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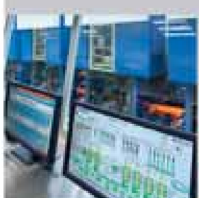

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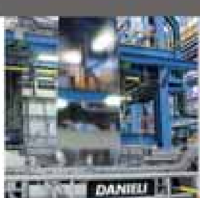


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# STEEL TECH

VOL. 15 NO. 2 JANUARY, 2021



# Green Steelmaking

Steel technology for today and tomorrow

**Editor's Office:** Mr. Pritish K. Sen; Sunny Apartments, 61 E, Manick Bandopadhyay Sarani, Kolkata-700 040, India, Mobile: +91-9230639343 / 8777341510 Email: psen2008@yahoo.co.in & info@steeltech-india.com

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## Focus Subjects for STEEL TECH in 2021

- **April:** PEB and use of Hollow Sections & LGSF (Light Gauge Steel Frame) & CFS (Cold Formed Section)
- **July:** Raw Materials, Refractories and Additives for Steel Making
- **October:** Application of Steel in New and Critical Areas. Digital Appilication and Marketing.

# Contents

# Editorial

A very happy and safe New Year to all of our Readers, Authors, Subscribers, Advertisers & other Stakeholders.

The year 2020 was a nightmare from March onwardswith a lot of learning as well. Although the global economy is growing again after a contraction of 4.3 % in 2020, the pandemic has caused a heavy toll of deaths and illness, plunged millions into poverty, and may depress economic activities for a prolonged period. Though pandemic scare is still very much there in many countries including developed ones, we in India are much better off with low death rates on account of proper planning and handling of the situation. However, there is no reason for being complacent as the situation may again turn grave looking at the trends ofdeveloped countries. We must remain vigilant.

The economy has suffered badly last year and will take afew years to comebackto the normal GDP growth. It got severely affected from march-end to June due to lockdown. Things started improving since then and in Q3, the production level in industrial sector especially in steel has recovered to the pre-COVID level and in some cases surpassed. As India has the rare honour of developing good qualityCOVID-19 vaccine, mood is very positive and things are set to be brighter in 2021. India, with motto of AtmaNirbhar Bharat, to achieve the target of 5 Trillion $ economy by 2025 transitions into an economic powerhouse. The steel demand is forecasted to grow at compound annual growth rate of 7.0-7.5% during fiscal 2022 to 2025. This growth is mostly spurred by the capital expenditure of 111 Trillion INR in infrastructure during FY20-25 by GoI through National Infrastructure Pipeline initiative.

ThisUnion Budget 2021 puts the economy on turbo charge for recovery and growth with increased spending on infrastructure (with special emphasis on rural sector), focus on job creation to help spur demand with raised fiscal deficit for the year to 9.5%. Big reform push has been given in banking, insurance, monetisation of assets and emphasis on transparency.

Due to unprecedented high demand of steel and consequently for iron ore in China, the prices of both steel and iron ore have soared notbeing seen since 2011. To help MSME and other steel user industry, the custom duty has been uniformly reduced to 7.5% for semi, flat and long product from 10-12% in this budget. Due to much improved financial positions of integrated steel plants on account of prevailing high prices of steel and good demand, there is already sign of placement of orders from them to technology providers and equipment suppliers for modernisation and brownfield projects which were held up since last one year which isa great encouraging factor for the suppliers.

The Union cabinet has recently approved reforms in mining to do away with the distinction between captive and non-captive mines and allowing transfer of mining leases.A comprehensive licence for exploration and production, clarity in illegal mining, national mineral index and joint auctions of bauxite and coal mines for the aluminium sector are some of the other proposals that have been approved by the cabinet. This will have far reaching consequences for many but production from mines are expectedto go up substantially.

To adhere to the promises made at Paris on climate change, most of the countries, especially in Europe are working all out to move from fossil fuel to carbon free emission route for iron & steelmaking. CCS (Carbon Capture and Sequestration)is not the long term solution and use ofHydrogen seems to be the only answer for becoming carbon neutral. Whereas blue hydrogen is relatively costly comparable, green hydrogen from renewable and nuclear source are being explored as option but will call for high capex and raise cost of production of steel by 25-30% from the current level. It is hoped thatcost will come down further with more research and development over time. It seems the days ofconventionalBF-BOF route and use of fossilfuels are numbered though not very soonand direct smelting & EAF route will be predominant in future steel plants.

Our January'21 issue is focused on green steelmaking and some valuable papers are included to look into the present status and the journey for hydrogen steelmaking to follow sustainable route and achieve carbon neutral by 2050 (CN50), if not by 2030 (CN30) as claimed by Liberty Steel. We hope our esteemed Readers will find this issueinteresting and enriching. We welcome their suggestions which will be of immense valueto us for our future issues and also to dwell further on the subject.

Happy Reading.

Pritish K. Sen


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### COMMISSIONING OF TWO 100T INGOT CASTING CARS AT OVAKO, SWEDEN

Two 100t casting cars are being commissioned at Ovako One of the largest casting cars that INTECO has ever designed is due to be commissioned shortly. The first of the two 100t cars, which are being installed at the Swedish steel producer Ovako, has already been delivered and on-site erection is progressing despite all the current obstacles. A particular challenge to be managed is that erection has to take place during casting operation. The hot commissioning was planned for the 1st quarter, but the restrictions imposed as a result of the coronavirus pandemic have delayed the hot commissioning to the 2nd quarter.

Finally, the first casts were successfully made shortly after the Swedish Midsommar Fest. The installation of the second casting carriage, which will be installed at a later date due to the limited space available, is planned for the summer of 2020.


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**INTECO melting and casting technologies GmbH**
Wiener Strasse 25, A-8600 Bruck an der Mur,
Austria – Europe
Tel: T: +43 3862 53 110 - 0 | F: +43 3862 53 844
E: inteco.austria@inteco.at | www.inteco.at

# Challenges of Steel Sector Decarbonisation

*Madhulika Sharma, Saurabh Kundu, Sudhansu Pathak, Amit Kumar and Jaison Thomas*
Tata Steel, Jamshedpur, INDIA

**Abstract**

Imbibing an underlying responsibility towards planet Earth in our operations, ensuring the health and safety of people at our workplaces, balancing economic prosperity and generating social benefits for the community are the core values which are deeply entrenched in Tata Steel's DNA. As a responsible corporate, Tata Steel supports the UN Global Compact and strives to integrate its 10 principles in all facets of business. Climate change is recognised globally as one of the key risks in the 21st century. Tata Steel has undertaken many initiatives in last decade to reduce our carbon intensity by more than 25%. However, the deep decarbonisation of steel sector will require breakthrough technologies and use of alternate fuel like hydrogen. The recently launched IEA Steel Sector report outlines the challenges of the sector and outlines a roadmap for long term decarbonisation. This article will talk about the decarbonisation challenges of steel sector which has been referenced from the IEA report and also touch upon Tata Steel's initiatives for deep decarbonisation.

## INTRODUCTION

Studies claim that carbon dioxide concentration in atmosphere has increased in pre-industrial era from 280 ppm to more than 400 ppm in Oct 2019. The average temperature of earth has already increased by one degree centigrade above pre-industrial level on account of higher concentration of GHG (greenhouse gases) in atmosphere. The impacts of climate change on society and environment will largely depend on humankind response through technology, lifestyle, economy and policy. Since these responses are uncertain, future scenarios are used to explore the consequences of different options.

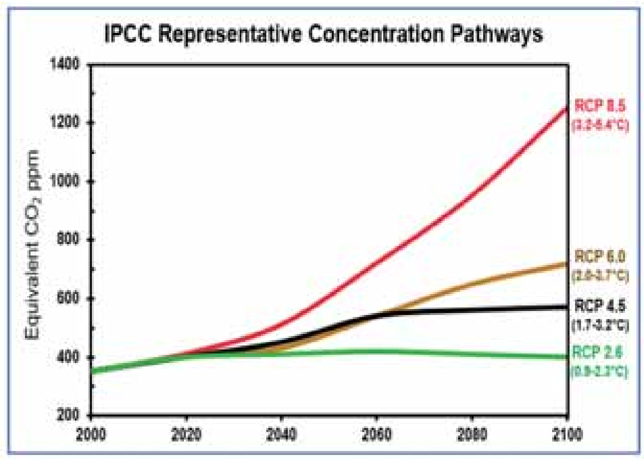


**Fig: 1: Ref: IPCC Report**

IPCC in its Fifth Assessment Report (AR5), 2014 has used four Representative Concentration Pathways (RCP) to depict the concentration trajectory of greenhouse gases in atmosphere and to model their impact on climate change for end of this century, as shown in Fig. 1.

The commitments made in Paris Agreement in 2015 will undergo a test of credibility at COP26, scheduled in November this year. While some countries have made their net neutrality commitments, the corresponding actions in line with the ambitions are yet to be witnessed. Recent reports claim that only India's NDC is in line for the 2-degree warming scenario amongst the G20 countries while most other countries are still on 2.5- or 3-degree trajectory.

### Steel: A Hard-to-abate Sector

The iron and steel sector is highly energy intensive industry, with coal accounting for about 75% of its energy inputs today. In 2019, the sector's consumption of coal stood at around 900 million tonnes of coal equivalent.

In other words, around 15% of global primary demand for coal is sourced for the steel industry. Coal is largely consumed in the blast furnace, a major proportion of which is transformed from coal to coke in the coke oven beforehand.

Steel industry accounts for nearly 7% of total GHG emissions and after power and chemical sector is the third largest emitter of carbon dioxide. Since the technologies for reducing the carbon emissions are yet to be technically feasible and economically viable, steel is considered as hard to abate sector.

**Steel: An Indispensable Alloy**

Life of Steel production assets are reasonably long. Most of it is produced through the traditional Blast Furnace – Basic Oxygen Furnace (BF- BOF) route. While, the basic counter-current blast furnace process for producing iron has remained the same for centuries, yet breakthrough improvements in cooling technology, process automation & allied processes ensured that it stays ahead of both competing materials as well as competing iron making technologies.

Alternate materials like composites, glass, plastics, aluminum or carbon fiber have found it difficult to completely replace this alloy of iron, because of following characteristics:

- For its cost, steel has the highest strength to weight ratio
- It is infinitely recyclable, without losing its inherent properties
- The existing ecosystem of steel for education, manufacturing, design & supply chain has taken decades to build, and is difficult to replicate.

So, steel continues to remain a material of choice for sectors like Construction, Auto, Capital Goods and Consumer Durables.

By 2050, the cost of steel production is likely to increase as the need to decarbonise steel takes precedence, yet, production of steel will be higher as compared to current levels to meet growing demand of emerging markets.

Steel is the third most abundant man-made bulk material on earth, after cement and timber. The steel industry forms an integral part of many economies and is also one of the most widely traded commodities in the world, with producers competing in an international market. The industry has faced several economic shocks in recent years, including overcapacity, trade tensions and low margins for producers. The steel industry and our global economic system are therefore deeply intertwined. Steel needs energy and the energy system needs steel. Even though the stock of steel in advanced economies saturate, it will be required to support a growing population and rising levels of economic welfare, particularly in emerging economies. Iron and steel production are a highly energyintensive industrial sector accounting for 20% of industrial final energy consumption and around 8% of total final energy consumption.

Steel is also a critical input for the clean energy transition. Steel is a key input material for wind turbines, transmission and distribution infrastructure, hydropower and nuclear power plants, among other critical energy sector assets. While being a facilitator of the clean energy transition, steel is also a large contributor to the current challenge we face in meeting our climate goals: direct $CO_2$ emissions.

**Steel Demand in India to Grow**

As per IEA, the dominance of the China in global production declines from just over 50% today to 35% in 2050, as India's production more than triples to cater for booming domestic demand. A dynamic growth is expected to take place in many emerging economies, particularly in India. This compensates for the decline in output from China, which is in the process of shifting its industrial structure towards less energy-intensive activities after having satisfied a certain level of infrastructure and housing development.

As of now, India's per capita steel consumption is only one-third of the world average. However, various studies suggest and predict that increasing population, rapid urbanisation, mobility and infrastructure requirements and government initiatives such as 'Make in India' are expected to boost steel demand growth. In addition, the government's focus on accelerating the rural economy and plans for building smart cities, affordable housing, dedicated freight and high-speed rail corridors, are expected to create significant demand for steel. The National Steel Policy (NSP) envisages per capita steel consumption to almost double to 160 kg by 2030-31. With a leadership position in chosen market segments and world-class production facilities, Tata Steel is well poised to benefit from this large opportunity.

**At Tata Steel**

Cognisant of India's commitment and the sectoral requirements, Tata Steel India (TSI) has been able to bring down its carbon footprint by improving resource efficiency and adoption of best available technologies. Tata Steel Jamshedpur is the Indian benchmark for $CO_2$ emission intensity at 2.27 $tCO_2$/tcs and has reduced from 3.12 $tCO_2$/tcs in last 15 years with significant CAPEX investments to adopt best available technologies.

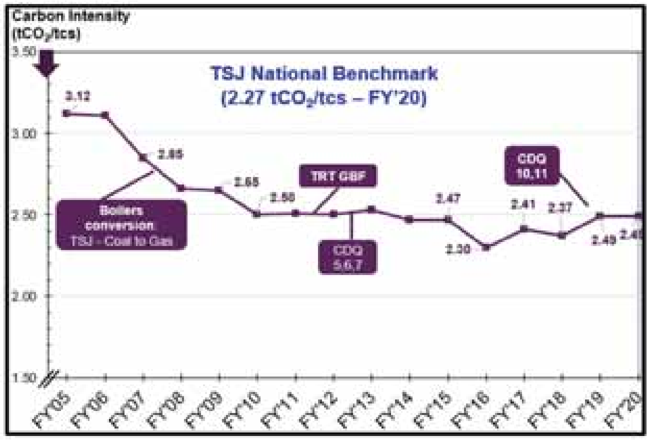


**Fig. 2: Tata Steel India's journey to decarbonisation**

TSI has been working with Government agencies and policy think-tanks to push for policy changes to support our interests while moving to clean technologies. For TSI, availability of economically viable clean scrap would be a major driver for sustainable growth. Accordingly, a separate business vertical of Scrap Recycling Business (SRB) has been created to make India future ready for higher scrap usage in steelmaking. This will also help in formalising the sector which is currently fragmented.

The short-term target for Tata Steel India is to achieve <2 $tCO_2$/tcs GHG emission intensity by 2025 by adoption of best available technologies at all operating sites. The long-term decarbonisation roadmap is being developed and scenario based modelling has been used to create different possibilities in line with the climate models of IPCC.

**Scenario based modelling**

Since the uncertainties in the longtime horizon (2020 – 2050) would be many, scenario based modelling is a good tool to model the decarbonisation trajectories based on the IPCC climate change models.

The IEA Iron & Steel Technology Road map has also used scenario modelling to project steel consumption and the resultant $CO_2$ emissions. Two scenarios have been considered in the report. STEPS (Stated Policies Scenario - reflecting the impact of existing policy frameworks and today's announced policy intentions.) and SDS (Sustainable Development Scenario - how the world can change course to deliver on the main energy-related Sustainability Development Goals (SDGs).

As shown in Fig. 3, the IEA scenario based modelling predicts that $CO_2$ intensity of steel will come down, however it will not become zero by 2050 even in SDS scenario.

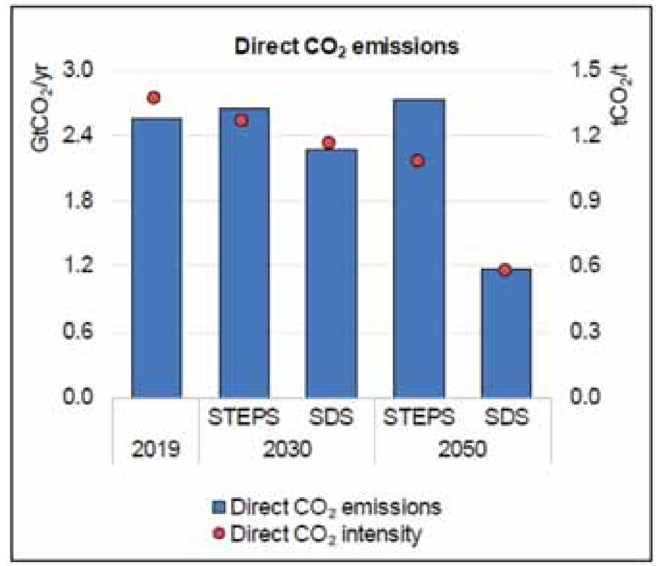


**Fig. 3: IEA-Direct $CO_2$ emissions and energy consumption in the iron and steel sector by scenario**

**The relative importance of different mitigation option evolves over time:**

- In the short-term, the largest role is played by energy and material efficiency (BAT/ BPT). BAT- Best available technology, BPT – Best Practises Technology
- In the medium-term, option to switch fuel to less intensive alternatives like natural gas, bio-energy and electricity are predicted to become viable
- Deployment of near zero technologies may become viable only in the long-term (2035 & beyond)

**Material Efficiency & LCA**

Improvement in material efficiency will be one of the biggest levers for reduction in absolute emissions, as it contains overall demand of steel. Primary reasons for this are

- Improvement in yields till semimanufacturing stage – 7% of cumulative reduction.
- Improvement in yield till product stage – 12%
- Change in design and end-use products – 12%
  - ✓ Reducing over specs
  - ✓ Optimising sections and profiles

- ✓ Innovative modular designs
- ✓ Light-weighting through use of higher-grade steel
- ✓ Increasing use of pre-tensioned and pre-cast concrete
- Extension of life-time of buildings – 30%

**Initiatives at Tata Steel for Improving Material Efficiency in Life Cycle of Products**

- Life Cycle Assessment (LCA) of steel products for Environmental Product Declaration (EPD)
- LCA models developed for TSJ and TSK sites with plan to cover all sites
- Joint projects with auto customers to augment use of high strength steel grades
- Tata Pravesh and Tata Structura are the first steel products to receive GreenPro certification in India
- Plan to come out with first EPD for products used in construction sector e.g. Tiscon (TMT Rebars) and Pravesh (Steel Doors)

**Best Available Technology & Energy Efficiency**

Over the years, the adoption of best available technologies for waste heat recovery such as Top Recovery Turbine (TRT), Coke Dry Quenching (CDQ), use of by-product gases in power generation and other energy efficiency initiatives have resulted in improving resource efficiency as well as reducing carbon footprint.

Tata Steel has focussed extensively on energy efficiency initiatives using following levers:

1. Maximise use of by product gases for power requirements
2. Maximise Process waste heat recovery for power generation e.g. CDQ and lowtemperature heat recoveries
3. Enhance efficiency of gas-based power generation
4. Fully exploit other potential energy recovery sources like Top Recovery Turbine (TRT), Micro turbines, Vapour Absorption Machine (VAM) using low grade waste heat etc.
5. Exploit solar power potential in and around manufacturing sites

Following results have been achieved because of these initiatives:

- **TSJ** - Achieved best by-product gas utilisation of 98.44%
- **TSJ** - Achieved highest ever in-house power generation of 245MW byutilising by-product gases and through waste heat recovery
- **TSJ** - Achieved lowest ever power rate of 378 kwhr/tss.

In addition, Tata Steel has commissioned pilot project on 'Energy Recovery Micro Turbine' to recover throttling loss in pressure reducing station for de-aeration application of Boiler feed water and commissioned pilot project on 'Vapor Absorption Machine' to utilise the waste heat of Boiler blow-down water and condensate/steam from steam traps.

