AIIFA SUSTAINABLE STEEL MANUFACTURERS ASSOCIATION

(FORMERLY KNOWN AS ALL INDIA INDUCTION FURNACES ASSOCIATION)

Voice of Indian Sustainable Steel Manufacturers

AIIFA News

VOL. No. XXV
ISSUE No. 12, Dec. 2024

What's Inside

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The Digital Transformation of Global Logistics: Driving Efficiency, Sustainability, and Competitive Edge

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Synopsis:

The logistics industry is undergoing a transformative shift, driven by the integration of cutting-edge technologies like artificial intelligence (AI), the Internet of Things (IoT), blockchain, big data analytics, and cloud computing. These digital advancements are revolutionizing logistics by enhancing the precision, speed, and efficiency of goods movement worldwide. They are also reshaping traditional supply chain practices to offer unparalleled transparency, sustainability, and a stronger focus on customer satisfaction.

This topic explores the many facets of digital transformation in logistics, examining how emerging technologies are not just improving operational efficiency but also establishing a competitive advantage and fostering sustainable growth. Key innovations such as real-time tracking, predictive analytics, automated warehousing, and secure blockchain data sharing are reshaping the industry landscape. With predictive tools allowing better demand forecasting, IoT-enabled smart warehousing optimizing inventory, and route optimization reducing environmental impact, digital logistics is setting new standards for sustainable, agile, and customer-centric service delivery.

Key Transformations in Digital Logistics

1. Enhanced Supply Chain Visibility: Enhanced supply chain visibility has become a fundamental pillar of modern logistics, driven by IoT and GPS advancements that enable real-time tracking and exceptional transparency throughout the entire journey of goods. This technology empowers logistics companies to monitor precise shipment locations, anticipate arrival times, and detect potential delays, enabling them to proactively address challenges and optimize operational flow, which minimizes disruptions and enhances efficiency.

This real-time visibility delivers value across the supply chain, benefiting not only logistics providers but also businesses and customers. With immediate access to accurate data, companies can make timely adjustments, optimize inventory management, and meet delivery expectations reliably. For customers, this transparency fosters confidence by providing reliable delivery information, reinforcing trust, and elevating the overall experience in a fast-paced, on-demand marketplace.

2. Automation and Robotics in Warehousing: Automation and robotics have revolutionized warehousing by transforming inventory management and order fulfilment with enhanced speed, precision, and cost-effectiveness. Technologies like automated guided vehicles (AGVs) and robotic picking systems streamline operations by significantly reducing the need for manual intervention, thus minimizing human error and lowering labour costs. These advanced systems enable rapid processing, allowing warehouses to accommodate growing order volumes without sacrificing accuracy or delivery speed.

Moreover, automation brings scalability, allowing warehouses to efficiently handle peak demand fluctuations. Robotic systems, whether functioning autonomously or in collaboration with human workers, maximize space utilization and ensure that items are promptly and accurately picked, sorted, and dispatched. This seamless integration of robotics and automation creates a highly efficient, adaptable warehousing environment capable of supporting the complex demands of today's dynamic supply chains.

3. Predictive Analytics for Demand Forecasting: Predictive analytics powered by AI has become a game-changer for demand forecasting by analysing historical data, market

trends, and external factors to produce highly accurate forecasts. This data-driven approach enables companies to anticipate demand more effectively, leading to better inventory management and minimized risks of overstock or stockouts. With precise demand insights, businesses can make informed decisions about stock levels, reducing unnecessary costs and optimizing resource allocation.

For logistics providers, predictive analytics provides valuable foresight, allowing them to plan capacities and adjust resources well in advance. This proactive approach not only enhances supply chain efficiency but also improves service reliability, ensuring that companies are prepared to meet customer demand fluctuations with agility and precision. By leveraging predictive analytics, businesses gain a competitive edge in responsiveness and operational efficiency, aligning inventory and logistics with actual market needs.

4. Blockchain for Data Integrity and Transparency: Blockchain technology is transforming supply chain management by providing secure and immutable records that significantly enhance data integrity and transparency. Its decentralized architecture facilitates the secure exchange of information among all stakeholders, ensuring that data remains unaltered and reliable throughout the supply chain. This feature is particularly crucial in complex global logistics networks, where the involvement of multiple parties heightens the risks of fraud and misinformation.

By implementing blockchain, organizations can improve traceability, allowing stakeholders to monitor products from origin to destination. This transparency fosters trust among participants, as every transaction is recorded in a verifiable manner, enabling stakeholders to authenticate the provenance and quality of goods. Such capabilities are essential for regulatory compliance and quality assurance. Ultimately, by leveraging blockchain technology, companies can enhance operational efficiency, reduce risks, and cultivate stronger relationships within their supply chains, resulting in a more resilient and trustworthy logistics ecosystem.

5. Route Optimization for Cost Reduction: AI-powered route optimization is transforming logistics by significantly lowering costs through the identification of the most efficient delivery paths. By analysing real-time variables such as traffic conditions, weather forecasts, and vehicle capacities, this advanced technology enables logistics providers to make informed, data-driven decisions that enhance route efficiency. Consequently, companies benefit from reduced fuel consumption and shorter delivery times, leading to both financial savings and improved environmental sustainability.

The implementation of route optimization not only streamlines logistics operations but also plays a crucial role in minimizing the carbon footprint associated with transportation. By directing vehicles along the most efficient routes, businesses can improve operational efficiency while better meeting customer demands. This comprehensive approach to route planning not only facilitates cost reductions but also aligns with the growing emphasis on sustainable logistics, positioning companies as responsible and eco-conscious participants in an increasingly competitive market.

