# Catalyst for Sustainable Solutions


Hindalco has set up India's first battery foil plant in Odisha.
The plant would cater to the rapidly growing market for  for EVs and battery storage systems

# Intellectual Capital

## KEY HIGHLIGHTS

**514** patents granted

**HIC Aluminium** established

**₹907 crore** spent on **R&D**

**30** new products and applications developed*

** The details provided are for India Operations*

## LINKAGES

### Capital Linkages

- *Financial Capital*
- *Manufactured Capital*
- *Social and Relationship Capital*

### Strategic Priorities

- ***SP-2** Value Enhancing Growth/Double-down on Upstream Capacities*
- ***SP-3** Strong ESG Commitment*
- ***SP-4** Value Enhancement through Portfolio Enrichment*

### Material Topics

- *Economic Performance & Market Growth*
- *Digitalisation & Cybersecurity*

### Key Risks and Opportunities addressed

- *R1 - Increased focus on decarbonisation*
- *R-2 Cybersecurity and data protection risks*
- *Supply chain risks*
- *Rising demand for aluminium and copper products*
- *Development of low-carbon products*
- *Emerging applications for specialty alumina*

### Contribution to SDGs

In a rapidly changing industrial landscape, we leverage the expertise of our people, deep process knowledge, and a culture of innovation to reimagine what materials can do. Spanning the entire value chain from refining and smelting to alloy development and fabrication, our teams deliver customised, high-performance solutions for diverse sectors such as packaging, automotive, home solutions, batteries and RE, electricals, defence, building and construction, thus Engineering Better Futures.

We safeguard our innovations through patents and trademarks.

We foster strategic alliances with industry leaders, academic institutions, research labs, and startups to strengthen collaboration, optimise resources, and accelerate technological advancement. These global partnerships have led to breakthrough materials and development of processes that drive operational efficiency and environmental sustainability.

As part of our commitment to innovation, we are accelerating digital transformation by integrating advanced technologies across operations. These include Industrial IoT (Internet of Things) for data management and dashboards, Machine Learning (ML) for optimising raw material blending and process KPI prediction, online sensors for real-time process and asset reliability monitoring, computer vision for detecting process and quality defects, and digital twins for optimising plant operations and reliability. These technologies help us to optimise production processes, improve product quality, and minimise environmental impact.

This technological evolution is closely aligned with our commitment to sustainability. By embedding sustainable practices across our operations and embracing circular economy principles, we are actively working to reduce our carbon footprint. Anchored by our 5R + 1S framework, we have taken initiatives that focus on cleaner technologies supporting decarbonisation, and enabling resource circularity.

### Focus Areas

**Strengthening R&D for value-added products and applications**

**New technological solutions**

**Product quality and performance**

**Digitalisation**

Scrap handling EOT crane at casthouse scrap bay at Aditya FRP

## Pioneering Progress Through Research and Development

At Hindalco, our commitment to innovation and excellence is brought to life through our robust R&D efforts. Led by a diverse team of scientists, researchers, and experts, at our DSIR-recognised Innovation centres at Belagavi, Taloja, Mahan, and Dahej, Aditya Birla Science and Technology Centre (ABSTC), and ABG's Corporate R & D centre at Taloja, serve as vibrant hubs for technical advancement and continuous improvement, reinforcing our pursuit of cutting-edge sustainable solutions.

This year, we have strengthened our commitment to cleaner and more efficient aluminium smelting with the establishment of HIC Aluminium at Mahan. This new centre will drive innovation in carbon anode technology and aluminium smelting through advanced cell design, process control and automation, setting new benchmarks in the industry in energy efficiency and environmental performance.

### HIC Aluminium – Our Commitment to Cleaner and more Efficient Smelting

HIC Aluminium at Mahan focuses on aluminium smelting process technology and sustainability, innovating carbon anode technology, cell design, process control & automation and engineering technology.

It is presently focused on detailed analysis and engineering design to ensure the seamless planning and execution of the booster section trial for the HiPOT-400 KA design at our Mahan smelter. The effort involves fine-tuning operational parameters and standard operating procedures to optimise performance.

In addition, the centre plays a key role in testing and evaluating indigenous control systems across low and high amperage pots. Working in close collaboration with ABSTC, academic institutes, and external technology partners, HIC-Aluminium is leading the development and implementation of energy reduction and decarbonisation solutions for our smelters.

