AIIFA SUSTAINABLE STEEL MANUFACTURERS ASSOCIATION

(FORMERLY KNOWN AS ALL INDIA INDUCTION FURNACES ASSOCIATION)

(Promoting Sustainability in Steel for Greener Future)

AIIFA News

VOL. No. XXVI
ISSUE No. 7, July 2025

What's Inside

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Green Steel Certification in India: From Compliance to Competitive Edge
By AVA Insights Partners LLP – A Member Firm of AIIFA

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The global steel industry stands at a pivotal moment—where the imperative to decarbonize converges with the need for resilient, long-term industrial growth. Accounting for approximately 7–9% of global greenhouse gas (GHG) emissions (IEA, 2023), the sector is one of the largest industrial contributors to climate change. Achieving the net-zero goals outlined in the Paris Agreement will be impossible without deep, structural transformation in steelmaking. The challenge ahead is not merely about technological upgrades; it is about reimagining competitiveness through the lens of environmental responsibility.

India, as the world's second-largest steel producer, is uniquely positioned to lead this shift. The Ministry of Steel's launch of a formal **Green Steel Certification framework** marks a bold step in aligning national industrial policy with global climate commitments. This science-backed, data-driven initiative represents a decisive move from voluntary sustainability efforts to a structured, government-recognized pathway for low-carbon steel. It reflects India's intent to not just keep pace with the global transition—but to shape it.

For stakeholders in India's secondary steel, alloy, and foundry segments, this is more than a compliance directive—it is a strategic opportunity. Green certification offers a platform to build resilience, attract ESG-aligned capital, meet the rising expectations of global buyers, and participate in the emerging ecosystem of climate-smart trade. First movers in this space will gain a clear competitive edge, positioning themselves not just as suppliers, but as sustainability leaders in the next era of industrial growth.

Green Steel Certification in India: What It Actually Is

In a landmark move toward sustainable industrial development, the Ministry of Steel formally introduced the **Green Steel Certification scheme** in December 2024. This first-of-its-kind initiative aims to officially recognize steel manufactured with lower carbon emissions. Developed in strategic partnership with the **National Institute of Secondary Steel Technology (NISST)**, the **Bureau of Energy Efficiency (BEE)**, and the **Ministry of Environment, Forest and Climate Change (MoEFCC)**, the framework is designed to align India's steel sector with national climate goals and international decarbonization benchmarks. Central to the scheme is the requirement for producers to **quantify and disclose their carbon emissions intensity**, which will determine their certification status.

Under this framework, only steel produced at facilities with an **emission intensity below 2.2 tonnes of CO_2 equivalent per tonne of finished steel (tCO_2e/tfs)** will be eligible for certification. To ensure transparency and differentiation, a **star-based rating system** has been introduced:

- ★ **5-Star** – Emission intensity less than 1.6 tCO_2e/tfs
- ★ **4-Star** – Emission intensity between 1.6 and 2.0 tCO_2e/tfs
- ★ **3-Star** – Emission intensity between 2.0 and 2.2 tCO_2e/tfs

To uphold the integrity and credibility of the certification, all emissions data must undergo **independent third-party verification** under a stringent **Measurement, Reporting, and Verification (MRV)** protocol. Certification will be granted **only after successful MRV clearance**, with NISST serving as the sole issuing authority. This rigorous, data-driven mechanism ensures that the Green Steel label reflects actual emissions performance—reinforcing India's commitment to

low-carbon manufacturing and strengthening its position in the emerging global market for climate-responsible materials.

Understanding Its Strategic Significance

The **Green Steel Certification** initiative goes beyond traditional quality standards—positioning itself as a formal measure of **carbon performance and production responsibility**. Unlike conventional certifications that focus solely on product specifications, this framework emphasizes **how steel is produced**, placing **GHG emissions at the core** of industrial validation. It is particularly relevant in today's global context of **carbon pricing, climate regulations**, and **sustainability-linked supply chains**, offering manufacturers a government-backed assurance of environmental compliance. For India's **alloy and foundry sectors**, this presents a timely opportunity to enhance market access and align with evolving international trade expectations.