**TECHNOLOGY**

To achieve the stringent target set before the steel industry and being a responsible corporate citizen, Tata Steel understands that radical shift in technology is imperative for deep decarbonisation. However, these technologies are yet to mature to a commercially viable level. Hence, as a strategy, Tata Steel is preparing itself extensively on a suite of technologies which are at various levels of readiness. Some of the technologies that would be key to decarbonisation of steel industry are as follows:

**Top Gas Recycling (TGR)**

TGR technology is based on lowering the usage of fossil fuel with the re-usage of the reducing agents (CO and $H_2$ ), after the removal of the $CO_2$ from the top gas. This leads to lower the energy requirements. Because of the advantages of high productivity, high PCI (pulverized coal injection) rate, low fuel rate, and low $CO_2$ emission, TGR-BF process is considered to be a promising Ironmaking process in future.

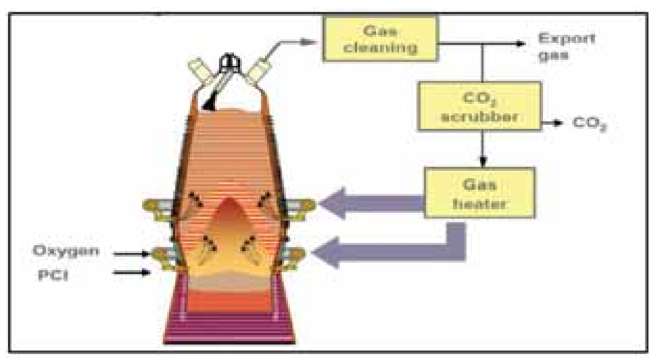


**Fig. 4: Process route for top gas recycling**

The technology has been developed and the demonstration of concept feasibility at experimental blast furnace scale has been done. Planning is ongoing to demonstrate the concept at industrial blast furnace scale.

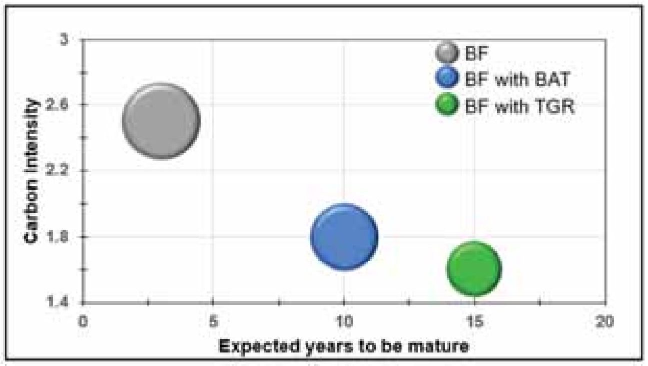


**Fig. 5: A comparison on the carbon intensity of each technology versus the expected years for its maturity**

Tata Steel has initiated projects to capitalise on this technology through separate projects i.e. $CO_2$ separation @ 5 TPD piloting & 500 TPD commercial scale, feasibility study on $N_2$ Separation from BF gas in collaboration with CSIR and feasibility study Syngas (CO+ $H_2$) injection on BF. The Fig. 5 gives us a comparison on the carbon intensity of each technology versus the expected years for its maturity.

TGR appears to be a promising technology and needs to be considered to any future expansions.

### Gas-based Direct Reduced Iron (DRI)

Direct reduced iron (DRI), also called sponge iron, is produced from the direct reduction of iron ore (in the form of lumps, pellets, or fines) to iron by a reducing gas or elemental carbon produced from natural gas or coal. Critical to this application is the availability of gas network. This technology is at a much higher Technology Readiness Levels and can be quickly implemented, except for the constraint due availability of natural gas/hydrogen infrastructure.

HYBRIT is a recent success story by becoming the first to develop world's first fossil free steelmaking technology with virtually no carbon. ArcelorMittal commissions MIDREX to design demonstration plant for hydrogen-based steel production in Hamburg. Salzgitter AG and Tenova signed a Memorandum of Understanding for the pursuit of SALCOS project for $CO_2$-reduced Steel Production based on hydrogen.


**Fig. 6: $CO_2$ footprint**

In step with its peers, Tata Steel has also collaborated with HYL and MIDREX: to evaluate TSL iron ore, fuel consumption, operating parameters and with Council of Energy, Environment and Water (CEEW) to gauge future availability and pricing of Natural Gas.

### HIsarna

A direct reduced iron process for iron making in which iron ore is processed almost directly into liquid iron (pig iron).

**Advantages of HIsarna:**

- Sinter plant, pellet and coke plant not needed - lower land footprint and CAPEX
- $CO_2$ enriched flue gas enabling capture readiness: Possibility to reduce $CO_2$ emissions by 80% when coupled with CCU/S
- Lower SOx, Nox, fugitive dust emissions
- Premium steel grades with ultra-low phosphorus
- Plans for executing longer campaigns with steel scrap, biomass and natural gas injection - reduce carbon footprint further
- Enabler for recycling LD slag as fluxing agent

The 0.1 Mtpa rated capacity pilot plant is in operation at IJmuiden and trials are being done for charging scrap and biomass. Though HIsarna is considered one of the most promising developments in reducing $CO_2$ emissions from the steel industry, yet it is not one without challenges as enumerated.

- Issues in scaling up from pilot to demo plant-refractory, design aspects, cooling circuit, etc.
- Ongoing cross-functional initiatives for demo plant - CFD modelling, heat and mass balance, design calculations, etc.

### Hydrogen – Key to a Low Carbon Economy

Considering 1.5°C or 2°C pathway by 2050, hydrogen would consistently play a critical role as an energy carrier. 18 percent of final consumption to be provided by hydrogen by 2050*, requiring a new zero-carbon hydrogen supply chain to be developed. Demand 8X in next 30 years from 10 EJ to 78 EJ.

**Challenges of Hydrogen**

- Low volumetric density
- Safety - a critical issue - combustibility, leakage, toxicity
- Optimal transport & storage will be scenario specific and will be a significant challenge

**Seeding initiatives at Tata Steel**

- Clean and efficient production solution: Feasibility of chemical looping combustion system within steel industry to produce hydrogen using Blast Furnace gas
- Has partnered with Ohio State University and pilot is expected to be done by 2022

**CCUS – Vital to Net-Zero**

The cement, iron and steel, and chemical sectors emit carbon due to the nature of their industrial processes and have high-temperature heat requirements. They are among the hardest to decarbonise. Several reports conclude that achieving net-zero emissions in industries like these may be impossible and, at best, more expensive without CCS. CCS is one of the most mature and cost-effective options for deep decarbonisation of hard-to-abate industry.

**Seeding initiatives at Tata Steel**

**Carbon Capture:**

- Pilot Plant of 5 tons per day (CCU) at Jamshedpur is expected to be commissioned by end of FY21
- The $CO_2$ capture technology pursued is amine-based for the separation of $CO_2$ from flue gas.
- Collaboration with M/s Carbon Clean Solutions, UK

Carbon capture in India can only be viable when coupled with utilisation opportunities, which needs to be explored with academia and other research institutes.

**Policy Landscape required to Accelerate this Transition**

Creation of global level playing field :

- **Carbon tax:** sets a price on carbon by defining an explicit tax rate on the carbon content of fossil fuels. Carbon pricing would play an important and fundamental role in the transition to a decarbonised economy for both governments and businesses. It can help to mobilise the financial investments required to stimulate clean technology and market innovation, fueling new, low-carbon drivers of economic growth. For governments, carbon pricing can also be a source of revenue, which is particularly important in an economic environment of budgetary constraints. Long-term investors can use carbon pricing to analyze the potential impact of climate change policies on their investment portfolios, allowing them to reassess investment strategies and reallocate capital toward low-carbon or climate resilient activities

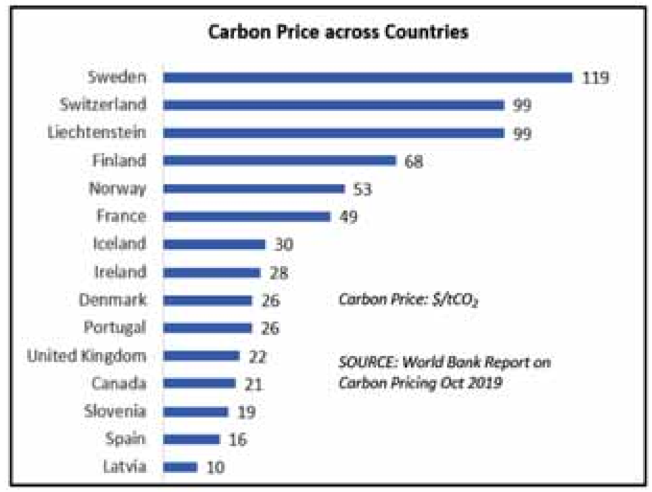


**Fig. 7: Carbon Price (>10$)-World Bank**

Fig 7 depicts the carbon price across countries (selected few shown)

- **Emissions trading system (ETS):** system where emitters can trade emission units to meet their emission targets by creating supply and demand for emissions units, an ETS establishes a market price for GHG emissions
- **Carbon border adjustment mechanisms:** This mechanism would counteract risk of carbon leakage by putting a carbon price on imports of certain goods from outside
- **Carbon offset:** Carbon offset schemes allow individuals and companies to invest in environmental projects around the world in order to balance out their own carbon footprints.

**Policies which encourages :**

- **Material efficiency:** Metric which expresses the degree in which raw materials are consumed, incorporated, or wasted, as compared to previous measures in construction projects or physical processes
- **R&D programme for clean technologies:** Development of technologies to replace fossil fuels with cleaner feedstock i.e. natural gas, hydrogen etc.

- **Collaboration and knowledge sharing:** Collaboration with academia and technology suppliers
- **Road maps and targets for steel emission reduction:** Reconfiguration/ addition of assets with near zero carbon emission intensity
- **Large scale infrastructure development:** Development of viable supply chain infrastructure for natural gas, hydrogen and CCU/S and creation of industry clusters
- Issues with emission related policies
- Uneven policy ambition in different regions may lead to relocation of production capacity - 'carbon leakage'
- Implementation of a uniform international carbon price would be impractical in short or medium term
- An international steel sectoral agreement may be a viable option in a 'low ambition' regime, as a smaller number of players would be involved. Government or companies to commit to 'commonly agreed' upon emission reduction targets (Top 10 countries - 85% steel production; top 50 steel companies- 60% steel production)
- Implementing a 'border carbon adjustment' mechanism by regions having high policy ambition may conflict with WTO & GATT. It is also difficult to track material carbon intensities
- Consumption based regulations would be less politically sensitive, would place the same carbon emission requirement for both, domestic and foreign steel and facilitate cost pass through to final consumer. Challenge - System for tracing carbon content of materials
- International co-operation would facilitate international transfer of technology and provision of concessional finances to enable lowemission technology deployment in developing economies.

## CONCLUSION

As India embarks on its journey towards 'selfreliance', Tata Steel remains committed to be a reliable and responsible partner in the nation's progress. Building a business that is as relevant and impactful tomorrow as it is today calls for a culture of agility. At Tata Steel, we are leveraging our innovation capabilities, technology leadership and sustainability focus to create long-term value for our stakeholders.

While a young fleet of production facilities presents challenges for reducing emissions, yet growing demand & scrap availability are opportunities to deploy clean technology based on $H_2$ or/ and CCU/S

With strong policy and collaboration across sectors, India could be a leader in clean energy transition in the Iron & Steel sector.

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## Glossary:

**BAT/BPT** – Best Available Technology / Best Practises Technology

**CEEW** - The Council on Energy, Environment and Water (CEEW) is a not-for-profit policy research institution. The Council uses data, integrated analysis, and strategic outreach to explain – and change – the use, reuse, and misuse of resources

**CDQ** - Coke Dry Quenching is a heat recovery system to quench red hot coke from a coke oven to a temperature appropriate for transportation and recover the sensible heat of the red hot coke and utilize for power generation or as steam

**CCU**- Carbon Capture and Utilization

**CCS**- Carbon Capture and Storage

**CSIR** - The Council of Scientific and Industrial Research was established by the Government of India as an autonomous research & development body in India

**COP21** - The 2021 United Nations Climate Change Conference, also known as COP26, is the 26th United Nations Climate Change conference.

**ETS** - Emissions Trading System (ETS) is to help achieve commitments to limit or reduce greenhouse gas emissions in a cost-effective way

**GATT** – The General Agreement on Tariffs and Trade is a legal agreement between many countries, whose overall purpose was to promote international trade by reducing or eliminating trade barriers such as tariffs or quotas

**IEA** – The International Energy Agency works with countries around the world to shape energy policies for a secure and sustainable future

**IPCC** – The Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental body of the United Nations

**LCA** – Life-cycle assessment or LCA is a methodology for assessing environmental impacts associated with all the stages of the lifecycle of a commercial product, process, or service.

**MIDREX & HYL** – Midrex is an innovative ironmaking process, developed for the production of direct-reduced iron (DRI) from iron ores and primarily natural gas.

**RCP** – A Representative Concentration Pathway is a greenhouse gas concentration trajectory adopted by the IPCC.

**TRT** – Top-Pressure Recovery Turbine Plant generates electric power by employing the heat and pressure of blast furnace top gas to drive a turbine generator

**TSJ/TSK** – Tata Steel Jamshedpur & Tata Steel Kalinganagar

**WTO** – The World Trade Organization is an intergovernmental organization that is concerned with the regulation of international trade between nations.

# Engineering the Green Revolution of Ironmaking – A Minimally Impacting Route to the De-Carbonisation of Existing Ironmaking Plants

*Paolo STAGNOLI[1], Andre ESTERHUIZEN[2] and Praveen CHATURVEDI[3]*

[1]Tenova SpA, ITALY, [2]Tenova Pyromet, SOUTH AFRICA and [3]Tenova Technologies Pvt Ltd, INDIA

**INTRODUCTION**

Steel, unlike many other structural materials such as concrete or even polymers, is an indefinitely recyclable material that can be used, re-molten and re-used without loss of quality and with an efficiencyof 80-90% depending on applications. Steel is everywhere in everybody's life: vehicles, house appliances, buildings, bridges, rails are only examples of the countless steel applications. Steel is undoubtedly one of the pillars of the transition from a linear to a circular economy. In 2019, the world produced 1,86bn tons of steel (about ten times more than in 1950), and the World Steel Association predicts the production to reach 2,7bn in 2050.

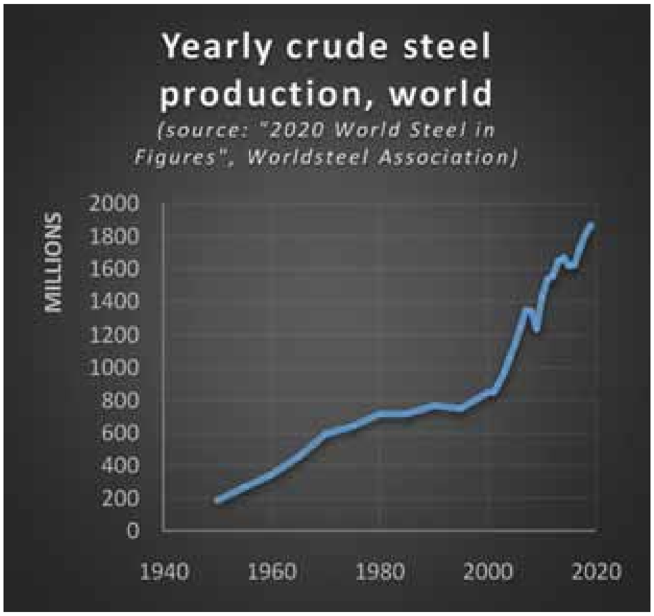


**Fig.1: Crude Steel production**

Depending on sources, the steelmaking industry is claimed to be responsible for about 12-15% of the total worldwide emissions of greenhouse gases.Steelmaking routes are very different in this respect: in the current

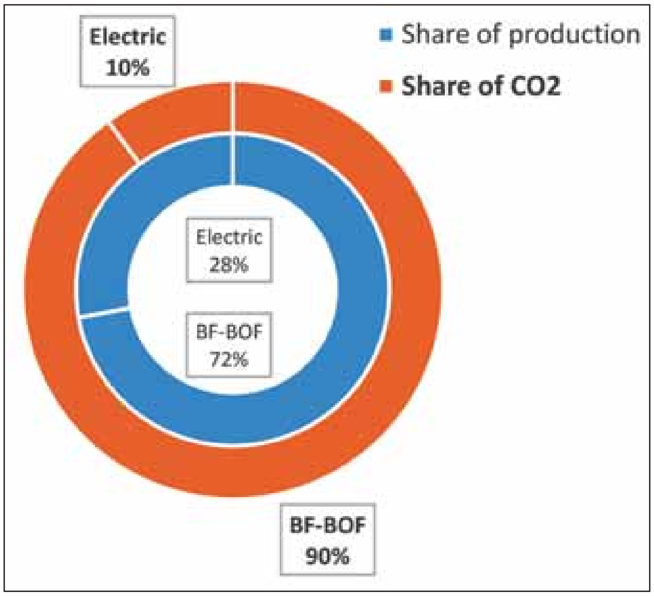


**Fig.2: Different routes, different $CO_2$ intensity for the production of steel**

EU context, where $CO_2$ intensity of electric power generation is about 290g/kWh, electric steelmaking generates about 400-500kg of $CO_2$ per ton of liquid steel whereas the integral cycle (via blast furnace and converter) remains at about 1600-1800kg per ton depending on the age and efficiency of the installation. As of 2019, 72%of the steel in the world came from BF-BOF route mostly processing iron ore, while only about 28% is producedvia the electric process,therefore 90% of the $CO_2$ generated for the production of steel came from the plants based onBlast Furnace-Converter route.

Ironmaking is anyway inevitable. Many high-end steel grades tolerate very low content (1000 ppm or less) of tramp elements such as copper, which is, unfortunately, abundant in recycled scrap (up to 4500 ppm in low-grade, cheaper scrap). Moreover, as the cycle of use and re-melt repeats, this average content of pollutants keeps on increasing as, for instance, copper wires remain entrapped within the body of a car or a dishwasher being demolished. But even if we imagine that a process for removing tramp elements from the liquid willeventually become available,there simply would not be scrap enough in the market to cover for a continuously increasing steel consumption. In mature markets (like north America) the available scrap covers about 50% of the total need of raw materials.

**Industrial Alternatives to the BF-BOF Route: Directly Reduced Iron**

The cleanest, least impacting, industrially-proven technology for ironmaking is reportedly the direct reduction of iron ore pellets using Natural Gas instead of Coke, coal or lignite to generate the reductant mix. The NG-based direct reduction is achieved by cracking the molecules of hydrocarbons to form a mix of CO and Hydrogen, whereas the carbon-based reduction processes such a s BF operate by partially oxidizing the charged Carbon to CO only. Some technologies use external reformer for cracking natural gas to generate hydrogen and carbon monoxide. For the case of the ENERGIRON® scheme, (ENERGIRON® is the DRI Technology jointly developed by Tenova and Danieli) the natural gas is directly fed to the process for in-situ reforming of hydrocarbons for a more efficient generation of reducing gases and the possibility of using the same scheme for any energy source. Once the iron oxides in the ore are reduced to solid metallic iron pellets (DRI), the hot pellets are fed into an EAF where they are molten using electricenergy and refined by injecting oxygen to remove the excess Carbon and reach the required temperature.It is also possible to blend up to 30% DRI pellets in the burden of a Blast Furnace to increase productivity andreduceCoke and PCI consumption.