6. Digital Twins in Logistics: Digital twins are transforming logistics by creating virtual representations of physical supply chain processes, enabling companies to simulate and analyse their operations in real-time. This advanced technology offers a holistic view of logistics systems, allowing organizations to pinpoint potential bottlenecks and inefficiencies before they develop into significant disruptions. By harnessing digital twins, businesses can conduct

simulations to evaluate various scenarios, understand the impact of different variables, and implement proactive strategies to optimize their operations.

This analytical capability enhances decision-making and drives continuous improvement within logistics operations. Insights gleaned from digital twin models enable organizations to refine processes, allocate resources more effectively, and respond swiftly to dynamic market conditions. This proactive methodology not only bolsters operational resilience but also elevates overall supply chain efficiency, equipping companies to tackle challenges with greater agility and effectiveness in an increasingly complex logistics environment.

7. Smart Warehousing with IoT: Smart warehousing, enabled by IoT technology, is transforming inventory management by delivering real-time insights into stock levels and environmental conditions. IoT sensors continuously monitor critical variables such as temperature, humidity, and inventory counts, allowing companies to maintain optimal conditions for sensitive products, especially in industries like pharmaceuticals and food. This capability not only ensures compliance with regulatory standards but also plays a vital role in preserving product quality, thereby enhancing customer satisfaction.

By integrating IoT into warehousing operations, businesses can proactively identify and address potential issues before they escalate. For instance, if temperature thresholds for perishable goods are exceeded, immediate alerts can trigger corrective actions. This enhanced visibility and responsiveness lead to improved operational efficiency, reduced waste, and increased consumer trust by ensuring the consistent delivery of high-quality products. Ultimately, smart warehousing powered by IoT strengthens the reliability and effectiveness of the supply chain, positioning companies to adapt to changing consumer demands and market dynamics.

8. E-commerce and Last-Mile Delivery Innovations: The rapid growth of e-commerce has compelled companies to explore innovative solutions for last-mile delivery, driven by an increasing consumer demand for speed and flexibility. Technologies like drones and autonomous vehicles are emerging as transformative alternatives to traditional delivery methods. Drones can navigate around traffic and deliver packages directly to consumers' doorsteps, while autonomous vehicles optimize the delivery process by reducing reliance on human drivers and cutting operational costs.

Moreover, crowd-sourced delivery models are gaining momentum, utilizing local gig economy workers to improve delivery speed and reduce expenses. This strategy not only broadens the delivery network but also enables companies to swiftly adapt to fluctuating demand and geographical challenges. By integrating these advanced innovations, businesses can significantly enhance their last-mile delivery capabilities, boost customer satisfaction, and secure a competitive advantage in the rapidly evolving e-commerce landscape.

9. AI for Real-Time Decision Making: AI is transforming real-time decision-making in logistics by harnessing extensive data sets to provide actionable insights for essential operations such as dynamic pricing, demand forecasting, and route planning. By analyzing real-time data, AI identifies patterns and trends that empower logistics companies to make informed decisions, optimizing their processes and improving service levels. For example, AI algorithms can dynamically adjust pricing in response to market demand fluctuations, ensuring that businesses remain competitive while maximizing revenue.

Additionally, AI-driven analytics enable logistics providers to quickly adapt to evolving market conditions. With accurate demand forecasts, companies can allocate resources more efficiently and fine-tune their operations to meet customer

expectations. This level of agility enhances operational efficiency and boosts customer satisfaction, as businesses are better positioned to deliver products promptly and at optimal prices. Ultimately, integrating AI into decision-making processes equips logistics firms to excel in an increasingly dynamic and competitive landscape, driving sustainable growth and innovation.

10. Sustainable Logistics Solutions: With growing environmental concerns, logistics companies are increasingly embracing sustainable solutions to reduce their carbon footprint and meet global sustainability objectives. Digital innovations such as route optimization, predictive maintenance, and data analytics are central to this shift. For instance, route optimization enables companies to pinpoint the most efficient delivery paths, significantly cutting fuel consumption and greenhouse gas emissions. Meanwhile, predictive maintenance allows for proactive servicing of vehicles and equipment, improving operational efficiency and extending asset lifespans.

Additionally, leveraging data insights on energy consumption and emissions equips logistics providers with the tools to continuously assess their environmental impact. By analysing this data, companies can develop targeted strategies to enhance energy efficiency and minimize waste. Such sustainable practices not only contribute to environmental preservation but also bolster corporate reputation, appealing to eco-conscious customers and investors. Ultimately, by adopting sustainable logistics solutions, companies can thrive in a market that increasingly values environmental responsibility while maintaining profitability.

11. Cloud Computing for Scalability and Flexibility: Cloud computing is transforming the logistics sector by offering scalable and flexible solutions that enhance data processing and foster collaboration across global supply chains. By utilizing cloud technology, logistics companies gain access to real-time data from diverse sources, which significantly improves coordination among partners and stakeholders. This connectivity enables more agile operations, allowing firms to swiftly adapt to shifting market demands, manage inventory efficiently, and optimize resource allocation.

Additionally, the inherent scalability of cloud solutions allows logistics providers to adjust their IT infrastructure in response to fluctuations in demand, eliminating the need for substantial upfront investments. This adaptability not only supports business expansion and entry into new markets but also encourages innovation while maintaining operational efficiency. By leveraging cloud computing, logistics companies can strengthen their competitiveness and resilience in a rapidly changing industry landscape, positioning themselves for sustained success.