A key strength of the certification lies in its **process-specific, data-driven approach**. It accounts for the varying carbon intensities of production routes—such as **BF–BOF, EAF, IF, and DRI**—rather than enforcing uniform thresholds, ensuring **fairness, transparency**, and recognition of **low-emission technologies**. India's widespread use of **scrap-based EAF and IF methods**, which inherently have **lower carbon footprints**, provides a **strategic advantage**. As per the **IEA Steel Technology Roadmap (2020)**, EAF using recycled scrap emits only **0.3–0.4 tCO_2/t of steel**, compared to **1.8–2.2 tCO_2/t** from BF–BOF. In India, BF–BOF emissions are even higher at **2.5–2.85 tCO_2/t**, while DRI–EAF routes can reach **3.0 tCO_2/t** due to fossil-fuel dependency. Steel's recyclability further supports emission reductions.

Importantly, the certification will aid compliance with emerging global frameworks such as the **EU's Carbon Border Adjustment Mechanism (CBAM)**, which from 2026 will require exporters to disclose embedded emissions and face levies accordingly. For Indian exporters, certification offers credible emissions validation, helping mitigate trade barriers and protect competitiveness.

Beyond compliance, the certification facilitates access to **ESG-linked finance**, enabling eligible producers to tap into **green bonds, concessional credit**, and **preferential procurement channels**. This is especially transformative for **MSMEs in the secondary steel sector**, improving their **creditworthiness**, reducing borrowing costs, and bolstering resilience in a future where **carbon accountability is a strategic necessity** rather than just a regulatory requirement.

Preparing for Carbon-Linked Trade Barriers

The introduction of the **European Union's Carbon Border Adjustment Mechanism (CBAM)**, scheduled for full implementation in 2026, marks a transformative shift in international trade policy—where carbon emissions will carry a financial cost at the border. Steel exporters to the EU will be required to disclose the **embedded emissions** in their products and may face levies if their carbon intensity exceeds benchmark levels. For Indian manufacturers, particularly those targeting European markets, this raises the stakes for emissions transparency, traceability, and regulatory alignment.

In this context, the **Green Steel Certification** emerges as a critical strategic asset. As a formal, government-endorsed verification of carbon performance, it equips Indian producers with credible, measurable, and internationally recognized documentation to validate their emissions profiles. For alloy and secondary steel players—many of whom already operate with inherently lower emissions due to scrap-based production routes—certification can serve as a **carbon compliance passport**, reducing exposure to CBAM-related tariffs while enhancing export readiness in an increasingly climate-conscious global marketplace.

A Step Toward Green Finance and ESG Capital

As environmental, social, and governance (ESG)

metrics become integral to investment decision-making, steel manufacturers are increasingly being assessed on their sustainability credentials alongside financial performance. In this evolving landscape, **Green Steel Certification** serves as a powerful, data-backed signal of low-carbon operations—enabling companies to tap into a growing pool of **ESG-aligned capital**, including green bonds, sustainability-linked loans, and concessional financing. By offering credible emissions verification, certification not only strengthens investor confidence but also aligns Indian producers with global financial flows that are rapidly pivoting toward climate-positive portfolios.

An illustrative example is **JSW Steel**, which in 2022 secured a **$700 million sustainability-linked loan**, with favourable terms directly tied to emissions reduction commitments. Such financing models are quickly becoming standard practice across global markets, rewarding enterprises that can demonstrate science-based, verifiable progress toward decarbonization. For India's secondary steel, alloy, and foundry sectors—particularly MSMEs—Green Steel Certification could unlock access to more affordable and sustainable capital, positioning them to grow competitively while contributing meaningfully to the nation's low-carbon transition.

Global Benchmarks: How India Aligns

As the global steel industry accelerates its transition toward verifiable decarbonization, a number of established frameworks have emerged to define and certify low-carbon steel production. Among the most prominent is **Responsible Steel™**, adopted by major global players such as ArcelorMittal, BlueScope, and Tata Steel Europe, which integrates environmental, social, and governance (ESG) criteria into steelmaking standards. Similarly, Sweden's pioneering **HYBRIT initiative**—a collaboration between SSAB, LKAB, and Vattenfall—achieved a historic milestone by delivering the world's first fossil-free steel to Volvo in 2021. On the domestic front, **GreenPro Certification**, developed by the Confederation of Indian Industry (CII), has recognized products such as Tata Steel's TMT rebars, signalling India's growing commitment to sustainable manufacturing.