Depending on Carbon intensity of the power generation in the context where the plant operates, producing 1ton of liquid steel through DR-EAF route producesat least 50% less $CO_2$ emissions than the conventional BF-BOFroute.The emissions can be even less if one leverages in full the peculiar features of the ENERGIRON™ Direct Reduction technology:the scheme includes by default a $CO_2$ absorption system that selectively removes $CO_2$ from the process gas stream for CCU/CCS applications. Additionally, ENERGIRON® modules allow use of variable percentages of Hydrogen in the feed and, eventually, the use of pure Hydrogen as fuel.

Thanks to the inherent flexibility of this technology, operating at high pressure and temperature and using the same DRI pellets as catalyst for the reforming, ENERGIRON® scheme has been chosen as basis for the first hydrogen-based steelmaking facility in the world, currently under construction and expected to be operative in 2021. According to the preliminary studies of the consortium of owners, the total emissions per ton of crude steel produced will be well below 50kg, thirty times less than the emissions of a conventional BF-BOF cycle.

The production of DRI worldwide has been continuously growing. The “shale gas revolution” has significantly lowered the cost of this commodity in several areas in the world, boosting the profitability of this route in countries outside of the traditional production areas such as MENA where large reserves of NG are available.

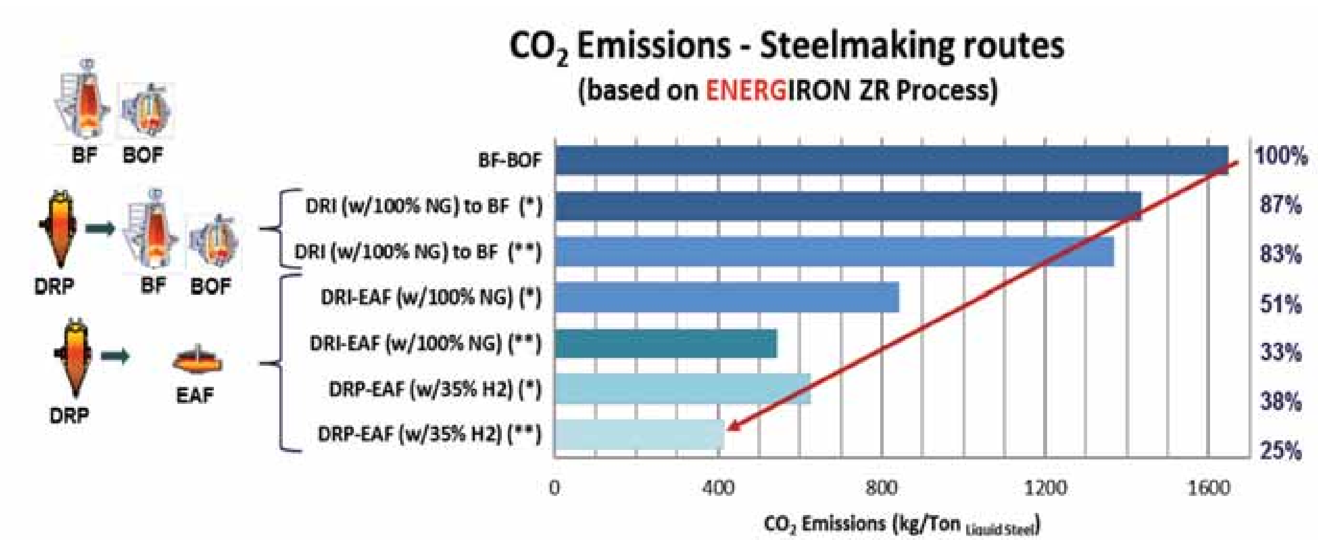


**Fig. 3: Notes:(*) Without $CO_2$ off-taking/commercialization(**) With $CO_2$ off-taking/commercialization, $H_2$% as energy input**

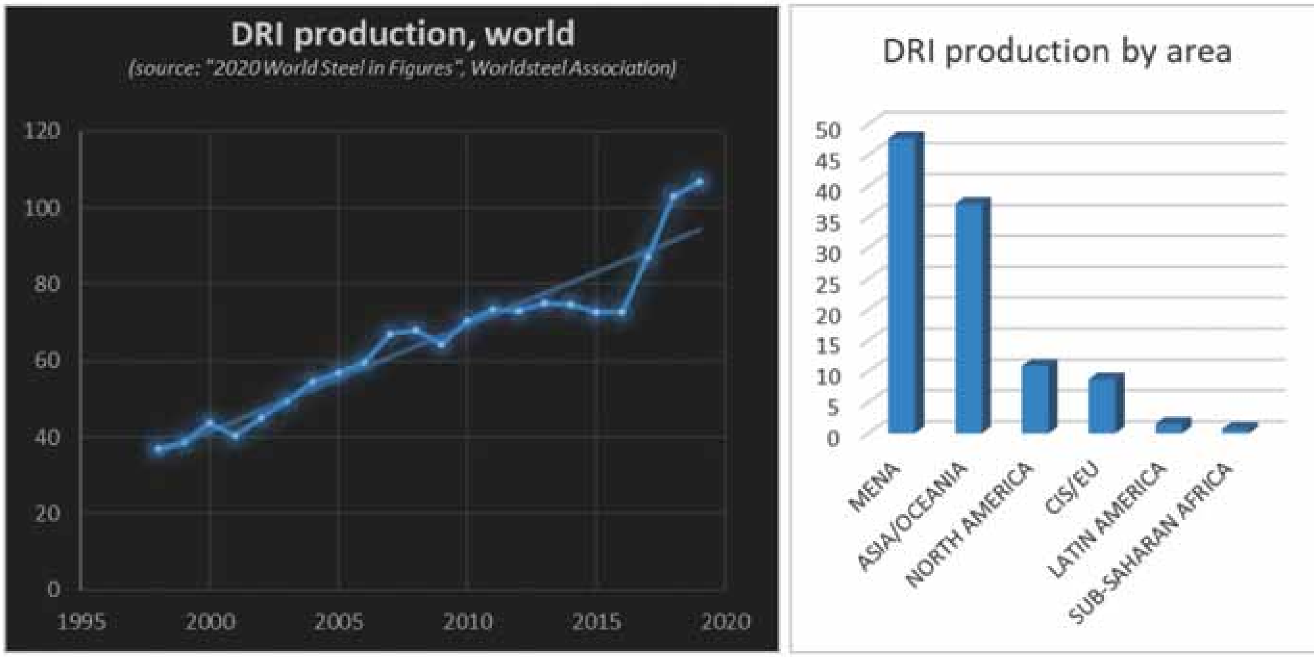


**Fig. 4: Production of DRI worldwide**

## Conversion from BF-BOF to DRI-EAF: Challenges and Constraints

Beyond the obvious consideration of capital expenditures, the transformation of existing integrated cycle facilities into DRI-based operations poses several challenges, the first being the availability of a power distribution grid with sufficient capacity to sustain the load of a large electric arc furnace and to tolerate the disturbances induced by this machine.

Let's consider a DRI-EAF line worth producing 2.5 Mt per year of DRI. The size of the transformer required to feed such a productive machine is 200-250MVA (depending on the chemistry of the pellets and feeding temperature), with a peak load of about

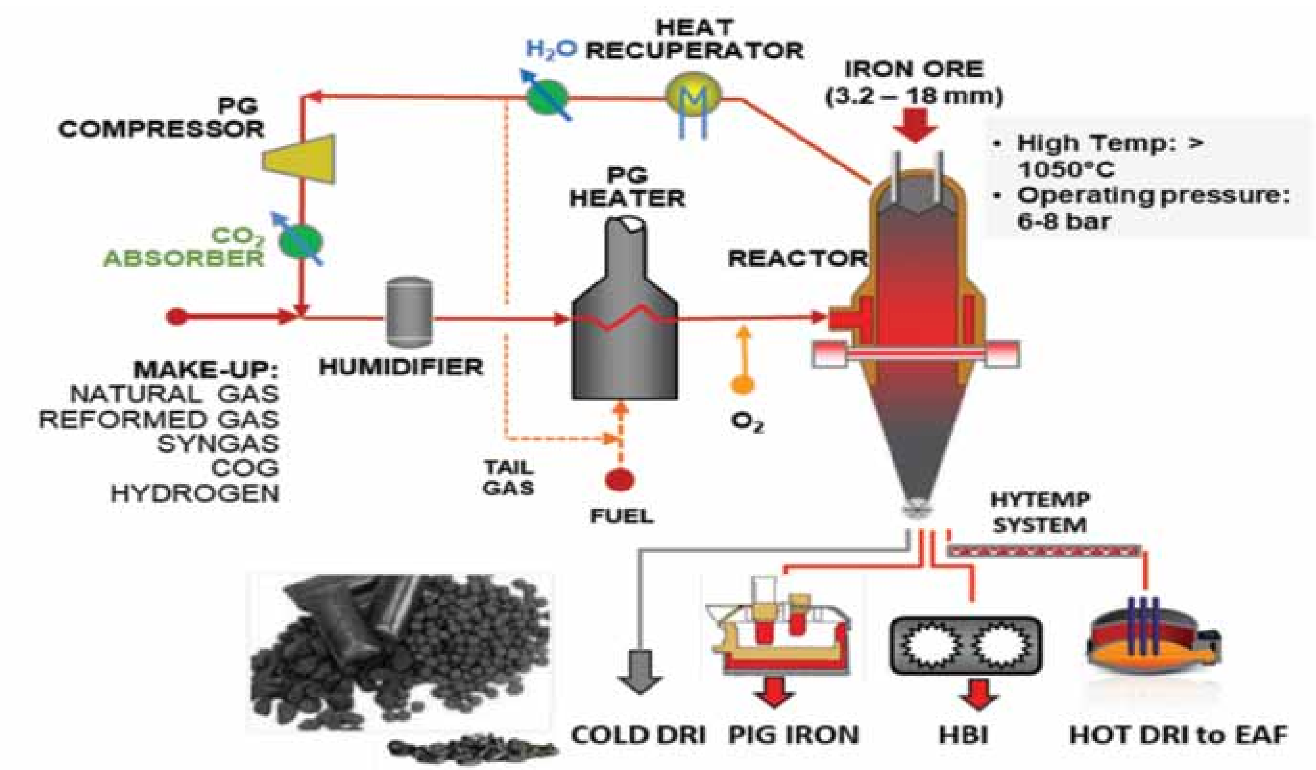


**Fig. 5: The ENERGIRON® process - Pig Iron production via Direct Reduction**

180MW. Besides the sheer availability of such an amount of power, the operation of the EAF generates disturbances (flicker) that reverberate on the upstream grid in inverse proportion to the short-circuit power of the same, causing high-frequency fluctuations of the active power. Even considering state-of-the-art flicker compensation equipment, able to reduce the flicker by a factor up to 4, the areas where such a machine can be installed are still quite limited. Power requirements of even the largest BF-BOF plant are not comparable, and large infrastructural investments are required to increase significantly the tolerable load of the power grid.

In addition to the infrastructural concerns, fitting a DRI-EAF route into an existing BF-BOF plant poses also logistic issues. Should a plant be willing to consider a gradual transition, progressively weaning the plant from the dependence of liquid hot metal but keeping the de-gassing and casting lines as they are, the operation team would have to integrate within the existing liquid steel stream a source characterized by a different pace (about 45 minutes' cycle time against around 30 for typical BOF), with a different tapping size and producing a liquid steel slightly different than the one produced in the preexisting facilities (even though DRI-EAF lines can be used to produce any kind of known steel grades).

Successful conversion to DRI-EAF route also requires changes in the choices of raw materials. The so-called DRI-grade pellets are formed by high-grade iron ore concentrates, typically with iron content in excess of 65%, and in the best ones the gangue is mostly basic (CaO and MgO). EAF operation requires the slag to respond to certain minimum criteria to allow for Phosphor removal, keep an adequate viscosity throughout the whole process and prevent chemical erosion of the refractory lining of the crucible, typically built with MgO-C bricks. If the pellets charged in the EAF contain significant quantities of Silica and/or Alumina, theprocess will require more than equal addition of basic fluxes to keep the slag within acceptable parameters, and since the fluxes require twice as much energy as the iron to melt, this results in an increase of the electric energy required by the process.

Moreover, as oxygen is blown to achieve the desired composition endpoint, the slag-steel equilibrium causes the concentration of FeO in the slag to be almost fixed for a certain required %C, so the more slag needed, the more Iron gets lost to the slag.High quantity of gangue implies high-energy consumption and low yield. Currently, low-grade pellets are used in DRI-EAF plants only in areas where the energy cost is almost negligible.

Last but not least, many BF-BOF plants are used to sell the BF slag to the concrete industry as an aggregate while the EAF slags, having high content of Iron oxide (20-40% depending on process) and being strongly basic, are not suitable for this purpose.

### A New Approach to Ironmaking: The HDRI-to-Hot Metal Route

Urged by several steelmakers, TENOVA began some years ago investigating a minimally impacting transitional solution to allow a gradual conversion of existing integral steelmaking plant. The purpose of the research was to find a production line mimicking a blast furnace but with significantly lower emissions. The objective was toeliminate the dependence from the coke while remaining able to process low-grade iron ore to produce an intermediate material compatible with the existing downstream processes, while tackling all logistic concerns related to the introduction of a DRI-EAF line into an existing BF-BOF plant.

The first item of this innovative production line is the ENERGIRON® Zero Reformer module. This direct reduction technology, developed by TENOVA and now managed within the ENERGIRON® consortium, uses a pressurized vessel to reduce iron ore pellets to DRI. Within the ENERGIRON® ZR module the same iron pellets in the module act as a catalyst for the cracking of the methane and of the other hydrocarbons contained in the feeding gas.The ZR operates at high pressureachieving metallization rates between 94 and 95%. It can produce DRI with Carbon content up to 5% (High-C DRI). The pellets can be charged directly inthe downstream melting unit at a temperature in excess of 600°C reducing significantly the required.

The solution proposed by TENOVA uses an OSBF to complete the reduction of the iron oxide remaining in the pellets through a reaction with a portion of the carbon contained in the same and melt the pellets, separate the gangue from the iron and bring the liquid to the desired temperature. A portion of the Silica contained in the gangue is also reduced to metallic silicon in the bath, achieving a composition of the liquid that is very close to the hot metal produced by blast furnaces, while the Sulphur content remains dramatically lower as natural gas (or hydrogen, or a mix of the two) is used to reduce the iron instead of Coke (which brings Sulphur to the hot metal produced via the traditional blast furnace route).

OSBFsfeature a large static vesselwith semi-permanent refractory lining, designed forlife cycles of severalyears.

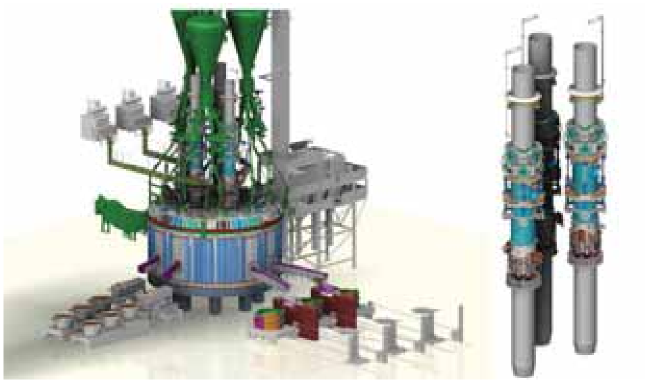

**Fig. 6: TENOVA PYROMET Open Slag Bath Furnace. On the right: Soederberg type electrodes (TENOVA, 2019)**

The feed, generally constituted by different ores, fluxes and reductants, is charged by gravity in the vessel and heated by means of resistive arcsthat spark through the slag layer. The OSBF ispowered by three independent single-phase AC transformers feeding Soderberg electrodes, independently regulated by means of hydraulic systems.

Periodically, the slag and metals are evacuated through tapholes and launders placed at different heights in the vessel (higher for the slag and lower for the metal). The tapping temperature can be adjusted by providing more or less electric energy to the bath, whilethe carbon content can be trimmed by adding carburizing agents to the feed. At the end of tapping, the holes are plugged with a clay gun and the cycle is repeated. The process maintains a large metal heel in the furnace sothe furnace always operates in liquid bath steady operation. This process generates an amount of electrical disturbances (flicker) that is almost negligible if compared with the noise generated in the power grid by an EAF of similar productivity.

OSBFs have a significantly lower power density (MW/ $m_2$) than EAFs and do not operate with open, radiating arcs as the EAFs do. Thanks to this feature, the slag requirements are dramatically less stringent as the protection of the sidewall refractories is achieved by a sheer temperature gradient, keeping the slag next to the wall below its solidifyingtemperature.

As the steady and static operation of an OSBF implies vastly lower mechanical stresses, the unit uses Söderberg electrodes. With this system, the gradual consumption of the electrodes near the tip is compensated by adding a paste composed by anthracite, pet coke and graphite that graphitizes with the process temperature as the electrode slips down. This material costs significantly less than standard graphite electrodes used in EAFs.

Logistic-wise, for the plants where the assembly needs to be installed away from the BOF shop (a configuration quite common in the integrated cycle plants) the liquid produced can be tapped into ladles ortorpedo cars and transported with a modest temperature drop at a significant distance, same as it is done in blast furnaces.

DR module and OSBF are integrated in an organic automation package controlling the operating

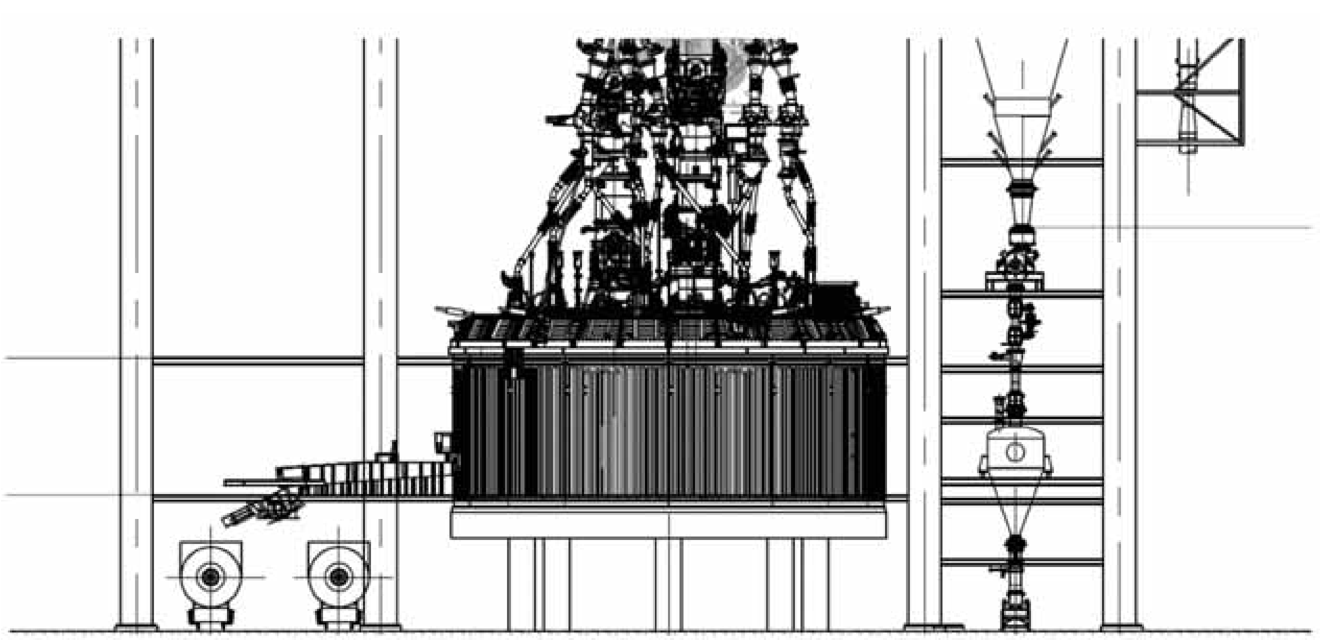

**Fig. 7: OSBF tapping in hot metal torpedo cars. On the right: DRI cooler for cold DRI discharge**

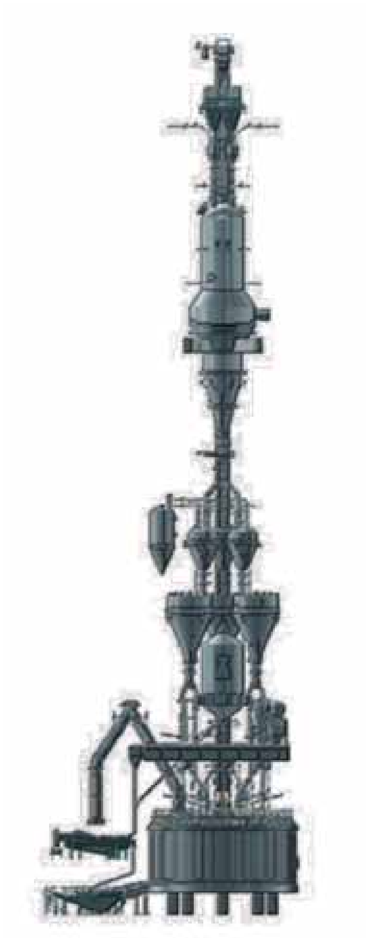

Fig. 8: Pig iron/vanadium slag production plant in Canada, basic engineering

parameters of both units,keeping under watch the process from the raw materials feed to the tapping into the receiving vessels in a fully automated way.

