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Aluminium in India

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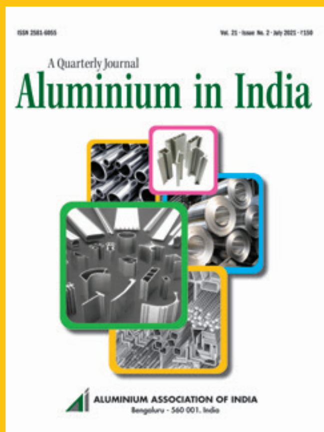

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Aluminium in India

A Quarterly Journal

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editorial desk

Ashok Kumar Murthy,
Editor-in-Chief

Dear Readers,

Government of India is Re-engineering its Vaccine Strategy, for survival and a better quality of life for the people as well as for the revival of the economy of India by various renewed economic measures & ensuring to safeguard the nation from the spread of the virus and has come out with more measures to boost the economy which has been hit by the second wave of the coronavirus pandemic.

To boost domestic production with consumption also to increase capabilities of MSME. The finance minister announced widening of the Emergency Credit Line Guarantee Scheme under which collateral-free loans are given to MSMEs.

India can set up manufacturing units and become an export-driven economy which will provide ample job opportunities for India.

Against the backdrop of a COVID-19 pandemic that has changed the course of daily life, the pandemic has triggered rapid development, transformed the way consumers perform, interact with businesses, and how corporations interact. New opportunities and business models are emerging for those that are ready.

Industries are embracing the unpredictability of COVID-19 in creative ways by identifying potential opportunities.

New innovations, new insights and perspectives pave way for enormous scope of opportunities for the downstream industries in aluminium in manufacturing conductors, extrusions, castings, foils and others including powder. Similarly, there will opportunities for ancillary industries (raw material inputs) in the areas of calcined petroleum, special refractory bricks, cryolite, caustic soda and aluminium fluoride and other related products

In this issue, papers on Developments and Innovative Applications of Special Alloys and Composites of Aluminium, Low Loss Conductor for Renewable Segment, Container Less Cold Forward Extrusion of Alm-TiB2p Composite Rods (Solid Bodies) and Hot Oil System Design and Maintenance Guide, from eminent authors are included.

We hope this information will be useful to all those concerned. We look forward to receiving feedback from reader of our journal on layout, contents, etc. It is only with the help of feedback from readers that we will be able to improve the journal and make it more and more useful to members.

Membership of the Association is open to all producers of aluminium and its downstream products, researchers, teaching faculty, technologists and personnel from Institutions engaged in education, research, consultancy and management services.

We value and understand the importance of cultivating relationships and expanding our horizons as to what is new in the area of technology development and added-value and benefits to the members.

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"Aluminium-in-India" (ISSN 2581-6055) which is the flagship quarterly journal of Aluminium Association of India.

The Journal is focused on technical articles and featured techno-commercial articles dealing with product development, process development focusing on tremendous change in the aluminium industry scenario both in India and world over and other articles of general interest for the benefit of Indian Aluminium Industry.

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DEVELOPMENTS AND INNOVATIVE APPLICATIONS OF SPECIAL ALLOYS AND COMPOSITES OF ALUMINIUM

PROF. SAROJ KUMAR NAYAK and **DR B K SATPATHY**, IIT, Bhubaneswar

After iron, aluminium is by far the most widely used metal in the world. It has a unique combination of attractive properties. Many of these are extremely important in our efforts to create a more sustainable society: Low weight, high strength, superior malleability, ease of machining, excellent corrosion resistance and good thermal and electrical conductivity are some of aluminium's most important properties. With a specific mass of 2700 kg/m3, aluminium is the lightest of all ordinary metals, nearly three times as light as steel. Unalloyed aluminium has a thermal and electric conductivity about 60% of copper, which accounts for its development as a conductor, in different forms. Aluminium and its alloys provide excellent resistance to atmospheric corrosion in marine, urban and industrial equipment which extends life and reduces maintenance costs of equipment. As far as suitability for surface treatment is considered aluminium and its alloys lend themselves to a huge variety of surface treatments and enhances its intrinsic qualities (Ex- anodizing of a few micrometers is enough to preserve the optical or decorative properties of the materials, while improving resistance to corrosion and stress).

It has a diversity of alloys and intermediates. No less than eight families of aluminium alloys offer properties suited to their contemplated use, including weld-ability, corrosion resistance, superior mechanical performance and can be converted or processed to different forms. Aluminium alloys are used in all the customary processes of forming, bending, vessel-making, stamping, machining and in high tech applications including space and defence and therefore a potential resource for downstream products.

Some of the emerging applications of special alloys of aluminium in different areas include:

- Aerospace - A 100 kg loss of weight reduces fuel consumption drastically. In the last 35 years, newly designed alloys and increasingly innovative conversion and assembly processes have halved the weight of an airplane's structure.
- Automotive - The automotive use of aluminium is expected to double in the next ten years. A fleet of aluminium vehicles saves the equivalent of 44 million tons of CO2 emissions.
- Marine - Marine transport is increasing its use of aluminium by capitalizing on its two leading qualities: lightness and corrosion resistance.
- Rail - Lighter structures, resistance and durability have made aluminium crucial to rail transport applications. The high-speed train is made of aluminium alloy sheet metal and extrusions.
- Building - Commonly used in extruded, sheet-rolled or moulded form for window frames and other glass supports, for siding and partitions, aluminium is a favourite element of modern architecture.
- Packaging - Modern packaging is one of the leading consumers of aluminium. Its lightness saves both on the material and the energy it takes to produce it.

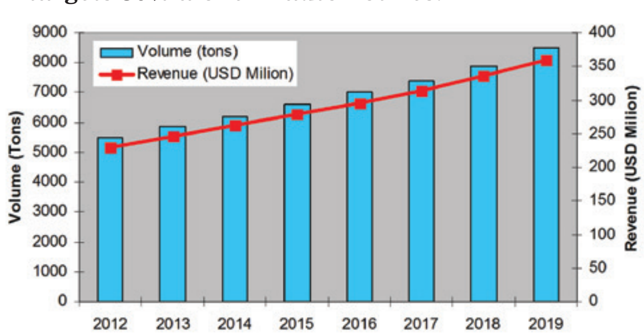
In addition to the major elements that define the alloy systems discussed, commercial aluminium alloys can contain other elements that provide special characteristics. Lead and bismuth are added to alloys 2011 and 6262 to improve chip breakage and other machining characteristics. Nickel is added to wrought alloys 2018, 2218, and 2618, which were developed for elevated temperature service, and to certain 3xx.x cast alloys used for pistons, cylinder blocks, and other engine parts subjected to high temperatures. Cast aluminum bearing alloys of the 850.0 group contain tin. Alloying aluminium improves its machinability. Elements in solid solution that make an alloy heat-treatable or work-hardenable increase the hardness of the aluminium matrix and thereby reduce the built up edge on the cutting tool; formation of burrs, roughness and tearing on the machined surface; and the length of chips. Some of the characteristics and challenging phenomena relating to special alloys and composites of aluminium are:

- Additions of lithium to increase mechanical performance and decrease density. Li-additions are often lower than other 'conventional' alloying elements.
- Reinforced alloys (metal matrix composites - MMC) consisting of aluminium alloys reinforced with whiskers, metal wires, boron fibres or carbon fibres.
- Not all alloys are weldable. Most high-strength alloys cannot be brazed.
- Alloys in space use should follow processes extremely reliable. Aircraft industry standards are normally to be followed.
- Processing of metals gives rise to residual stresses that may cumulatively reach design-stress levels, particularly as regards fatigue phenomena etc.

Metal Matrix composites (MMCs) with tailored properties have the potential of becoming one of the fastest growing families of new materials, which can have a large impact in India. At this time the best performing and the most expensive MMCs are being considered for high value added, relatively low volume military and aerospace applications. However, automotive and other engine and electromechanical energy applications which require lower cost and higher volume are now being commercialized and these should be of greatest interest to India. With continued development of composites manufacturing processes and improvement in alloy design including the possible use of particulate composites, high performance and low cost will draw close together. The development in near future will involve using the casting and powder processes to produce tailored interface, new matrix alloys of aluminium which will yield higher ductility and toughness along with higher strength in the products. The science of predicting properties and performance of metal matrix particulate composites will considerably grow. Presently the low cost particulate composites such as cast aluminium alumina-silicon carbide and aluminium graphite composites appear to be most promising in India. These composites can be introduced using readily available ingredients and simple techniques, and can be used in energy and materials saving applications. It will be best to begin with simple application like bearing, pistons, cylinder liner and then more into other high performance components. Aluminium and its alloys provide the use of different reinforce and improve materials. The basic advantages of composite materials with aluminium matrices in relation to materials without reinforce materials are:

- Higher strength
- Higher stiffness
- Reduced density (weight)
- Improved properties at high temperatures
- Controlled thermal expansion coefficient
- Controlled heating of material
- Improved and adoptive electrical conductivity
- Improved resistance to abrasion and wear
- Controlled weight (especially for applications with piston like motions)
- Improved amortization ability.

The market projection of MMCs is as below which targets 50% alone in automotives:



India should pay special attention to the possible use of MMCs in energy, housing and transportation sectors which are of high priority including solar photovoltaic, semi conductor and super conductor industries. Some of the new material, processes being developed in this direction are as below:

- **Aluminium Graphene** composites prepared in different processes are being tried and likely to emerge as new potential material for auto and energy sectors. Graphene is one of the potential material significantly improves conductivity and strength when introduced in to the body of aluminium and its alloys.
- **Hot Form Quench (HFQ)** process allows manufacturers to form deep drawn complex shapes from high and ultra high strength aluminium using a fast process with cycle time suitable for a range of volumes from niche to high (For high strength aluminium structures for body and chassis applications).
- **Peter the Great St. Petersburg Polytechnic University (SPbPU) has developed** a technology that can produce **porous aluminium alloy** that can float. In this process, foaming gas is added into liquid aluminium during re-melting process. According to the developers this technology can be successfully used in aluminium shipbuilding to achieve unsinkability during leaks in the hull.
- **Constellium N.V. (A company) has introduced a new generation of high-strength 6000-series alloys, Constellium HSA6TM,** to help automakers meet growing demand for lighter weight vehicles. Ideal for extrusion-based Crash Management Systems, Body-in-White structural components and battery enclosures, Constellium HSA6TM allows designers to optimize extrusion shapes and reduce wall thickness to achieve weight savings of 15-30% compared to conventional aluminium alloys. With ultimate tensile strength (UTS) higher than 400MPa, Constellium HSA6TMalso provides enhanced recyclability, machinability and corrosion resistance. Alternately, Constellium HSA6TM can provide 15-30% additional strength to reduce intrusion in the event of a crash, thereby enhancing protection of batteries, cooling systems and other critical vehicle systems.
- **Russian researchers** have created a new nano powders that can be added to aluminium alloy. Nano powders when added with aluminium alloy offers high strength and enhanced qualities to the alloy and makes them more flexible. The aluminium processing technology with use of special nano powders unveils new opportunities to produce composite materials with improved properties, that is, with higher strength, rigidity of flexibility etc.

Additive Manufacturing (AM) is one of the latest technologies applied to Powder Metallurgy (PM) to achieve precision and avoid multi steps operation like: casting, homogenising etc. and can take care of producing products out of special alloys and composites of aluminium. The European Market alone has an annual turnover of over 6,000 M€, with annual worldwide metal powder production exceeding 1 million tones. Atomization of aluminium powder for AM process is evolving and innovating. The technology is new and upcoming when application to aluminium is concerned. As far as its application in aluminium and its alloys are concerned, we are yet to make a beginning in India. Similarly, process for production of aluminium powders through atomization is a high tech area and India depends on import fully. By producing parts with a homogeneous structure the Aluminium PM Process (through atomization and AM) enables manufacturers to make products that are more consistent and predictable in their behavior across a wide range of applications with value addition which include the following:

- Structural pieces with complex shapes;
- Controlled porosity;
- Controlled performance;
- Good performance in stress and absorbing of vibrations;
- Special properties such as hardness and wear resistance
- Great precision and good surface finish;
- Large series of pieces with narrow tolerances.

To take full advantage of AM design possibilities, it is important to redesign conventional parts. Design optimization can be done in several directions using aluminium powder with an objective to: Reduce the total number of parts; Design for functionality; Lightweight; Topological optimisation (integration) and Design for ease of fabrication. The use of composite materials has been rapidly growing in the aerospace industry. The latest generations of aircraft have demonstrated huge progress with the A350 XWB's structure at 53 % composite and the Boeing 787 at 50 %. The most common target within the industry is to achieve 50 % composite content and 20 % weight reduction by 2020. With implementation of the new generation of twin-aisle jets, composite demand is expected to triple over the next 20 years. Composite materials are significantly more expensive to produce than aluminium. For example, thermo set composite materials cost about 15 times and thermoplastics cost around 75 times what it costs to produce the equivalent in machined aluminium.