*Innovation centres at Belagavi, Taloja, Mahan, Dahej, and ABSTC driving next-gen solutions across the value chain.*

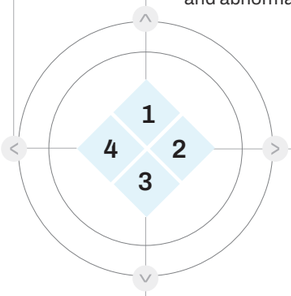
**Figure: Focus areas of HIC Aluminium**

**Aluminium Smelting Process Technology & Sustainability**

+ Enable adoption of new cell design and lining practices, pot start-up, and operation
+ Pot trials special measurements, evaluation and creating new SOPs
+ Develop new methods to reduce / manage emission at GTC, $Al_2O_3$ enrichment and SPL
+ Provide technical support to smelters for process stability and abnormality management

**Engineering Technology**

+ Collaborate with ABSTC for new pot design and its detail engineering
+ Engineering analysis of superstructure and material handling system, process equipments, insulation etc
+ Establish advance maintenance protocols and safety methods




**Process Control & Automation**

+ Enable adoption of new pot control system including new sensors, hardware and automation systems
+ Pilot testing of new control logics, data analysis, system programming and networking to enable process digitalisation
+ Evaluate and support control system for other critical processes such as ABF, etc

**Carbon Anode Technology**

+ Evaluate raw materials for carbon anode and characterisation
+ Optimise anode recipe, GAP, ABF and rodding processes for better anode quality, energy reduction and decarbonisation in smelting process
+ Establish new measurement system for anode/cathode quality checks

## 400 KA Booster Trial Section at Mahan

Mahan, originally designed to operate at 365 KA, has successfully enhanced amperage through process optimisation and change in lining design to 376.3 KA. To increase the current beyond 380 KA, new cathode lining design, larger anodes, and magnetic compensation loops (MCL) are essential.

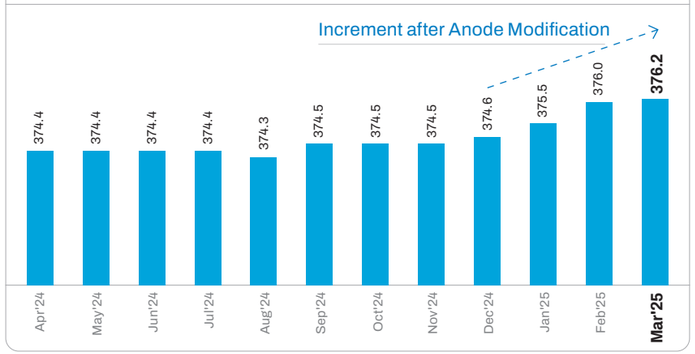
In line with this objective, HIC Aluminium along with Mahan, conceived a trial booster section comprising 10 pots with each pot designed to operate at 400 KA. These pots are equipped with an additional booster rectifier, magnetic compensation loop, extended anodes, and a newly developed cathode lining, created in collaboration with our technology centre.

The project is being executed in two phases, with phase 1 focused on the production of larger anodes with larger area. This involved the installation of vibro-compactor assemblies, FTA height adjustments, upgrades at Anode Baking Furnace (ABF) and Anode Rod Shop (ARS), and induction furnace enhancements. All installations have been completed and the production of larger anodes is underway In phase-2 the anodes shall be converted with higher slots for reducing energy and increasing amperage with the in phase 2 the anodes shall be converted to higher slots with the support of a new slot cutter machine.

Installation of the slot cutter is in its final stages, while erection and commissioning of the new equipment is underway. The project is on track and commissioning is expected to get completed in FY 2025-26.

After successful testing, amperage creep shall be rolled out in the entire potline. This would help increase our production capacity.

**Mahan Monthwise KAmp**




At Novelis, the focus is on developing innovative solutions that increase the recycled content of our alloys, reduce the carbon footprint of our processes and products. These efforts are seamlessly integrated across our operations – through strategic scrap sourcing, targeted investments in recycling infrastructure, and optimised alloy selection and mix design.

This innovation journey is supported by a global network of 11 world-class Innovation Centres, strategically located across North America, South America, Europe, and Asia. These centres serve as the backbone of our R&D ecosystem, seeking to accelerate product development and technological breakthroughs in alignment with our Novelis 3×30 vision. In doing so, we believe they not only help propel our sustainability goals but also enhance our role as a trusted partner – helping customers meet their own environmental objectives by incorporating materials with higher recycled content and lower carbon emission.

Leading this network, is our flagship research and technology centre in Kennesaw, Georgia, a key hub for developing advanced solutions across the automotive, beverage, and specialty markets, leveraging our expertise to develop client-focused solutions. In Spokane, Washington, our global casting engineering and technology centre is a leading authority on molten metal processing, producing high-quality aluminum products.