**CONCLUSION**

TENOVA, through productive interaction with European and Eastern steelmakers, developed an innovative process route based on industrially proven, referenced units. This fully integrated line can produce hot metal with adjustable Carbon (up to 5%)and Silicon (0,2-0,4%) content from low-grade iron ore pellets, while producing BF-like slag that can be granulated and sold as a byproduct.

In order to overcome the constraints inherent in the DRI-EAF routeTENOVA leveraged its experience in ore smelting furnaces, owned by the South African branch of the group (Tenova PYROMET) specialized in the design and supply of Submerged Arc Furnaces (SAF) and Open Slag Bath Furnaces (OSBF) for the production of ferroalloys and base metals.

The proposed solution, for the cases analyzed, will allow a reduction of $CO_2$ emissions by roughly 70% (85% if using carbon-neutral electricity)and enables existing ironmaking plants to plan a gradual reconversion during which the operation of the downstream units (BOFs) will remain substantially unchanged.

At the moment of publication of the present article two projects involving this route are active as well as several negotiations with various international players.

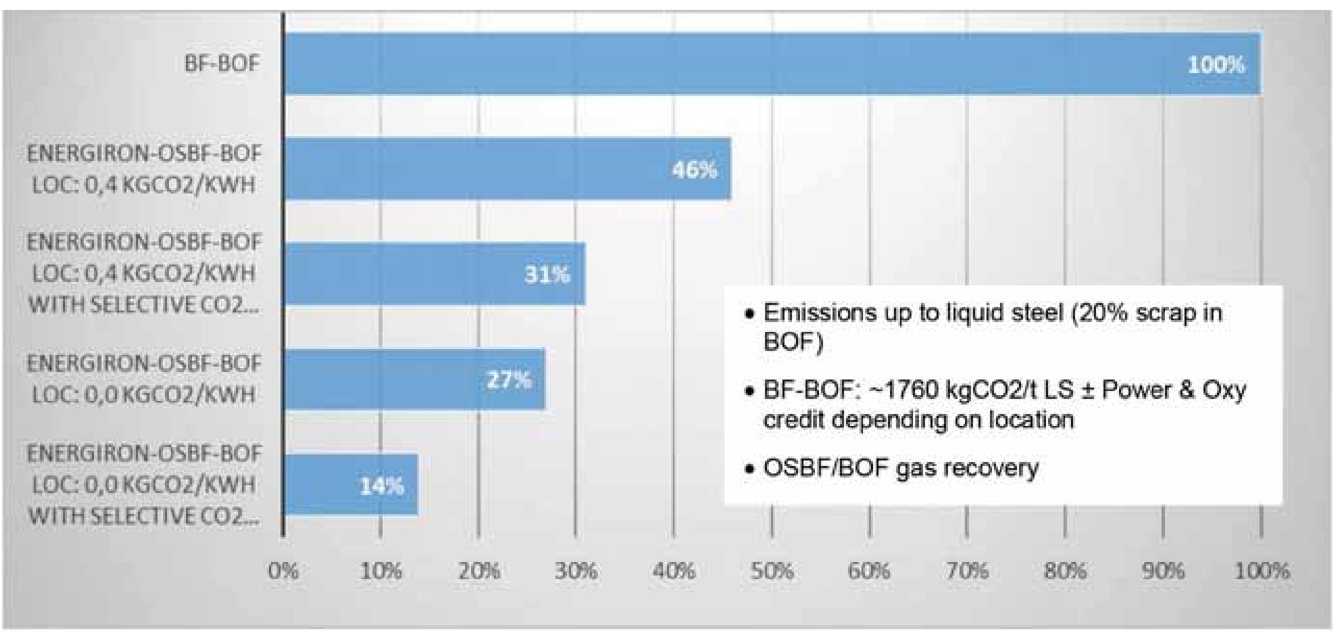


Fig. 9: $CO_2$ emission comparison with reference process (BF-BOF) for different plant operating conditions

Contact data: Praveen CHATURVEDI ●Tel +91 9167725604; ●Email : praveen.chaturvedi@tenova.com

# Developing Technologies to Support Sustainable Steelmaking

*Rolando Paolone*
Danieli, ITALY

In the past, steel producers around the world were focused mainly on increasing productivity and product quality, as a way to either strengthen or increase market share.A plant's output, with focus on transformation costs, is key for the producer's Return on Investment (ROI) for capital expenses (CapEx) and operating expenses (OpEx). In this century, and mainly for the Western Hemisphere, arguments like workers' safety and environmental issues have become more and more important for steel industry sustainability.

Proper use of resources, circular economics, and reduced emissions are concerns that regularly rise on the list of companies' top priorities. Individual nations have grown to understand the importance of environmental sustainability and have defined emissions targets from 2020 to 2050 (starting with the Kyoto Protocol in 1997 and, in greater detail, with the Paris Agreement in 2015). The action plan outlined objectives and dates for steps needed to reduce greenhouse gas emissions (GHG), keeping temperature increases below the 2°C threshold, with a target of zero emissions by 2050. To do so, the EU has been asking industrial organizations to develop technologies to help reach this ambitious goal, while helping fund relevant research activities.

Structural changes require decisions and strong actions. In recent years the steel community understood that, because the defined dates are inching closer, it is necessary to advance steadily and quickly towards such goals. Carbon dioxide ($CO_2$) is the main issue when thinking about greenhouse gas emissions. This is gas that is commonly present in nature: it is emitted by animals, human beings, plant respiration and decomposition, and it is regularly transformed through different natural processes, such as plant photosynthesis: to foster their growth, they absorb $CO_2$ and release oxygen instead. Industrial activities have increased $CO_2$ emissions, using fossil fuel to produce energy, resulting in an unbalanced system. The diagram in (Figure 1) shows the percentage of greenhouse gases emitted by the different sectors, while (Figure 2)

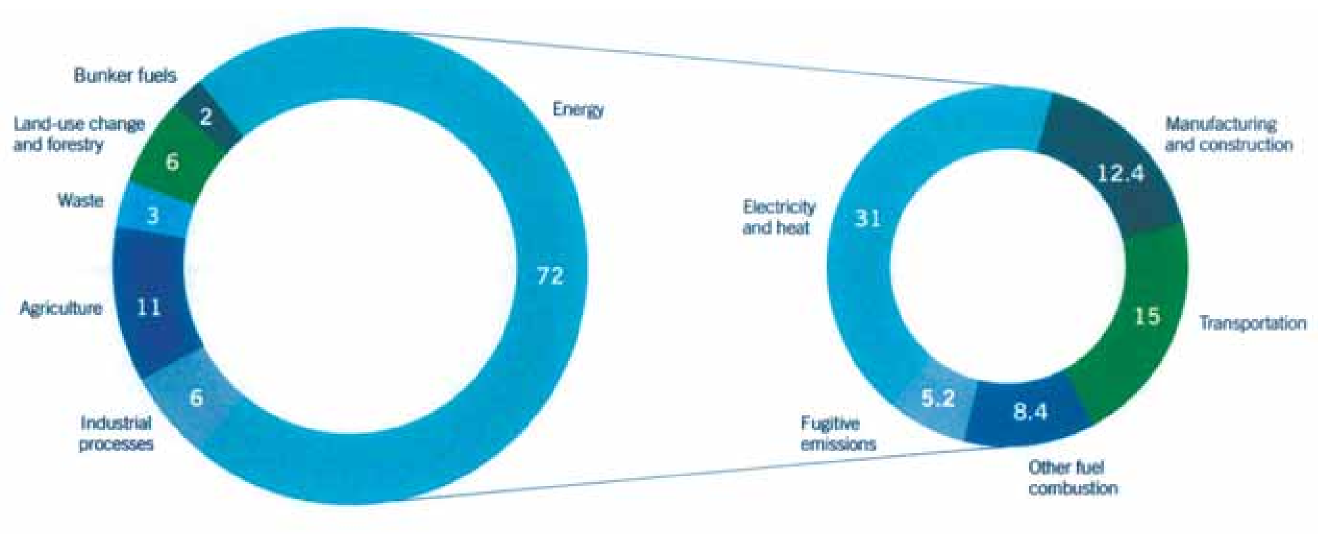


**Fig.1: The percentage of greenhouse gases emitted by the different sectors**

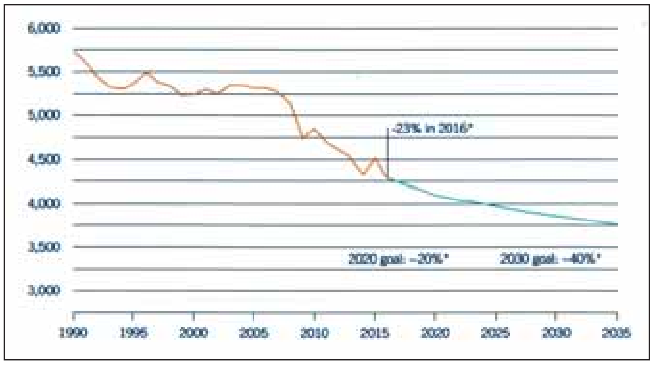


**Fig.2: Greenhouse gas emission trends: emissions, projections and targets for th EU compared against 1990 levels (Million tons of $CO_2$ equivalents)**

*Source: European Environmental Agency*

highlights the trend versus the target fixed by the Paris Agreement.

The 2020 target was reached in Europe in 2016, while the next target is extremely challenging: assuming the current trend remains steady, the 2030 objective will be missed. “On average, 1.85 tons of $CO_2$ were emitted for every ton of steel produced in 2018: The steel industry generates between 7% and 9% of direct emissions from the global use of fossil fuel”. (Source: worldsteel.org). The main routes for crude steel production (Figure 3), depending on raw material (iron ore or scrap) and process (for iron ore: BFBOF or DRI-EAF) have completely different $CO_2$ emission rates.

Note: Each of the routes for crude steel production generates a vastly different amount of $CO_2$ emissions based on both raw material and process adopted.

In this context, processing iron ore into steel through the BF-BOF route results in the most pollution, with around 2 tons of $CO_2$ for each ton of liquid steel, while the EAF (from scrap) produces less than 0.4 ton of $CO_2$ for each ton of liquid steel.The DRI-EAF route is able to cut $CO_2$ emissions in half; and, using hydrogen instead of natural gas as a reducing atmosphere, lower the relevant emissions close to zero. As iron ore represents 75% of the raw material in steel production, it is clear how fundamental is the transition from the BF-BOF traditional route to the Direct Reduction plus EAF.

Danieli is well present in this scenario with its Energiron technology, a “$H_2$ ready” process. In the sector, everybody now considers $H_2$ a dramatic step ahead for steel production from iron ore. $H_2$ introduces a transformative shift in emissions reduction, comparable to the deep change that electrical mobility is bringing to transportation (from cars to trucks, trains etc.).

The issue arises when we start asking where the energy needed to produce $H_2$ (or electricity for EV) is coming from; fossil fuel is clearly not the answer, since it will maintain the level of $CO_2$ unchanged, but would just move them away from the user. Then, the next step forward is the creation of green energy from renewable sources, and Danieli is supporting this transition with hybrid plant solutions. We are ready to supply the H-MIDA, an evolution of the well-known MIDA concept for continuous casting and rolling of long products, able to self-produce up to 25% of required energy from renewable sources.

This technology is possible thanks to a different application Danieli offers, on top of which is the Q-ONE for the DDM (Danieli Digital Melter, our evolution of the EAF). The original MIDA itself, thanks to a process that does not need intermediate heating, is able to cut almost to zero the direct $CO_2$ emissions after the melt shop. Grey electrical energy for motors and arc furnace electrodes represents indirect $CO_2$ emissions minimized thanks to the H-MIDA.

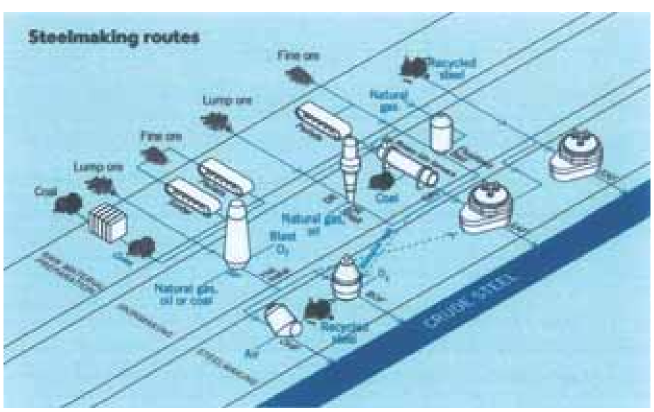


**Fig.3: Each of the routes for crude steel production generates a vastly different amount of $CO_2$ emissions based on both raw material and process adopred**


**Fig.4: With Energiron, It’ll be possible to make huge strides in green steelmaking by generating $H_2$ from renewable sources, steel production emissions will be drastically reduced**

All of this means that, while a conventional minimill melting scrap will rate close to 400 kg $CO_2$ /ton of steel, the MIDA will drop emissions down to 300 kg $CO_2$ /ton steel, with H-MIDA representing another step towards greater reductions, to approx. 230 kg $CO_2$ /ton steel. This rate also can be maintained with iron ore as the raw material, using our DRIDDM using hydrogen (Figure 4). Danieli's approach to environmental issues is to prioritize solutions that avoid the use of fossil fuel before investing in energyrecovery processes.

Note: With Energiron, it'll be possible to make huge strides in green steelmaking: by generating $H_2$ from renewable sources, steel production emissions will be drastically reduced.

This happens thanks to the use of big data to improve process control, while increasing overall efficiency at the same time. On the other side, in the last 50 years the steel industry saw a significant reduction in energy consumption, resulting in a plateau for the past 15 years, which makes it apparent that additional and different efforts are required.

Circular economics is a strong asset for the Group: different solutions are available to reduce the waste, and maximize the reuse of resources in every area of the steel plant. When reheating is required by the process or for existing plants where MIDA and QSP-DUE cannot be applied, we have developed burners that minimize NOX emissions and increase efficiency to reduce their consumption, thanks to a L2 developed for the purpose.

Minimized scale formation is another target we developed, to be able to increase the yield to reduce the OpEx. Compressed air can be produced with an exclusive process directly using the exhaust fumes of the RHF.

We must take advantage of renewable energy that is available; therefore equipment electrification is a step forward for the transition to $CO_2$ -free emissions. On the other hand, the "$H_2$ ready" approach will give the final user the possibility to easily convert this gas to hydrogen when it is available in large volumes, securing today's investments.

In conclusion we can say that most of the technologies needed for a clean "steel industry" are already available, and some more will be added soon. Sometimes the investments are relevant (mainly, in the iron-ore-to-liquid-steel process) but they also represent the only way to significantly reduce the greenhouse gases.

The pandemic breakout has become an opportunity to bolster investments, as countries decide to face the potential recession with huge financial resources. The steel industry must take this chance and use the available resources to establish a low-carbon future and climate-resilient society.

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*Chief Technology Officer and Member of the Group Executive Board Danieli, ITALY

# Increase of Scrap Rate in Converter Steelmaking

*Gerald Wimmer, Krzysztof Pastucha and Bernhard Voraberger*
Primetals Technologies Austria GmbH, Linz, AUSTRIA

**Abstract**

Steel is an ideal material for recycling and the production of steel out of scrap is much more efficient and has lower ecological footprint than the production of steel out of iron ore via the blast furnace route.

In countries like India enormous investments in infrastructure as well as consumer goods have been made in the last decades and consequently, as some of them reach end of lifetime, the amount of scrap available on the market is increasing a lot. As the total amount of steel produced worldwide is rather stable, the pressure to increase the ratio of scrap used for steel production is increasing and solutions are required, that allow processing higher scrap rates in the existing integrated plants using converter technology.

Primetals Technologies has developed several solutions for increase of scrap rates in converter steelmaking. This solutions include upgrade packages that can be installed on existing converters like scrap preheating system, post combustion lances or process control models to optimize the heat balance and reduce reblow rate. Combination of such packages is possible and scrap rates up to 30% can be achieved. For higher scrap rates combined blowing converter is required to ensure proper mixing and melting of larger scrap pieces. Highest scrap rates can be processed with Jet Process, a process employing bottom blowing converter with coal injection and special post combustion lance. This way very efficient heating can be done and scrap rates up to 50% combined with highest productivity can be achieved.

**Keywords:** Scrap rate, BOF converter, Green steelmaking, $CO_2$ footprint

## 1. INTRODUCTION

Scrap generation for the last decades are shown in Figure 1 together with numbers for consumption [1]. The amount of scrap available is expected to grow further in future. In combination with a predicted stable or even slightly declining total steel production such increase in scrap availability will lead to an increase in scrap utilization also for integrated steelmaking. Processing more scrap in e.g. BOF converter steelmaking is also an easy and fast to implement measure to reduce $CO_2$ emissions per ton of steel produced.

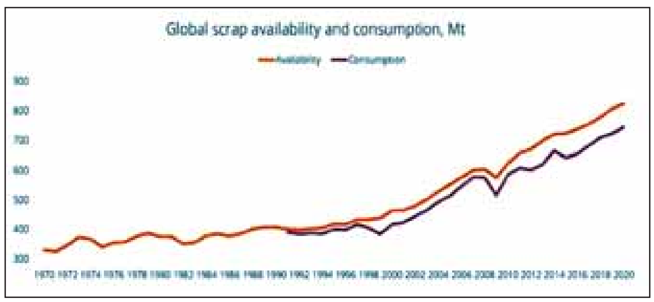


**Fig.1: Prediction of scrap availability and consumption [1]**

Hence, solutions for higher scrap rate processed in BOF converter are required. Such solutions range from packages for normal BOF for moderate increase of scrap rates via combined blowing converters for medium scrap rates up to Jet process for highest scrap rates[2]. This solution also allows for highest flexibly, a switch between hot metal and scrap or direct reduced iron, can be applied easily to deal with volatility of raw material supply.