India's newly formalized **Green Steel Certification** framework is a timely and strategic response to this global movement. Anchored in scientific methodology and emissions intensity thresholds, it positions Indian steel producers to participate credibly in international markets where **carbon transparency is becoming a procurement prerequisite**. By institutionalizing this certification process, India is not only aligning with evolving global norms but also enabling its domestic industry—particularly the secondary steel and alloy segment—to compete on the strength of verified environmental performance in the emerging low-carbon economy.

What Secondary Producers and Foundries Should Do Now

For many **AIIFA member firms**, especially those operating in the **scrap-based, induction furnace (IF), and secondary steel segments**, the Green Steel Certification is not only within reach but also a strategic lever for long-term growth. These producers already benefit from relatively low carbon intensity due to their process routes and recycling-based operations. With the right approach, they can lead India's green steel transformation—securing competitive advantages in both domestic and global markets.

The journey begins with establishing a **baseline emissions profile** through a structured internal carbon audit. This need not be resource-intensive; standardized tools such as those from the **Bureau of Energy Efficiency (BEE)** or **ISO 14064** offer accessible templates to track key variables like electricity usage, fuel consumption, and production volumes. Once this foundation is laid, firms can implement **targeted, cost-effective improvements**—including the use of energy-efficient furnaces, solar-powered pre-heating, and refined scrap segregation techniques—to further reduce their emissions footprint.

With performance improvements underway, the next step is to align with the requirements for **Measurement, Reporting & Verification (MRV)**—a critical prerequisite for certification. Firms should compile the necessary digital documentation and engage accredited third-party verifiers to validate their emissions data. Applications can then be submitted to the designated certifying body, currently the **National Institute of Secondary Steel Technology (NISST)**. Beyond compliance, this certification positions secondary producers to unlock **ESG-aligned financing**, gain preferential access to green procurement markets, and actively contribute to India's vision of sustainable and inclusive industrial growth.

Looking Ahead: How Certification Will Shape the Sector

In the coming 3 to 5 years, **Green Steel Certification** is poised to evolve from a voluntary compliance measure into a strategic cornerstone of India's industrial policy, trade ecosystem, and infrastructure development agenda. As public procurement increasingly incorporates sustainability metrics, it is expected that **certified low-carbon steel will become a prerequisite** for participation in major infrastructure tenders—spanning sectors such as railways, metro systems, highways, and ports. This shift will effectively create a **differentiated and preferential market** for certified producers, embedding emissions performance into mainstream supply chain competitiveness.

Simultaneously, **financial incentives and Production-Linked Incentive (PLI) schemes** are likely to be tied to certified low-emission outputs, reinforcing the economic rationale for early adoption. Access to **green bonds, concessional credit, and tax-linked sustainability benefits** will depend on measurable, verified emissions data—placing Green Steel Certification at the heart of future industrial financing frameworks. Internationally, **carbon transparency will become a trade imperative**, particularly under regulatory mechanisms such as the European Union's **Carbon Border Adjustment Mechanism (CBAM)**, where export competitiveness will hinge on verifiable carbon intensity disclosures.

To ensure inclusive participation, especially among **micro, small, and medium enterprises (MSMEs)**, cluster-based or **consortium-led certification models** are likely to emerge—facilitated by organizations such as **AIIFA and SIDBI**. These models will help distribute costs, simplify compliance, and accelerate adoption across the broader manufacturing ecosystem. In doing so, India can ensure that its decarbonization journey is not only globally credible but also **domestically equitable and scalable**, reinforcing its leadership in sustainable industrial growth.

Conclusion: Certification Is a Strategic Imperative, Not a Formality

Green Steel Certification transcends regulatory compliance—it is a forward-looking strategic enabler that reflects an organization's commitment to operational excellence, carbon accountability, and long-term competitiveness. For progressive firms, it opens doors to ESG-aligned supply chains, preferential financing, and export resilience in an increasingly carbon-conscious global marketplace. It is a clear statement of intent: to lead responsibly in a decarbonizing world.