Further, our centres in Shanghai, China, and Sierre, Switzerland, are focused on automotive research, while Göttingen, our Germany based facility specialises in product and process development for can and specialty customers. The customer solution centres at Detroit and Michigan in the US, and São José dos Campos in Brazil, are focused on automotive and beverage packaging, respectively. We have also established a research and development laboratory to advance carbon neutral solutions for aluminium manufacturing in Sierre, Switzerland. For the aerospace industry, our innovation centres in Koblenz, Germany, and Zhenjiang, China, are dedicated to advancing research and is complemented by Voreppe, a subsidiary and global leader in cast house expertise and equipment.

Together, the Innovation Centres at Hindalco and Novelis are at the forefront of developing sustainable processes and enhancing the value of our products. In FY 2024-25, we invested ₹907 crore in research and development, with ₹39 crore dedicated specifically to standalone operations. These strategic investments have delivered tangible results, ranging from improved process and product quality to the introduction of breakthrough technologies such as battery-grade aluminium foils and boehmite.

Our innovation efforts have also led to the deployment of advanced tools like blend advisers and soft sensors, which have significantly boosted copper smelter productivity and elevated product quality. These achievements underscore the impact of our R&D strategy, which continues to drive operational excellence and technological leadership. Reflecting this momentum, our innovation centres filed 439 patents and were granted 514 patents during FY 2024–25, further solidifying our position as a global leader in sustainable industrial innovation.

### Advancing Process Optimisation

At Hindalco, our R&D efforts are central to our transformative journey, driving operational excellence, optimising cost and elevating product performance, thus delivering greater value to our customers.

Our innovations focus on improving product quality, maximising resource recovery and improving process efficiency. Key achievements include:

+ Increased oxalate removal in the Bayer process
+ Enhanced cathode and anode quality
+ Improved copper wire rod performance
+ Higher recovery of copper, gold, and silver
+ Elimination of hazardous gypsum generated during processes
+ Improved bauxite processability
+ Optimised sintering of fine alumina

We direct our efforts on developing in-house materials to reduce dependencies on external suppliers and imports, while enhancing cost efficiency and process reliability. Notable innovations include, fume-free cutting oils that improve product quality and reduce reliance on monopolistic suppliers, in-house closure and SRC stock coatings, and advancements in food-grade coating. These breakthroughs reflect our commitment to self-reliance, and long-term value creation.

We implement comprehensive Life Cycle Assessment (LCA) programmes across our downstream and refinery operations to identify and mitigate environmental impacts throughout a product's lifecycle. These assessments ensure our offerings meet the highest standards of sustainability and performance.

Novelis focuses on developing innovative solutions that increase the recycled content of aluminium across our value streams – automotive, beverage cans, aerospace and specialty products. A key pillar of this effort is our closed-loop recycling system, which enables production scrap from our automotive customers to be returned back to our facilities for reuse – advancing our circular economy model.

Recycling a single aluminium can save up to 1.56 MJ of energy and prevents 98.7g $CO_2$ equivalent. During the reporting period, Novelis recycled 84 billion cans avoiding 8,290 MT $CO_2$e. Our average recycled content across input material reached 63% leading to an estimated 20 million metric tonnes of $CO_2$e avoided, demonstrating our role in decarbonising aluminium production. Through these efforts, we believe we can reduce the environmental footprint of our operations and reinforce our leadership in the transition to low-carbon economy.

**15**

**recycling centres in the Novelis network spread across North America, South America, Europe, and Asia**

**63%**

**is the average recycled content in our input material leading to an estimate 20 million $tCO_2$e avoided**

## Optimisation of Sintering Process for High Density, Low Shrinkage Ceramic Components

The initiative aimed to produce high-quality alumina ceramics with superior density, minimal shrinkage, and excellent performance in demanding engineering applications.

We focused on studying the effects of temperature and sintering aid on the sintering kinetics with a perspective to obtain maximum sintered density with minimal shrinkage, reducing the need for excessive post-machining of ceramics parts. The objective of the initiative was to enhance densification efficiency, minimise shrinkage during sintering, refine microstructure for superior properties, improve thermal and mechanical performance, and optimise cost and energy efficiency.

By optimising the sintering process of fine alumina, the initiative led to the development of high-performance, low-shrinkage ceramics with improved properties, making them ideal for cutting-edge engineering applications.

## Technology Development for Oxalate Removal for Belagavi

Oxalate is an impurity in Bayer liquor that impacts product quality and retards the precipitation process. Hence, we wanted to develop a suitable process to increase oxalate productivity in the liquor. The plant conducted trials with different liquor streams. Trials were also conducted with blends of spent liquor and thick liquor at different ratios.

It was observed that a higher oxalate productivity of ~1.5 g/L was obtained with 50:50 blend ratio compared to 1.0 g/L productivity with only spent liquor.