In the present paper solutions for converter steelmaking with increased scrap rate will be presented. In the first part general overview about different processes for steelmaking and their area of application is given as well as energy balance for converter that drives the amount of scrap that can be melted. In the second part packages for conventional BOF to increase scrap rate are discussed followed by combined blowing converter a Jet Process in the last part.

## 2. Processes and Energy Balance

There are three main sources used for steel making in industrial scale: hot metal, scrap and direct reduced iron like DRI or HBI. The latter is gaining importance due to the low gas price in some areas in the world and the additional capacities for direct reduction plants installed there. The two main ways of its utilization are direct charging of the hot DRI to a furnace that is installed next to the direct reduction plant or briquetting of the DRI to HBI and transport in cold condition. For processing of scrap and HBI energy for heating up and melting is required. In converter process such energy is provided from chemical sources via the combustion of C and Si in the hot metal or in heating agent added to the process. In electric arc furnace such energy is provided from electrical energy via the electrodes plus chemical sources from the burners and combustion of e.g. Carbon or Silicon contained in the charge or added for heating purpose. There is basically no limit for the energy that can be provided via the electrodes, hence, electric arc furnace can be used to run with 100% solid charges. For converter steelmaking the amount of combustibles in the process is limited and further addition of heating agents like Coal or Ferro-Silicon is limited by process and economics. Hence, the share of solid charges that can be processed in a converter is limited. Typical ranges for normal BOF (LD) converter are 15% to 20%. Combined blowing converter (KOBM) have better mixing due to bottom blowing installed and top blowing lance can be operated on higher level increasing the post combustion degree. Hence, scrap rate is some 5% to 10% higher than for BOF. Higher post combustion and additional heating by coal injection is done with Jet Process resulting in a maximum scrap rate of 50%.

For higher rates of solid charges electric arc furnaces are typically used. For furnaces running with scrap only preheating of the scrap with the hot off gas coming from the furnace is latest step of development. Such preheating allows the consumption of electricity per ton of steel tapped compared to normal furnace.

An overview about these processes and their typical area of application is summarized in Figure 2. DRI and HBI still contain some percent of iron oxide that was not reduced in the reduction plant as well as some non-metallic fraction called gangue. Therefore, the energy for heating and melting in steelmaking is higher for one ton of HBI than for one ton of scrap and consequently the maximum share of scrap that can be processed is higher than the maximum share of HBI. In addition HBI is more challenging to melt than scrap and special care

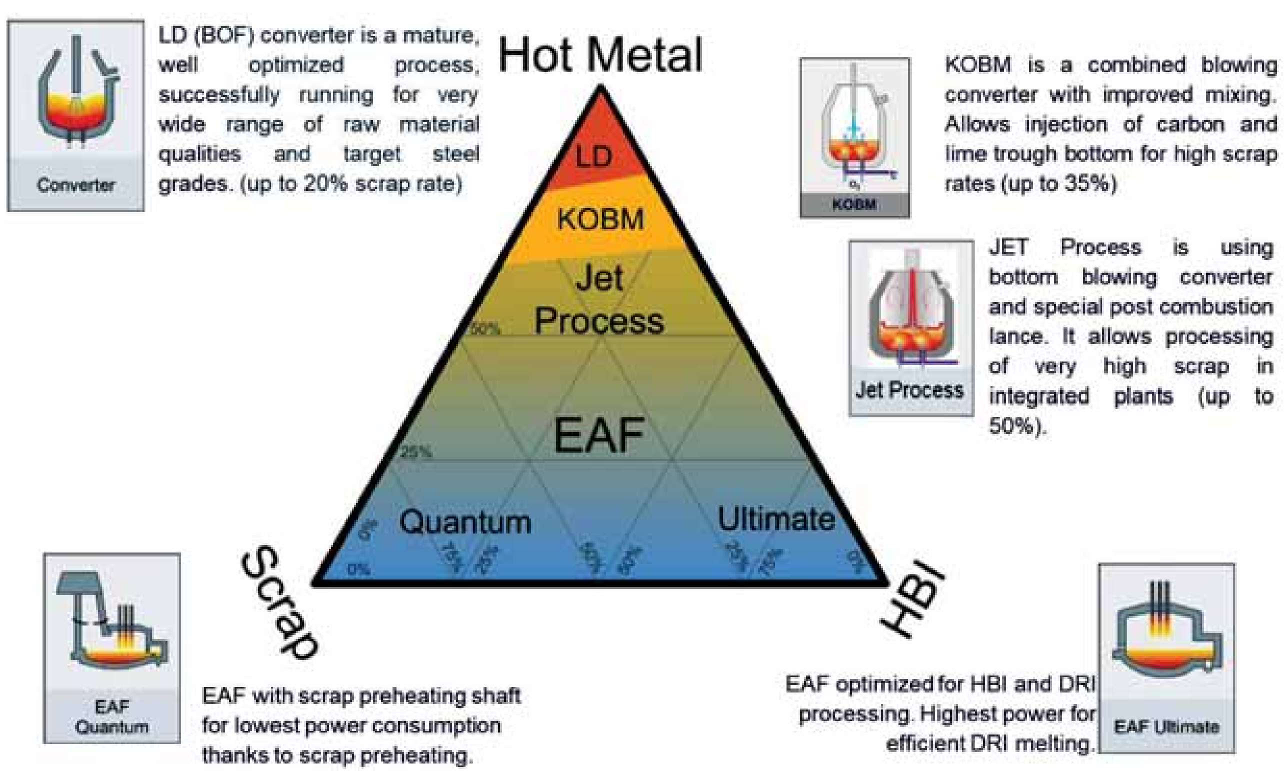


**Fig. 2: Area of typical application of different steel making processes depending on charge-mix**

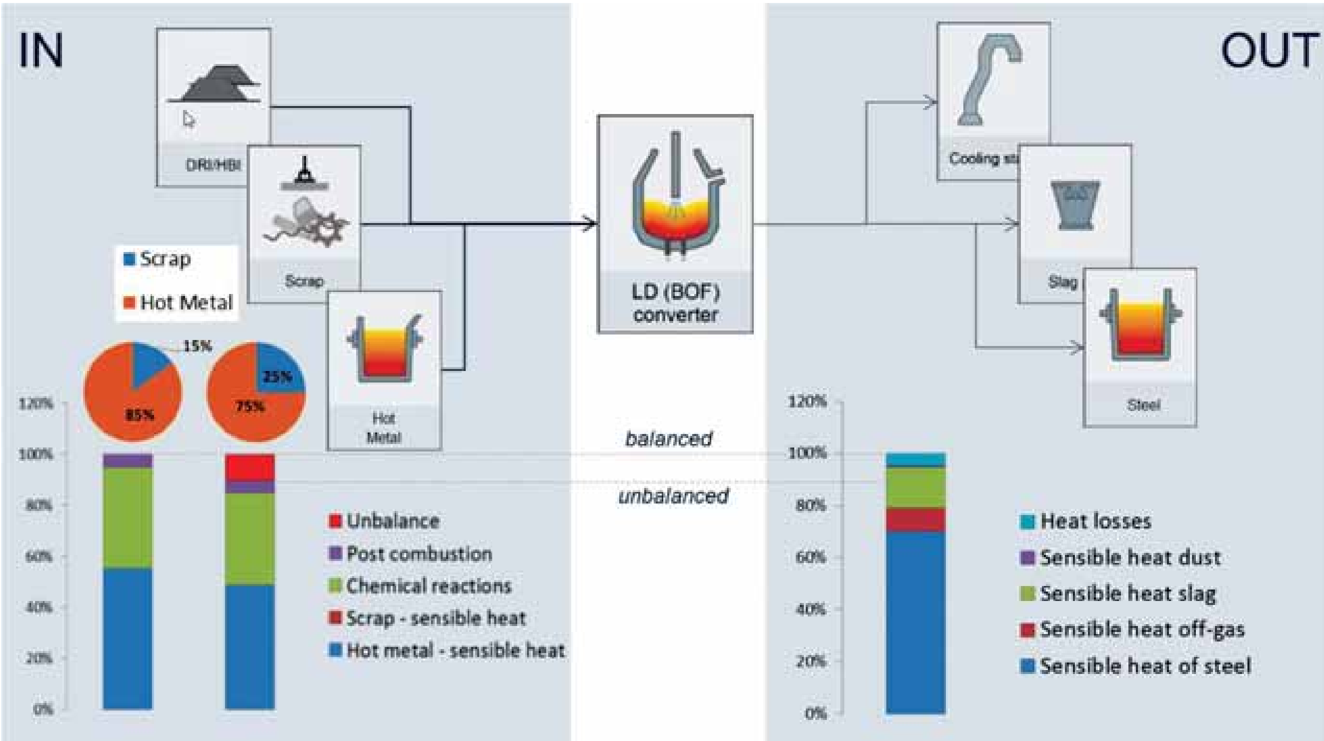


**Fig. 3: Energy balance BOF process. Example for process well balanced for 85%HMR is shown. For lower HMR energy not balanced, not enough energy to meld down all cold inputs (Scrap, DRI) and reach target tapping conditions**

for the charging step and mixing during processing is required.

The conventional BOF (LD) process with oxygen top blowing and bottom stirring by inert gas is the presently mostly applied converter steelmaking process worldwide. Main advantages of the BOF process are its simplicity, proven equipment solutions, flexibility for application of different solid charge, low maintenance demand, etc. The maximum scrap rate that can be processed within a heat in a converter is defined by the energy balance of this heat. In Figure 3 an example is given showing the main energy inputs as well as the energy outputs. In this example energy balance is achieved with 15% scrap rate. For higher scrap rate of e.g. 25% the energy input is not sufficient to match the energy output, e.g. the target tapping temperature cannot be achieved.

One of the main energy contributors is the combustion of C and Si contained in the input materials. While Si is combusted in one step to $SiO_2$, C is combusted in a first step in the steel bath to CO only and in a second step outside the bath to $CO_2$. The latter step is called post combustion and generates about two thirds of the total energy released if Carbon is combusted to $CO_2$. In conventional BOF operation the post combustion degree is rather low with 8% to 12% only. Hence, only small part of the total energy available is used inside the converter and a gas with high calorific value is leaving the process which is typically collected in a gas holder and used for heating purposed in the plant later.

In order to increase scrap rate additional heating agents can be added like C, SiC or FeSi. The latter two will increase the slag amount and acquire additional lime additions to keep slag basicity high. This is increasing the total costs and together with limits on total slag amount is creating a boundary for the extent of heating that can be done. Same is true for C additions, as combustion to CO is done mainly and only small portion is fully combusted to $CO_2$ the efficiency is rather low. In practical applications additions not more than 10kg/t are used allowing for an increase of scrap rate of some 2% to 3%.

Another point that restricts the scrap rate in conventional BOF converter steelmaking is the bath mixing. In order to melt down high amounts of scrap per heat in short time, strong mixing of the bath is required to keep temperature gradients small and avoid formation of cold spots. Hence, proper bottom stirring is required throughout the entire vessel lining campaign.

## 3. Packages for Increased Scrap Rate in Conventional BOF Operations

Several measures exist to increase the energy input and decrease the energy output for BOF converter

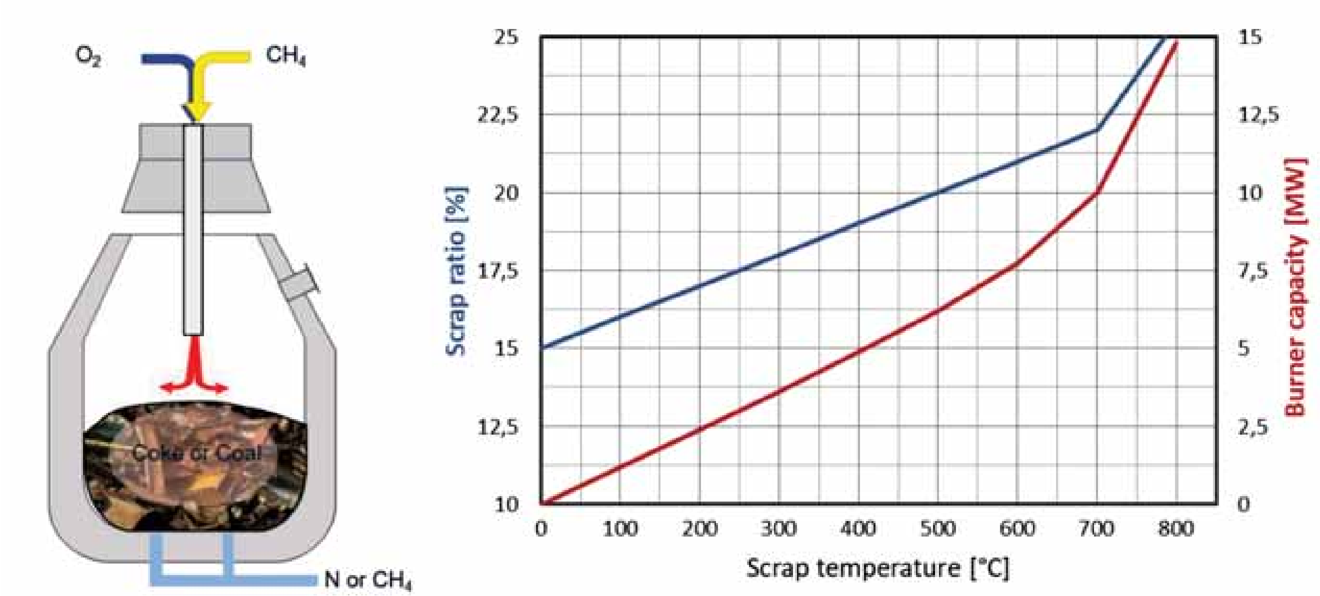


**Fig. 4: Converter equipped with burner lance for scrap preheating (left). Increase of scrap ration as function of scrap preheating temperature. Required burner capacity to achieve this scrap temperature in average within 15min heating time for 100t BOF (right)**

operation, this increases the energy available to melt additional scrap and increases the scrap ratio. Such measure are i) increase of charging temperature of hot metal and decrease of tapping temperature, increase of carbon and silicon content of the hot metal, ii) addition of heating agents, iii) preheating of the scrap as well as iv) increase the post combustion degree.

Reduction of transport times by improved logistics, better insulation and installation of covers on ladles as well as optimization of hot metal properties are measures to improve point i). The increase in scrap rate that can be achieved with such measures always depends on the starting point and is of course smaller for a plant that is already well optimized. In typical cases some 3% are achieved, resulting in a scrap rate around 20%. Addition of heating agents ii) is possible to a certain extent and was discussed in the last section. In daily operation it is typically used for corrections and minor increase of scrap rate of 1% to 2% only.

Preheating of the scrap iii) should be done inside the vessel to avoid any handling of the preheated scrap which would cause a lot of dust generation in the bay. After the scrap is charged preheating is done by a burner lance installed instead of the top oxygen lance. In addition some coal can be charged with the scrap or some gas blown through the bottom stirring plugs for additional heating. Lumpy coke or coal charged for scrap preheating does not lead to essential pick-up regarding S and N in crude steel at end of main blow because during the scrap preheating process S and N from coke or coal is removed with the off-gas almost completely. Hence, rather cheap coke or coal can be used here. This is different to coal added after hot metal charging for additional heating. S and N of such coal will increase S and N content of the steel bath and hence, higher quality coal is required. In Figure 4 (left) a principle sketch of such preheating situation is shown, the increase in scrap rate as function of the average temperature of the scrap after preheating is shown in Figure 4 (right) together with the burner power required to achieve such temperature in a heating time of some 15 minutes.

The energy transfer from the burner flame to the scrap takes time and strongly depends on the scrap size and density. The longer the preheating time, the higher is the temperature of the scrap and the maximum possible

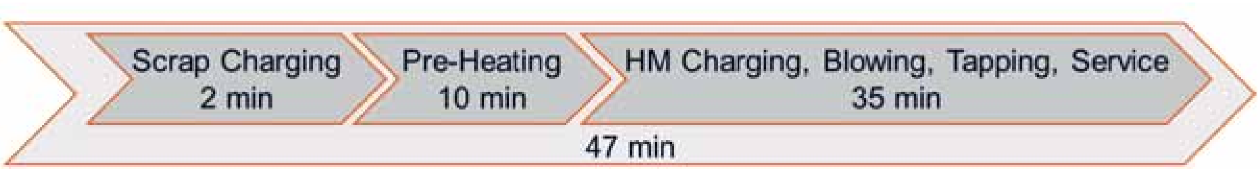


**Fig. 5: Scrap preheating – cycle time**

scrap ratio. The scrap temperature should not be too high to avoid iron oxidation, typical target temperature for preheating are some 800°C. Preheating time needs to be at least 6min, better 10min – see Figure 5 - and will result in an increase of scrap rate of some 5% to 7%. The additional time required for the preheating of the scrap and charging higher scrap amount can only be partly compensated by reduction of charging time for hot metal and reduction main blowing time due to the reduced hot metal ratio. In total Tap-to-Tap time will increase if scrap preheating is applied.

Similar process is used in northern country for de-icing and drying of scrap in winter time to avoid contact of water or ice with hot metal.

Another measure to increase energy input into the converter process is an increase of the post combustion degree. Post combustion lance that is installed instead of the normal top blowing oxygen lance is used for this purpose. Such post combustion lance has similar lance tip as normal oxygen blowing lance – called main port - and a secondary port above the main port where additional oxygen is blown in. The secondary

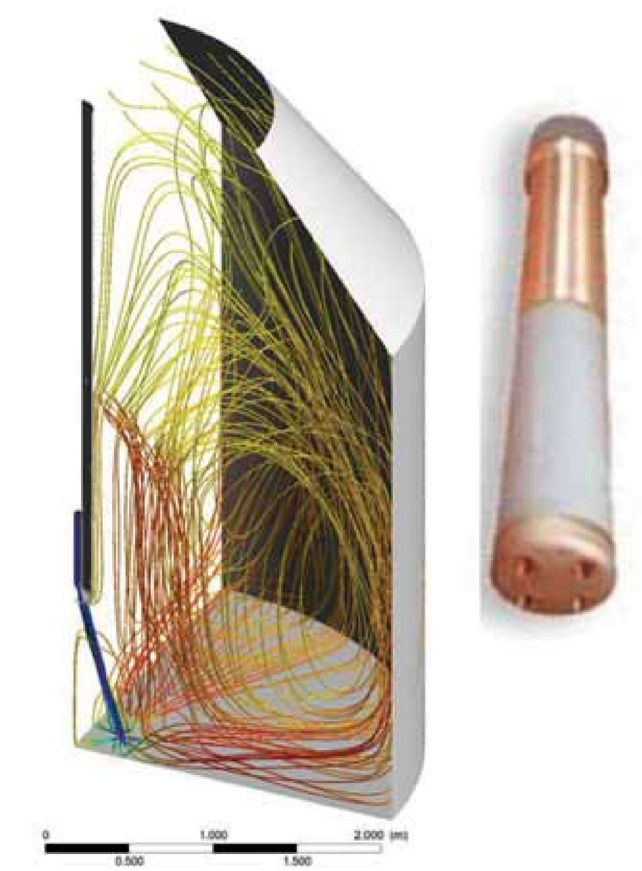


**Fig. 6: Dual flow post combustion lance with secondary port for individual control of PC to increased HTE and scrap rate (right). Results from simulation for optimization of that lance (left)**

port is designed regarding nozzle diameter, height and angle in a way to ensure that the oxygen blown through this port is mainly for post combustion of CO coming from the bath. A picture of such post combustion lance is shown in Figure 6 (right); for optimization of the geometry modern simulation tools like CFD are used. A result from such simulation is shown in Figure 6 (left).