As a proud member of **AIIFA**, we believe the alloy, foundry, and secondary steel sectors must seize this moment of transformation. Engaging early and decisively with the certification journey will not only strengthen individual business resilience but also collectively shape the trajectory of India's steel sector toward a greener, more sustainable future. In this new era, leadership will be defined not merely by output—but by impact.

India's Carbon Credit Mandate: Implications for Steel Sector Compliance and Competitiveness

By AVA Insights Partners LLP – A Member Firm of AllFA

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As India intensifies its commitment to climate action in line with national and international goals, a pivotal regulatory development has emerged through the Ministry of Environment, Forest and Climate Change (MoEFCC). The issuance of a draft notification under the Carbon Credit Trading Scheme (CCTS), 2023 marks a significant step forward in formalizing a carbon pricing regime at the industrial level. Building upon the earlier April 2025 notification, which targeted sectors such as aluminium, cement, chlor-alkali, and pulp & paper, the revised draft issued in June 2025 extends mandatory compliance to five additional energy-intensive sectors, including iron and steel. This extension positions the steel industry squarely within India's climate accountability framework. The ongoing public consultation period, open until 24 August 2025, provides a critical opportunity for industry stakeholders to assess, engage, and influence the policy trajectory.

The CCTS represents India's first binding carbon performance regime, integrating enforceable greenhouse gas (GHG) intensity thresholds and establishing a domestic carbon market. This structure is designed to incentivize emission reductions, accelerate technology adoption, and embed sustainability into core industrial operations. For the steel sector—a key pillar of India's manufacturing base and among its most carbon-intensive industries—the implications are profound. Transitioning from a voluntary reporting regime to one anchored in statutory compliance marks a strategic reorientation, signaling India's intent to balance industrial growth with environmental stewardship.

The draft framework extends coverage to the full spectrum of steel production, including integrated steel plants, sponge iron units using coal-based rotary kilns, electric arc furnace (EAF) operators, induction furnaces, and rolling mills. Tailored GHG intensity targets are proposed based on production routes, with BF-BOF (Blast Furnace–Basic Oxygen Furnace) plants—currently averaging emissions of 3.2 tCO2e per tonne of crude steel—expected to reduce intensity to approximately 2.9 tCO2e by FY 2026–27. In contrast, EAF units with inherently lower emissions may generate surplus credits, positioning them advantageously in the emerging carbon market. This underscores a policy thrust toward promoting low-emission technologies and operational efficiencies.

The CCTS is rooted in the Energy Conservation Act, 2001, and its operationalization is guided by Sections 14A and 14B of the Act and Rule 5 of the scheme. It introduces a market-based approach to decarbonisation while reinforcing compliance obligations. Oversight and administration are divided among three core institutions: the MoEFCC, which serves as the apex policy body; the Bureau of Energy Efficiency (BEE), which provides technical support, develops sectoral benchmarks, and manages the carbon credit registry; and the National Designated Authority for CCTS (NDA-CCTS), which ensures inter-agency coherence and final approvals.

The compliance regime applies to Designated Consumers (DCs) across 13 high-emission sectors, including over 250 units from the steel industry. These entities are assigned GHG intensity targets based on unit-level historical data and are evaluated over two defined compliance periods: FY 2025–26 and FY 2026–27, using FY 2023–24 as the baseline year. Surplus reductions will result in the issuance of tradable Emission Reduction Units (ERUs), while deficits require credit procurement or the payment of a penalty equal to twice the average market value of the shortfall ERUs. This performance-linked framework creates both compliance risk and market opportunity.

Central to the scheme's integrity is a robust yet pragmatic Monitoring, Reporting, and Verification (MRV) system. Though the term "MRV" is not explicitly stated, its core elements—annual digital reporting, third-party verification, and audit requirements—are embedded in the compliance architecture. A centralized GHG credit registry and a digital trading platform, to be administered by BEE, will support transparency, traceability, and market confidence. These digital systems will enable real-time tracking of emissions data, credit issuance, and trading activity.