## Development of Coating for Closure Stock

We produce approximately 500 tonne / month of coated closures for pharmaceutical uses. The coating material is sourced from external supplier as there are very few manufacturers of pharma-grade closure stock coating in India.

To gain a competitive edge and reduce cost of production, we started manufacturing the coating in house. In FY 2024-25, 4 trials of the coating were successfully conducted and samples were supplied to customer for qualifications. Currently, we are fine-tuning the formulation to optimise performance and process compatibility. The coating is expected to bring about 30% cost reduction and minimise our dependency on external suppliers.

## Development of Food-grade Coating for Semi-Rigid Containers (SRC)

Coated wrinkle-free food container is a niche segment for the Indian market. Producing coated, wrinkle-free food containers requires a specialised food-grade coating that is not readily available in India. As a result, all such containers are currently imported. This reliance on imports directly impacts production costs.

To address these constraints, Hindalco decided to develop an in-house food grade coating. This proprietary solution was aimed at reducing dependence on external suppliers and offering a competitive, high-performance alternative. Initial trials revealed cracking during punching, prompting ongoing formulation improvements to enhance flexibility, adhesion, and resistance to forming stresses. In FY 2024 -25, the SRC coating project advanced to successful customer verification trials, resulting in approximately 30% cost reduction.

## Development of Fume-Free Cutting Oils

At Alupuram and Silvassa plants, significant health risks were faced by the workforce due to harmful fumes and smoke from the cutting oils used in sawing operations.

To address this, we developed a fume-free cutting oil specifically for the Puller Saw and Finish Cut Saw. The initiative was focused on creating a low-emission, eco-friendly cutting oil. We conducted lab evaluations and successful plant trials which significantly reduced smoke generation, improved air quality, and enhanced operator safety.

The new oil ensured smoother cuts, reduced material waste, and optimised lubricant consumption, leading to a 20% reduction in lubricant costs. Introducing the fume-free cutting oil led to improved workplace air quality, better cutting performance, and a more flexible and reliable supply chain.

## Cathode Quality Improvement: Parallel Flow Trials

To improve current density in copper refining electrolysis, our Dahej copper operations focused on reducing the diffusion boundary layer — one of the most controllable factors influencing ion transport to the cathode. Industrial operations typically operate at only 30–35% of the theoretical limiting current density.

Different configurations were studied to eliminate carry over slime from the bottom to the cathode surface. The new configuration increased the relative velocity of the electrolyte, resulting in a measurable reduction in the thickness of the diffusion boundary layer. This led to improved mass transfer and more effective distribution of inhibitors. The modified setup enhanced process efficiency and brought operations closer to the theoretical current density limit.

## Formulating Innovative Products and Solutions

At Hindalco, our Innovation Centres are at the forefront of advancing our new brand positioning – a strategic shift from traditional metal manufacturing to a value-added, innovation-led, and sustainability-driven enterprise. This vision is reflected in our R&D efforts to meet evolving market needs with high-performance future ready solutions. In FY 2024-25, we developed 11 new products and applications that were accepted by customers. We also developed 19 additional innovations, reinforcing our commitment to innovation and long-term value creation.

Among the notable innovations in FY 2024-25 were advanced material solutions designed for high-performance and emerging applications. We developed a High Crystalline Alumina (HCA) series for electro-ceramic applications, Sub-micron Alumina (SMA) series for high-value refractory use.

In the EV segment, we introduced BB59 alloy-grade sheets, designed for busbar applications offering higher wire bond strength and corrosion resistance. By integrating additive manufacturing with aluminium extrusion we enabled efficient production of EV motor housings. Additionally, we have improved the material properties of aluminium foils and extrusions used in Li-ion battery enclosures, reinforcing our position as a partner in next-generation mobility.

Recent developments include EV battery enclosures, aluminium bulkers, trailers, chassis, railway wagons, and even modular kitchen solutions. We also made significant progress in manufacturing marine-grade aluminium sheets, expanding our portfolio to support high-performance, specialised application.

Our proactive approach to product development, driven by continuous market applications, has given us a first-mover advantage. This is reflected through developing of Spherical Alumina, Hydratable Alumina, and Bimodal Hydrate for solid surface applications. At the same time, we are expanding our research into new areas such as copper anode and cathode quality, refinery bleed optimisation, metal purification and recycling, and effluent treatment plant (ETP) load reduction. Together, these initiatives reflect our holistic innovation strategy, balancing performance, sustainability, and self-reliance.