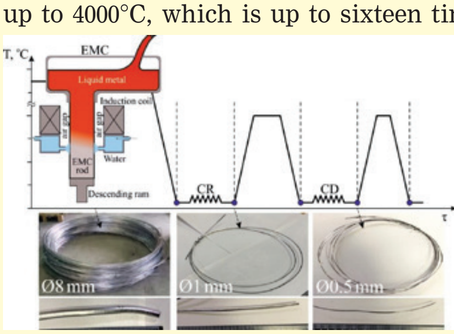
Since the above applications described need special alloys and few composites of aluminium having continuous developmental needs and specialised processes with high capex, entry of primary producers for development and production of such alloys, is necessary. Subsequent, processing of the same to finished products could be taken up by the secondary producers. With ongoing advances in aluminium alloys and composites, its environmental credentials and potential in automotive, space and defence the products will witness significant growth and utilities in these sectors in Asia in general and China and India in particular.

RUSSIAN SCIENTISTS DEVELOP NEW HIGHLY HEAT-RESISTANT ALUMINIUM ALLOY

Russian researchers have developed a new process for producing a heat-resistant aluminium alloy that is more durable than comparable alloys.

Researchers from the National University of Science and Technology "MISiS" (NUST MISIS), the Siberian Federal University and the Research and Production Centre of Magnetic Hydrodynamics (Krasnoyarsk) published an article in the Materials Letters academic journal describing the discovery, which they say has the potential to replace heavy copper conductors in the aircraft industry.

The new aluminium alloy is produced in 10 mm billet using an electromagnetic crystalliser. It is thermally stable up to 4000°C, which is up to sixteen times higher than conventional aluminium alloys.



Nikolay Belov, Chief Scientist and Professor of Materials Science and Light Alloys at MISiS, said the new process also simplifies the once-complicated production of such aluminium alloys.

"Before, alloys with such a structure were attempted to be produced using complicated and expensive technology involving ultrafast melt crystallisation, pellet production and subsequent methods of powder metallurgy."

Key to the production of the new alloy is the ability to produce thermally-stable nanoparticles by joining copper, manganese, and zirconium with elemental aluminium. The process uses annealing and casting techniques that are distinctly different from traditional homogenization and hardening methods.

Torgom Akopyan, senior researcher at NUST MISIS Department of Metal Forming, said his team will be taking the next steps in bringing the new aluminium alloy to the wider public.

"We have been able to produce a high-strength heat-resistant wire from this alloy. We are now determining its physical and mechanical properties, and the first results are already very impressive. We are planning to patent the method of producing this type of wire."

In addition to aerospace, researchers say the new aluminium alloy could find use in high-speed rail transport sector and the aluminium semis market.

LOW LOSS CONDUCTOR FOR RENEWABLE SEGMENT

CHINTAN PANDYA, Asst.Manager – NPD, Sterlite Power Transmission Ltd.
RAKESH TRIPATI, Manager – NPD, Sterlite Power Transmission Ltd.
ANANTHAKUMAR R, Chief Manager – Technical, Sterlite Power Transmission Ltd.
VISHAL SHARMA, Operational Head, Sterlite Power Transmission Ltd.
SAIKRISHNA BENDAPUDI, Chiel Operational Officer, Sterlite Power Transmission Ltd.

Abstract

India is one among the largest producers of Renewable energy. It's around 35% of installed capacity. Effective transmission of the generated power to main grid from hydel, solar, wind, biomass etc is one of the key aspects to have this development worth for society and nation. The power generated from these sources is categorized as clean energy and loss of such energy for any reasons is loss of value. The power generated in the Wind farm, Solar farm or any other renewable source is of Medium voltage level, in the range of 6.6kV to 33kV. In this medium voltage range on transmission of power, there are huge I^2R losses in comparison to higher voltages ranges. Also, renewable energy developers need a vast network of these Medium voltage level for interconnection between these Wind turbine Generators and connecting all of them to nearest ISTS (Inter/Intra State Transmission System) Substation which will eventually increase the I^2R loss. Considering the challenge of medium voltage and vast networks, use of conventional ACSR/AAAC conductors will result in huge losses to renewable energy developers.

The stern competitive bidding among the IPP's (Independent Power Producers) has lowered the tariff of Renewable energy which also enabled advancements and exploration of new technology among the IPP's for increasing the returns on the investment. In order to reduce the power losses and with no major impact on structure loadings, Sterlite Power developed an innovative solution of new combination of aluminum conductor which has least loss compared to other conventional conductors by margin of up to 40%.

Keywords — High Performance Conductor, ACSR, Al59, AAAC Conductor, Power loss

1. INTRODUCTION

Wind Turbine generators are placed at mean distance of approximately 25-50m apart based on the topology and various other parameters. The average circuit bus length of the interconnection between different wind turbine generators varies from 25-50km based on size of the farm. The distance between the WTGs and vastness of the wind farm will increase the internal I^2R losses. The interconnection between the turbines to feeder bus and then to the main bus for power transmission to the grid will have its own internal loss.

The voltage across the interconnection feeder bus is 33kV and the average route length of the feeder bus is 50km. The available conductor which are used by the Independent Power Producers are ACSR & Al59 Panther Conductors for such medium voltage range as conventional products. The power evacuation required by IPP is 30MW through 33kV Double Circuit line. The ampacity in the conductor required to meet the 30MW in Double Circuit is 322A per conductor.

The ACSR Panther and Al59 Panther can transfer power of 30MW in the double circuit system. The difference in Power Loss between the conductors is 302kW/hr with Loss Load Factor of 0.3. The Al59 conductor will reduce the losses in the circuit by 302kW/hr.

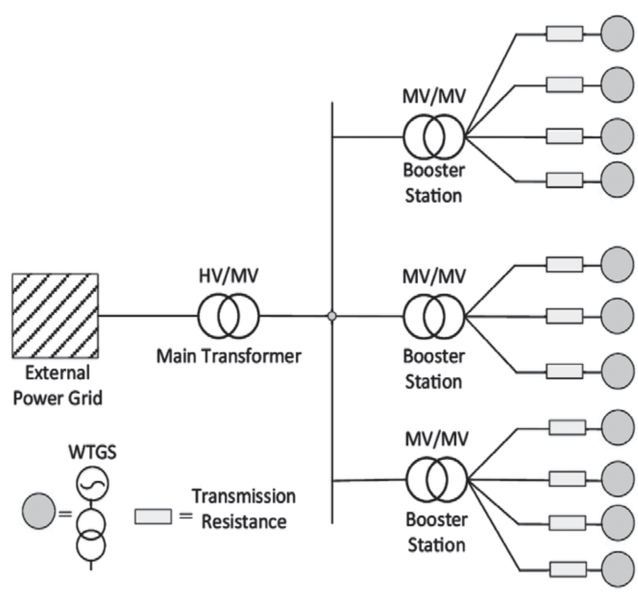


Fig-1: - General Electrical Layout of Wind Turbine

Conductor	Temp. at 322A	Rac at 322A	I^2R Losses (kW/hr)
ACSR Panther	75	0.1698	1584.50
Al59 Panther	72.61	0.1374	1282.16

The value of losses which the utility saved is analyzed below by changing the conductor from ACSR to Al59.

Conductor	I^2R Losses (kW)	Life time Losses (MW)	Cost of Losses (Rs)	Difference in Cost (Crs)
ACSR Panther	1584	416406	108Crs	---
Al59 Panther	1282	336951	87.6Crs	~21 Crs

The difference in losses for entire lifetime is approximately Rs. 20 Cr by changing from ACSR Panther to Al59 Panther. However, not lucrative enough for changing line from ACSR to Al59. The pole parameter is below the tower tension limits and is having higher factor of safety compared to ACSR conductor. With the objective to reduce the Losses further New Eco Series Conductor is introduced in Mkt by Sterlite named as ECO Max.

2.PRODUCT SPECIFICATION

The ECO Max conductor is composition of two different material of different properties to have reduced losses in transmission line. The ECO Max conductor has AlMgSi Alloy with higher tensile strength and with 59% conductivity and also trapezoidal shaped EC grade aluminum with 61% conductivity in different layers of conductors. The combination of Al59 Alloy with EC grade aluminum will provide the conductor better conductivity than Purely alloy based conductor. The average conductivity of Al59/ECO conductor is 58.84% whereas for ECO Max conductor the average conductivity will be 60%. The increase in conductivity will facilitate lower losses.

The ECO Max Conductor can transfer 30MW power in 33kV through double circuit line. The losses in the line is reduced by ECO Max will be in the range of 730kW/hr compared to ACSR Panther and 427kW/hr compared to Al59 Panther. (i.e. 46% to ACSR & 33% to Al.59)

Conductor	Temp at 322A	Rac at 322A	I^2R Losses (kW)
ACSR	75	0.1698	1584.50
Al59	72.61	0.1374	1282.16
ECO Max	69.31	0.09159	854.68

The Power loss reduction by replacement of conventional conductor will save the IPPs a sum of Rs. 49.86Cr.

Conductor	I^2R Losses (kW)	Lifetime Losses (MW)	Cost of Losses (Rs)	Difference in Cost of Losses (Crs)
ACSR	1584	416406	108	---
Al59	1282	336951	87.6	~21
ECO Max	855	224609	58.39	~49.86

The ECO max conductor has lowest loss among the conductors and has been a differentiator. The loss performance of the ECO Max conductor is detailed in fig:2

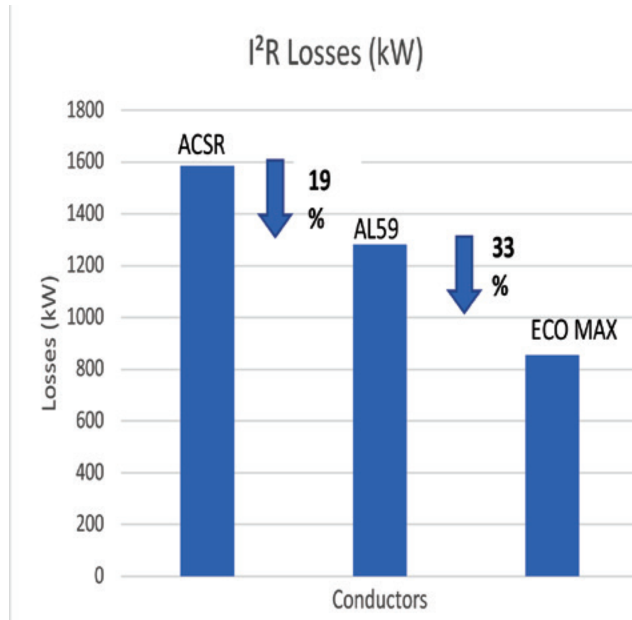
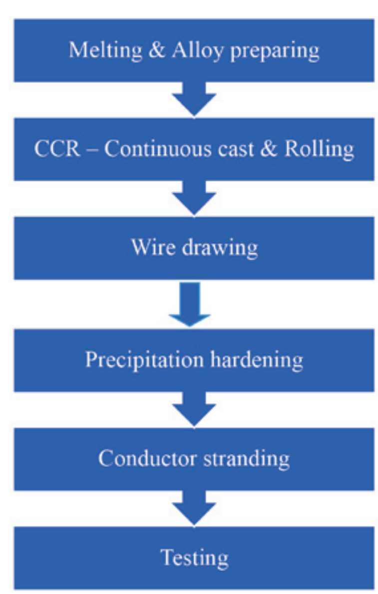


Fig:2

3.PRODUCTION & VALIDATION



This Bi-aluminum conductor was successfully developed by Sterlite Power Transmission Ltd and validated at third party lab for following tests [5,6].

DC Resistance	As per IS 398 Part 2	Complied
UTS	SMFL Guaranteed & as per IS 398 part2	Complied
Stress strain	As per IEC 61089	Complied

4.CONCULTION

- Innovation Solution by Sterlite which results better power loss reduction (~ saving 40%, 30%, 10% against ACSR/AL.59/ECO respectively)
- Innovative Bi-Aluminium conductor (ECO MAX) with Conductivity of 60%,
- which is better than Conventional Al.59/ECO.
- Environmental friendly - Reducing the carbon emissions (Eg. 1,34,834 Tons/30 years compared to ACSR conductor)
- Stringing & Installation Similar to Conventional Conductor.
- No need of Special Hardware & Accessories required.
- Trapezoidal Shaped give additional advantage of Self Damping which improves the conductor Fatigue Properties to Aeolian Vibration
- Application is in Distribution Segment.

5.REFERENCE

[1] ASTMB230-Specification for Aluminium 1350-H19 wire for Electrical purpose

[2]. ASTMB524-Specification for concentric lay stranded aluminum conductor, alloy reinforced.

[3]. SS 4240813 Aluminium alloy wire strandard conductor for overhead line

[4]. SS 4240814 Aluminium alloy strandard conductor for overhead line.

[5]. IS 329 part2: Aluminum conductors for overhead transmission purpose.

[6]. IEC 61089: Round wire concentric lay overhead electrical stranded conductor.