Furthermore the heat generated in this post combustion needs to be transferred to the largest possible extent to the liquid bath and not to the off gas. This is described by the so called heat transfer efficiency.

To allow for control of the post combustion the flow at the secondary port needs to be controlled independently from the flow at the main port. Hence, a second control line needs to be installed and the lance is therefore called dual flow post combustion lance (DFPC lance). In addition mixing with nitrogen is installed for the oxygen blown through the secondary port providing a second lever of control of post combustion degree. Usage of DFPC lance allows increasing post combustion degree up to 20% during main decarburization period with high heat transfer efficiency resulting in an increase of scrap rate of 5 %.

There is an essential difference of the above mentioned DFPC lance from standard single flow lances with post combustion ports where only pure $O_2$ is applied as post combustion gas and the oxygen flow for the post combustion is not separately controlled. Such single flow lances are mainly used to reduce skull formation on blowing lance and converter mouth and top cone and show minor impact on scrap rate only.

Taking all the above described measures together will allow achieving scrap rates between 25% and 30%. For such high scrap rates scrap logistic need to be checked in detail, especially the capacity of the scrap chute. Enlargement of scrap chute, increase of scrap density by scrap processing are measures to improve, if not sufficient scrap needs to be charged with two chutes which of course will take additional time. Furthermore, good bottom stirring is required to ensure intensive mixing of the bath and proper melting of all the scrap added. Last critical point is the oxygen ignition at blowing start which is not that easy in case of such high scrap rates and cold surface temperatures caused by it.

To overcome this limitations for processing of high scrap rates change from standard BOF converter with top blowing of oxygen and bottom stirring with inert gas to combined blowing converter with oxygen blowing from top and bottom can be done.

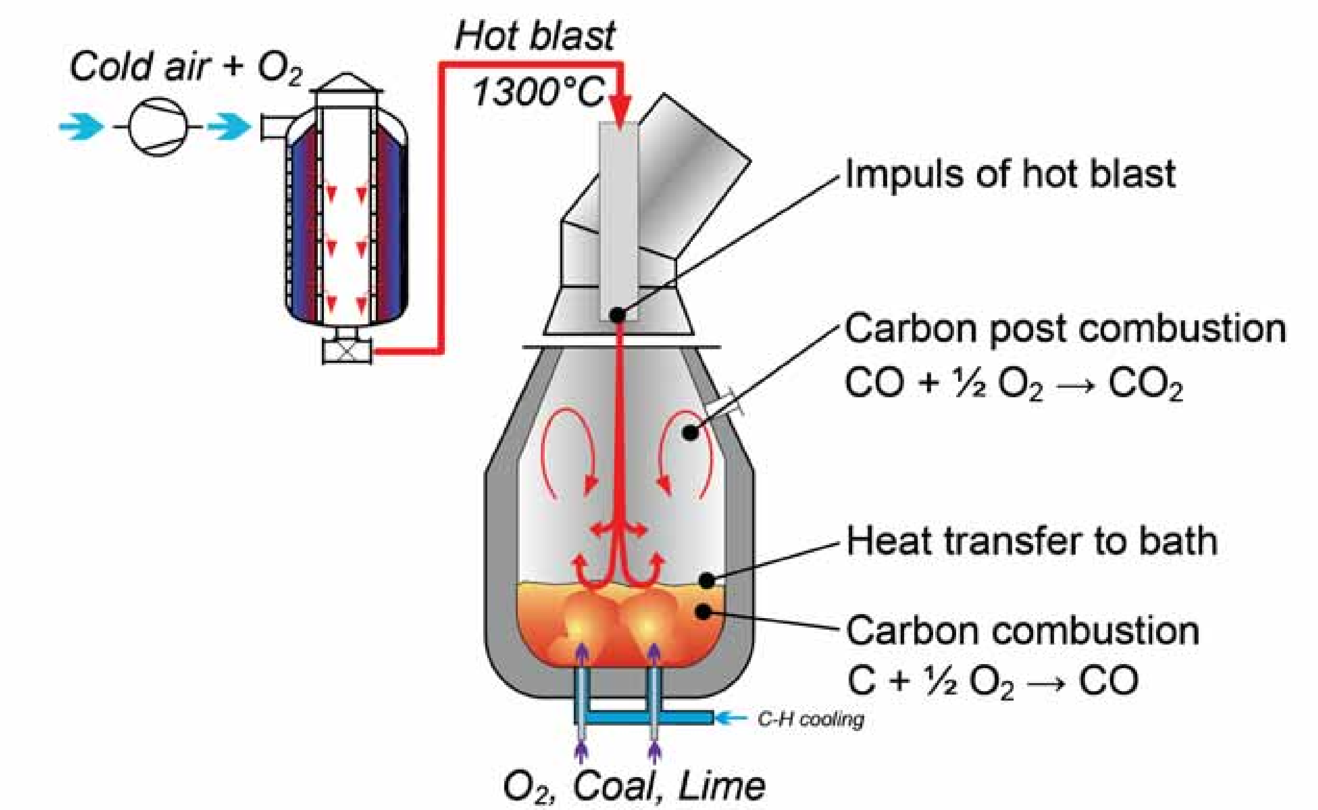


**Fig. 7: Jet Process consists of a bottom blowing converter and a hot blast lance, intensive mixing allows efficient use of the coal injected**

#### 4. Combined Blowing Converter and Jet Process

Stable processing of high scrap rate is achieved by changing from normal BOF operation to combined blowing converter. The oxygen blown from bottom via gas cooled tuyeres leads to intensive mixing of the bath. This ensures uniform melting of scrap and allows for softer blowing with the top lance which automatically results in a higher post combustion degree. In addition the tuyeres installed in the converter bottom can be used for scrap preheating. Such combined blowing converter is for example operated at AM Dofasco, Canada and an increase in post combustion and scrap rate is reported[3].

The Jet Process was developed for further increase of scrap rate by higher post combustion degree and addition of heating agents by injection of coal directly into the steel bath. The Jet process comprises a bottom blowing converter with coal and lime injection combined with a hot blast lance[4, 5]. The coal injected via the converter bottom as well as the coal already dissolved in the hot metal is again combusted in two steps; combustion to CO in the steel bath followed by post-combustion to $CO_2$ outside the bath. A simplified picture of this process is given in Figure 7.

In order to ensure high post combustion and HTE an efficient mixing is required. This is achieved by a hot blast blown with a lance from top onto the bath. The hot blast consists of air which is enriched with oxygen to about 30% and heated up in a pebble heater to 1300°C. The velocity of the hot blast at lance exit is slightly below to the velocity of sound which is around 700m/s at this temperature. Due to the high speed and the high volume of the hot blast, a jet with a very high penetration length is formed and a lot of surrounding media is sucked into the jet. This leads to an excellent mixing inside the converter, the CO coming from the bath is intensively mixed with the oxygen in the hot blast and combustion to $CO_2$ takes place. Due to the high mixing energy of the jet, droplets from the slag and the steel path are generated. Because of the high surface to volume ratio such droplets are heated up very easily and contribute tremendous to the heat transfer from the hot gas to the liquid bath. The intensive mixing with the hot blast ensures post combustion up to 60% and high heat transfer efficiency leading to an off gas temperature that is in average about 150°C above the steel bath temperature [1, 4]. The total efficiency of coal used in the Jet Process for melting of solid charges is above 50%. This is much higher than the efficiency

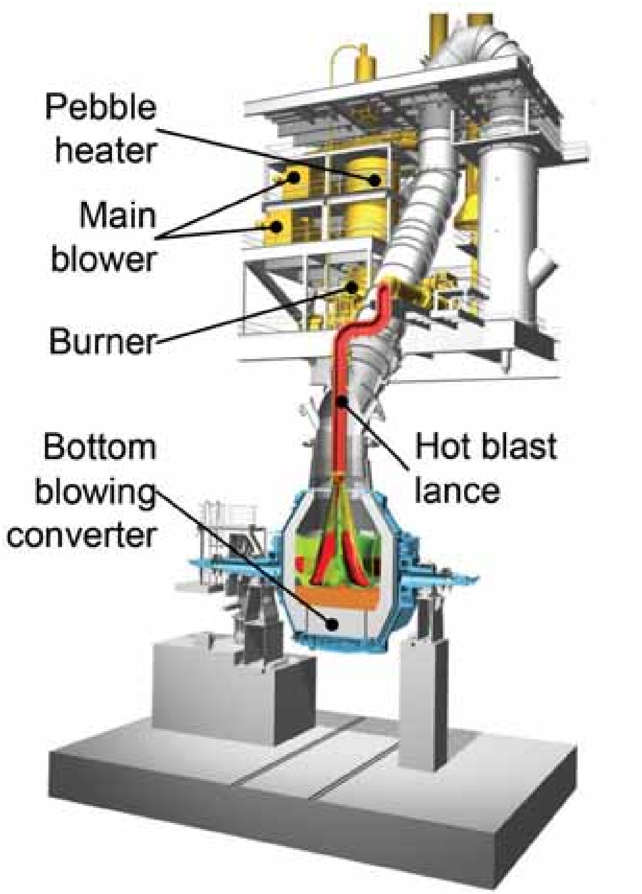


**Fig. 8: Jet Process: Main components of the hot blast system (cut through converter and lance)**

that can be achieved if coal is used for electric power generation and melting is done in an EAF due to the losses during electrical power generation and transfer.

In standard Jet Process operation the pebble heater is operated in a two-step procedure. In the first step, during converter tapping and charging of the next heat, the pebble heater is reheated with natural gas for about 20 minutes. The energy is stored in the pebble bed and used during the blowing period – the second step - to heat up the oxygen enriched air for another 20 minutes. Consequently, for one converter only one pebble heater is required.

In Figure 8 the hot blast system and its core component, the pebble heater, are shown. The pebble heater is a very efficient, regenerative heat exchanger that uses pebbles to store the energy. Due to the high surface of the pebbles they have very high storage power and are ideally suited for short term heat storage. This in combination with the high storage density of the pebbles leads to very compact design of the pebble heater.

Oxygen for decarburization of the hot metal (HM) is blown via tuyeres in the converter bottom. This tuyeres act like flame cutters and allow melting also large pieces of scrap fast and efficient. The bottom blowing leads to excellent mixing of the bath; hence all reactions are close to the equilibrium. This increases productivity and yield of the process, as less iron oxide is generated, tendency for slopping is low and total slag amount as well as iron content of the slag is low.

A full industrial reference for the Jet Process was implemented in POSCO, Pohang on a 100t converter, see [6, 7] for details. The principles of the process and performance have been proven in this reference as well as the design of the equipment. A wide range of scrap rates has been processed successfully, including heats with 50% of scrap. In the picture below a photograph of the converter bottom is shown highlighting the bottom blowing system installed. This system is capable for oxygen blowing as well as coal and lime injection.

**Fig. 9: Converter Bottom, Jet Process, 100t converter size, POSCO, Pohang.**

### 5. $CO_2$ Reduction

All measures shown allow for an increase of scrap rate processed in the BOF converter and consequently a reduction in hot metal processes. Replacing hot metal by scrap improves the $CO_2$ balance for the steel produced as less hot metal is required and therefore, less reduction work and emissions at the BF are generated.

Of course, some of the measure presented generate additional $CO_2$ emissions e.g. by the burning of natural gas for scrap preheating or coal injection for Jet Process. Total $CO_2$ emissions per ton of crude steel have been calculated for all options discussed and results are shown in Figure 10. Base for comparison is a standard BOF operation with a scrap rate of 16% and a non optimized process using some cooling materials, limestone, raw dolomite and others.

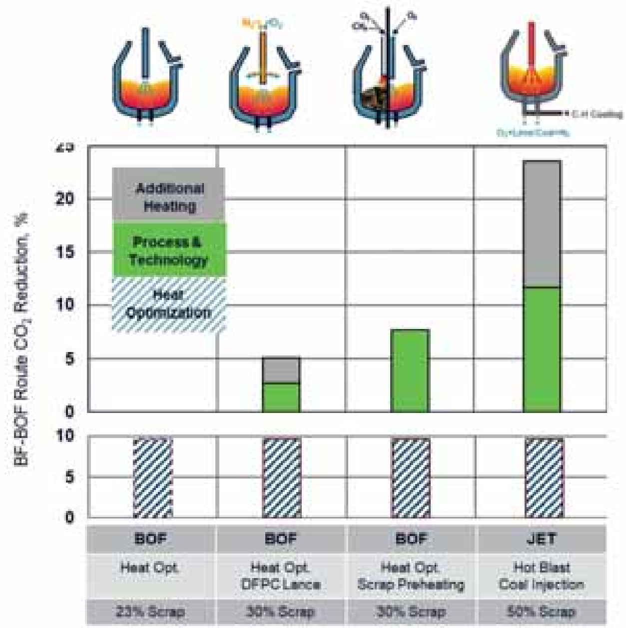


**Fig. 10: Reduction of $CO_2$ emissions for different packages compared to base case with 16% scrap and standard process.**

The results show that the higher the scrap rate, the higher are the savings in $CO_2$ emissions compared to the base case. Even moderate additions of coal in the converter for heat balance for the case of DFPC lance or Jet lead to savings in $CO_2$ emissions at the end. This is due to the fact that the savings on the BF caused by the lower hot metal ration are much higher than the additional $CO_2$ emissions on the converter caused by the coal addition.

## 6. CONCLUSION

The availability of scrap will increase significantly in the next decades worldwide, especially in Asia, and together with a moderate growth of total steel production the share of scrap used in converter steelmaking has to increase.

Several solutions for increase of scrap rate exist, ranging from rather simple packages for installation on existing converters like process optimization, scrap preheating or dual flow post combustion lance via revamping solutions that transform existing BOF converter into combined blowing converter or Jet process for highest scrap rates.

First industrial references for all these solutions exist and flexible solutions that allow processing of wide range of scrap rates can be generated. This allows fast savings in $CO_2$ emissions.

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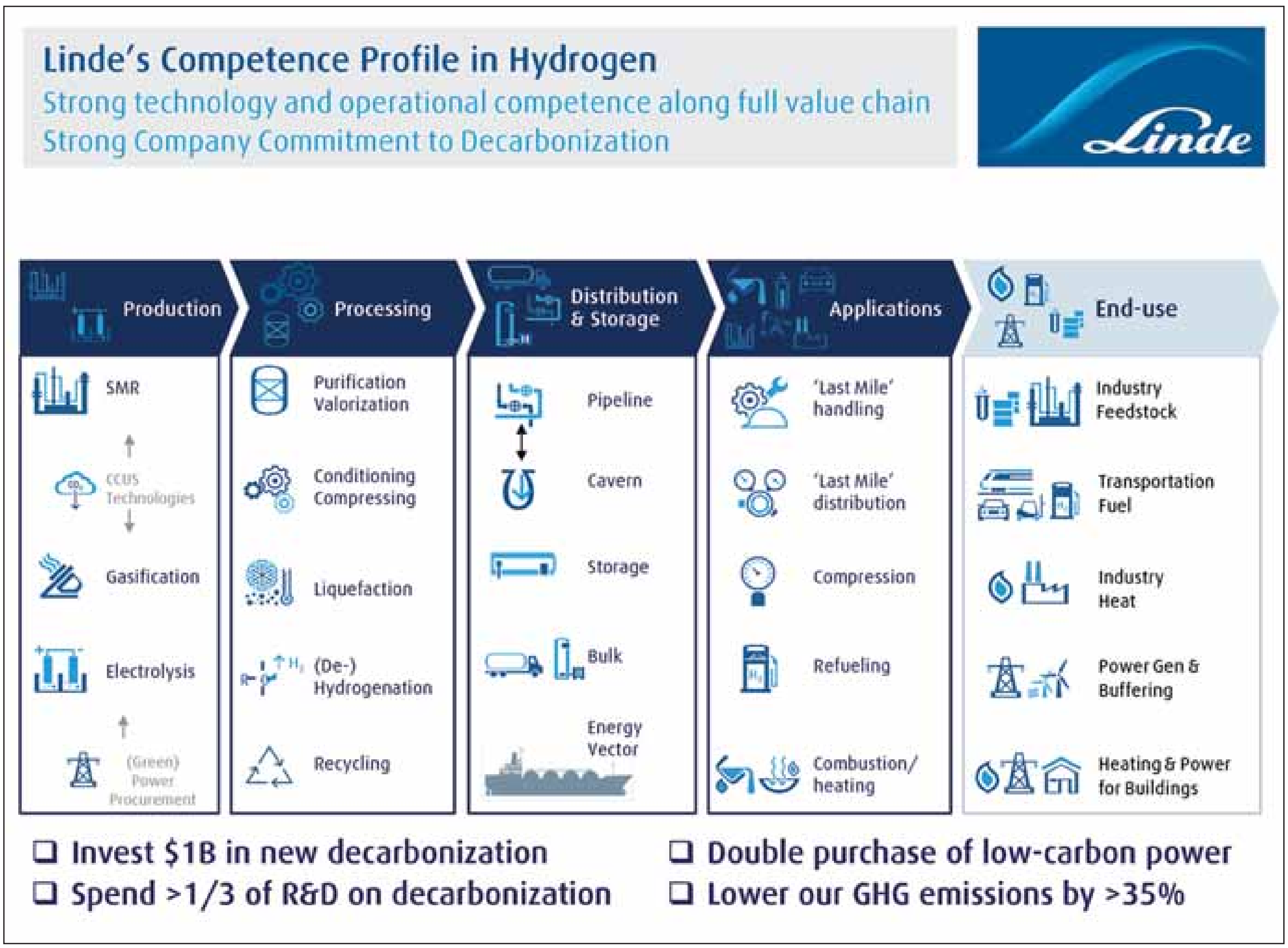
# Hydrogen Steelmaking Solutions for Melting, Reheating and Gasification

*Joachim von Scheele, William J. Mahoney and Ola Ritzen*
Linde, GERMANY



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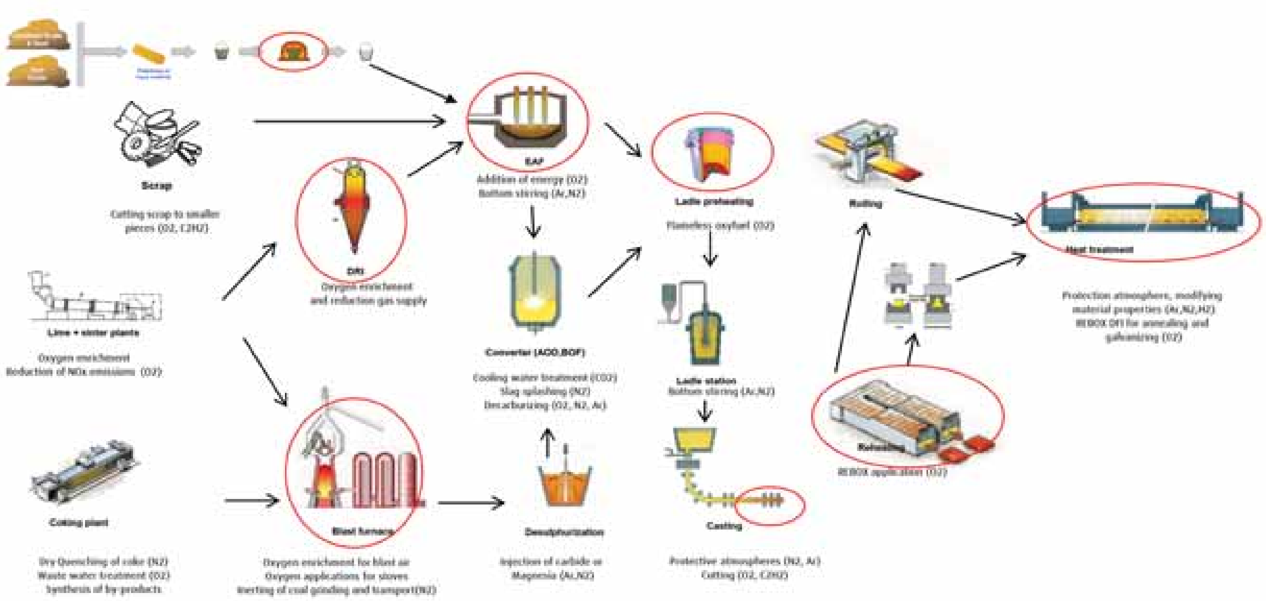