12. Customer-Centric Approaches with Personalization: Data analytics-driven customer-centric approaches are transforming the logistics industry by enabling highly personalized services that cater to individual preferences. By leveraging customer data, logistics providers can offer a diverse range of delivery options, allowing clients to select services that best meet their needs—whether that's expedited shipping, specific time slots, or environmentally friendly delivery methods. This degree of customization not only enriches the customer experience but also fosters loyalty, as clients feel recognized and valued.

Additionally, personalized logistics services enhance proactive communication by keeping customers informed about their orders in real time. This level of transparency builds trust and satisfaction, as customers appreciate timely updates and the flexibility to modify their delivery preferences. By adopting a customer-centric model, logistics companies can stand out in a competitive marketplace, leading to increased customer retention and positive referrals, ultimately driving sustainable business growth.

13. Cybersecurity in Digital Logistics: The digital transformation of logistics has revolutionized operational efficiency but also brought forth significant cybersecurity challenges. As businesses become more reliant on interconnected systems and data sharing, implementing robust cybersecurity measures is essential to protect sensitive information from breaches and cyberattacks. Comprehensive security protocols—such as data encryption, stringent access controls, and regular security audits—are critical in preventing disruptions that could jeopardize supply chain continuity and affect customer service.

Furthermore, prioritizing strong cybersecurity practices not only safeguards company assets but also enhances customer trust and loyalty. Clients are more inclined to partner with logistics providers that demonstrate a commitment to data security and transparency. By investing in advanced cybersecurity solutions, logistics companies can effectively mitigate risks, bolster operational resilience, and establish themselves as reliable partners in an increasingly digital landscape, ultimately contributing to their long-term success and competitive advantage.

14. Augmented Reality (AR) for Training and Maintenance: Augmented Reality (AR) technology is revolutionizing logistics training and maintenance by providing real-time, interactive guidance through devices like smart glasses. This cutting-edge approach significantly enhances operational efficiency by overlaying step-by-step instructions directly onto the user's field of vision, empowering logistics staff to execute tasks with increased precision and confidence. By immersing trainees in AR environments, they can better visualize complex processes, effectively reducing the learning curve and minimizing the potential for errors during critical operations.

Moreover, AR is pivotal in streamlining maintenance tasks within logistics. Technicians can access digital manuals, schematics, and diagnostic tools while working on equipment, which facilitates quicker troubleshooting and repairs. This integration of AR not only reduces equipment downtime but also enhances workplace safety by allowing staff to adhere to safety protocols more effectively. By embedding AR into training and maintenance routines, organizations can significantly boost productivity and elevate employee skill levels, ultimately resulting in enhanced performance across logistics operations.

15. Inventory Management with AI: AI-driven insights are revolutionizing inventory management by accurately predicting stock requirements and automating replenishment processes. By analyzing historical sales data, seasonal patterns, and market dynamics, AI systems can forecast demand with exceptional accuracy. This forward-thinking strategy allows businesses to maintain optimal inventory levels, effectively mitigating the risks of overstocking and stockouts. As a result, organizations can implement cost-effective warehousing strategies, reducing excess inventory that incurs holding costs while ensuring that in-demand items are readily available to satisfy customer needs.

Furthermore, automating inventory replenishment significantly enhances operational efficiency and responsiveness. With AI overseeing stock levels and ordering workflows, businesses can streamline their supply chain operations, minimizing manual errors and enabling staff to concentrate on higher-value tasks. This not only improves demand fulfilment and boosts customer satisfaction but also optimizes resource allocation throughout the organization. By harnessing the power of AI in inventory management, companies can gain a competitive advantage through increased agility, substantial cost savings, and the capacity to swiftly adapt to evolving market conditions.

16. Automated Documentation and Compliance: Automating documentation management is revolutionizing compliance processes across organizations by dramatically improving speed and accuracy. By harnessing advanced technologies, companies can efficiently

generate, track, and store vital documents, significantly reducing the risk of human error that can jeopardize compliance efforts. This level of automation ensures that all essential documentation is consistently updated and easily accessible, enabling businesses to navigate complex regulatory landscapes with confidence. As a result, organizations can adhere more effectively to global trade regulations, minimizing the chances of incurring penalties and delays associated with non-compliance.

Moreover, automated documentation management streamlines cross-border transactions by accelerating the compliance verification process. With real-time access to crucial documents and compliance statuses, organizations can quickly respond to regulatory inquiries and expedite approvals from customs authorities. This operational efficiency not only enhances overall workflow but also boosts customer satisfaction by ensuring the timely delivery of goods across international borders. Ultimately, automating documentation and compliance processes equips companies to thrive in a rapidly evolving global marketplace, allowing them to concentrate on strategic initiatives while upholding rigorous compliance standards.

17. Data-Driven Strategic Planning: Data-driven strategic planning, underpinned by big data analytics, is transforming the logistics sector by providing organizations with critical insights into market trends, customer preferences, and competitor strategies. By harnessing vast datasets from various sources, companies can uncover patterns and correlations that inform their decision-making processes. This analytical capability allows logistics firms to anticipate customer needs, optimize supply chain efficiencies, and tailor their services to align with evolving market demands. As a result, organizations can maintain a competitive edge by leveraging data to refine their strategies and enhance operational performance.