AN ELECTRIC VEHICLE BATTERY THAT DOESN'T NEED ELECTRICITY FOR CHARGING

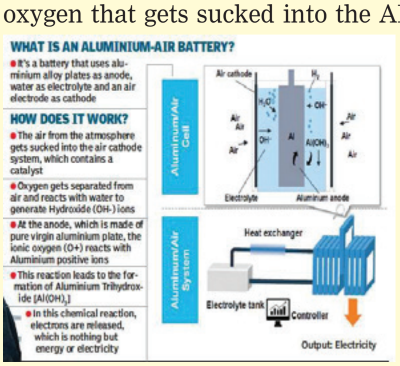
What if you no longer had to plug your electric vehicle (EV), which uses expensive and heavy Lithium ion batteries, into an electrical socket for charging?

What if there was a much lighter, cheaper and greener battery that uses just air, water and the metal aluminium to generate electricity and does the job more efficiently by giving a driving range that's more than double that a Li-ion battery offers, that too without the need for electricity to charge it?

This could become a reality in the country a year or two down the line thanks to state-run oil marketing giant Indian Oil Corporation (IOC) and Israeli clean energy startup Phinergy that are working on commercialising Aluminium-Air (Al-Air) batteries for EVs in India.

A prototype has been developed with 25 Al-Air cells stacked in a series and is being tested in electric cars with Tata Motors, in electric trucks and buses at Ashok Leyland and in electric three wheelers with Mahindra & Mahindra.

The technology behind Al-Air batteries is simple. The oxygen that gets sucked into the AI-Air cell from the air reacts with water and aluminium to generate electricity. The best part is that once the Aluminum has been fully eroded, the battery can be reloaded with a new anode (aluminium plate) and fresh electrolyte. For the consumer it means just swapping the used battery for a new one.



"What makes Al-Air tech attractive is that it has among the highest energy density (energy stored for a given mass/volume) of 8kwh per kg as compared to 1-1.5kwh per kg of Lithium and others. That's why an EV using the most evolved Li-ion battery offers only a 100-150 km range per charge, while with Aluminium, even with half the energy density, you can still get a four times higher range," said Dr SSV Ramakumar, director-R&D, IndianOil.

So, what makes Al-Air technology eco-friendly, safe and ideal for India? For one, AI-Air batteries require no electricity as they don't need to be charged.

Secondly, the Aluminium Hydroxide solution generated in the used battery can be sent to a recycling unit to get 100% aluminium back, explained Dr Ramakumar.

Al-Air tech is safer because it uses only a water-based electrolyte that is free from toxins and has a wide range of temperature operability, unlike Li-ion technology which uses organic toxins-based electrolytes that are highly inflammable, he added.

Aluminium is abundantly available locally, while all lithium reserves are located outside India. Also, Aluminium being a lightweight metal there is no negative consumption of energy due to the battery's weight unlike Li-ion batteries that are much heavier, he added.

The only hitch today is that as Al-Air technology has low power density, a reduced size Li-ion battery would be required to augment it as peak load operations and starting of vehicles require higher power density.

Apart from e-mobility, Ramakumar said Al-Air batteries can also cater to stationary applications like powering mobile phone towers that currently run on polluting diesel sets.

CONTAINER LESS COLD FORWARD EXTRUSION OF Al_m-TiB_{2p} COMPOSITE RODS (SOLID BODIES)

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Abstract
Container less extrusion for a dispersion hardened composite is presented. Forces for extrusion is experimentally measured and theoretically calculated. Both are compared and discrepancy between the two has been explained.

1. INTRODUCTION

Dispersion hardening is a very promising method to develop composites for high temperature (T>ECT=0.6Tm) applications [1].

Is strain rule of mixtures should be applied for calculating the properties of composites from individual components(matrix and reinforcement).These composites are more isotropic than fibrous composites[2]. The dispersed particles are chemically inert and stable at elevated temperature. They donor decompose or coarsen at such temperature. They are useful for making components for creep resistant applications. The volume fraction of particles is important in component design and the usual processing methods should be appropriately modified and adapted[3].For shaping such composites two prominent methods are available namely conventional cold warm or hot solid forming or unconventional semi solid or mushy state forming[4,5]. Here the former is adopted. Cold container less forward extrusion is investigated for aluminium -titanium diboride composite. The schematic of the process is shown in Fig 1. The composite can be produced in situ and volume fraction of particle is 5% the particle size is 0.6 (side length)microns and shape is hexagonal[6]. Container less extrusion has been investigated for metals and alloys[7,8,9,10,11,12] such as steels, aluminium,Al-Zn-Mg,titanium,Ti-6Al-4V etc. Here the process is extended to composites. In Container less extrusion low diet included angle (20°-30°)is used and short lengths are produced. Extension ratio 'R' is low(1.25-1.4) [13].In conventional cold forward extrusion of rod angle will be 90° to 120° and R will be 10 to 50. In hot extrusion R will be ~500

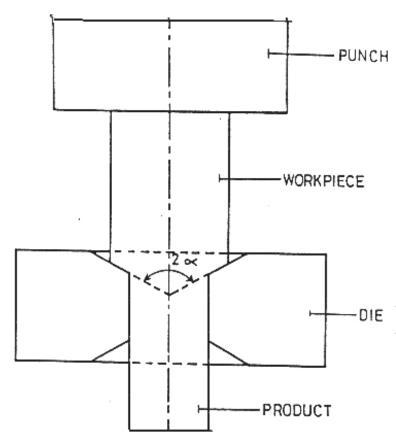

Fig.1 Schematic of the process

2. EXPERIMENTAL

Cylindrical samples of height 37.5 mm and diameter 25mm (aspect ratio 1.5) were machined from cast composite rods produced by the institution chemical reaction method. Extrusion tests were carried out with 20 conical dies of four different reductions and five different angles for each reduction. A 100T UTM was used. Graphite lubricant was used for minimizing friction. The strain rate employed was.07s-1. Force-Stroke diagrams were plotted and the constant force for extrusion was taken. Punch pressure was calculated. If upsetting had taken place the force corresponding to slope change was taken and punch pressure calculated. Theoretical calculations were done using Slab Analysis. Yield stress and friction factor are taken from compression and ring compression tests done in the same 100T UTM and reported in an earlier paper cited in Introduction as reference 6.

Table 1: Relevant Properties of Composite

Yield stress	48MPa
Friction factor	0.4
Density	2.79Mg/m^3
Heat capacity	0.9J/Kg/K
Melting point	1062K

3. RESULTS & DISCUSSION

The experimental pressures are shown against angle for various reductions and against reduction for various angles in Figs 2 and 3 and similarly theoretical punch pressures are shown in Figs 4 and 5 respectively. The extruded samples are shown in Fig 6 and the upset samples in Fig 7.

Table 2: Experimental Punch Pressures

r 2α	12	15	25	30	40
0.15	15	49	20	30	28
0.22	48	55	55	105	180
0.30	96	75	70	135	175
0.36	02	120	75	150	170

Table 3: Theoretical Punch Pressures

r 2α	12	15	25	30	40
0.15	60	50	40	35	40
0.22	80	70	65	60	60
0.30	130	115	80	75	70
0.36	170	150	115	105	95

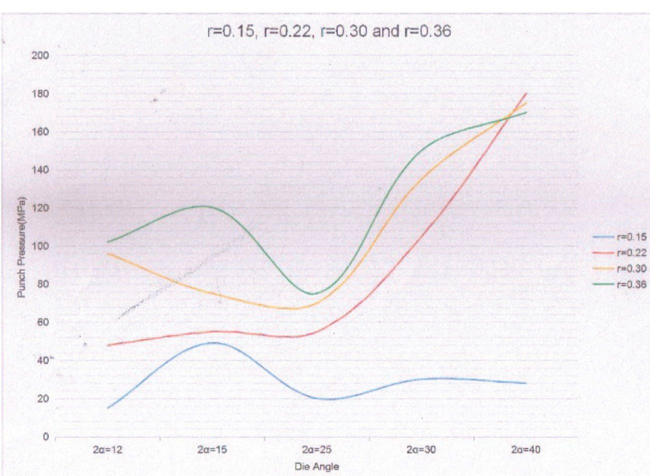

Fig.2 Experimental punch pressure against die angle

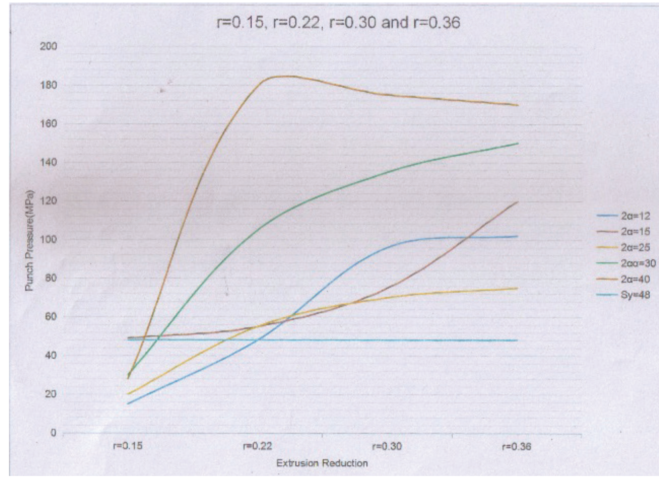

Fig.3 Experimental punch pressure against reduction

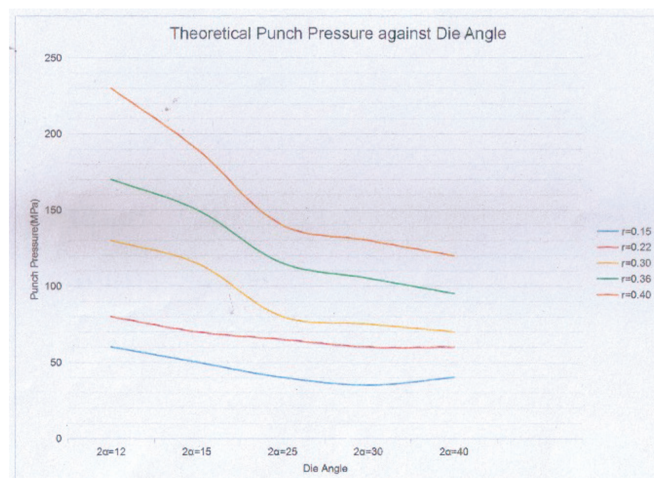

Fig.4 Theoretical punch pressure against die angle

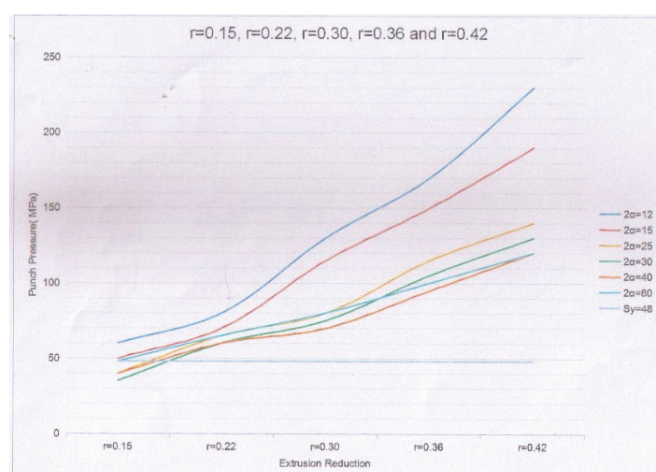

Fig.5 Theoretical punch pressure against reduction

Fig.6 Extruded samples

Fig.7 Upset samples

As angle increases experimental punch pressure decreases and then increases for all reductions except at a reduction of 0.15 .Theoretical punch pressure decreases with an increase in angle initially and then increase. There is an optimum angle at which punch pressure is least. As reduction increases both experimental and theoretical punch pressures increase at a given angle. For every angle there is a maximum reduction permissible at which pressure is equal to yield stress. Among them one will be the largest and it occurs at the optimum angle. This reduction is called the limiting reduction for the material. At the optimum angle the pressure is the least. One can infer from Fig 2 and 3 that for a reduction of 0.22 and 0.18 pure extrusion take place. At all higher reductions upsetting interferes with extrusion. From Fig 4 one can observe that minimum much pressure occurs at angle 12 and 25. But at lower angle the deformation zone surface (contact)area is large and friction will be large and surface finish and dimensional accuracy will be poor. So one can take the optimum angle to be 25°. Theoretically the optimum angle is 30° as seen from Fig 5. Maximum reduction is less as given by theory (0.18) compared to experiment (0.22).At maximum reduction for the optimum angle punch pressure will be equal to yield stress. Since the reduction is small one can take flow stress to be yield stress itself. Only samples that underwent pure extrusion is considered for comparison. Wherever upsetting interfered with extrusion one cannot apply the slab analysis meant for extrusion.