Transitioning from the Perform, Achieve, and Trade (PAT) scheme to the CCTS signifies a structural shift in India's industrial decarbonisation approach. The PAT scheme focused on energy intensity improvements with relatively moderate compliance pressure. In contrast, the CCTS introduces enforceable carbon liabilities that directly affect a company's financial and operational profile. While efficient players can monetize surplus performance, underperforming units face real cost exposure and regulatory penalties. For the steel sector, this elevates emissions management to a boardroom-level priority.

The degree of sector readiness, however, is uneven. BF-BOF plants face steeper decarbonisation trajectories due to higher baseline emissions, whereas EAF and induction furnace operators may benefit from technological headroom. Smaller and mid-sized units, particularly those using induction furnaces, may encounter operational hurdles in MRV compliance, data management, and audit preparedness. Addressing these disparities will require targeted capacity-building, regulatory clarity, and access to financial and technical support.

From a strategic standpoint, companies should begin mapping projected emissions profiles and scenario-testing the cost implications of ERU pricing volatility. In parallel, aligning internal ESG systems—such as Business Responsibility and Sustainability Reporting (BRSR)—with CCTS requirements will enable seamless regulatory integration. The introduction of global instruments like the EU's Carbon Border Adjustment Mechanism (CBAM) further raises the stakes, making carbon transparency a prerequisite for export competitiveness, particularly in emissions-intensive industries like steel.

Emission reduction strategies must be tailored to plant type and operational scale. Options include transitioning to EAF technology, increasing scrap utilization, integrating renewable energy, improving process efficiency through automation and energy management, deploying waste heat recovery, and exploring carbon capture and green hydrogen solutions. With regulation and investor expectations converging around climate performance, decarbonisation must become a strategic pillar of long-term industrial competitiveness.

Nevertheless, critical questions remain as the scheme advances toward implementation. Will the benchmarking methodology equitably reflect technological heterogeneity? Will ERU availability

and pricing remain stable, or will credit scarcity inflate compliance costs? And can MRV protocols be designed to ensure both credibility and operational simplicity across a diverse industrial base? Addressing these concerns through stakeholder consultation and adaptive policy design will be essential.

In conclusion, the draft notification under the CCTS, 2023 represents a watershed moment in India's climate policy architecture. By formalizing carbon pricing and market-based compliance at the industrial level, it compels sectors like steel to embed sustainability into their strategic and operational core. The success of this transition will hinge on early engagement, institutional readiness, and the ability to adapt swiftly to a climate-conscious regulatory and market environment. For the steel industry, this is not merely a compliance challenge—it is an inflection point that will shape its global relevance and future resilience.

Green Steel Taxonomy
Defining moment for Indian Steel Industry

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*This is the **second in four** in a series of articles written for AIIFA Sustainable Steel Manufacturers association. The earlier article published in the last edition focussed on the CBAM related regulations and its impact on Indian steel exporters.*

*The **series of 4 articles** is intended to focus on assessing immediate compliance and regulatory challenges, emerging opportunities and a roadmap to sustainability and competitiveness in the fast evolving Low-Carbon Economy for Indian Steel Industry players.*

The **Green Steel Taxonomy** was officially released by the Indian Ministry of Steel in December 2024 and notified in the eGazette on 23rd December, 2024 as a moment defining step to decarbonize India's steel sector. A copy of the Gazette is available for viewing/downloading at https://egazette.gov.in/WriteReadData/2024/259382.pdf.

The taxonomy defines steel as green steel based on carbon dioxide equivalent (CO2e) **emission intensity per tonne of finished steel (tCO2e/tfs)**. In simple terms,

Star Rating	Emission intensity
*****	lower than 1.6 tCO2e/tfs
****	between 1.6 and 2.0 t-CO2e/tfs
***	between 2.0 and 2.2 t-CO2e/tfs

So what happens to the Steel with emission intensity above 2.2 t-CO2e/tfs ? Well, for now it is **not eligible** for green certification under this taxonomy.