At Novelis, as part of our commitment to sustainable innovation, we are advancing the development of high recycled content alloys across key sectors such as beverage packaging, automotive, aerospace, and specialty applications. In beverage packaging, we are pioneering circular solutions through alloys like AA3104 (Unialloy) and intermediate AA5xxx series, which offer enhanced recyclability and performance for can ends. These materials not only reduce environmental impact but also maintain the performance standards required by the industry. Leveraging our deep expertise and advanced tools surface characterisation – we are streamlining the adoption of these next-generation alloys.

Building on the momentum, in aerospace, we collaborated with a leading aircraft manufacturing company on a novel friction stir welded (FSW) fuselage demonstrator, using a newly developed clad layer material system. This innovation, part of a German government-funded project, achieved a 21 kg weight reduction per aircraft section – translating to an estimated 7 tonnes of $CO_2$ savings annually. In the specialty segment, we introduced a high-recycled-content 3105+Zn alloy for industrial heat exchangers, replacing high prime content materials while maintaining electrical conductivity and mechanical performance.

These advancements are complemented by our progress in the automotive sector, where we are developing alloys that are more tolerant to recycled content. We have also completed the development of Hot Roll to Gauge process technology for producing thicker gauge sheet materials, and are advancing roll-formedw, high-frequency welded aluminium tubes for vehicle crash structures. Additionally, our work on pre-coated aluminium sheets is enabling more sustainable and efficient solutions for automotive applications.

*11 new products and applications commercialised, with 19 additional innovations under development- reinforcing our commitment to long-term value creation.*

## Development of Low Soda Boehmite for Lithium-ion Battery Separator Application

Boehmite (γ-AlOOH) is monohydrate aluminium oxide and a Super Value-Added Product (SVAP), used primarily in the electroceramics industry especially in separators for lithium-ion batteries. High-purity Boehmite for lithium-ion batteries is expected to see significant growth in the coming years, driven by the rise of electric vehicles. Its key applications include battery separators, anode edge coatings, catalysts, thermal conductive fillers, and flame retardants.

We initiated the development of low-soda Boehmite using hydrothermal technology, enabling precise control over temperature and pressure.

A Boehmite production process was successfully developed through the dedicated efforts of scientists and technicians at our innovation centres. The final product has been approved by our customers. We also established three design of experiments using the Taguchi method to support the commissioning of a pilot plant at Belagavi. The method developed is now being scaled up for full-scale production. Boehmite will enable us to further diversify our portfolio into Super Value-Added Products (SVAPs).

## Hydrate as a Filler in Aluminium Composite Panels

Aluminium Trihydrate (ATH) is preferred by industries due to its environmental friendliness, with a potential to reduce the amount of costly materials used in the Aluminium Composite Panel (ACP) core, thus lowering manufacturing costs. The ATH's properties like flame retardancy, smoke suppression, mechanical strength improvement, and thermal stability are ideal for use in ACP. After the building and construction industry, transportation and electrical appliances are the next biggest users of ATH-filled composite panels. It is anticipated that ATH will grow in demand as a flame-retardant across a range of industries as fire safety awareness and regulatory compliance rise. Due to the high profitability of this industry, Hindalco took the initiative to enter the Flame-Retardant segment of ACP industry.

Our initiative to use ATH in ACP follows a structured methodology to ensure fire safety, mechanical strength, and cost-effectiveness. During the research and development stage, we first selected the appropriate materials, optimised the ATH to be used in ACP and tested it in the lab. Further, in the manufacturing stage, the focus was on high purity ATH. In the third-party vendor stage, the suitable formulation using ATH has been made into the core of ACP and subsequently various fire performance tests, mechanical properties evaluation and regulatory compliance tests have been carried out.

We established the MHV20 grade which is a ball-milled hydrate, and has already been commercially supplied to the customer end. Furthermore, the moisture reduction (< 0.15) of ATH has been initiated to improve further performance of ATH in ACP. The ATH has already attracted commercial supplies and is opening new market segments for Hindalco.

## Development of Modular Kitchen Components

Aluminium is fire, moisture, and termite resistant and has high strength-to-weight ratio and thus has a strong potential to be a material of choice in the rapidly growing modular kitchen market.

In FY 2024-25, we developed aluminium modular kitchen components that has high strength, corrosion resistance, and a premium surface finish, targeting households in tier 1 and tier 2 cities in India.

The initiative, developed in collaboration with the ABSTC, worked on the design feasibility, material finalisation, and prototyping. We developed four kitchen designs in line with customer demographics and requirements. The modular kitchen has the potential to significantly impact the market, with an estimated EBITDA of ₹4 crore per annum by FY 2030 and ₹116 crore per annum by FY 2035. The Hindalco kitchen was unveiled at the Hindalco Masterbrand launch event on 18 March 2025, and prototypes are in preparation for the product launch in August 2025.