The discrepancy between theory and experiment can be attributed to the following two reasons:

1. There will be a temperature rise in the deformation zone which has three components. (See appendix).In this case it comes to ~11K. Melting point of composite is large compared to this. So softening and consequently reduction of yield stress will not be appreciable.

2. The plausible reason is that Slab analysis assumes homogeneous deformation which implies that the shear strain rates are zero. In reality deformation is heterogeneous and shear straight rates are very much present. This gives more reduction than what is estimated theoretically.

5. CONCLUSION

Experimental limiting reduction is more than that predicted by theory and optimum angle is less than that predicted by theory. Temperature rise in the deformation zone is not consequential. The discrepancy between theoretical and experimental values is due to the assumption of homogeneous deformation by theory while in reality it is heterogeneous. One should use the die corresponding to optimum angle and limiting reduction for realizing the full potential of the process.

6. APPENDIX

1. Equations governing the process:

Punch pressure is given by

$$P_p = S_y\,[(⅔)\,\alpha + (1+2\mu/\sin 2\alpha)\,\varepsilon] \quad \ldots\ldots. 1$$

P_p -Punch pressure
S_y -Yield stress
α -Semidie angle
μ -Friction factor
ε -Extrusion Strain

Optimum die angles are given by:

$$\cos(2\alpha)_{opt} = -3\mu\varepsilon_{max} + \sqrt{(9\mu^2.\ \varepsilon^2_{max}+1)} \quad ..2(a)$$

$$\cos(2\alpha)_{opt} = -3\mu\varepsilon_{max} - \sqrt{(9\mu^2.\ \varepsilon^2_{max}+1)} \quad ...2(b)$$

r-reduction $=(A_0 - A_f)/(A_f)$
ε-strain$=\ln(A_0/A_f)$
Both are simply related.

2. ROM or VFR for composites

$$\rho c = V_m\,\rho_m. + V_p\rho_p \quad \ldots\ldots\ldots.3$$
$=2.79$

ρ_c -Density of composite
V_m -Volume fraction of matrix
ρ_m -Density of matrix
V_p -Volume fraction of particle
ρ_p -Density of particle

$$C_c = V_m\,C_m. + V_pC_p \quad \ldots\ldots\ldots.4$$

=0.9
C-specific heat

$T^{mc} = V^m T^{mm} + V^p T^{mp}$.......5
=1062K
T_m -Melting point
c-composite, m-matrix, p-particle

3. Temperature rise in deformation zone:

1. Adiabatic heating:

$\Delta T_{Ad} = (.95) S_y \varepsilon / \rho C$................ 6
$= (.95)(48 \times 0.25) / (2.79 \times 0.9)$
$= 5.1°$
$\varepsilon = 0.25$

2. Friction heating:

$\Delta T_{Fr} = [\mu S_N V_R \text{Cos}\alpha\, (A/V) \Delta t] / \rho C$.......7
$= [0.4 \times 51 \times 0.22 \times 3.3 \times 10^{-4} \times 0.98 \times 0.17 \times 3.7] / 2.79 \times 0.9$
$= 3.5°$

SN =Sy Sin(α) -Stress acting on the inclined surface of deformation zone

VR -Velocity of ram=3.3×10^{-4} m/s
(A/V)- Ratio of Deformation zone surface area to volume=$0.17 m^{-1}$

Δt-Time of travel between die entry and exit=3.7s
(α)=12.5°=(.21)radians
d_0 =Entry diameter=25mm
d_f =Exit diameter=22mm

3. Shear heating:

$\Delta T_{Sh} = [(2/3)(\alpha) S_y] / [\rho C]$.............. 8
$= [(2/3)(0.21 \times 51) / 2.79 \times 0.9$
$= 2.8°$
Total rise in temperature:
5.1°+3.5°+2.8°=11.4°

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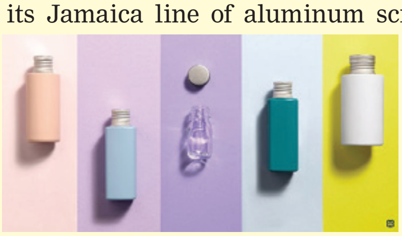
BARALAN INTRODUCES NEW ALUMINUM SCREW CAPS FOR GLASS BOTTLES AND JARS

Baralan, a consolidated player in primary packaging for the cosmetics and beauty industries, has introduced its Jamaica line of aluminum screw caps, while also expanding its Mussau line with two new sizes. Both lines of aluminum caps are available for use with glass bottles and jars primarily for skin care products.



Produced with extremely versatile, lightweight, durable and fully-recyclable material, the aluminum caps provide a sustainable option compared with traditional plastic caps.

Offering a distinctive packaging closure in a market that is increasingly demanding environmentally-friendly materials, its aluminum is 100% recyclable for an infinite number of times without losing technical and mechanical characteristics.

We offer

Aluminium Beryllium (Al-Be) Master Alloy

Grades: AlBe5.5%, AlBe2.5%

Applications:-
Avionics, space-related optical systems, structural components for small satellites, propellants, high-performance engine pistons, computer disc drives, high-performance defense parts, missile parts, aerospace parts

Aluminium-Beryllium Master Alloy
With 4.8 - 5.5 mass % of Be in Ingots, in pieces.
AlBe5 weight of Ingot up to 2.5 kg

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TECHNICAL PAPER

HOT OIL SYSTEM DESIGN AND MAINTENANCE GUIDE

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Introduction

Aluminium smelters produce green anodes from calcined petroleum coke, recycled carbon dry aggregates and the liquid pitch. The green anode plant uses enthalpy of the hot oil to heat the dry aggregates and the liquid pitch. These two fractions are pre-heated, mixed/ blended and then compacted to form the anode blocks from paste at required temperature. The hot oil supply facility has heater, expansion tank, storage tank, pumps, and valves and insulated piping with field instruments and control systems. The hot oil runs through closed loop of primary and secondary circuits supplying enthalpy at required to rate to the various consumers like preheater, mixer, pitch storage tank and piping in the process. The basic operation, maintenance, design of the circuit, and selection of the hot oil, particular to field maintenance, safety and life of the hot oil, is discussed in this paper.

Hot Oil System

Hot oil system can be liquid phase system, and liquid/ vapor system. The green anode plants adopt liquid phase system as it operates in broad temperature range (about 40 to 280°c) at low pressure, low installation and operating cost. It avoids large diameter pipe, safety valves, steam traps, and water treatment facilities as required in liquid/ vapor system. The hot oil system is high temperature heating system is used in industrial application as it can operate at much higher operating temperature range and at low pressure. The other common heat transfer fluids are steam and water, however steam and water has limitation in application for the range of temperature to be applied (i.e. between 0 to 175°c). Refrigerants, ammonia, and brines solutions ate used for temperature below the freezing point of water. The high temperature hot oil system key area are selection of the heat transfer media, system design, and application for the process equipment.

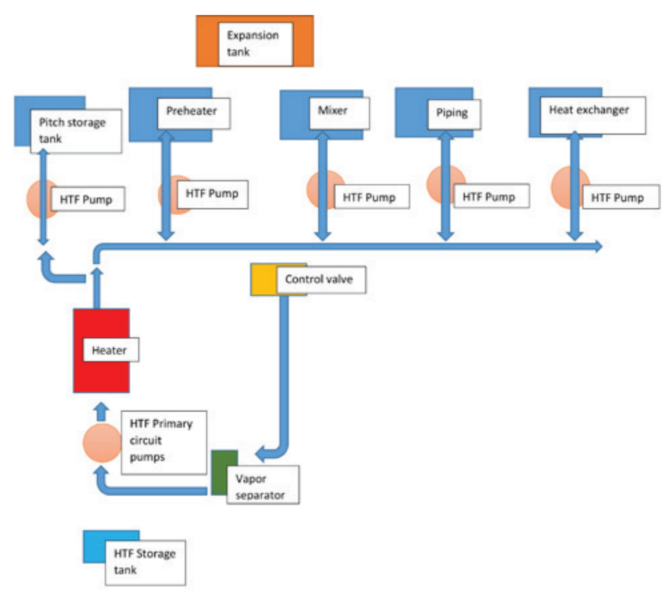
Selection of Hot Oil

The selection of hot oil should be based on effect to the environment and sub- floor, toxicity, low freezing point, absence of thermal decomposition in the working temperature range, high thermal conductivity, high specific heat capacity, low viscosity index, corrosiveness to the materials of construction of the circuit, flammability, high thermal stability and engineering properties.

HTF is selected from reputed suppliers like Dow, Mobil, Exxon, Bayer, Monsanto and Esso. The brand name of the oil should be suitable to the operation and shall provide stability and long life.

Hot Oil System Design

The thermic fluid circuit comprises of a thermic fluid tank, a thermic fluid heating system, a primary loop, secondary loop, an expansion vessel, and various pumps to feed HTF to different loops. The secondary loops has elements like pitch storage tanks, pitch unloading station for liquid pitch tankers, pitch melter in case of using solid pitch, pitch/ HTF heat exchanger, preheating screw, mixer and pitch piping. These are basic components of the thermic fluid circuit at any modern pre-baked technology aluminium smelter green anode plants.

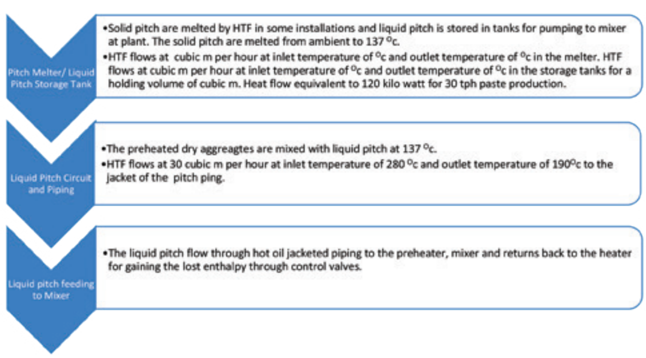


Sketch 1: Basic block diagram of hot oil system in green anode plant.

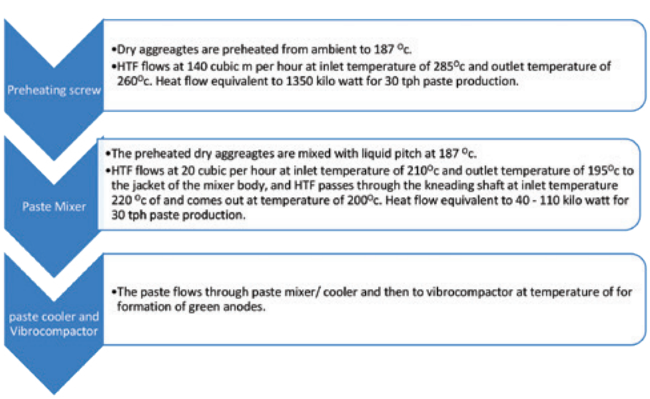
The basic process block diagram explains the hot oil system of the green anode plant as above in sketch No. 1. The primary loop has heater, vapor separator and control valve with main header of HTF which supplies to secondary loop. The secondary loop has enthalpy consumers like pitch storage tank, preheater, mixer and piping. The hot thermic fluid (HTF) circulates through both loops by respective HTF centrifugal pumps. The refilling of the HTF is carried out by filling pump installed at lowest position of the facility with a storage tank of capacity of 40 cubic m. This is equivalent volume of the circuit, so the entire fluid can be drained back and refilled if required. The vapor separator takes out the return vapors and releases to the top expansion vessel. All fill and drain line are connected to underground storage tank. The vent lines and the safety lines from each equipment and from all loops are connected and terminate at expansion vessel. The HTF occupies space during the expansion and contraction of the entire volume of HTF during operation for variation in temperature. So, it is placed at top and it has volume of 10 cub m and provided with nitrogen gas as blanket as safety. There should be a minimum level of HTF in the expansion vessel to keep feeding all consumers avoiding the starvation of pumps. The extra water is drained out from the lowest point of the circuit periodically from the underground storage tank. The vapor is vented out from the expansion vessel through preset relieve valve.

Application of Hot Oil System in Smelter

The green anode plant input raw materials like coke, butts, green scrap and pitch consumes enthalpy from HTF and are detailed in the following process diagram.



Sketch 1: application of hot oil system for the heating of solid pitch, liquid pitch storage, and for heating the pitch lines in green anode plants.



Sketch 2: application of hot oil system for the heating of dry aggregates in preheater, and in mixer in green anode plants.