Moreover, big data analytics enables companies to make well-informed decisions that drive growth and profitability. By gaining a deeper understanding of customer behaviours and preferences, organizations can improve service offerings, streamline inventory management, and optimize distribution networks. Additionally, insights into competitor tactics empower businesses to identify market gaps and seize emerging opportunities. In an increasingly dynamic and competitive environment, leveraging data for strategic planning not only enhances organizational agility but also positions companies for sustained success in the logistics industry.

18. Dynamic Pricing with AI: AI-driven dynamic pricing models are transforming pricing strategies across industries by optimizing rates in response to real-time fluctuations in supply and demand. By leveraging extensive datasets—including market trends, customer behaviours, and competitor pricing—these advanced models empower organizations to adjust their pricing dynamically, maximizing profitability while ensuring competitiveness. This responsive approach enables businesses to swiftly capitalize on peak demand periods, driving sales, while also protecting profit margins during slower times.

Moreover, AI-enhanced dynamic pricing creates a more personalized experience for customers. By tailoring prices to reflect individual purchasing patterns and preferences, companies can not only improve customer satisfaction but also uphold profitability. This strategic personalization fosters customer loyalty by ensuring fair and transparent pricing. In a rapidly evolving marketplace, the ability to implement AI-driven dynamic pricing allows organizations to maintain a competitive edge, effectively meeting customer expectations and driving sustainable growth.

19. Digital Collaboration Platforms: Digital collaboration platforms are transforming logistics management by effectively connecting shippers,

carriers, and logistics providers in a unified system. These platforms enable real-time communication and information sharing, simplifying complex logistics processes and enhancing transparency throughout the supply chain. By serving as a centralized hub for tracking shipments, managing inventory, and coordinating logistics activities, they empower all stakeholders to operate with greater clarity and efficiency. This heightened visibility not only streamlines operations but also optimizes asset utilization, enabling organizations to make data-driven decisions regarding resource allocation.

Moreover, the adoption of digital collaboration platforms significantly reduces operational costs. By fostering improved coordination among stakeholders, businesses can minimize delays, eliminate redundancies, and optimize routing and delivery schedules. This increased efficiency not only lowers operational expenses but also elevates service levels, thereby enhancing customer satisfaction. In an increasingly competitive landscape, leveraging these collaborative tools equips organizations to swiftly respond to market demands and adapt to evolving conditions, ultimately driving improved performance and profitability within the logistics sector.

20. Real-Time Operational Control: Real-time operational control powered by advanced analytics is transforming logistics management by offering managers immediate visibility into warehouse and fleet performance. Utilizing sophisticated data analytics tools, logistics professionals can continuously monitor key performance indicators, enabling them to quickly identify and address potential issues as they arise. This proactive approach effectively mitigates disruptions—such as inventory shortages, shipment delays, or equipment failures—enhancing operational efficiency and minimizing downtime.

Moreover, real-time analytics significantly elevate service quality by empowering logistics managers to make informed decisions on the fly. They can optimize routes, reallocate resources, and implement contingency plans in response to evolving conditions. This agility not only improves customer satisfaction through timely deliveries and responsive service but also drives overall cost savings. In today's dynamic logistics landscape, maintaining real-time operational control equips organizations with the tools they need to meet customer expectations while continuously refining their operational processes for sustained success.

21. 5G Connectivity for Enhanced Communication: 5G connectivity is poised to transform communication within the logistics sector by delivering exceptional speed and reliability, significantly enhancing Internet of Things (IoT) applications. With the capabilities of 5G networks, logistics companies can transmit vast volumes of data swiftly, enabling real-time monitoring and management of fleets and warehouses. This enhanced connectivity facilitates seamless communication between devices, ensuring that critical information—such as vehicle locations, inventory levels, and equipment statuses—can be accessed and acted upon without delay. Consequently, logistics operations achieve greater efficiency, benefiting from improved tracking and coordination.

Moreover, the low latency and high bandwidth of 5G empower advanced analytics and automation within logistics processes. Fleet managers can harness real-time data to optimize routing and maintenance schedules, while warehouse operations can implement automated systems for inventory tracking and sorting. This leads not only to streamlined operations but also to significant cost savings and elevated service quality. As the logistics industry increasingly embraces 5G technology, organizations will be strategically positioned to capitalize on IoT innovations, driving

enhanced efficiency and competitiveness in an ever-evolving marketplace.

22. Predictive Maintenance for Fleet Management: Predictive maintenance, driven by IoT and AI, is revolutionizing fleet management by forecasting equipment maintenance needs before they escalate into critical failures. By continuously gathering and analysing data from sensors embedded in vehicles, these advanced technologies can identify trends and anticipate potential issues. This proactive strategy empowers fleet managers to schedule maintenance activities at optimal intervals, significantly reducing the risk of unexpected breakdowns and minimizing operational downtime. As a result, logistics operations become more streamlined, ensuring uninterrupted service and boosting overall productivity.

Moreover, predictive maintenance offers considerable cost savings by addressing maintenance requirements before they lead to more significant problems. This approach helps companies avoid expensive repairs and extends the lifespan of their assets. Additionally, with fewer service disruptions, fleets can enhance their reliability, which is crucial for meeting customer demands. As organizations increasingly implement predictive maintenance techniques, they can leverage the capabilities of IoT and AI to optimize operational efficiency, lower expenses, and enhance decision-making in fleet management.