## Development of Battery Enclosures for Electric Vehicles

We have made a significant stride in India's electric vehicle (EV) ecosystem by delivering 10,000 aluminium battery enclosures to a leading automotive manufacturer for their new electric SUV models.

**Co-developed with them, the aluminium enclosures offer:**

+ Up to 40% weight reduction compared to traditional steel designs
+ 8–10% improvement in driving range
+ Enhanced crash safety and superior thermal management, crucial for battery performance in diverse Indian climate

The enclosures are made using low-carbon aluminium, aligning with the commitment of both companies to sustainable mobility. This partnership is a strategic move to localise high-performance EV components and reduce dependence on imports, while also supporting their ambition to lead India's EV transition.

Hindalco successfully delivered 10,000 aluminium battery enclosures from its Chakan plant to an auto major, notching a milestone in India's clean mobility journey

## Collaborating towards New Technological Solutions

At Hindalco and Novelis, innovation is central to our transformation journeys. Guided by the Hindalco H vision and Novelis 3x30 strategy, we are moving beyond traditional manufacturing to focus on value-added products, and sustainable solutions. Strategic collaborations with academic institutions, research bodies, and industry leaders are helping us accelerate innovation, enhance performance, and deliver long-term impact across our operations.

At Hindalco, partnerships with IIT Bombay, IIT Madras, ABSTC, and global partners have led to significant advancements. For instance, the RAMFLICs project, developed with IIT Bombay, IIT Madras, and German partners, focuses on hybrid additive manufacturing for EVs. Our work with ABSTC has enhanced process optimisation and product development across multiple sites – improving performance at Mahan, digital transformation at Muri and Belagavi, and reducing downtime at our copper operations at Dahej.

Further partnerships with BITS Pilani and IIT Kharagpur support improvements in copper cathode quality and pyrometallurgical research. International collaborations include one on arsenic removal with Dundee Sustainable Technologies (Canada) and one on zero hazardous waste solutions with GlassLock. Ongoing R&D partnerships include aluminium and

alumina innovations with IIT Madras, Pondicherry University, E Port Korea, NICERA Coimbatore, NETZSCH Germany, and ICT Mumbai.

Advancing low carbon innovation at Novelis, we extended our partnership with HES-SO Valais-Wallis, EPFL, and OIKEN at the Net Zero Lab, Valais. This two-years extension reinforces our commitment to carbon neutral aluminium production with continued exploration of decarbonisation strategies.

Co-developing with customer is also a key focus. We have partnered on tailored solutions such as aluminium billet casting lubricants and greases for leading global manufacturer of aluminium casting technologies and supported an OEM's SUV with lightweight aluminium applications. Our government-funded project with a leading aircraft manufacturer led to the development of a novel friction stir welded fuselage demonstrator showcasing next-generation airspace innovation.

We actively engage with the wider industry through knowledge sharing platforms. Hindalco hosted the National Workshop on Strengthening R&D in the Indian Minerals & Metals Sector, while Novelis co-organised ICAA19 in Atlanta, highlighting global leadership in aluminium alloys. We also hosted an industry workshop on innovation and sustainability in beverage packaging and were honoured with the 2023 PDMA Outstanding Corporate Innovator Award.

These partnerships and engagements reflect our deep commitment to innovation, sustainability, and co-creating the future of materials, ensuring our leadership in a rapidly evolving global metals industry.

## Performance Improvement at Renukoot Anode Baking Furnace

At Renukoot, we faced challenges with sub-par baking levels of anodes and high specific energy consumption. ABSTC, along with the plant team, conducted computation fluid dynamic (CFD) simulation analysis and measurements (thermal mapping, gas pressure, temperature, and composition) to identify the root causes.

The analysis of the existing design using CFD, helped us identify key factors for improvement.

We initially tested a modified design in two flue walls, and based on encouraging results, we deployed this design in 16 more flue walls. To improve combustion and baking homogeneity, we changed the injection pattern from co-current to counter-current mode. As a result, the initiative helped in improving baking homogeneity and a reduction in low sulphur heavy stock (LSHS) consumption.

## Development of Carbon Coating for Lithium-ion Battery Foils

For higher power and fast charging applications, carbon-coated aluminum foils are preferred due to their ability to reduce interfacial resistance, improve rate capability, and enhance cycle life.

At ABSTC, we developed a carbon black-based conductive primer coating for aluminum battery foils, which are used in various energy storage applications like Li-ion batteries. The work focused on developing and scaling up this coating to meet the specifications required by domestic and international customers. We optimised the slurry formulation, conducted roll-to-roll coating trials, and achieved the desired physical and electrochemical properties.

The domestic demand for coated battery foil is expected to grow significantly, with potential additional EBITDA of ₹50 crore by 2030. We are planning further trials in China to validate our product on a commercial scale.