And what happens to the producers of uncertified steel (i.e. steel with 2.2 t-CO2e/tfs), should be easy to comprehend. They are most likely to confront increased evaluation (read rejection) with customers and lenders.

A. The Need and Rationale for Green Taxonomy Framework

The Indian government introduced the Green Steel Taxonomy to address the urgent need to decarbonize the steel sector, which is one of the most carbon-intensive industries and a major contributor to India's greenhouse gas emissions. The intent is to -

- **Provide Clear Benchmarks**: clear, quantifiable standards for low-carbon steel production, defining “green steel”. This standardization helps steel producers align with national climate goals and global sustainability norms.
- **Supporting India's Net-Zero 2070 Vision**: Steel production is critical to India's industrial growth but also a significant source of emissions. The taxonomy is a strategic tool to drive the transition toward low-carbon technologies and achieve the government's target of net-zero emission intensity in the steel sector by 2070.
- **Enhancing Global Competitiveness**: By setting emission thresholds and certification mechanisms, the taxonomy helps Indian steel producers meet stringent international environmental regulations such as EU-CBAM.

This enables Indian steel to remain competitive in global markets demanding sustainable products.

B. It's a framework, not a legislation.

Unlike EU-CBAM, the green steel taxonomy does not have an a penal or a binding mandatory provision. But it does serve as a guideline for the industry and is expected to influence policy and procurement practices. In essence, it is

- A framework, not a law
- Its promotional, not regulatory
- It influences, doesn't dictate
- It is for voluntary adoption

C. The Certification Framework

The Indian Ministry of Steel through NISST (National Institute of Secondary Steel Technology) will be the sole certifying body in the country. NISST plans to employs a rigorous Measurement, Reporting, and Verification (MRV) process to verify and certify green steel. Over time, NISST shall require steel producers to submit detailed data on greenhouse gas emissions covering Scope 1 (direct emissions), Scope 2 (indirect emissions from energy consumption), and limited Scope 3 (supply chain emissions) to calculate carbon intensity per tonne of finished steel.

Moving forward, we may have NISST or other nominated entities spearheading other broader roles like Monitoring and Verification Audits; Process Audits, undertake independent verification of emissions data and processes, Green Steel Certification Issuance, creation and Maintenance of a Green Steel Manufacturer's Registry etc., for the larger benefit of the Industry.

D. Steps to 'green steel'

The Ministry of Steel, with NISST (National Institute of Secondary Steel Technology) and BIS, is setting up a structured Green Steel Certification process. Here's how your company can participate and prepare:

1. Register / Express Interest to NISST for participation. The details are available at the NISST Website.

2. Baseline Emissions Assessment by Calculating carbon emissions per tonne of steel (Scope 1 & 2). BIS/ISO 14404, IPCC etc. provide important inputs.

3. Setup an industry specific MRV (Monitoring, Reporting, Verification) digital platform for real-time carbon tracking while ensuring traceable and auditable emission records.

3. Capacity Building & Gap Analysis by Access training and audits by NISST

4. Adopt Cleaner Technologies by using energy-efficient furnaces, renewables, scrap-based EAFs. Shift away from coal/FO to lower-carbon fuels

6. Third-Party Verification of the emissions data by approved auditors. Submit verified data to MoS/NISST

7. Evaluation & Certification after Emissions benchmarked against Green Steel criteria

8. Ongoing Compliance & Recertification

Not all these steps are sequential and one can be taken preceding other. Also the information is as sourced from secondary sources and liable to change. Pls do visit www.NISST.org for updated details.

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F. Conclusion

Adopting the Green Steel Taxonomy is no longer just a sustainability measure — it's a strategic imperative for long-term growth, competitiveness, and compliance. As global markets move swiftly towards carbon border regulations, ESG-linked financing, and green procurement policies, Indian steelmakers that align early with recognized green standards will lead the transition.

By embracing this taxonomy, companies gain more than a certification — they gain credibility, access to premium markets, lower regulatory risks, and stronger investor confidence. It also enables measurable progress toward India's net-zero goals, while catalysing innovation and resilience across the value chain.

The message is clear: those who adopt green steel practices today will define the steel industry of tomorrow — cleaner, smarter, and globally respected.