23. Enhanced Cross-Border Logistics: Enhanced cross-border logistics are experiencing significant advancements through the deployment of digital platforms that automate compliance and documentation processes. By leveraging cutting-edge technologies, these platforms enable seamless communication among shippers, carriers, and customs authorities, effectively mitigating the complexities typically associated with international trade. Automation reduces manual errors and expedites the preparation of essential documents, ensuring that compliance requirements are met promptly and accurately. This streamlined methodology not only minimizes delays in customs clearance but also accelerates the overall pace of cross-border transactions.

Furthermore, these digital solutions enhance visibility throughout the logistics chain, allowing stakeholders to monitor shipments in real time and proactively tackle potential challenges. This increased transparency fosters better coordination among all parties involved, leading to more informed decision-making and improved customer satisfaction. As organizations embrace these innovative platforms, they significantly enhance their capacity to navigate the intricacies of international logistics, resulting in smoother and more efficient trade across borders while lowering operational costs and boosting competitiveness in the global market.

24. Future Prospects in Digital Logistics: The future of digital logistics is on the brink of transformative advancements, driven by the rapid evolution of emerging technologies. Autonomous delivery systems, bolstered by breakthroughs in robotics and artificial intelligence, are set to redefine transportation methods, significantly boosting efficiency and lowering operational costs. As these technologies develop, logistics companies will increasingly adopt sustainable practices, such as green logistics, which focus on reducing carbon footprints and minimizing waste throughout the supply chain. This shift towards eco-friendly solutions will not only help organizations comply with regulatory standards but also resonate with consumer preferences for sustainable practices.

Moreover, AI-driven innovations are enhancing decision-making capabilities by enabling logistics firms to analyze vast datasets for improved forecasting, inventory management, and route optimization. This agility allows businesses to

adapt quickly to changing market conditions and customer demands, fostering a more resilient supply chain. As the logistics sector continues to progress, organizations that embrace these technological advancements will enhance their operational efficiency and secure a competitive advantage in a rapidly evolving market. The integration of automation, sustainability, and data analytics will create a logistics ecosystem that is not only more efficient but also better equipped to address future challenges and opportunities.

Conclusion

The digital age has significantly transformed logistics, driving the industry toward more intelligent, efficient, and sustainable operations. The seamless integration of digital tools and advanced data analytics enables logistics companies to accurately forecast demand and respond promptly to real-time challenges. This proactive strategy not only optimizes operational efficiency but also elevates the customer experience, ensuring services are both effective and adaptable to shifting requirements.

As sustainability gains prominence, the logistics sector is embracing environmentally responsible practices that resonate with global initiatives aimed at reducing carbon emissions. By harnessing innovative technologies and data-driven insights, logistics firms are well-equipped to meet customer expectations while fostering a greener future. Ultimately, this digital evolution in logistics will cultivate a more resilient and agile industry, adept at navigating the complexities of an ever-evolving market landscape.

Waste Heat Recovery in Steel Industry and Usage

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Continued from last article.....

Recovery Technologies:

There are various technologies available for recovering medium to high-temperature waste heat. For example, medium-temperature (350°C) exhaust gases from kiln hood clinker coolers and kiln tail preheaters can be captured using a boiler system. Additionally, high-temperature (1000°C) heat recovery from hot coke can be efficiently achieved using Coke Dry Quenching (CDQ) technology. In this process, hot coke, removed from coke ovens at approximately 1,000°C, is cooled and kept dry with inert gas. The resulting steam, generated by the waste heat recovery boiler, is then used to produce electricity.

The heat recovery process in CDQ systems provides clean, environmentally friendly energy, as the sensible heat transferred during the cooling phase is utilized for steam generation. Compared to conventional wet quenching systems, CDQ offers advantages such as reduced dust emissions and improved coke quality. For instance, Nippon Steel & NIPPON STEEL ENGINEERING CO., LTD. has developed the world's largest single-chamber CDQ system, with a capacity of 280 t/h, and is the sole supplier offering CDQ systems in a range of capacities, from 56 t/h to 280 t/h, tailored to meet the specific needs of each customer.

Reputed Suppliers:

1. **Green India Technologies, Pune, India**

   Green India Technologies is a leading manufacturer and supplier of Waste Heat Recovery Systems (WHRS). The company specializes in capturing and recovering heat from industrial processes that would otherwise be wasted, offering efficient solutions to reduce energy consumption and enhance sustainability.

2. **Esteem Power Equipment's (India) Pvt. Ltd., Maharashtra, India**

   Established in 2007, Esteem Power Equipment's is an ISO 9001:2008 certified company renowned for its expertise in designing and manufacturing heat, power, and process equipment. With vast experience in design and project management, the company focuses on providing heat transfer equipment that meets precise specifications at optimal costs. Their innovative technology allows for the recovery of various forms of waste heat, which can be repurposed for applications such as water heating, air heating, thermic fluid heating, or steam generation. Esteem Power Equipments is committed to delivering high-quality products, supported by a state-of-the-art manufacturing facility adhering to rigorous quality systems.

3. **Thermax, India, Pune**

   Thermax is a well-established name in the field of energy and environment solutions. The company provides a wide range of waste heat recovery systems designed to optimize energy use and enhance process efficiency across various industries.

4. **Sigma Thermal Incorporated**

   Sigma Thermal is another prominent supplier offering both domestic and international solutions for heat recovery systems. They provide advanced technologies and equipment tailored to meet the specific needs of their clients in diverse industrial sectors.