Hot Oil System Operation and Maintenance

The temperature of the fluid leaving the heater is set according highest loop temperature required for the target product temperatures. The heater has capacity of 2.8 megawatt or equivalent enthalpy to transfer to HTF. The highest temperature set points are fixed for liquid pitch temperature in the storage tank, pitch temperature at in the feeding loop, coke temperature at the preheating screw outlet, and paste temperature at mixer outlet. The operator shall check the facility once in a shift, and report for any leakages and any abnormal noise. The leakage can be vapor or liquid, it should be reported and rectified at priority as it is safe for the plant and for the environment. The quality of the thermic fluid changes over time. The quality of the fluid changes faster as it is used at higher temperature. The maximum usage temperature of the fluid shall be followed strictly as per the recommendation of the supplier. The fluid quality checking frequency shall be adhered without fail. The daily check of the system includes expansion vessel HTF level, working of all valves and field instrumentations, control circuits, and mal-function of temperature set point apart from the leakages and noise. The system shall avoid falling or ingress of dust and fume from the plant operation. The HTF gets filtered continuously through the metallic filters, which are installed in the suction line of the primary pumps. The HTF gland leakages from the pumps, valves, flanges, piping and rotary unions shall be avoided. The periodic top up of the fluid shall carried out as the fluid level decreases in the underground storage tank. Sometimes there are chances of mixing of fluid with process input materials like pitch in the heat exchangers, in the jacketing of the pipe, which should be checked periodically and avoided. The leakage of HTF at high temperature when come in contact with any hot rotating or rubbing parts of any equipment, it may catch fire inside the plant. The hot vapor of the HTF may initiate ignition when any electrical spark comes in contact. The hot oil system should not be kept exposed to atmosphere at different points like expansion vessel and underground storage tank inspection top cover. In few installation the heater is boiler type, where the inside refractory fails, the combustion temperature damages the HTF pipe and supporting structure, then the HTF starts leaking and gets burned inside the boiler. This causes erratic operation and the loss of the HTF from the circuit and need periodic maintenance of the boiler refractory lining.

The HTF decomposes due to thermal degradation, lower flash point, lower ignition point, and lower auto-ignition temperature than original values. Lower viscosity is better for the heat transfer, but change in viscosity indicates the thermal degradation of hot oil. Hydrolysis or oxidation can be checked by acid number, which is important periodic check. In order to avoid erosion the carbon and solid contents of the oil is checked. The presence of water forms light volatile compounds and acidic compounds, and it is harmful for operation as wells as for the life of oil and other components.

Safety

There are safety systems installed in the plant dedicated to the HTF circuit. The fire alarm system warns presence of smoke and fire. The fire deluge system sprays the water over the storage tank, if it is activated. The operator gets alarm when the HTF temperature rises beyond the various set points on the pipelines and in the different loops. The electrical heaters terminals are enclosed inside sealed cover and are fire resistant. There are chances of HTF leak through the worn out casing of preheater and mixer, forming vapor inside preheater and inside mixer. This may cause fire. The expansion vessel level decreases and HTF gets mixed with the anode paste. Any mal-operation in control systems and instrumentations or due to unavoidable reasons the HTF temperature rises and it get hot fumes/ fire at top of the expansion vessel and hence the nitrogen blanketing is must in the hot oil system in green anode plants.

Conclusion

The hot oil system is a supporting operation in green anode plant of aluminium smelters. This provides enthalpy to calcined petroleum coke and to pitch for forming paste. The installation has various assemblies and components with network of piping. It should be provided equal importance as major process in operation and in maintenance. The periodic checks, condition monitoring and testing of the HTF can result a longer life to the HTF. The safety of the system is most important to protect the plant from fire hazards. The leakages of HTF vapors should be avoided as it is hazards to the operators in the green anode plant.

FORTHCOMING EVENTS

ALUMINUM USA

August 31 – 2 September 2021
Kentucky International Convention Center
221 S 4th St, Louisville, KY
https://www.aluminum-us.com/en-us.html

ALUEXPO – 7TH INTERNATIONAL ALUMINIUM TECHNOLOGY, MACHINERY AND PRODUCTS TRADE FAIR

14-16 October 2021
İstanbul Expo Center, Halls 1 and 2, İstanbul
https://aluexpo.com/home-en/

39TH CONFERENCE AND EXHIBITION HYBRID ICSOBA 2021

22 -25 November 2021
Manama, Bahrain and online
https://icsoba.org/upcoming-icsoba-event-2021/

CONTRIBUTION OF ICSOBA IN SETTING DEVELOPMENT TRENDS IN GLOBAL BAUXITE, ALUMINA AND ALUMINIUM INDUSTRY

C. VANVOREN, F. FERET, A. PANOV, M. REVERDY, HOUSHANG ALAMDARI; Icsoba

The modern aluminium industry was born with the invention of the Hall-Héroult process in 1886, and for more than 130 years the technology development has never stopped. Equipment development has been the most spectacular. However, during the second part of the 20th century, automation, PLC and computers as well as lean organizations further transformed the aluminium industry, in line with the 3rd industrial revolution. For the last few years, a new revolution, Industrie 4.0, born in manufacturing industries, has gained momentum. The aluminium industry, like most process industries, is somewhat lagging behind in this journey. However, numerous signals show the ball is now rolling. Icsoba, which was founded in 1963, has since supported technology developments by increasing the shared knowledge in the field of bauxite and encouraging exchange of ideas and cooperation between the alumina and aluminium professionals. Those considerations are as important today as ever, and Icsoba is transforming itself to support the aluminium industry in its journey towards Industrie 4.0.

The participants of the Hamburg Conference in 2017

1. Introduction

In 2018 we celebrated Icsoba's 55 years of activity. More than half a century of vocation for an organization such as Icsoba is quite an achievement by all means. Many entities created around the same time no longer exist today, but Icsoba is alive and doing better than ever. In order to understand the success of Icsoba over the years, one has to look at the reasons and motivation behind bringing it to life1. The first Icsoba symposium was organized by the Yugoslav Academy of Sciences and Arts in Zagreb in October 1963. The Academy took the leadership role by realigning its scientific activity for solving economic and technical problems. By giving scientists and scientific institutions of various countries an opportunity to remain in direct contact, the Academy contributed to establishing solid links for international collaboration in the interest of progress in science. After the Congress, a very successful visit was arranged to the bauxite deposits of Dalmatia. During the concluding session, the Hungarian and French participants made the proposal that the Yugoslav Academy contemplate the possibility of establishing a permanent international working community. The Yugoslav Academy accepted this proposal and elaborated the Statute of the International Committee for the Study of Bauxite, Alumina and Aluminium. Icsoba was established.

2. Icsoba contribution to industry development trend

Since Icsoba was founded, the industry size has increased over ten times. All the time, Icsoba has unwaveringly supported technology developments by increasing the shared knowledge in the fields of bauxite, alumina and aluminium and encouraging the exchange of ideas and cooperation between the professionals in these fields, and in this way more often than not set the development trend of our industry.

a. Bauxite resources and mining

Icsoba's role is significant in knowledge sharing in the field of geological research, analyses, data interpretation and exploration of alumina bearing raw materials in the last 55 years – mainly bauxites but also non-bauxitic ores2:

- Exploration techniques developed: double / triple walled bits, air-core drillings, bucket auger, etc.
- Development in material testing and new methods introduced: DTG, X-ray diffraction, scanning electron microscopy, mass spectrometry, infrared spectroscopy, atomic absorption, Mösbauer method, RD / Rietveld method, Al, Si concentrations determined in situ, etc.
- Geomathematical methods: geo-statistics, kriging, semi-variogram, fuzzy function, etc. resulted in

reducing the errors in the resource estimate and risks in mining

- New huge resources have been identified and new mines established in Australia, China, India (Eastern Ghats), Vietnam, Indonesia, Guinea and Brazil
- Bauxite beneficiation at Weipa (Australia), Bao Lok (Vietnam), Zhengzhou (China), Trombetas and Paragominas (Brazil) became a common, routine procedure
- Conveyor belt system (Australia, India) and slurry pipeline (Brazil) are applied for the first time in bauxite supply to refineries.

b. Alumina refining

In the last 40 to 45 years, a very intensive development of the Bayer process took place with the support of Icsoba, whose publications captured the following most important tendencies3:

• The conversion from batch to continuous tank reactors in the early days. The development of the tube digestion technology increased the production capacity of a single line and reduced operation cost4

• Red mud thickening and washing technol- The participants of the Hamburg Conference in 2017 © Icsoba ogy and equipment have been significantly improved, resulting in low soda loss with residue and high throughput of the units5

• The transition from pond-type bauxite residue storage areas to dry stacking after paste thickeners and then after press filters allowed to significantly reduce the required surface area and capital cost. The development and proposal of best practices of bauxite residue disposal6 and utilization7,8 was explored as well

• The change from floury to sandy alumina quality is a significant tendency taken by the industry. On equipment side, using of larger units, better mechanical performances, higher liquor productivities at precipitation allowed to save electrical energy and steam, and to reduce capital cost for building new lines/plants9.

• The shift from rotary to stationary alumina calcination units was overwhelming. Continuous evolvement of Fluid Bed10 and Cas Suspension11 calciners equipment allowed not only to improve product quality in terms of alpha phase content and particle size distribution but also to achieve energy consumption close to theoretically possible level. Along with the Bayer process, the details of alternative technologies to process low grade bauxite, nepheline, alunite and clays including sintering, Bayer-Sintering, acidic processes have been presented and discussed giving insights on development and industrial implementation of those technologies12,13.

c. Aluminium smelting

Icsoba accompanied the rapid development of the aluminium reduction technology in the last 30 years, most notably:

1. The fast cell amperage increase in many existing potlines by as much as 20 to 40%14. At the same time new potlines increased the current from 300 kA to more than 600 kA. The fastest development of new cell technology took place in China15.

2. The development of the pneumatic transport of alumina to the cells16, the development of cell point feeding technology and control to operate the cells without sludge and anode effects, which enabled very low PFC emissions.

3. The increasing anode quality in spite of deteriorating raw materials17 and the introduction of slotted anodes, which resulted in better cell performance by decreasing bubble voltage drop18.

4. The development of potroom service equipment such as pot tending machines (PTMs), allowing easy anode changing and cavity cleaning as well as laser marking for accurate anode positioning. The safety of crane operations increased by the automatic monitoring of crane insulation resistance[19].

These examples of the development of process technology and equipment illustrate the huge progress our industry made in the second half of the 20th century. However, during the same period, automation, PLC and computers as well as lean organizations further transformed the aluminium industry in line with the 3rd industrial revolution.

3. New industry development trends

Most refineries and smelters have reached a competitiveness plateau today and future gains cannot come from a new wave of headcount and cost reduction but from a significant improvement in process performance. In recent years, new solutions that have emerged in the manufacturing industry have gained momentum: automation and digitalization in the overall framework of Industrie 4.0. The aluminium industry, like most processing industries, is somewhat lagging behind in this journey to 4.0. However, numerous signals show that the ball is now rolling.

a. Automation

Driverless trucks in bauxite mining, developed by the major mining companies (20% of Rio Tinto's existing fleet of almost 400 trucks in the Pilbara, Australia, drive autonomously today) 20, are currently contemplated for new projects, for example at the new Rio Tinto Amrun bauxite mine in Cape York, Australia21. Driverless trucks mean that more material can be moved efficiently and safely, creating a direct increase in productivity. They use predefined GPS courses to automatically navigate haul roads and intersections and to know actual locations, speeds and directions of other vehicles at all times.

Unmanned vehicles are also making their way into aluminium smelters as anode and/or metal hauler[22,23]. Those vehicles are aimed to be associated with autonomous devices for tapping, measurements and sampling.

Prof. Dr. S. S. Augusthithis, Prof. Dr. Olga Lahodny-Sarĉ, and Prof. Dr. J. Nicolas

A group of participants on the Plenary Session of the Congress

Automation has also progressed in the smelter area. As an example, mechanized reduction cell hood handling[24,25] has been deployed as an intermediate step on the journey towards automated anode change, for which several tests have already been made during the last decade. Other examples are automated equipment aimed at supplying additional information for quality control and process enhancement. There are numerous illustrations around the concept of predictive anode quality: online electrical resistivity measurement (Fives ECL Mirea)[26], automated butt characterization (Stas Abis)[27], etc. This type of equipment, used as 'soft sensors', is integrated in an overall endto- end anode tracking system, which perfectly illustrates the transition to our next point: factory digitalization.

One cannot forget about a tremendous progress in chemical characterization of the aluminium industry materials. Automatic bauxite sample preparation and analysis systems, on-line crushing, grinding, pressing and briquette handling of electrolytic bath specimen or fully automatic metal analysers – all aided by LIMS (Laboratory Information and Management System) have deeply transformed current laboratory operations.

b. Digitalization

Considerations regarding 'Refinery of the Future' and 'Smelter of the Future' have been around for some years now[28,29]. Industrial implementations of the digitalization approach, as illustrated by such 'predictive anode quality', based on processing (advanced analytics) large numbers of real time and historical process data, are rapidly spreading. Machine learning has been recently presented in the field of anode quality interaction with reduction cell performance[30]. Digitalization is moving a step further with experimentation of cell process control via 'digital twin' as pioneered by Aluminium of Greece[31].