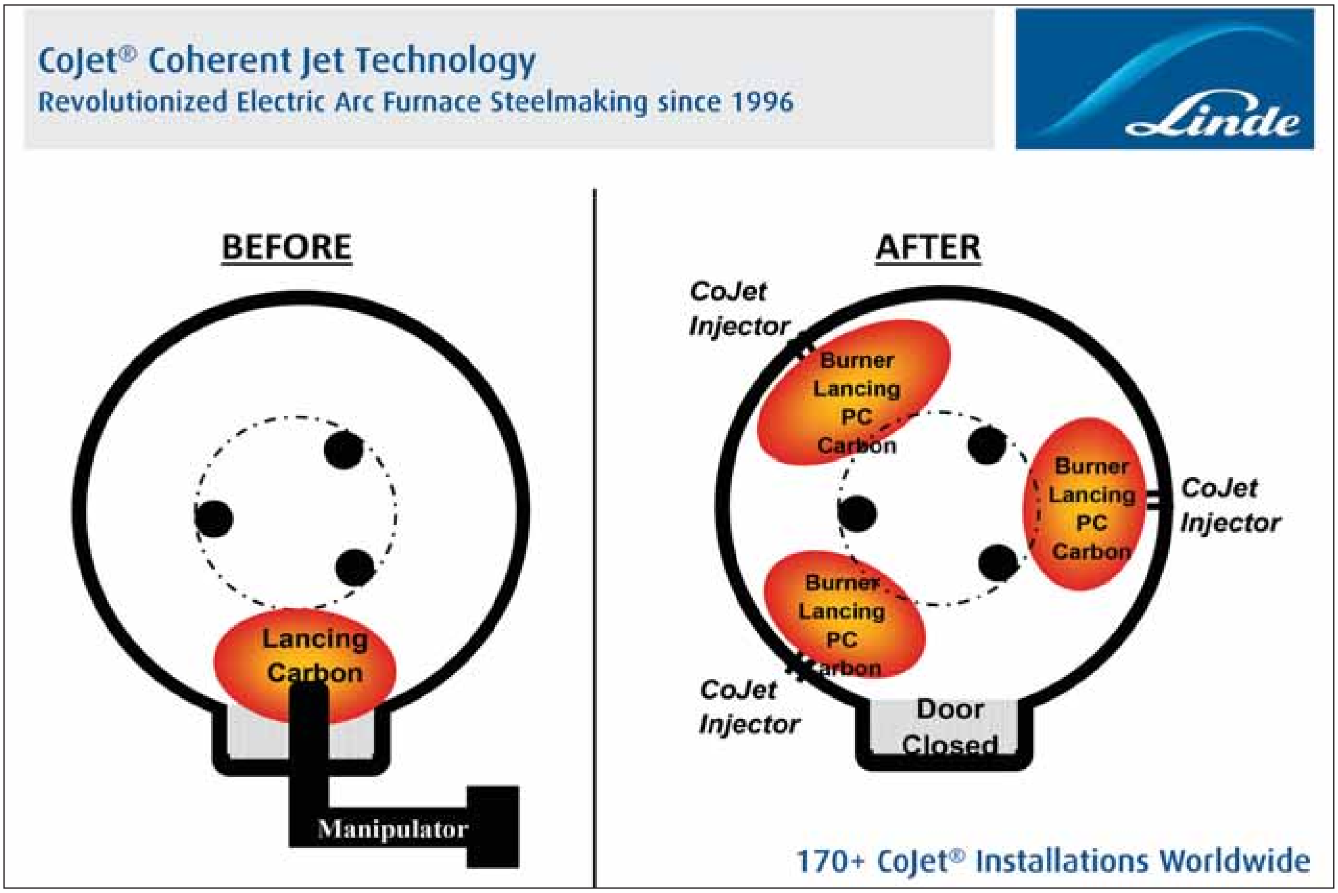
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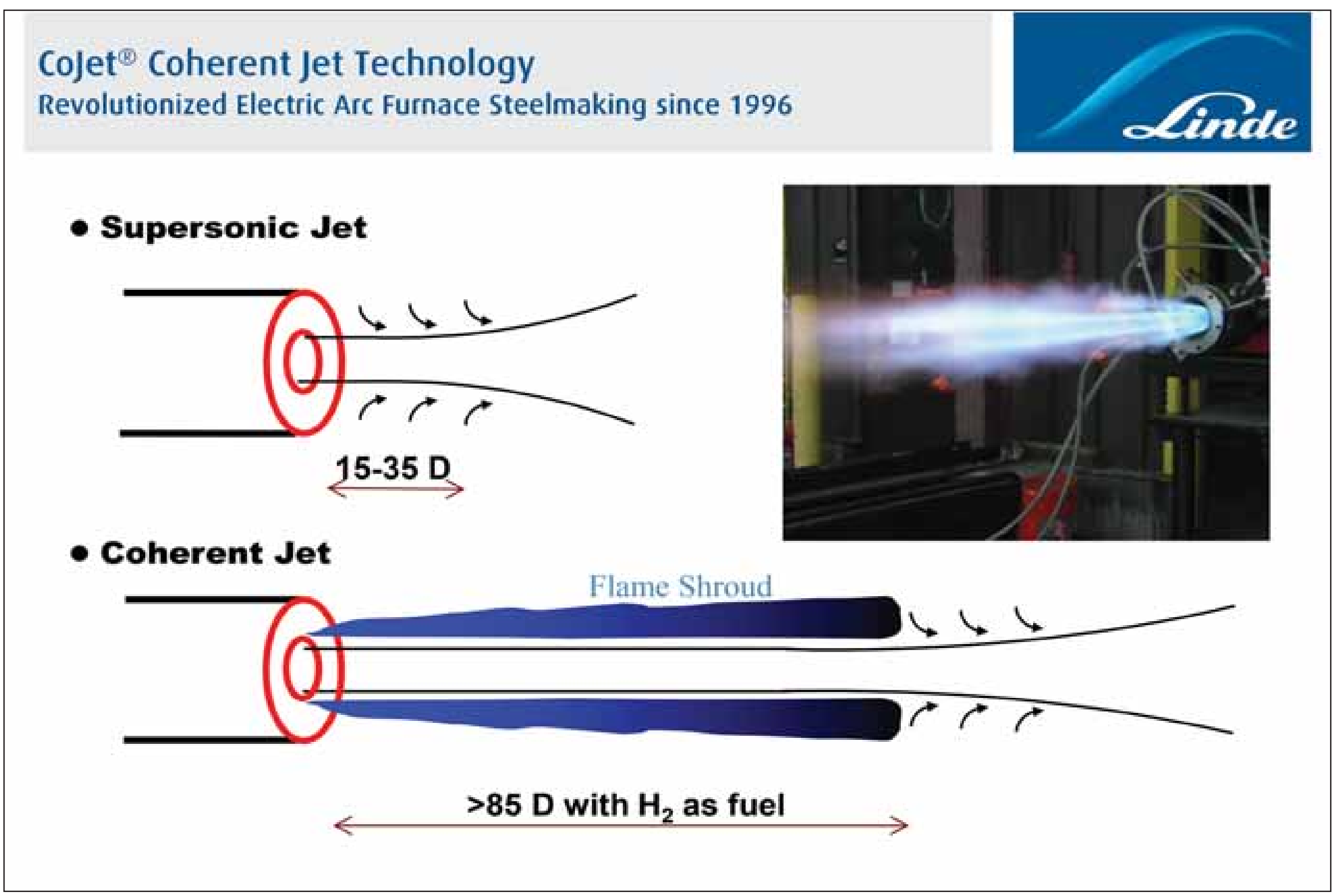
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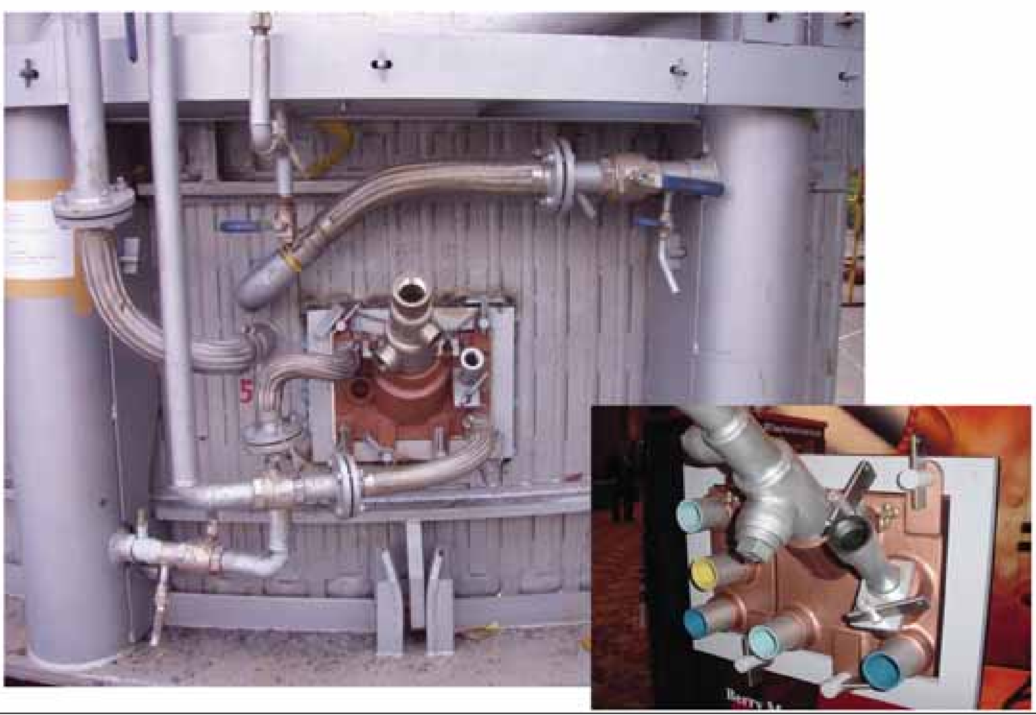

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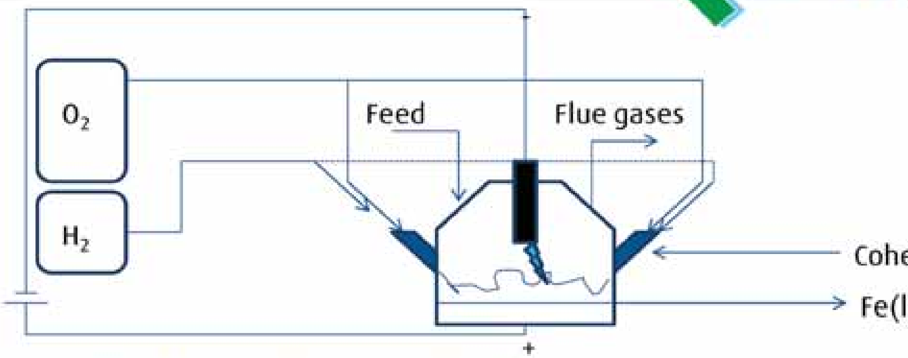


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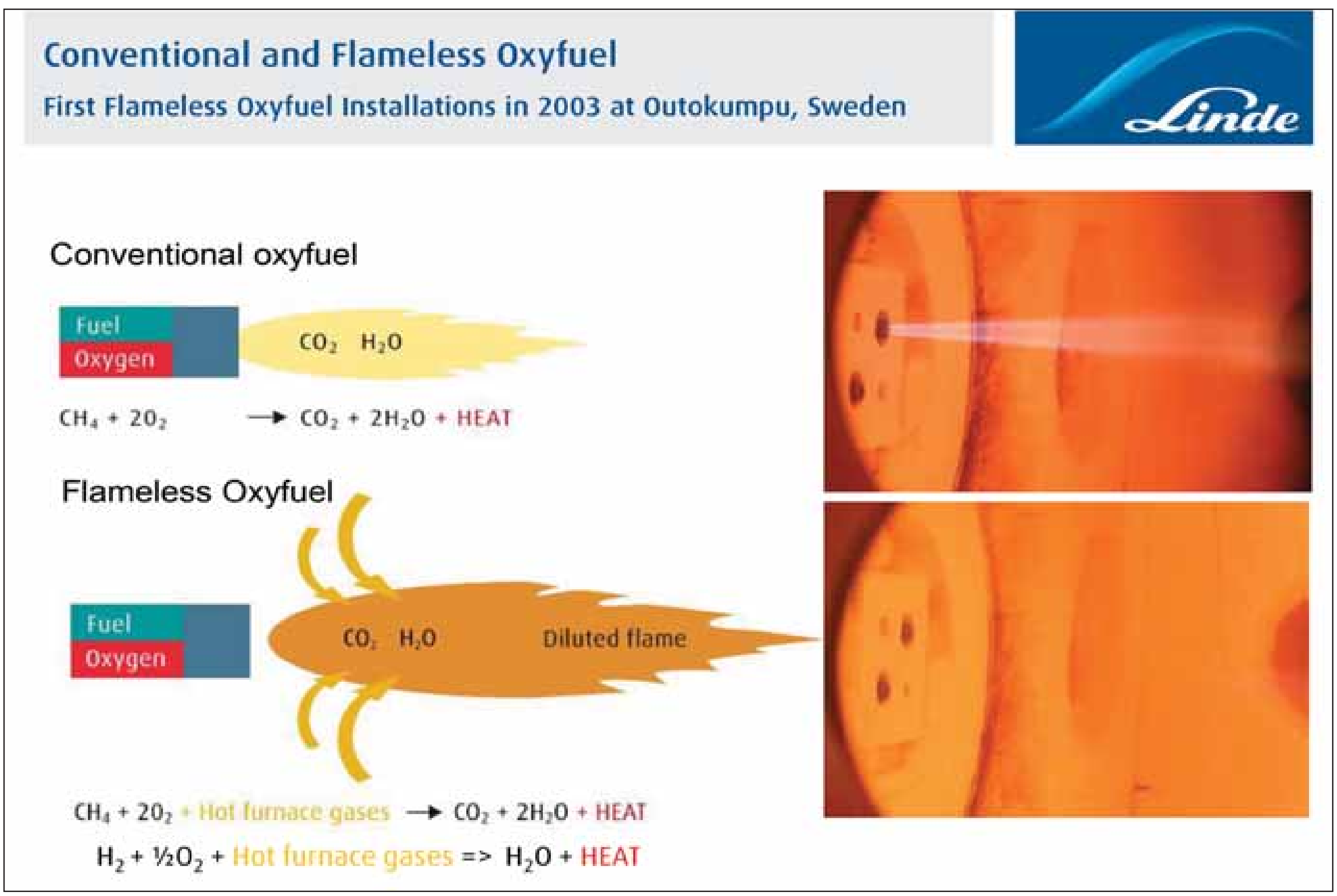
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Oxygen
CO2 H2O
Diluted flame
CH4 + 2O2 + Hot furnace gases → CO2 + 2H2O + HEAT
H2 + ½O2 + Hot furnace gases => H2O + HEAT


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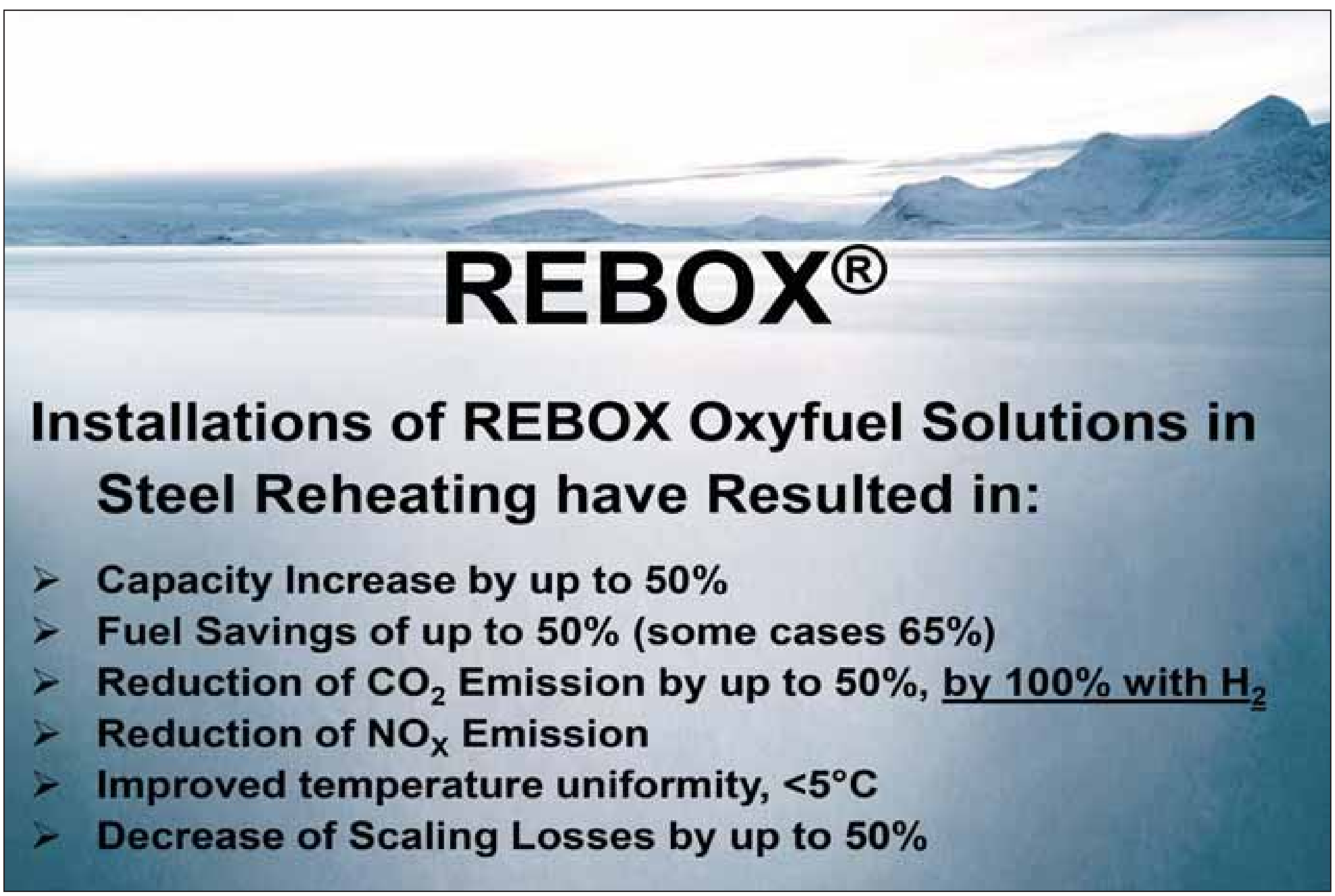
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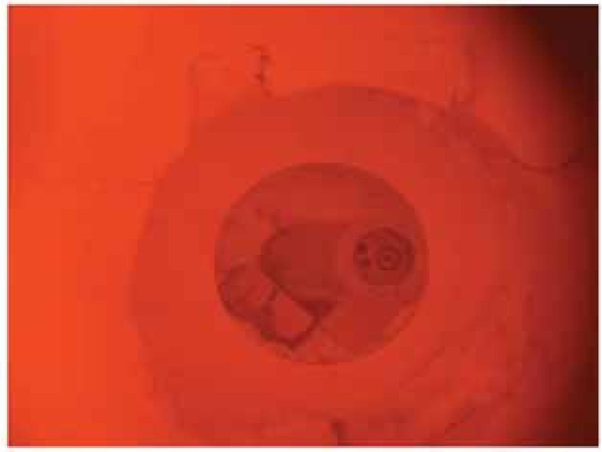
➢ Reduction of $NO_X$ Emission
➢ Improved temperature uniformity, <5°C
➢ Decrease of Scaling Losses by up to 50%

## Flameless Oxyfuel with Hydrogen as Fuel
## Burner Testing and Development to Secure Benefits

Natural Gas fired Flameless Oxyfuel at Rotary Hearth Furnace for Tube Production



Hydrogen fired Flameless Oxyfuel at a Linde Technology Centre

## Steel Reheating Tests with Hydrogen
### Linde Technology Centre Stockholm, October 2019

Steel samples from four different steel makers were heated with Flameless Oxyfuel using Hydrogen or LPG (as reference) in a box type furnace.