Research and Development in the Field:

The Indian Iron & Steel industry must prioritize research and development (R&D) to foster the

adoption of new technologies that align with the country's natural resource base, minimize environmental impact, and optimize resource utilization. To remain competitive globally, it is critical to address R&D challenges that lead to techno-economic solutions for the efficient use of indigenous raw materials. Additionally, there is a pressing need for advancements in product and process development to produce high-performance steel domestically. Enhancing productivity, improving efficiency, and advancing strategic steel applications should be central to these efforts, enabling India to meet international standards and contribute to the global steel market.

Customized Solutions for Diverse Applications:

The Indian waste heat recovery market is evolving, with a growing number of pilot projects showcasing its potential for widespread adoption. Due to the diversity of industrial processes across sectors, customized waste heat recovery solutions are essential to maximize energy efficiency and reduce operational costs.

Developed Solutions:

- **Boilers and Gas Engines:** Established technologies in waste heat recovery, such as boilers and gas engines, are proven to improve overall efficiency by 15-20%. These systems capture waste heat and convert it into usable energy, significantly enhancing operational efficiency in various industrial applications.
- **Emerging Technologies:** Ongoing innovations in areas such as chillers, compressors, and thermal energy storage are pushing the boundaries of waste heat recovery. These emerging technologies aim to convert waste heat into cooling or store thermal energy for future use. Pilot projects in these areas have shown promising results, indicating the potential for large-scale implementation.

Challenges:

- **Nascent Industry:** The waste heat recovery industry in India is still in its early stages, with many applications underdeveloped. There is a clear need for customized solutions that are specifically tailored to the unique conditions of Indian industries, considering local resource availability, infrastructure, and environmental factors.
- **Lack of Standards:** The absence of standardized practices and certified solution providers can impede progress. Establishing industry-wide standards and certifications is essential to ensure the reliability, efficiency, and scalability of waste heat recovery systems, fostering greater adoption and trust in these technologies.
- **Investment and Awareness:** High initial investment costs and a lack of awareness among industry stakeholders are significant barriers to the widespread adoption of waste heat recovery solutions. Many companies are unaware of the long-term cost savings and environmental benefits these technologies can offer, making it difficult to secure the necessary investments for implementation. Increased awareness and targeted education are critical to overcoming this challenge.

Waste Heat Recovery Potential & Activities in the Indian Iron & Steel Industry:

1. **TATA Steel** has successfully commissioned a facility to recover waste-gas heat from its 'G' blast furnace, significantly enhancing energy efficiency in its operations.
2. **SAIL Plants** have implemented various waste heat recovery initiatives, including the installation of Top Pressure Recovery Turbines (TRT), Coal Dust Injection (CDI) systems, and Waste Heat Recovery (WHR) systems. These technologies are deployed in large-volume blast furnaces (>4000 m^3) to

capture and reuse heat from the process, improving overall energy efficiency.

3. **Bhilai Steel Plant (BSP)** has incorporated waste heat recovery measures as part of its Blast Furnace technology for iron making. The plant has also introduced pollution control equipment as part of its energy-efficient approach, contributing to the reduction of emissions and optimizing energy use.
4. **Bokaro Steel Limited (BSL)** has implemented waste heat recovery systems across all industrial processes, ensuring that energy recovery is maximized throughout the plant's operations.
5. **Rourkela Steel Plant (RSP)** has developed a waste heat recovery system that utilizes heat from the process or Combined Heat and Power (CHP) exhausts. Additionally, the plant takes advantage of off-peak energy when prices are lowest to support its decarbonization goals.
6. **Durgapur Steel Plant (DSP)** utilizes its waste heat recovery system to generate power by capturing heat energy lost to the surroundings from thermal processes, all without requiring additional fuel inputs.
7. **Rashtriya Ispat Nigam Limited (RINL)** has implemented a 20.6 MW waste heat recovery project on the Sinter Cooler and sinter machines under the Green Aid Plan of NEDO (New Energy and Industrial Technology Development Organization) of Japan. This project, commissioned in July 2014, marked a pioneering effort in the Indian steel industry, with a dissemination workshop held to share knowledge and results.
8. **IISCO Steel Plant** has also integrated waste heat recovery into its blast furnace operations. The project design document for this initiative outlines the strategies employed to capture and reuse waste heat in the process.
9. **JSPL (Jindal Steel and Power Limited)** has faced challenges with high-velocity waste-gas laden with particulate matter, which results in abrasion of the waste heat recovery boiler system. However, improvements have been made to mitigate these issues, leading to enhanced operational efficiency and revenue generation.
10. **JSW Steel, Vijayanagar** commissioned a 150 TPH boiler for power augmentation, alongside a 45.13 TPH steam generation system through a sinter cooler waste heat recovery boiler. These boilers operate with 100% byproduct gas firing, generating process steam without the use of coal, aligning with sustainable energy practices.
11. **VISA Steel** has implemented an integrated waste treatment and recovery system, recycling effluent from each unit through SRTS, ETP, and RO plants, ensuring that water and energy resources are used efficiently within the plant.
12. **Electric Arc Furnaces (EAF)** are estimated to recover up to one-third of the total energy supplied to the process as waste heat. This presents significant opportunities for further energy recovery and efficiency improvements in EAF operations across the industry.

Usage of Recovered Waste Heat:

1. Waste Heat Recovery Boilers:

In sponge iron plants, waste gases from the sponge iron kilns, exiting the post-combustion chamber at temperatures of around 900–950°C, are utilized to generate steam in a Waste Heat Recovery Boiler (WHRB). This process helps capture and reuse high-temperature exhaust gases, enhancing the overall energy efficiency of the plant.