Many digitalization examples are also found in the upstream part of our industry. An illustration is the approach taken by Emirates Global Aluminium (EGA) when preparing the start-up of the first Middle East alumina refinery at Al Taweelah in Abu Dhabi. Taking the The Icsoba Congress in 1978 opportunity of being a greenfield project, the authors claimed to have developed "one of the most modern Process Information Management Systems (PIMS), applying the latest of the Industrie 4.0 elements as a first step towards the Smart Refinery"[32]. The concept of the whole refinery digital transformation has been also discussed by Honeywell: it includes elements of big data analysis, the connected worker and the connected plant. It is rightly said that it takes a big step to implement the emerging and most challenging technologies in the field including smart sensors and autonomous machines[33].

Other illustrations are given, for example, with the development of a digital twin to achieve predictive analysis of wear mechanisms in the refinery digestion plant facility, supplementing the non-destructive monitoring34. On the white side, the construction of process simulation models and detailed equipment model allowed further significant optimization of the alumina calcination plant35. It is worth mentioning a concluding remark from the authors: "A comprehensive digital system will not be able to achieve the desired level of performance without the inclusion of process understanding."

Finally, we should also mention the application of 4.0 quality concepts of digitalization, data acquisition, scalability, analytics and connectivity to elevate traditional management system tools to the Industrie 4.0 standard in the context of bauxite mining36.

4. Icsoba evolution to support industry transformation

As shown above, multiple examples demonstrate that the aluminium industry has entered the era of digitalization. This transformation is unlocking new opportunities along the whole value chain and all the players have either started or are about to start the journey. Transforming our industry is requiring and will require for several years to look at our processes with different lenses from different angles. It will require different skills, knowledge and probably people whilst, at the same time, the fundamentals principles will remain. How can a technology conference support such a transformation? This is the challenge Icsoba is presently facing and aiming to meet successfully!

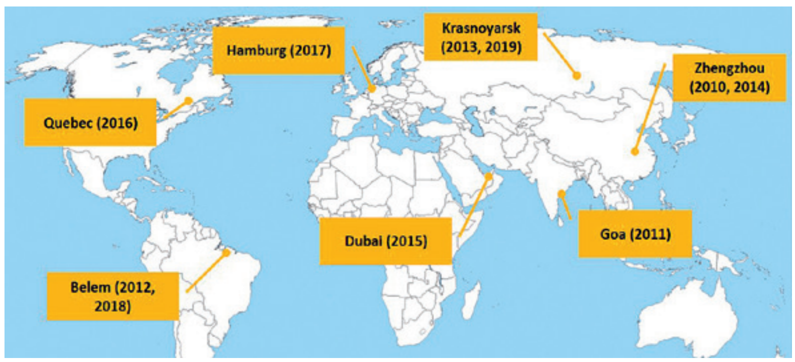
a. Build on Icsoba DNA which proved so successful during the last 55 years

i. Multiculturalism of its board of directors

Icsoba is an international association of members, which elect the board of directors. The board is responsible for managing and supervising the activities and affairs of the corporation and is accountable to the members.

The directors have legal responsibility for Icsoba and are registered with Canadian authorities. The present composition of the board confirms not only its international status but also reflects its multicultural character. Among the board directors are two Canadians (with Polish and Iranian backgrounds), two French, a Swiss, a Russian and an Indian. Such board composition promotes universal understanding and vastly facilitates global communication.

ii. High quality of publication and scientific content
A key element of Icsoba's reputation is the high quality of publications and scientific content. The Technical Committee oversees maintaining and enhancing the reputation of Icsoba publications through the rigorous selection of high-quality papers and of the practical organization / running of the sessions during the annual conference. The Technical Committee (TC) is composed of the programme director (a member of the board of directors) as its chairperson and of three to five subject organizers. The TC members jointly represent the technical areas: bauxite, alumina, bauxite residue, carbon and aluminium. The author guidelines and template for Icsoba abstracts, papers and presentations provide a uniform standard and appearance of each contribution. Approximately 100 papers and corresponding presentations are selected each year for the conference and the papers are included in the Travaux volume of the conference proceedings, which have reached more than 1,000 pages in recent years.



iii. Travelling around the world
Icsoba's international success is based on the practice of rotating the venue of international conferences to countries that play an important role in the global aluminium industry. Unlike many other organizations that are stationary, Icsoba moves from place to place around the globe and the delegates attending the annual conference travel with it. Visitors often bring expertise and solutions that locals may not have, and the opposite is also true. Icsoba provides a unique forum for discussions and plant visits, allowing its members to see the aluminium world, to learn and share know-how from research and current practices. Over the years Icsoba has been travelling the world visiting major bauxite and aluminium production centres: Goa (India, 2011), Belem (Brazil, 2012), Krasnoyarsk (Russia, 2013), Zhengzhou (China, 2014), Dubai (UAE, 2015), Quebec (Canada, 2016), Hamburg (Germany, 2017) and Belem again in 2018. In the last two decades China, Middle East and India had an extraordinary growth of activity in alumina and aluminium production thanks to available energy. To put emphasis on these countries, Icsoba has plans to stage conferences there again in the near future.

iv. Proposing field trips associated with each conference
Field trips (plant visits) organized at the end of each Icsoba conference are highly instructive and appreciated by the delegates. For example, at the end of the 2018 conference in Belem, the delegates enjoyed visiting three different Hydro plants: the Albras aluminium smelter, the Alunorte alumina refinery and the Paragominas bauxite mine. A year before (in Hamburg) visits were organized to the DadCo alumina refinery and the Trimet aluminium smelter. The field trips offer the delegates a unique opportunity to see the production facilities, meet local personnel and discuss selected technical issues.

v. Offering grants to students
The student grants originate from the Icsoba funds and mark our presence in a specific country. The grants are offered to two to three students who present papers at the conference Location map of Icsoba Conferences since 2010 and who are nominated as grant recipients by a local academia representative. Two student grants were offered in 2018 to the students from the Universidade Federal do Este do Para, Brazil. In addition, the elected students obtain free access to the conference.

b. Enhancing collaboration within the aluminium industry

i. Integrating industry input: the Icsoba Corporate Members Council
The vision of Icsoba to become 'The Technology Conference of the Aluminium Industry, for the Aluminium Industry' translates our view that the future of our organization lies in the high engagement of the aluminium industry.

The industry engagement requires participation from companies to orient Icsoba conferences to industry issues and challenges, pragmatically. To this aim, Icsoba revisited its corporate membership status and set up a Corporate Members Council in order to get direct feedback on industry needs and to ensure that all industry players from major producers, engineering firms, equipment suppliers to service providers get the opportunity to influence the Icsoba strategy and its deployment.

The Corporate Member Council meets once a year, during the annual conference. Icsoba's activity report is presented as well as the progress report on developments associated with the current strategic plan. The Corporate Members input is collected and further discussed during the board meeting for integration in its development plan.

ii. Partnering with aluminium associations
Icsoba undertakes to play the role of the industry's leading voice, providing global standards, business intelligence, sustainability research and industry technical expertise to member companies, policy makers and the general public. In the spirit of equality, mutual benefit and friendly co-operation, Icsoba has identified a framework within the aluminium sector. The objectives of this framework are to contribute to the industrial knowledge base and to stimulate economic activities along the aluminium value chain.

Several organizations have signed Memorandum of Understandings (MoUs) for cooperation with Icsoba, which is beneficial for both sides. For example, over the years the MoUs were signed with the Aluminum Association of Canada, China Nonferrous Metals Industry Association, The Aluminium Association of India and Associação Brasiliera do Alumínio (Abal). Icsoba highly values these partnerships and intends to further extend their number in the coming years.

iii. Partnering with other conference organizers
As already discussed, digitalization implies different knowledge. As a consequence, different players, namely automation and IT companies, are taking up more space in the process industry landscape. However, as the fundamental principles remain, it is of prime importance to ensure a close connection between the data and cooperation among systems experts and process experts. The mission of 'The Technology Conference of Aluminium Industry, for the Aluminium Industry' is to provide a platform for such connection.

This is why Icsoba signed an MoU with Quartz Business Media to organize an Icsoba session within the framework of the next 'Future Aluminium Forum'37, which was held on 22 and 23 May 2019 in Warsaw, Poland. The Icsoba session dealt with 'Aluminium 4.0: when process approach meets data-driven approach in mining, refining and smelting' and saw representatives from aluminium companies willing to share their developments and success in their journey toward Industrie 4.0.

With this initiative, Icsoba aims to encourage and facilitate cross fertilization between process and data approach of our industry.

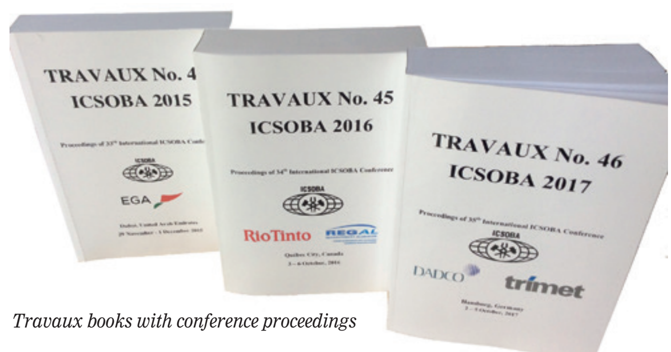
c. Enhancing knowledge dissemination
Dissemination of knowledge is the key factor to promote the collective effort of people acting in the whole aluminium value chain, from mine to metal. Therefore, beyond the organization of its annual conference and exhibition, which enhances the generation and exchange of ideas during the four-day event, Icsoba has a proactive strategy for knowledge dissemination and deploys all efforts to maximize the impact of the knowledge and know-how developed and shared by its members:

• A particular attention is made to invite influential keynote speakers with different backgrounds; i.e. technology, science, mar- Travaux books with conference proceedings ket, environment, etc. Dissemination of such a broad spectrum of keynote talks enhances the development of all facets of the industry.

• Icsoba has an agreement with MDPI to publish some selected papers in the open-source journal 'Metals' to further disseminate the knowledge to a broader audience.

• The Icsoba Platform for Industry-University Collaboration for Innovation is another example where our members share their valuable knowledge about the R&D infrastructure and available resources worldwide.

• Several thousand technical papers have been published in the Travaux volumes over more than half a century. All submitted papers are subject to a rigorous peer-review and edition process, performed by experienced Icsoba members from industry and academia. The value of this documentation for building a collective knowledge is better understood if one assumes that each paper addresses a hurdle of the industry, which is usually determined by the industry. All published documents have been electronically scanned and Icsoba will soon launch a user-friendly interface for access to this documentation.



Travaux books with conference proceedings

5. Conclusion
Icsoba, who celebrates 55 years of activity, has unwaveringly supported the aluminium industry and, in many respects, contributed to set its development trends. This resulted in the impressive developments experienced during the decades of Icsoba history in the bauxite, alumina and aluminium industries that have grown 10-fold and reached what it is today. Now, the aluminium industry is starting its journey towards digitalization. Icsoba considers that sharing knowledge and encouraging exchange of ideas and cooperation between the alumina and aluminium professionals is as important as ever. Icsoba is therefore acting to minium sector. The objectives of this framework are to contribute to the industrial knowledge base and to stimulate economic activities along the aluminium value chain. Several organizations have signed Memorandum of Understandings (MoUs) for cooperation with Icsoba, which is beneficial for both sides. For example, over the years the MoUs were signed with the Aluminum Association of Canada, China Nonferrous Metals Industry Association, The Aluminium Association of India and Associação Brasiliera do Alumínio (Abal). Icsoba highly

values these partnerships and intends to further extend their number in the coming years. transform itself to support this new development trend. This transformation is based on three pillars, namely:

• Building on Icsoba DNA which proved successful for the last 55 years (multi-culturalism of its board members, high quality of publications, travelling around the globe, proposing field trips and grants to students)

• Enhancing collaboration within the aluminium industry (widen its corporate members base and integrating their input through the Corporate Members Council, partner with aluminium associations and other conference organizers)

• Enhancing knowledge dissemination (inviting influential keynote speakers, proposing a platform for industry-university cooperation and a user-friendly interface to access to the 2,000 technical papers of the Icsoba library). With those actions in place, and with an open mind regarding input and suggestions from all of its members and partners, Icsoba aims at its vision of being ‘The Technology Conference of the Aluminium Industry, for the Aluminium Industry’.

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Note: Extract of communication made by ICSOBA to International Aluminium Journal – July/Aug-19

BALCO REDUCING CARBON FOOTPRINT THROUGH NEXT-GENERATION TECHNOLOGY

Balconagar, Korba, June 11, 2021: Bharat Aluminium Company (BALCO), India's iconic aluminium producer is a strong proponent of leveraging next generation technology to make its manufacturing process sustainable and reducing carbon footprint. BALCO has reduced its power consumption in its 'potline 1' at its smelter in Chhattisgarh to 12,862 KWH/MT which is at par with global standards. This potline has hence, the best performance amongst potlines in India and the Gulf countries in terms of specific power consumption and has thus reduced its carbon footprint significantly. A smelter is a plant where aluminium is produced through the process of smelting, which involves extracting it from its oxide, alumina. A potline is a long building, or collection of buildings, which contain a series of "pots", or large. electrolytic cells, in which aluminium is made. The company has achieved this benchmark by deploying a smart combination of high-end technology and indigenous innovations.