Govt. Of India, Min. Of Steel, NISST, MSME ministry and your association – AIIFA Sustainable Steel Manufacturers Association, all are available to extend all possible support to the Industry.

Stay tuned in for the next article on **'Carbon Opportunity: CCTS, Carbon Credits & IRECs for India's Steel Sector'** in the next publication of your monthly magazine. Pls. feel free to reach out to the authors for any queries, feedback, help/support if required.

Optimized Furnace Charging and Charge Mix Management in Induction Furnace Steelmaking for Special Steels

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INTRODUCTION

Steel remains a cornerstone of modern industrial development, playing a crucial role across infrastructure, transportation, manufacturing, and energy sectors. Traditionally, steel production via the primary blast furnace–basic oxygen furnace (BF–BOF) route is associated with significant environmental impact due to its high carbon emissions. As global decarbonization goals become increasingly pressing, the steel industry is adopting cleaner production routes. Electric Furnace Steelmaking — especially through Induction Furnaces (IFs) — offers a viable, lower-emission alternative to conventional methods, particularly when powered by renewable energy.

Induction Furnaces, alongside Electric Arc Furnaces (EAFs), melt steel scrap and other iron-bearing materials using electricity, thereby reducing the carbon footprint. While both technologies have advantages, IFs are particularly suitable for small and medium-scale steel plants and offer near-zero direct carbon emissions when used effectively. However, feedstock availability remains a limiting factor. Optimizing the furnace charge mix in IF operations is critical to achieving cost-effective, high-quality, and sustainable steel production.

SAFE CHAGING OF RAW MATERIALS IN INDUCTION FURNACE

In induction furnace operations, the primary feedstock includes clean ferrous scrap, sponge iron (DRI), and occasionally pig iron. Scrap recycling supports the circular economy, reduces reliance on virgin ores, and lowers overall emissions. Safe charging practices are essential to prevent explosions and promote efficient melting. Operators must avoid charging wet, oily, or oversized scrap, which can create violent steam explosions due to moisture vaporization. Scrap dimensions should generally not exceed one-third of the furnace diameter, and a dense, preheated initial charge is recommended to facilitate optimal coupling with the induction field.

Sponge iron, due to its high metallization (typically 88–94%), high porosity, and low impurity content, is a key component in IF charge mixes. It contributes to consistent melt chemistry, stable furnace operation, and enhanced stirring due to CO gas evolution. Charging sponge iron after the initial scrap layer minimizes oxidation and promotes homogeneous melting. Depending on operational design, sponge iron may be added in batches or through continuous feeding mechanisms.

USE OF IRON ORE PELLETS IN CHARGEMIX

Pellets, typically used in primary steelmaking, are gaining attention in IF operations due to potential benefits in cost, quality, and yield. When used appropriately, pellets reduce energy consumption and metal losses. However, pellet size, feeding rate, and slag behaviour must be carefully managed to avoid localized overheating and facilitate complete melting. Slag formation must be controlled to ensure good separation from the molten metal and minimize alloy losses.

Some plants have introduced continuous pellet feeding systems, though smaller units may rely on batch charging. Individual plants must undertake

charge mix studies to determine the optimal balance for their operational setup and targeted grades.

SUGGESTED CHARGE MIX FOR TRIAL OPTIMISATION

An example of an optimized charge mix for special steel production could include:

- Sponge Iron: 55–60% (yield ~85%)
- Iron Ore Pellets: 20–30% (yield ~66%)
- Ferrous Scrap: 8–10% (yield ~92%)
- Pig Iron (optional): 5–8% (yield ~94%)

Final mix design should consider material cost, yield, melting behaviour, and chemical requirements for the intended steel grade.

IMPORTANCE OF ACCURATE CHARGING QUANTITY

Under- or overcharging the furnace can severely affect melting efficiency, energy consumption, and refractory life. Undercharging increases specific energy consumption, prolongs heat time, and may lead to poor melt homogeneity. Overcharging, on the other hand, can damage the furnace lining, lead to uneven temperature distribution, and complicate composition control.