2. Global Market for Waste Heat Recovery Boilers:

The global market for waste heat recovery boilers reached a value of approximately USD 7.4 billion in 2023. It is expected to grow to USD 11.8 billion by 2032, with a compound annual growth rate (CAGR) of 5.2% during the

period from 2024 to 2032. This growth reflects increasing demand for energy-efficient technologies across industries.

3. Electricity Generation:

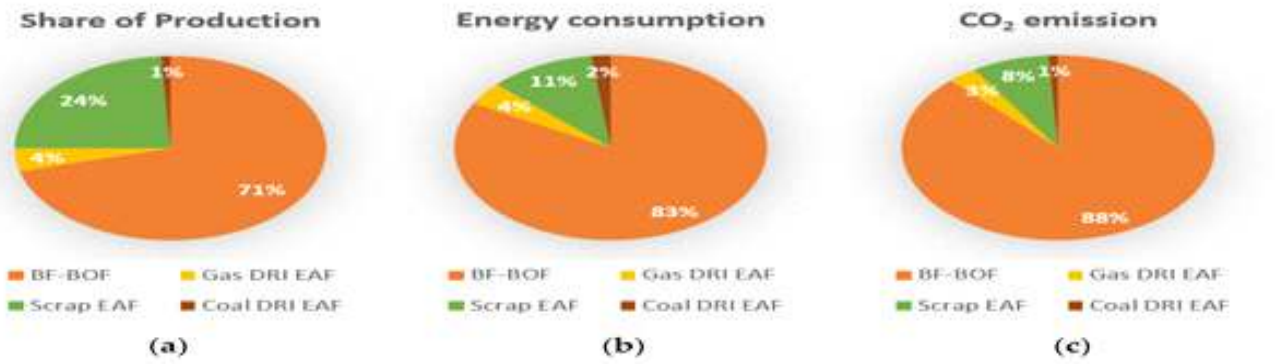
Recovered waste heat can be harnessed for electricity generation through several methods, including the Steam Rankine Cycle, Organic Rankine Cycle (ORC), and thermoelectric generators. These technologies convert waste heat into usable electrical power, contributing to the reduction of overall energy consumption and supporting sustainability goals.

4. Heating Applications:

Waste heat can also be utilized for a variety of heating purposes, such as space heating, preheating combustion air, or providing process heat for various industrial operations. This application is particularly valuable in industries where large amounts of heat are generated but not fully utilized.

5. Typical Consumers of Waste Heat Recovery Systems:

Waste heat recovery plants typically serve industries or systems requiring district heating, chilled water production, electric power generation, or steam generation. These systems can supply energy to both internal plant operations and external consumers, helping reduce overall energy demand and costs. However, the process can be energy-intensive, particularly when contaminants are present in the exhaust stream, requiring additional treatment or filtering steps.



Key Players in the Waste Heat Recovery Market:

The global waste heat recovery market is supported by several prominent companies, including ABB Ltd., Mitsubishi Heavy Industries Ltd., TLV Co., Ltd., Thermax Ltd., Siemens AG, Robert Bosch GmbH, General Electric Company, Echogen Power Systems, Schneider Electric SE, and Kawasaki Heavy Industries Ltd.

Common Waste Types in Steel Plants:

Steel plants generate various types of waste, including:

- **Solid Waste:** Hot metal pre-treatment slag, dust, GCP sludge (generated during the production of ferromanganese via submerged arc furnace), mill scale, refractories, scrap, muck, and debris.
- **Liquid Waste:** Industrial effluents, oil, grease, etc.
- **Waste Heat Sources:** Hot off-gases, cooling water, hot intermediate products (slabs, billets, etc.), and hot slags.

Waste heat is classified into different temperature categories:

- **Low-Temperature (<200°C)**
- **Medium-Temperature (200–500°C)**
- **High-Temperature (>500°C)**

Waste heat in steelmaking units can reach very high temperatures, ranging from 600°C to 1000°C,

with various technologies in place to recover this heat.

Technologies and Heat Sources in Steelmaking:

Some of the key methods and technologies for waste heat recovery in the steel industry include:

- **Medium-Temperature Heat:** Recovery from exhaust gases (e.g., from kiln hoods, clinker coolers, and preheaters) using boilers, as well as the recovery of high-temperature coke heat using Coke Dry Quenching (CDQ) technology.
- **High-Temperature Heat:** Recovery from flue gases such as Coke Oven Gas, converter gas, Electric Furnace Gas, and heating furnace flue gas.
- **High-Temperature Liquids:** Iron slag, steel slag, and high-temperature water.
- **High-Temperature Solids:** Hot sintering materials, hot coke, and high-temperature steel.

Potential Heat Sources by Grade:

- **High-Grade Heat:** Coke Oven Gas, converter gas, electric furnace gas, and heating furnace flue gas.
- **Medium-Grade Heat:** Blast Furnace gas, sintering flue gas, and exhaust gas recovery from primary after flue gas.
- **Low-Grade Heat:** Waste steam, hot water, and low-temperature flue gases.

Conclusion:

The primary goal of waste heat recovery in the iron and steel industry is to drive sustainable energy development. While material waste is often more visible, waste heat, especially low-grade heat, is frequently released into the environment unnoticed. Identifying and recovering waste heat offers substantial opportunities to reduce energy costs and mitigate environmental impacts.