Speaking on BALCO's carbon footprint reduction in its manufacturing process Mr. Abhijit Pati, CEO and Director, BALCO, said, "We are committed to sustainable development and across all our areas of operations using leading-edge technology, and judicious utilization of resources. BALCO has been one of the early adopters in India to explore the field of smart technologies for heightened operational efficiencies. These investments and skills further bolster the culture of safety and productivity that we have meticulously fostered across the organization. We are conscious of our responsibility towards building a stronger and sustainable tomorrow and, therefore, are actively exploring innovations that help reduce carbon footprint as early as possible in the creation process. We are ensuring a future-ready organization for a self-reliant India."

The company has integrated smart technologies and design modifications in its potlines progressively to reduce its specific power consumption by using graphitized pot with thermal modelling and other digital interventions. The company relentlessly drives innovation and continuous improvement in its smelting technology.

BALCO's specific energy consumption has been one of the lowest in the aluminium industries across the country. BALCO has also brought down its specific water consumption today by 170% from its previous specific water consumption levels, which is also one of the lowest amongst its peers. These figures are a testimony to BALCO's spirited endeavours towards environment and energy conservation which contribute to a greener and better planet.

BALCO has been the recipient of various awards and accolades for its environmental conservation efforts. For the year 2020, BALCO has won the 'CII Energy Efficiency Award', 'Golden Peacock Sustainability Award' and 'CII HSE Excellence Award, Chhattisgarh'. BALCO has also achieved the 'International Green Apple Award' 'CII Energy Excellence Award', 'Sustainable Business of the year Award', 'National Award for Excellence in Energy Management' and 'Energy & Environment Global Environment Award' in recent years.

Bharat Aluminium Company Limited (BALCO) is India's iconic aluminium producer. It is owned 49% by the Government of India and 51% by Vedanta Limited. Vedanta Limited is one of the world's largest diversified natural resources companies and the largest producer of aluminium in India. BALCO operates a 0.57 million tonne per annum (mtpa) aluminium smelter in Korba, Chhattisgarh. It is also a leader in value-added aluminium products that find critical applications in core industries. With its world-class smelter and power plants, the company fulfills its mission of spurring emerging applications of aluminium as the 'Metal of the Future' for a greener tomorrow.

METAL IMPACT ACQUIRES LUXFER ALUMINIUM GAS CYLINDERS DIVISION

Metal Impact believes the addition of the manufacturing operations of Luxfer in Graham, North Carolina, as well as its range of products and services, makes it "one of the premier aluminium gas cylinder suppliers to the medical and healthcare industries".

"As a Thunderbird company, Metal Impact is dedicated to growth - organically and through acquisitions," said Phil Kretekos, President of Thunderbird, parent company of Metal Impact.

"This addition to our aluminium gas cylinders operations will assure the industries that rely on us that we have the best talent and resources to support the growing demand for our products and services. It also positions us to address individual needs and foster relationships in a timely manner like never before."

The acquisition will more than double the cylinder capacity and manufacturing footprint of Metal Impact, supporting a more expansive line of cylinders for a broad range of markets, including industrial, food and beverage, fire extinguishing, performance racing, SCUBA, and life support.

Metal Impact is a provider of aluminium and steel impact extrusions and gas cylinders.

"Our commitment to continual improvement ensures we are a dependable, reliable supplier to the industries we serve," said Kevin Prunsky, Chairman of the Board of Thunderbird.

"With our expanding operations and depth of experience, we have the capacity to support the growing demand for our products and services.

In a Form 8-K filing to notify investors, Luxfer Holdings PLC said, "The divesture is consistent with the company's February 23, 2021 announcement that it intends to discontinue the majority of its aluminium operations."

NALCO'S NET PROFIT JUMPS BY 840% TO RS. 1300 CRORE IN 2020-21

National Aluminium Company Limited (NALCO), the Navratna CPSE, under the Ministry of Mines, GOI and India's largest integrated manufacturer and exporter of alumina and aluminium, has reported results for the Financial Year 2020-21.

According to the audited financial results, taken on record in the Board of Directors meeting held today at Bhubaneswar, NALCO has posted an impressive net turnover and net profit of Rs.8869.29 crore and Rs.1299.56 crore respectively in FY20-21 compared to Rs.8425.75 crore and Rs.138.23 crore achieved during the previous year. The net profit of the company for the financial year 2020-21 has jumped by 840% over last financial year. The results were driven by strong operational performance by units, with effective sales strategy, cost saving measures, supported by favourable LME price.

During the year 2020-21, NALCO has achieved the highest ever production of bauxite at 73.65 lakh tonnes. Similarly, the Company also achieved the highest-ever export of 1.92 lakh tonnes of Aluminium metal in 2020-21, surpassing the decade old record of 1.46 lakh tonnes achieved in 2009-10. Further, the Company also achieved production of 20.85 lakh tonnes of alumina hydrate and 4.18 lakh tonnes of Aluminium metal.

Attributing the success to the teamwork and dedication of the employees, Shri Sridhar Patra, CMD, NALCO, said that the company had made exemplary contributions in promoting and putting focus on plant, production, productivity and people. "After the peak period of COVID19 outbreak and with the opening of the markets, we witnessed a significant recovery in the second half of the financial year of 2020-21. With further easing of restrictions and resumption of economic activities, we are optimistic for a robust growth in the long run with our focus on increasing the production in mining and refining segments and opening up of the new coal blocks," he said.

CONSTELLIUM SUPPLYING ALUMINUM SOLUTIONS FOR AUDI E-TRON GT EV

Constellium SE has expanded its longstanding partnership with Audi to supply advanced aluminum solutions for the Audi e-tron GT.

Electric vehicles require strong, yet lightweight solutions to optimize range and prioritize safety. Constellium provides ASI-certified aluminum Auto Body Sheet solutions for closures and inner parts, as well as extrusion-based components for the vehicle's front and rear Crash Management Systems.

Constellium's Surfalex Auto Body Sheet solution, used for the rear doors and fenders of the Audi e-tron GT, is well-suited for the vehicle's design, as it allows bold styling while maintaining perfect surface aesthetics.

Constellium's Securalex solution, used for the hood inner, has a high-tech crash absorption capacity designed to fulfill the most demanding pedestrian safety requirements. Both Auto Body Sheet solutions are supplied from Constellium's plant in Neuf-Brisach, France.

Constellium HSA6, a family of high-strength 6XXX-series extrusion alloys used on the vehicle's Crash Management Systems, meets the demanding requirements of structural components in electric vehicles, as it provides additional strength in the event of a crash. The Crash Management Systems are produced at Constellium's ASI-certified plant in Gottmadingen, Germany.

These products are also supplied for Audi's first fully-electric model, the Audi e-tron SUV, along with extruded components for the e-tron's battery enclosure and side impact beams. Aluminum-extruded components make up the structure of the Audi e-tron battery enclosure, providing the strength, crash and intrusion resistance required to safeguard EV batteries.

Constellium is a long-time supplier to Audi for both rolled products and structural components. Constellium is a founding member of the Aluminum Stewardship Initiative and its plants in Neuf-Brisach, France and Dahenfeld, Gottmadingen and Singen, Germany have been certified against the Performance and Chain of Custody standards. These facilities have the capability, combined with the sourcing of ASI metal, to supply their customers independently-certified, responsibly-sourced and sustainably-manufactured aluminum products.

NEW RECHARGEABLE BATTERIES SET TO REVOLUTIONISE ENERGY STORAGE

New rechargeable batteries will make energy storage more affordable

Researchers have developed low-cost materials to create rechargeable batteries that will make energy storage more affordable. This new kind of battery could provide a safer and more environmentally friendly alternative to lithium-ion batteries, which currently dominate the market but are slow to charge and have a knack for catching fire.

The cost of harvesting solar energy has dropped considerably in recent years that it's giving traditional energy sources a run for their money. However, the challenges of energy storage—which require the capacity to bank an intermittent and seasonally variable supply of solar energy—have kept the technology from being economically competitive.

Cornell University researchers, led by Lynden Archer, Dean and Professor of Engineering, have shown that a new technique incorporating aluminium results in rechargeable batteries that offer up to 10,000 error-free cycles. The study has been published in Nature Energy.

Among the advantages of aluminium is that it is abundant in the earth's crust, it is trivalent and light, and it therefore has a high capacity to store more energy than many other metals. However, aluminium can be tricky to integrate into a battery's electrodes. It reacts chemically with the glass fiber separator, which physically divides the anode and the cathode, causing the battery to short circuit and fail.

The researchers' solution was to design a substrate of interwoven carbon fibers that forms an even stronger chemical bond with aluminium. When the battery is charged, the aluminum is deposited into the carbon structure via covalent bonding, i.e., the sharing of electron pairs between aluminum and carbon atoms.

While electrodes in conventional rechargeable batteries are only two dimensional, this technique uses a three-dimensional—or nonplanar—architecture and creates a deeper, more consistent layering of aluminium that can be finely controlled.

The aluminium-anode batteries can be reversibly charged and discharged one or more orders of magnitude more times than other aluminium rechargeable batteries under practical conditions.

INDIAN AUTOMOBILE STATISTICS

• Source: SIAM

	PRODUCTION		DOMESTIC SALES		EXPORTS	
Category	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
Passenger Vehicles	3,424,564	3,062,221	2,773,519	2,711,457	662,118	404,400
Commercial Vehicles	756,725	624,939	717,593	568,559	60,379	50,334
Three Wheelers	1,132,982	611,171	637,065	216197	5,01,651	392,941
Two Wheelers	21,032,927	18,349,941	17,416,432	15,119,387	3,519,405	3,277,724
Quadricycle	6,095	3,836	942	-12	5,185	3,529
Grand Total	**26,353,293**	**22,652,108**	**21,545,551**	**18,615,588**	**4,748,738**	**4,128,928**

PRIMARY NON-FERROUS METALS: PRODUCTION (TONNE)

ALUMINIUM

	2015-16	2016-17	2017-18	2020 / 2021			
				Jan'21	Feb'21	Mar'21	Apri'21
National Aluminium Co. Ltd.	3,72,184	3,87,423	4,25,513		**33,016**	29,777	33,022
	13.8	4.1	9.8	37,535	34,799	39,912	36,551
Hindalco Industries Ltd.	4,09,376	4,05,354	4,08,904	10.5	-7.4	-10.3	-11.5
	-0.1	-1.0	0.9	1,08,488	98,398	1,08,819	1,05,023
Bharat Aluminium Co. Ltd.	3,31,324	4,26,140	5,68,932	-2.8	5.6	0.8	-9.1
	1.5	28.6	33.5	49,191	44,500	49,229	47,729
Vedanta Ltd.	5,15,398	5,26,932	4,08,904	1.0	2.8	-0.5	-3.2
	-4.1	2.2	-22.4	1,31,773	1,19,796	1,35,562	1,31,521
Total	**16,28,282**	**17,45,849**	**18,43,416**	**3,26,986**	2,97,493	**3,33,522**	**3,20,824**
	1.7	**7.2**	**5.6**	**6.0**	**-2.9**	**-3.3**	**-10.9**

• Source: Minerals & Metals

ALUMINIUM STATISTICS

Source: Japan Aluminium Association

PRODUCTION OF ALUMINIUM AND ITS FABRICATED PRODUCTS

(Thousand Metric Tons)

	Total 2020	%Chg 20/19	2020	2020	2020	2021	2021		2021	2020	%Chg
			QI	QII	QIII	QIV	March	%Chg (21/20)	3 Months	3 Months	
Primary Aluminium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Secondary Aluminium	690.2	-13.2	130.4	161.4	204.2	202.0	72.3	7.5	202.0	194.2	4.0
Semi-fabricated products											
F.R.P.*	1,054.5	-8.4	263.4	253.1	274.7	276.5	105.8	8.9	276.5	263.3	5.0
Extrusion	664.1	-12.1	150.2	156.8	184.6	172.2	64.0	4.2	172.2	172.5	-0.2
Die-Castings	822.9	-17.8	128.2	208.2	248.1	239.4	87.5	8.9	239.4	238.4	0.4
Castings	343.7	-21.4	52.4	86.2	102.6	98.2	36.6	5.5	98.2	102.5	-4.2
Electrical Conductor	35.7	5.4	7.2	8.7	9.4	10.6	4.6	-11.9	10.6	10.4	1.9
Foil	105.6	-2.3	26.6	25.4	28.2	29.3	11.1	19.3	29.3	25.4	15.5
Aluminium Windows	137.3	-12.7	32.5	34.1	37.1	31.0	11.7	-1.6	31.0	33.6	-7.7
Aluminium Cans	356.6	-2.1	96.4	96.0	79.5	82.8	31.1	-0.7	82.8	84.7	-2.3

**including foil stock*

IMPORTS AND EXPORTS

(Thousand Metric Tons)