The charge mix must align with the furnace's rated capacity. Operators should follow best practices for charge sizing, including avoiding pieces larger than one-third of the furnace diameter, and ensuring materials are clean and free from contaminants such as oil, dirt, or rust.

MELTING CHARACTERISTICS OF SPONGE IRON

Sponge iron's metallurgical characteristics—such as its Fe(M) content, porosity, and impurity levels—directly impact melting behaviour and steel quality. Low sulphur, phosphorus, and tramp elements ensure cleaner steel output. The FeO content should be controlled to avoid excessive slag formation and reduce the risk of carbon boil. Sponge iron melts at around 1538°C, and its gas evolution properties support melt agitation, contributing to better mixing and temperature uniformity.

MODES OF CHARGING AND SAFETY PRACTICES

Charging can be conducted manually or via crane systems and may involve cold or preheated materials. The safety of personnel and equipment during charging is paramount. Key practices include:

- Use of full PPE: goggles, aluminized coats, gloves, flame-resistant clothing, and safety boots.
- Ensuring materials are dry and free of flammable contaminants.
- Avoiding charging scrap into a furnace that is already filled with molten metal.
- Steady ladle handling during tapping and teeming to prevent spillage.
- Inspection and turnaround of ladles between heats to ensure structural integrity.

MAINTENANCE AND OPERATIONAL TRAINING

Regular inspection of critical furnace components — crucibles, induction coils, tops, and cooling systems — is vital for operational continuity. Furnace areas and pit-side zones must remain clean and free of flammable debris. Cooling systems should be actively monitored to prevent overheating.

Training shop floor personnel on process safety, optimized charging techniques, and emergency protocols is essential. Regular discussions and

briefings enhance awareness, empower operational teams, and directly contribute to productivity, steel quality, and safety.

CONCLUSION

Optimizing the charge mix and ensuring safe charging practices are foundational to efficient, cost-effective, and sustainable steelmaking via induction furnaces. A well-balanced charge mix not only supports desired metallurgical outcomes but also impacts energy efficiency, slag generation, refractory life, and overall plant economics. Each plant should tailor its charge composition based on grade requirements, cost factors, and operational parameters. Continuous process monitoring, plant-specific trials, and adherence to safety standards are critical to achieving profitability and sustainability in special steel production through induction furnace technology.

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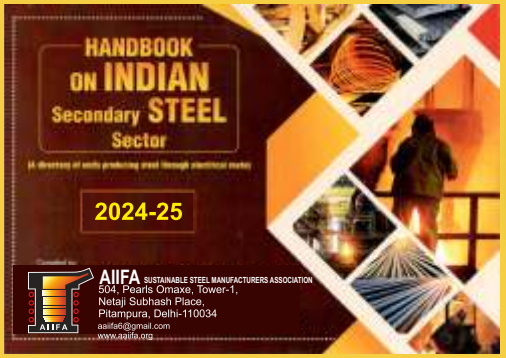

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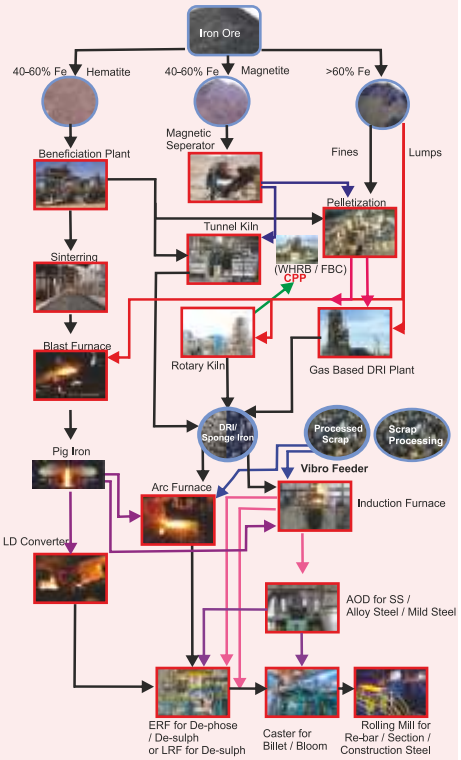

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