Utilizing low-grade waste heat sources can significantly improve energy efficiency in energy-intensive industries, including steelmaking. Research and development activities are crucial to understanding and optimizing waste heat recovery technologies across various industries.

It is estimated that around 72% of global primary energy consumption is lost after conversion, with 63% of waste heat streams arising from temperatures below 100°C. The potential for recovering waste heat, especially in the steel industry, is vast, with sustainable technologies offering considerable promise for both energy savings and environmental benefits.

For example, increasing the use of scrap in steelmaking can lower CO2 emissions, though it can present challenges related to the quality of liquid steel. Overcoming these challenges through effective use of post-combustion heat and off-gas heat recovery for scrap preheating could further reduce emissions. If these issues are addressed, there is significant potential for reducing CO2 emissions from processes such as the Basic Oxygen Furnace (BOF) process.

The Indian steel industry, facing increasing environmental pressure while striving to meet future demand, is focusing on leveraging waste heat to meet these challenges. With steel demand expected to grow at an annual rate of 1.4% by 2035, there is a growing emphasis on improving the performance of steelmaking processes while minimizing environmental impacts.

Steel production, particularly via the BF-BOF and DRI/scrap EAF routes, is responsible for a significant share of global CO2 emissions. In 2020, the iron and steel industry emitted approximately 9% of global greenhouse gases, highlighting the critical need for technological advancements and energy-efficient solutions in the sector.

Steel Ministry proposes 37% purchase preference to green steel in government tenders

Date: 12/12/2024

India's steel ministry has proposed that over a third of the total government steel procurement will be of low carbon variant. This 'Green steel' is defined as steel produced with emissions lower than 2.2 tonnes of carbon dioxide per tonne of finished steel. A star-rated grading system will also measure the greenness of steel, with five-star rating for emission intensity lower than 1.6 tonnes of CO2 equivalent per tonne of finished steel.

According to a steel ministry presentation, up to 37% of all future steel procurement will be earmarked for green steel as an incentive to lower carbon intensity.

A definition for Green steel was also announced by the Steel Ministry on Thursday. Speaking at an event to the mark the same, Union Steel Minister, H D Kumaraswamy said, "The green steel taxonomy will help set a benchmark for adopting global best practices and help India emerge as global leader in green steel production."

Responding to queries from journalists on the imports of chinese steel, Kumaraswamy said his ministry has proposed a safeguard duty to protect the domestic industry.

Source: The Economic Times

India announces formula for classifying green steel

Date: 12/12/2024

NEW DELHI: India's steel ministry on Thursday announced a formula for defining 'green steel,' classifying it under three categories based on the quantity of carbon emissions per metric tonne of the alloy produced.

Steel produced with carbon dioxide emissions of less than 2.2 tonne per tonne of finished steel would be defined as "green steel," a ministry presentation released in New Delhi showed.

Steel produced with emissions below 1.6 tonnes per tonne of alloy would be classified as "five-star green-rated steel," the cleanest of the three.

Meanwhile, steel produced with emissions between 2 to 2.2 tonnes per tonne of the alloy will be classified as "three-star green-rated steel" - the least clean of the lot.

This threshold limit for defining the categories will be reviewed every three years, a government handout showed.

India, the world's biggest steel producer after China, has been working on a green steel policy in a bid to decarbonise procurement and production of the key construction material, amid a wider push towards cutting down greenhouse gas emissions.

Prime Minister Narendra Modi has set 2070 as the target for achieving net zero emissions.

The country is also considering mandating green steel for government projects, steel secretary Sandeep Poundrik said on the sidelines of an event.

Source: The Economic Times

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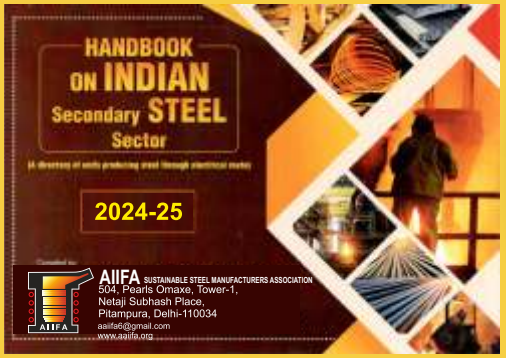

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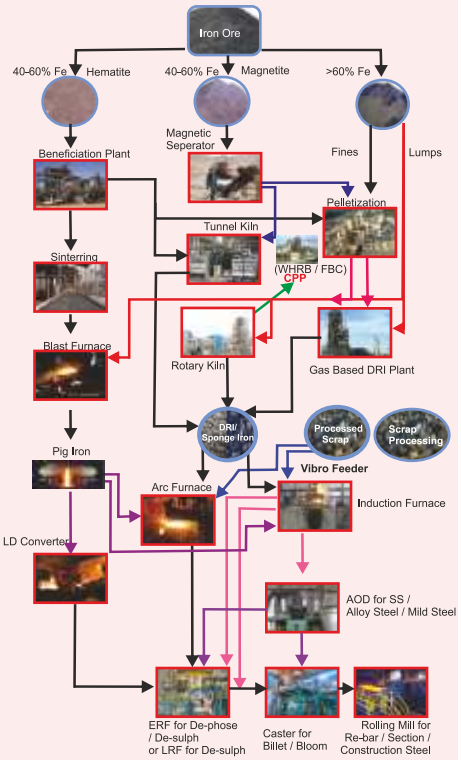

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