	H S	Total 2020	%Chg 20/19	2020	2020	2020	2021	2021		2021	2020	%Chg
				QI	QII	QIII	QIV	December	%Chg (21/20)	3 Months	3 Months	
IMPORTS												
Aluminium waste & scrap	7602	52.8	18.4	10.6	11.0	18.9	17.4	6.2	43.5	17.4	12.3	41.1
Unwrought aluminium												
Aluminium not alloyed	7601-10	1,169.5	-17.6	324.3	246.4	269.6	342.2	110.2	-2.8	342.2	329.3	3.9
Aluminium alloyed	7601-20	882.6	-24.5	216.1	148.3	259.7	281.5	102.2	18.1	281.5	258.6	8.9
Wrought aluminium												
Plates, sheets & strip	7606	130.8	-8.2	35.1	26.9	32.7	32.5	12.5	-2.3	32.5	36.1	-10.0
Bars, rods & profiles	7604	24.8	-20.5	7.6	4.9	3.8	4.9	1.7	-30.5	4.9	8.4	-41.9
Tubes & pipes	7608	3.6	-17.9	0.9	0.7	1.0	1.0	0.3	-11.6	1.0	1.0	-0.9
Wire	7605	11.8	-7.8	3.5	2.4	2.9	2.6	0.9	-26.5	2.6	3.0	-13.9
Foil	7607	56.0	-7.1	15.2	13.8	14.7	15.4	6.0	23.4	15.4	12.3	24.9
Rolled prod. sub total		**227.0**	**-9.6**	**62.4**	**48.7**	**55.1**	**56.4**	**21.5**	**-1.3**	**56.4**	**60.9**	**-7.4**
EXPORTS												
Unwrought aluminium	7601											
Not alloyed, alloyed	-10,-20	20.7	14.4	4.9	4.1	4.8	8.5	2.7	8.9	8.5	6.9	24.5
Plates, sheets & strip	7606	145.7	-19.0	31.3	33.6	49.4	45.3	18.7	65.7	45.3	31.3	44.7
Bars, rods & profiles	7604	15.0	-8.5	3.5	2.9	4.4	4.6	1.8	28.1	4.6	4.2	10.2
Tubes & pipes	7608	4.0	-17.0	0.8	0.9	1.2	1.6	0.6	90.9	1.6	1.1	51.6
Wire	7605	6.7	8.9	1.4	1.5	2.4	2.4	0.7	54.5	2.4	1.5	66.0
Foil	7607	66.3	0.3	14.5	13.5	21.8	21.3	8.6	43.9	21.3	16.5	29.2

1. Detail may not add to the each quarter and year totals due to rounding
2. The figures of 'Total 2020' are final ones of 2020. It might be different from the total figure of each quarter of 2020, because the data of each quarter is based on temporary statistics for preliminary release

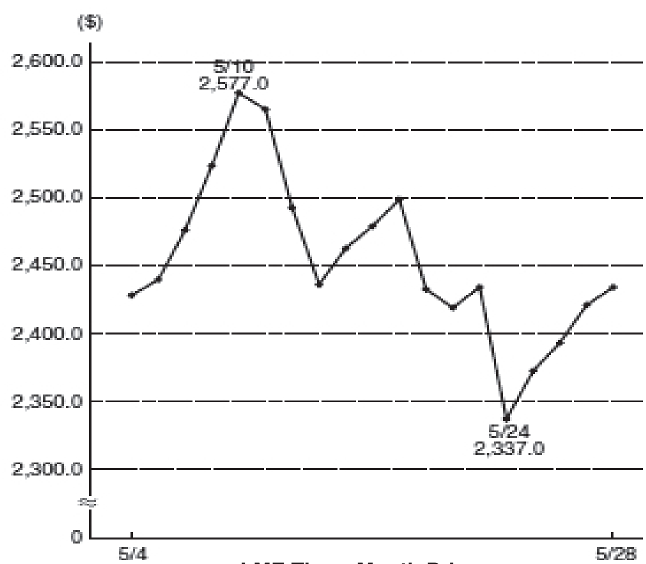
JAPANESE ALUMINIUM MARKET

Source: Nalk Report, Vol.367 June 2021

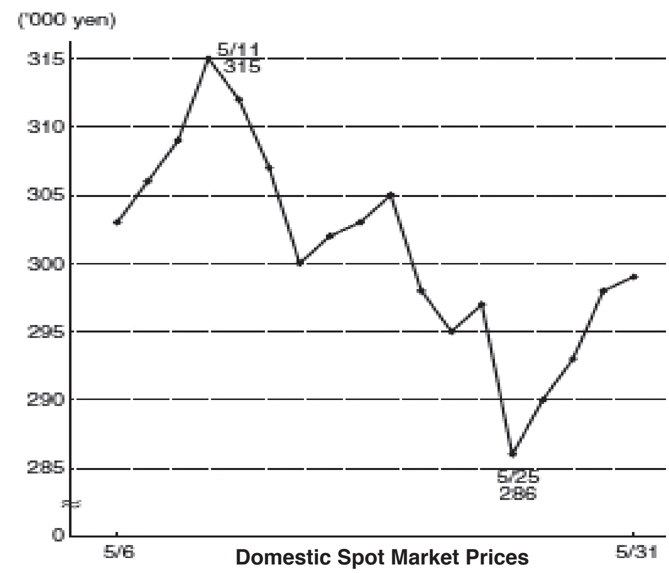
ALUMINUM PRICE TRENDS IN MAY 2021

The LME 3M price which has been rising since February of this year has taken a downturn after peaking at $2,577 on May 10, dropping to $2,434 at the end of the month. Spot aluminum price in Japan recorded a high of ¥315,000/ton at the peak but fell to ¥299,000/ton at the end of the month. In June, the LME 3M aluminum price remained at the mid-$2,400 level. However, in some cases, there are concerns for the rise in long-term interest rates and US dollar buying due to the accelerated pace in the US economy, resulting in the market movement being somewhat weak.

LME 3M price as of June 11 was $2,477.5. Spot price in Japan was quoted at ¥304,000/ton. On the other hand, talks to settle the premiums for primary aluminum shipments to Japan for the 3rd quarter of fiscal 2021 (July-September) kicked off. Producers have reportedly offered $180-200 and some have been settled at $185. This figure exceeded the previous quarter by $36-37, registering a consecutive increase for 4 quarters. This is a reflection of the strong demand trend in the US, Europe, China and Japan. End-May primary aluminum stocks at the three major Japanese ports totaled 292,600, recording an increase of 12,000 tons from the previous month as well as an increase for 3 straight months, according to data from The Daily Light Metal News.



LME Three-Month Prices



Domestic Spot Market Prices
Source : The Daily Light Metals News

Selling prices of secondary aluminum alloys shipped in small lots in May 2021 appears to have reflected the cost increase in raw materials including aluminum scraps and the robust demand trends and rose ¥5-10/kg from the previous month. Prices of ADC12 sold in small lots in the Tokyo area stood at ¥364-369/kg, ¥8/kg higher than the previous month.

PRODUCTION AND SHIPMENTS OF SECONDARY ALUMINUM AND SECONDARY ALUMINUM ALLOYS IN APRIL 2021

Production and shipments of secondary aluminium and secondary aluminum alloys climbed 34.4% and 30.3% in April 2021 from a year earlier to 71,074 tons and 71,082 tons respectively, the Japan Aluminium Alloy Refiners Association announced. This was a 6 months of successive increase for both production and shipments, exceeding the previous year's level. Data by sector shows that shipments to the main die casting sector rose 32.6% year on year, recording

an increase for 8 straight months. Shipments to the casting sector also surged 48.8%, registering an increase for 6 consecutive months.

Shipments of Secondary Aluminum and Secondary Aluminum Alloys by Market in April 2021 **(tons)**

	Castings	Die Castings	Rolled Products	Extruded Products	Steel	Alloys	Exports	Others	Total
	18,567	39,307	5,081	1,635	4,144	2,095	89	164	71,082
Y-on-Y% Chg	148.8	132.6	107.4	87.1	111.9	115.5	445	61	130.3

The following papers/articles were published in Aluminium-in-India in the last four issues

- DEVELOPMENT OF SUPER THERMAL RESISTANT ALUMINIUM ALLOY FOR OVERHEAD CONDUCTOR APPLICATION -Chintan Pandya, Prasad S, Rakesh Tripati, Ananthakumar R, Vishal Sharma, Saikrishna Bendapudi, Sterlite Power Transmission Ltd.
- LIMITING ASPECT (SLENDERNESS) RATIO IN CONTAINER LESS EXTRUSION OF Al-5Zn-1Mg ALLOY - Prof. K. Srinivasan
- INSTRUMENTATION AND PROCESS CONTROL IN ALUMINIUM PROCESSES - Vishwas Kale, Vijayesh Instruments Pvt. Ltd.
- EFFECT OF BORIDES FROM ALB MASTER ALLOY IN THE REDUCTION OF TRAMP ELEMENTS TO MAKE CONDUCTOR GRADE ALUMINUM ALLOY - Pallavi Deshmukh, Prakash Tiwari, Archana Gupta, Suman Sao, S. B. Misra, Minex Metallurgical Co Ltd.

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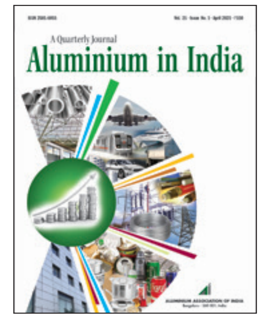

- ALUMINIUM METAL MATRIX COMPOSITE PROCESSING BY LIQUID METAL INFILTRATION TECHNIQUES - T.P.D. Rajan, M.G. Akhil, A.G. Arsha - CSIR-NIIST & AcSIR, K.M. Sree Manu, CSIR-NIIST & BCAST, Visakh Manoj - CSIR-NIIST, H. Sundara Murthy - Fenfe Metallurgicals, B.C. Pai - CSIR-NIIST
- CELL LINING REDESIGN FOR SPL MINIMIZATION AT HIRAKUD SMELTER Mahesh Sahoo - Hindalco Industries Ltd, Hirakud, Amit Gupta - Aditya Birla Science & Technology Company Pvt. Ltd., S. K. Badajena - Veer Surendra Sai University of Technology, University of Burla
- DESIGN & DEVELOPMENT OF HPC CONDUCTOR: A PERMANENT SOLUTION FOR LONG SPAN RIVER-CROSSING– 400KV D/C QUAD - Prasad S, Rakesh Tripati, Ananthakumar R, Vishal Sharma, Saikrishna Bendapudi - Sterlite Power Transmission Ltd.

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- CRU EXPLAINS HOW TO UNDERSTAND INDIA'S COMPLEX CARBON EMISSIONS PROBLEM -Shankhadeep Mukherjee, Team Leader, CRU India
- BUILDING A SUSTAINABLE FUTURE WITH 'GREEN METAL' ALUMINIUM Mr. Ajay Kapur, CEO – Aluminium & Power Business, Vedanta Ltd.
- OPTIMIZATION OF BATH SHOP CRUSHING CIRCUIT FOR SUITABLE PARTICLE SIZE Mr. Maheswar Behera, Consultant – Aluminium Industry
- ALUMINIUM INDUSTRIES DURING COVID-19 AND ACTION PLAN POST COVID Dr. B.K Satpathy, Visiting Scientist, Indian Institute of Technology, Bhubaneswar
- INDIAN ALUMINIUM INDUSTRIES REVITALIZING GROWTH OPPORTUNITIES Prof. K.S.Sreenivasa Murthy, Founder & Former General Secretary, Aluminium Association of India

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- FRICTION STIR WELDING OF ALUMINUM ALLOYS: OPPORTUNITIES AND POTENTIAL - Dr. Partha Sarathi De, Assistant Professor, School of Minerals, Metallurgical and Materials Engineering, Indian Institute of Technology Bhubaneswar
- ALUMINIUM –THE WAY AHEAD - Mr. Apte Ashish, Segment Manager, Fronius India Pvt. Limited
- FORCED CONVECTION NETWORK IN POTS – A DESIGN ASPECTS FOR INSTALLATION - Mr. Maheswar Behera, Consultant – Aluminium Industries
- METALLURGI CAL INVESTIGATION OF CRACK IN JACK BODY OF RUDDER PCU OF A MILITAR Y AIRCRAFT - V. Ram Prasad, Vaisakhi Nandi & Dr. R R Bhat - Central Materials & Processes Laboratory, Foundry & Forge Division, Hindustan Aeronautics Limited (HAL)
- PROVIDING EXPERIENCE FOR BIG PROJECTS - Mr. Carmelo Maria Brocato,,Head of the Aluminium Division, GMS/Engitec Group

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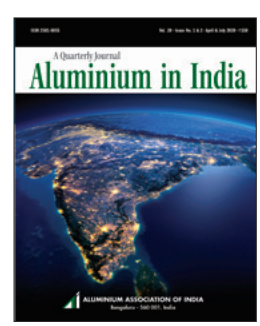

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