## Optimisation of Pre-Calcination Circuit to produce High Surface Area Alumina

At our Belagavi refinery, we produce high surface area alumina using flash calcination. This alumina, known as activated or hydratable alumina, contains Rho and Chi phases and is used in applications like catalyst support and special cement. Currently, we achieve a surface area of 150-180 $m^2/g$ and are aiming for 200-250 $m^2/g$ to meet market standards.

Our ABSTC team optimised operations using CFD studies and experiments. After this, we developed models, built a pilot calciner, and redesigned our pre-calciner circuit, achieving 255 $m^2/g$ in initial trials. More controlled trials are planned for bulk production.

Hydratable alumina for castable applications has a potential market demand of 5 KTPA, with estimated annual benefit of ₹10 crore in EBITDA. We further plan to explore the market demand for activated alumina.

## Development of Indigenous Soda Ash Briquettes for Aluminum Smelters

When global supply chain disruptions and rising operational risks began to impact our aluminium smelting operations, we recognised the urgent need to rethink our dependence on imported soda ash briquettes. Mahan aluminium team turned adversity into innovation by developing India's first indigenous soda ash briquettes for aluminium smelters. We were reliant on a dominant overseas supplier whose products, while effective, came at a high cost and were vulnerable to international crisis. The only domestic alternative, powdered soda ash, posed significant safety risks, frequently causing "soda blasts" during potline start-ups.

Through the IGNITE innovation platform, a cross-functional team at Mahan collaborated with an external organisation to overcome technical challenges such as achieving the right density, strength, and moisture resistance in the briquettes. After multiple trials and process optimisation, they successfully engineered a robust, cost-effective, and safer alternative that matched imported quality.

This innovation led to introduction of a domestic alternative, which disrupted the monopoly held by foreign suppliers and compelled them to reduce prices. The solution helped in achieving savings of ₹18,000 per metric tonne, totalling ₹58 lakhs over 14 months, with projected annual savings of ₹76 lakh at our Mahan plant. Adoption by Aditya Aluminium added another ₹26 lakh in savings, validating the solution's scalability.

Our Copper smelting and processes take place in a state-of-the-art plant in India

## Technology Development for Gallium Recovery from Bayer liquor

Gallium is an important strategic metal with major applications in high-capacity data storage devices, wireless infrastructure and defence applications, including new 5G networks. About 90-95% of the total consumption of Gallium is in the form of Gallium Arsenide (GaAs) and Gallium Nitride (GaN). At present, India imports Gallium metal from China and other countries. To avoid any disruptions due to import restrictions, we are conducting initial lab studies to optimise the conditions for extracting Gallium metal from Bayer liquor at our Renukoot refinery.

In FY 2024-25, we have been working with various vendors and technology partners to extract Gallium as part of the alumina refinery operations. We have identified a technology provider, with whom the work has been done for setting up pilot operations at Muri, considering the higher percentage of Gallium present in Bayer liquor. The quality of the product from this process is expected to be 4N purity gallium.

## Reduction in Process Downtime of Copper Smelter

We used to face frequent downtime caused by the formation of hard accretion at the throat of the Waste-Heat Boiler (WHB).

To address this problem, the ABSTC team conducted a comprehensive analysis and implemented a solution. Accretion samples were characterised, revealing the composition and formation mechanisms, and CFD modeling was used to study gas flow and dust deposition and identify high-risk areas. Based on these insights, we designed a solution to inject air at the throat of the WHB to prevent dust accumulation and improve dust sulphation.

This initiative can help save costs by preventing the need for frequent shutdowns and reducing maintenance required for accretion removal. A gain in production is also expected due to the increase in furnace uptime, increase in boiler life due to reduced blasting to remove buildup as well as manpower safety because of fewer manual interventions. The expected profit after full implementation is estimated at ₹12 Cr. due to 50% reduction in downtime.

## Improvement in Copper Wire Rod Performance at Dahej Copper Operations

Wire breaks during the drawing of 8 mm copper rods into fine wires were primarily attributed to a combination of process issues in Continuous Cast Rod (CCR) production and drawing stage defects. In the CCR process, improper control over key parameters resulted in porosity and inclusions, affecting rod quality. Additionally, improper drawing parameters and non-uniform coating contributed to cracks, dust generation, and central bursts during wire drawing.

To address these issues, the ABSTC team conducted detailed fractographic and microstructural analyses of broken wire samples. Using data analytics, they correlated break types with CCR process conditions, identifying critical parameters and defining their optimal control ranges.

Simultaneously, trials were conducted to optimise the drawing process. Finite Element Method (FEM) thermo-mechanical simulations revealed that optimised die parameters reduced chevron crack formation.

