacturing' keep BFPL optimistic in achieving exponential growth in various segments in the coming years.

BFPL identifies transport segment as one of the major industry for growth. The light weight of aluminium is making it the metal of choice across the segment – Aerospace, Railways, Metro Rail, Commercial Vehicles, passenger vehicles, and defence vehicles.

The metro rail segment is emerging as a strong sector with almost 25-30 cities in India looking to establish metro for mass transport. The new technology, such as the bullet train recently launched by India-Japan partnership, also presents opportunity for highly technical products.

The advantage of an aluminium car is the light weight, which is one-third compared to steel. It's higher initial cost is returned in the first two years of operation because it can carry more cargo and has higher acceleration and deceleration speed. In rapid transit and suburban rail systems where trains have to make a lot of stops, significant savings can be achieved as less energy is needed for acceleration and braking with aluminium cars.

The paper deals with various applications and prospects of aluminium in transport and metro rail industry.

Key Words: *Aluminium usage, Opportunity, Value addition, Transport segment, Light weight.*

Ingenuity at Work through Digitization

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Abstract

In the current business scenario "**Data**" has become the most critical resource of any organization to build the organization for future which will give new promises to shop floor for lowering operating cost, better visibility, process reliability and improved Overall Equipment Effectiveness.

This paper aims to define **innovative way of working** and step jump in the pattern that is known today. The journey sees the release of creative energy, accept failure as learning and ultimately rebound to build the future success. It has transformed manufacturing facility into smart facility by introducing real time intelligence for facilitating quick decision making to ensure process & equipment reliability, sustainable and green practices. The driving philosophy behind this is that smart machines are better at accurately and consistently capturing and communicating real-time data which will enable us to pick up on inefficiencies and problems sooner, saving time and money and supporting business intelligence efforts.

The **Intelligent Plant Framework** is a web-based platform that provides real-time visibility and historical data analysis. The uniqueness of this solution lies in capturing data directly from machine, ERP, Utility system, Operators and providing impact analysis for profitability and performance.

Keywords: *Data, Innovative way of working, Intelligent plant framework.*

Microstructural Characteristics of Strip Cast Aluminium Alloys

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Abstract

Strip casting of a wide variety of **aluminium alloys** is in commercial operation in the world with annual production of several million tonnes. It is well known that **twin roll casting (TRC)** can refine the microstructure by several orders of magnitude compared with direct chill casting and static casting processes. There is consistent trend in **microstructural refinement** with increasing cooling rate. TRC generates a fine grain size in the range of 30-100 μm and secondary dendrite arm spacing (SDAS) in the range of 3-8 μm. However, TRC is often characterised by columnar grains that nucleate at the roll surface and grow inward in a highly oriented manner but with slight inclination towards the casting direction. Therefore, aluminium alloys are usually inoculated with suitable grain refiner prior to casting. In addition to microstructural refinement, high solidification rate associated with strip casting of aluminium alloys favours formation of metastable phase, reduces the volume fraction of phases, increases the solubility of alloying elements and hence promotes supersaturation. Thus, strip produced by this process is susceptible to a number of characteristic casting defects. These defects can be classified into two broad categories, viz. macro

and micro defects and are the result of combination of solidification and application of the rolling load that occurs in twin roll casting. Such microstructural features and defects eventually affect the forming characteristics of the sheets. JNARDDC is working on the forming characteristics of the twin roll cast alloys and some of the findings are presented in the paper.
Keywords: *Aluminium alloys, Strip cast, Twin roll casting, Microstructural refinement.*

Die Design for Generic Tube Profile Using Port Hole Dies

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Abstract

Aluminium extrusions are widely used in various applications ranging from architectural, automobile, heat transfer to aerospace. Design of dies and tooling is the critical step in aluminium extrusions. Based on the requirement of customer, dies are being designed and manufactured in tool room. Various empirical relationships are being used in the shop floor for **die design**. These empirical relationships are based on metal flow knowledge of operator and may vary with respect to alloy, operator and also on profile.

In this technical communication, a generic tube profile of 2 mm think was taken up for studies. The profile was extruded using port hole dies. Design of dies was based on metal flow analysis by numerical simulations based on plant process data and first principles. **Design validation** was performed by fabrication of die based on design data. Also, a pressure estimate was derived based on states of the extruded during port hole die extrusion. AA6063 alloy billets of diameter 90 mm were used for valuation of real time extrusion press of capacity 450 tonnes. The results indicated good correlation between simulation and real time plant data and the profile was successfully extruded in first trial itself.

Keywords: *Aluminium extrusions, Die design, Design validation.*

Recycling Aluminium Chips / Scrap Effectively by Briquetting

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Abstract

Recycling aluminium scrap effectively is the current trend worldwide to increase revenue. By **Briquetting** aluminium chips / scrap, resources can be conserved, energy costs reduced, and the plant can be kept clean and safe.

The advantages of briquetting aluminium scrap are:

- Energy savings,
- Volume reduction,
- Recovery of the expensive cooling lubricant,
- Reduction of logistics costs,
- A clean production,
- A contribution to resource and environmental protection, and
- Value addition.

Furthermore, the melting efficiency increases by briquetting. Typically, when loose aluminium chips / swarf are charged in fuel fired melting furnaces, melt losses are up to 20%. By using briquettes with aluminium scrap, melt losses are 2-3%.

The first Briquetting System supplied more than 20 years ago to a well-known plant at Sweden, reduced the volume of the Aluminium Chips to one tenth the volume of loose chips.

We will evaluate how plants use briquetting to improve efficiency and profitability in this paper with some case studies.

Keywords: *Recycling, Aluminium Scrap, Briquetting.*

Apar's Contribution to Aluminium Industry

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Abstract

Apar Industries Ltd (Apar), a US $ 1.0 Billion diversified conglomerate, is a dynamic example of meeting downstream customers' growing needs through the manufacture of niche Specialty Oils, **Power Transmission Conductors and Cables.** Apar's involvement in core aluminum Industry includes speciality with its Product Mix, Product Range specific from Conductors Division, Manufacturing and Testing Capability, Specialization with indigenously developed Superior Quality **Aluminum Alloys** for use in New Technology **High Temperature Conductors** which offer an attractive option for high capacity EHV transmission lines and a viable solution for uprating / upgrading of existing powerlines. Apar also has expertise in metallurgical domain during aluminium smelting.

This presentation will discuss about Apar's strength and special contribution to the **global power sector** with emphasis on aluminium smelting and products as well as its role to the business of the customers through proactive product development, timely delivery and superior product attributes by reinforcing innovation, cost leadership and premium quality and living its vision 'Tomorrow's Progress Today' resulting in, Reliability, Respect, Reputation and Repeat Businesses.

Keywords: *Power transmission conductors and cables, Aluminium alloys, High temperature conductors, Global power sector.*

BAUXITE, ALUMINA AND ALUMINIUM MARKETS

Data Report on Chinese Demand for Imported Bauxite

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Abstract

Chinese **bauxite supply** in inland regions including Henan and Shanxi became tight from 2017 and a few major alumina refineries are managing to import bauxite for test production.

Big new alumina refineries with annual capacity above 2 million tonnes are moving to coastal provinces like Liaoning of East China, in a bid to depend on **imported bauxite**.

Chinese dependency on imported bauxite is growing.

Keywords: *Bauxite supply, Imported bauxite, Chinese dependency.*

Bauxite-Alumina Supply and Demand Scenario of China

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Abstract

China is the world's **largest alumina and aluminium producer** and China's development of Al industry may impact the world's Al industry in the largest extent. This paper mainly introduces China's **current status** in global Al industry and **forecast** in the next decade. China's overseas investment in Al assets and how China's overseas investments may reshape the global bauxite and alumina industries in the future. Besides, China's **environmental policy** may be the main restricting factor to China's development in Al industry. This paper will make a simple interpretation of how China's environmental policy may impact China's alumina and aluminium industry.

Keywords: *China, Largest alumina and aluminium producer, Current status, Forecast, Environment policy.*

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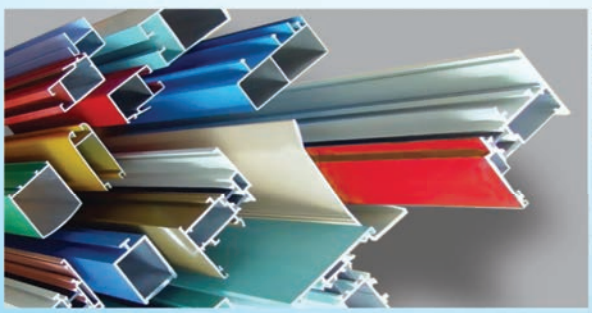

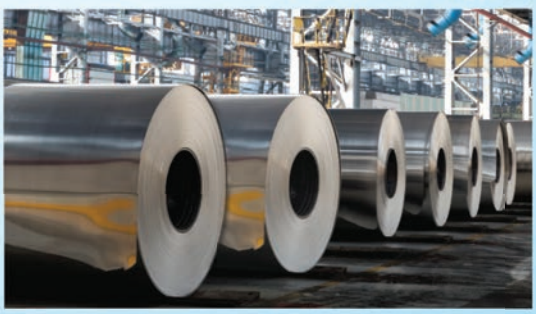

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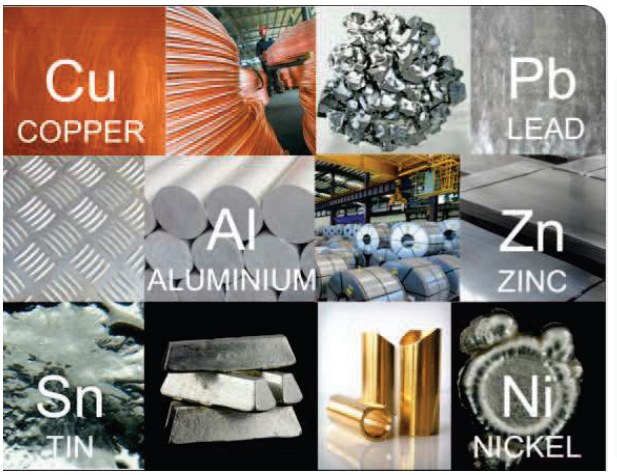

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