This comprehensive optimisation of both CCR and drawing processes led to a significant reduction in wire breaks, resolved central burst issues, thus enhancing product quality and reducing customer-end defects. The project prevented sales returns of 200 MT copper rod.

## Novelis Collaborated with OEM for Aluminium Intensive Vehicle

An OEM developing a new vehicle platform faced challenges in forming complex aluminium parts and considered switching to steel, which would have compromised their aluminium-intensive vehicle strategy. Novelis stepped in with critical support, supplying four aluminium grades for tool trials, ultimately leading to the selection of the product which met the requirements of the customer. Novelis also supported the OEM by developing complex aluminium solutions which strengthened the aluminium-intensive vehicle strategy. The collaboration ensured the OEM could meet design goals in aluminium and was successful in launching their SUV as a full AIV programme.

Our Copper Business is the world's second-largest producer of copper rods (excluding China) and the leading copper producer in India

# Digitalisation and Cyber Security

At Hindalco, we are guided by a dual commitment to digital transformation and uphold an uncompromising cybersecurity posture. Governed by our robust Information Security Policy, our advanced Information Security Management System (ISMS) integrates cutting-edge technology, stringent security processes, and proactive awareness initiatives to manage emerging risks.

Led by our Chief Digital Information Officer (CDIO) and Chief Information Security Officer (CISO), we embrace global best practices. We follow the NIST cybersecurity framework and regularly conduct Cyber Maturity Assessments (CMA) to refine our digital risk posture.

Our ISO 27001 certification across the IT infrastructure reinforces our commitment to global standards. Semi-annual vulnerability assessments and penetration tests by external auditors, enable early detection and swift remediation of risks. Advanced cybersecurity mechanisms– such as network segmentation and Endpoint Detection and Response (EDR) are in place. We are actively exploring and implementing emerging technologies like Micro-segmentation, Privileged Access Management (PAM), Cloud Security Posture Management (CSPM), and Email DLP systems to strengthen security infrastructure.

A comprehensive IT risk register forms the backbone of our strategy. It documents key threats, their potential impacts, and mitigation strategies. This is supported by our Cyber Defence Command Centre (CDCC), which ensures 24x7 monitoring, rapid threat detection and effective response. Independent audits continue to enhance our Business Continuity Management System (BCMS) and overall risk management practices.

Our internal campaign “Cyber Suraksha Abhiyaan” trains our employees into the first line of defence. It includes threat simulation exercises, e-learning modules, online training sessions, and a dedicated information security helpline that fosters continuous learning and rapid response to emerging threats.

Through DISHA 2.0, we are equipping our teams with digital capabilities essential for Industry 4.0. Over 3,000 managers have been trained in digital technologies, and 300+ managers in data analytics. 1,500+ employees were engaged through webinars on Generative AI and OT-IT cybersecurity.

Initiatives such as "Data First," the "Data ki Duniya" movie, and digi-talk sessions continue to build digital fluent and future ready culture.

As part of our data privacy initiatives, we have implemented cookie management across our six organisational websites. The initiative ensures user consent is obtained, and preferences are respected in line with applicable regulations. It has enhanced transparency and control over personal data collection for all site visitors.

Our integrated approach and efforts have yielded a strong track record over the past four financial years; zero data breaches or information security incidents, no stakeholder complaints regarding data privacy. We remain steadfast in our mission to integrate technology strategically, safeguard digital assets, and build a resilient, future focused IT environment that supports innovation, trust and long-term value creation.

## Optimising Plant Operations Using Digital Tools

In our alumina refineries, evaporation circuits consume 20-25% of the total energy per tonne of alumina. We concentrate spent liquor using steam, and the thick liquor output must be carefully controlled as its concentration affects water balance and alumina recovery.

As samples of thick liquor are tested only twice per 8-hour shift in labs, this leads to delays in controlling the process. Hence, our objective was to reduce reliance on lab analysis which would enable quicker process control thus improving operational stability and efficiency.

A team from ABSTC optimised feed split and used an additional equipment design to stabilise operations. We also developed an ML-based soft sensor to predict steam economy and the concentration of thick liquor while adapting to real-time data.

At the Muri refinery, we created a steam prescription model, and at the Belagavi refinery, we developed an ASPEN-based model to improve performance. Both refineries saw a 0.2 per train improvement in steam economy.

We also developed an interactive dashboard for Muri refinery to visualise steam input predictions and prescriptions, monitor system health in real-time, leading to potential monetary benefits.

The initiatives have led to steam savings of 14-16 KTPA at Muri and 4.75 KTPA at Belagavi and improvement in process performance in addition to reduction in caustic losses.