"Probably the First Fossil Free Steel Heating in the world"

99% $H_2O$ in furnace atmosphere

No quality issues with any of the steel grades

## 18th of March 2020: Ready for Full-Scale! Ready to Switch from LPG to Hydrogen!

Linde


OVAKO

## 18th of March 2020: Charging Time!

### Furnace running on 100% Flameless Oxyfuel with Hydrogen

Linde

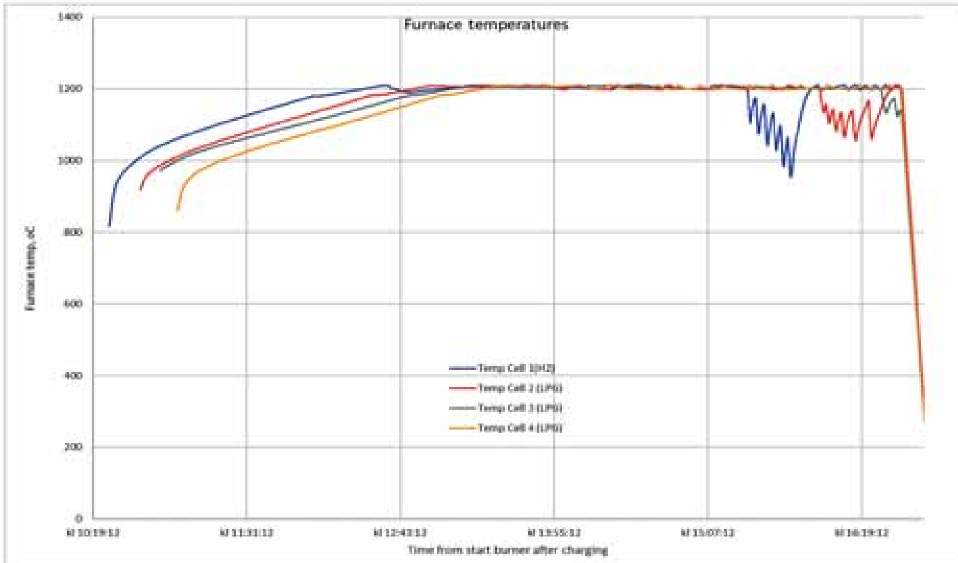
Four pit funaces, one with H2 and three with LPG. All same power, 650 kW.

Furnaces heated to 1200°C before charging

6 x 4.2 ton ingots per pit furnace, all same ball bearing steel grade

OVAKO

## 100% Flameless Oxyfuel with Hydrogen
### Comparison of Heating Curves




**Time from 1000->1200 oC**
**Cell 1: 106 min**
**Cell 2: 115 min**
**Cell 3: 128 min**
**Cell 4: 122 min**

**Heating followed by 3 hours soaking**

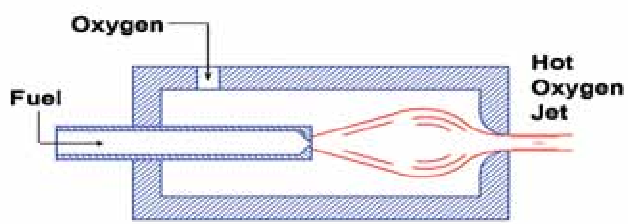
## Discharging and Rolling of First Fossile Free Heated Steel Ingot in the World

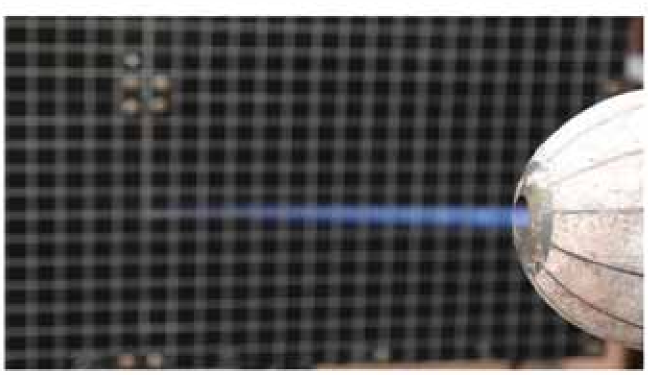
## Results of all quality tests shown OK and normal Hydrogen Can be Used in Full-scale Reheating!

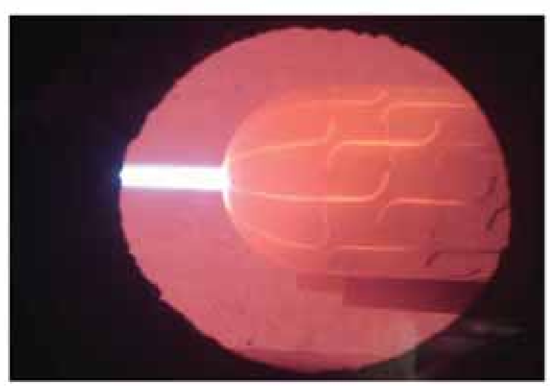

"Hydrogen can be used simply and flexibly, with no impact on steel quality, which would mean a very large reduction in the carbon footprint."
Göran Nyström, EVP, Head of Technology and Marketing at Ovako

## Linde's Hot Oxygen Technology (HOT) Small Scale Gasifier to Generate Low Carbon Fuel or Reducing Gas

- HOT utilizes small quantity of fuel to produce super-heated, high velocity oxygen stream at ~1650°C
- Rapid atomization and mixing of any material, even viscous, sticky materials
- Highly reactive oxygen stream
- Compact and robust burner and reactor – Hot Oxygen generated at point of use





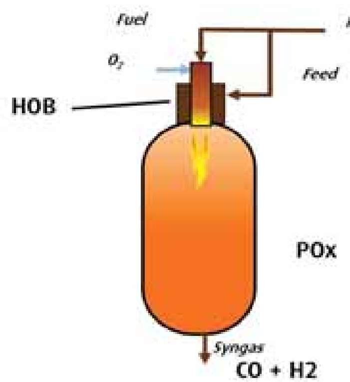
## Partial Oxidation with Hot Oxygen Technology
## Any Feedstock (Solid, Liquid, Gaseous)

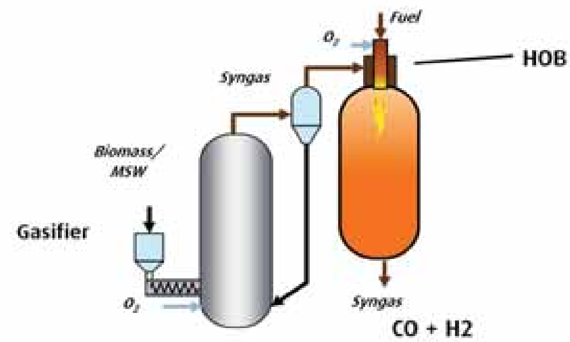
**Primary Syngas Generation**

- Feedstock: NG, COG or hydrocarbon gases
- HOT function: Partial oxidation for Syngas/CO supply
- Scale per unit: Up to 34,000 Nm³/h syngas from NG

**Secondary Reforming**

- Feedstock: Biomass, Municipal Solid Waste, other waste
- HOT function: Reforms tar and other hydrocarbons and yield increase
- Scale per unit: Up to 42,000 Nm3/h reformed syngas




## Summary

- Hydrogen can be used in Electric Arc Furnaces combined with Linde's CoJet technology. Produces longer jets than any other fuel. Mixed with or replacing other fuels.
- It has been demonstrated in full-scale production that reheating furnaces can be operated with Hydrogen as fuel without any negative impact on the steel heated.
- Flameless Oxyfuel works well with Hydrogen as fuel, still maintaining all its benefits including reduction of NOx at Ladle Preheating, Steel Reheating.
- Linde's Oxyfuel solutions are prepared for replacing existing fuels partly or fully with Hydrogen
- Use of Oxyfuel combustion decreases the Hydrogen need – a transitional step towards carbon free production
- Three out of four of Linde's Technology Centres for combustion globally are already equipped for Oxygen–Hydrogen firing.
- Hot Oxygen Technology can be used for production of Syngas from, e.g., biomass or Coke Oven Gas. HOT removes tar!
- Development and implementation of combustion technologies for use of Hydrogen as Fuel in Industrial Furnaces pace ahead of the Hydrogen availability/supply.

# Decarbonisation Route for Iron & Steelmaking

*Liberty Steel*

The steel industry faces a three way dilemma of rising demand, high emissions (9% of global total from fossil fuels) and increasing regulatory pressure to decarbonise. At the same time our customers are demanding more sustainably produced materials for cars, buildings and packaging. We believe to meet these challenges, and to be competitive in the future, we must embrace low carbon technologies and reinvent the way steel is produced as quickly as possible.

LIBERTY Steel Group has pledged to become carbon neutral by 2030 through our GREENSTEEL strategy that involves greater use of steel recycling, development and application of low carbon and renewable energy to power processes, and eventually application of breakthrough technologies such as hydrogen steel making. Our strategy is underpinned by the belief that carbon prices will rise significantly and renewable power generation will become increasingly competitive enabling lower emissions and competitive production of green hydrogen within ten years.

LIBERTY Steel Group has GREENSTEEL transformation plans at each of our integrated steelworks which account for approximately 90% of our direct emissions currently. At our integrated steelworks in Whyalla, Australia and Galtati, Romania, we have published plans to install Direct Reduced Iron facilities initially fed by gas before transitioning to hydrogen. In Ostrava, Czech Republic, we have launched a tender to replace the tandem furnaces with hybrid furnaces which can vary the mix of liquid metal and steel scrap in the steel making process. Each of these transformation plans provide a pathway to carbon neutrality by 2030 and will be financed through a mix of funding sources.

Around 35% of LIBERTY's production is already from electric arc furnaces in Australia, US, UK and now also in France, which generate significantly less emissions than conventional coal based production. Where there is an abundance of scrap our strategy is to maximise recycling and combine those processes with low carbon or renewable energy to bring emissions down to almost zero.

In addition to these plans, LIBERTY Steel group has continuous improvement programmes at each of our major plants to reduce energy consumption and remove waste. Through its membership of GFG Alliance, LIBERTY also benefits from renewable power developments under its sister company SIMEC Energy, and through offsetting programmes such as the restoration of peat land and new tree planting across JAHAMA Highland Estates in Scotland.

To help speed up the journey to carbon neutrality in the steel sector LIBERTY Steel Group see the need for further consolidation in the European steel sector to build the scale to drive change. Greater collaboration to share technology development costs, and crucially a supportive policy framework that encourages investment in low carbon technologies and protects the industry's competitiveness. We continue to push for a fair global carbon pricing system as well as the introduction of carbon border tax mechanisms to incentivise regions to implement carbon pricing where they have yet to do so. This will enable European producers to make the major investments needed to transform their businesses without operating at a huge commercial disadvantage to higher carbon producers.

# Recycling of Waste Plastics in Coke Making

*A.S. Chaitanya, Prashanth B, Vikas U, G Ravikanth and Mrunmaya K P*

JSW Steel Ltd., Vijayanagar Works, Bellary, Karnataka, INDIA

**Abstract**

Effective disposal of waste plastic is an area being seriously explored as a part of environmental initiatives. An attempt is made to assess the impact of waste plastics in coal blend on the coke properties at pilot scale studies. The present study explores addition of up waste plastic inthe coal blend. Experimental trials were conducted in a 120kg pilot scale coke oven. The coal maximum fluidity at 1% plastic addition was found to be in line to the base composition. Results show that up to 1% plastics can be effectively recycled in the coal blend without any detrimental effect on coke quality. Addition of higher percentages of plastics resulted in deterioration in coke properties and coke yield. However, the Coke Strength after Reaction (CSR) and Coke Reactivity Index (CRI) deteriorates with increase in plastic addition above 1%. The waste plastic utilisation at coke ovens aims at a cleaner and greener environment around us. Addition of waste plastics to coal blend in coke making can be attributed as one of the effective way for waste plastic recycling.

**Keywords:** Waste plastics, CSR, CRI, Coal, Coke, Fluidity.

## INTRODUCTION

Metallurgical coal is used for producing coke, which is used as a reducing agent for iron oxide reduction in blast furnace. Utilisation of plastic waste in the industrial sector is required to take initiatives. Coal carbonization with other carbon sources like biomass, wood, polyethylene and paper is gaining significance. As disposal of plastics is a serious global problem, various routes for recycling waste plastics need to beinvestigated. Coke making found to be effective and cost intensive route for disposal of plastics.

Tata steel used 0.003 - 0.008% of waste plastics in the coal blend at plant scale for six months in two stamp charged batteries nos. 8 and 9[1]. Based on their lab scale studies, they have concluded that maximum 0.5% plastic addition is safe to use without affecting the coke properties. Utilization of recycled plastics in coking processes was introduced at Nippon Steel, Japan in 2006, focused on utilization of waste plastics for decreasing energy consumption with the aim of obtaining 10% energy reduction[2,3]. Kenji Kato etal establishedupto 1% plastic addition to coal blend and found no deterioration of coke properties and resulted in 1.5% energy consumption[4]. Kenji Kato et.al studied the effect of chlorine containing plastics during coal carbonization[5]. Chlorine is converted into ammonia liquor by thermal decomposition treatment.

Veena et.al Investigated alternate dissolution of carbon from coke/HDPE blends and compared to that from metallurgical coke alone[6]. The blend of coke and plastics resulted in the difference in physical and chemical properties, because of the individual characteristics of each polymeric material[7]. Sidorov et.alstudied the laboratory carbonization of coal blend with plastics at 850°C in order to determine the benzo-pyrene emissions[8]. In carbonization, the exhaust gases from all the polymers contain benzo-pyrene in levels far exceeding workplace air standards.

In JSW R&D, we have added waste plastic granules, together with the coal blend, charged into a 120 kg pilot coke oven, in which they are carbonized in an oxygen-free reducing atmosphere at about 1100°C. As a result, the waste plastic and coal blend is thermally decomposed into coke and coke oven gas. These products obtained by the carbonization of waste plastic have their own uses.

## EXPERIMENTAL

Waste plastics experiments were conducted in 120kg pilot coke oven (Fig. 1) in R&D unit, Vijayanagar Works, Karnataka with different percentages of plastics (0 to 2%). Specification of pilot coke oven given in Table 1. Initially 120kg of coal blend is taken with no plastics added to it, it was considered as base blend experiment. Plastic granules taken were of size 1-3mm in size. Typical properties of plastics were shown in Table 2.

**Table1: Specification of pilot coke oven**

| Parameter | Equipment details |
|---|---|
| Capacity | 120 Kg |
| Heating | Electrical heating |
| Wall | Refractory brick |
| Temperature | 1100°C |
| Coking Time | 20 hr |

**Table 2: Properties of waste plastics**

| Parameter | Value |
|---|---|
| Volatile Matter, % | 99.53 |
| Ash, % | 0.45 |
| Fixed Carbon, % | 0.02 |
| Total Carbon, % | 85.06 |
| Sulphur, % | 0.12 |
| Hydrogen, % | 13.68 |
| Nitrogen, % | 0.69 |
| GCV, KCal/kg | 11,019 |

The coal blend used in the study were blend of prime coking coals, medium coking coals and inerts. Coal carbonization during the process the coal particles undergo a succession of changes as the heat is transferred from the oven walls to the coal mass via conduction process.

The following phase changes occur during carbonization process:

a) Upto 200$^0$C : the moisture removal from the coal

b) 375- 475$^0$C: Coal decomposes to form plastic layers near the wall

c) 475-600$^0$C: evolution of tar and aromatic hydrocarbon compounds, followed by resolidification of the plastic mass into semi coke.

d) 600-1100$^0$C : coke stabilization phase begins. This is characterized by contraction of coke mass, structural development of coke and final hydrogen evolution.

To analyse the coke properties, two important parameters are analysed such as Coke strength after reaction (CSR), Coke reactivity Index (CRI).

Table 3 shows the coal blend composition for the pilot coke oven trials. A total of nine experiments were planned. Three prime coking coals, two medium coking and two kinds of inerts were used for this study. Proper mixing of coal and inert particles is always a challenge.Coal is a complex material with a structure

**Fig.1: Pilot coke oven in R&D unit, Vijayanagar Works, Karnataka**

**Table 3: Coal blend composition**

| | Coal Name | Exp.1 | Exp.2 | Exp.3 | Exp.4 | Exp.5 | Exp.6 | Exp.7 | Exp.8 | Exp.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Prime Coking coals | A | 25.00 | 24.88 | 24.85 | 24.83 | 24.80 | 24.78 | 24.75 | 24.63 | 24.50 |
| | B | 11.00 | 10.95 | 10.93 | 10.92 | 10.91 | 10.90 | 10.89 | 10.84 | 10.78 |
| | C | 15.00 | 14.93 | 14.91 | 14.90 | 14.88 | 14.87 | 14.85 | 14.78 | 14.70 |
| Medium coking coal | D | 16.00 | 15.92 | 15.90 | 15.89 | 15.87 | 15.86 | 15.84 | 15.76 | 15.68 |
| | E | 17.00 | 16.92 | 16.90 | 16.88 | 16.86 | 16.85 | 16.83 | 16.75 | 16.66 |
| Inerts | F | 11.00 | 10.95 | 10.93 | 10.92 | 10.91 | 10.90 | 10.89 | 10.84 | 10.78 |
| | G | 5.00 | 4.98 | 4.97 | 4.97 | 4.96 | 4.96 | 4.95 | 4.93 | 4.90 |
| Plastics (kg) | | 0.00 | 0.50 | 0.60 | 0.70 | 0.80 | 0.90 | 1.00 | 1.50 | 2.00 |

**Table 4: Coal blend properties**

| | % of Waste Plastics addition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **0.0** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** | **1.0** | **1.5** | **2.0** |
| Moisture (%) | 9.87 | 9.78 | 9.93 | 9.78 | 9.85 | 9.85 | 9.88 | 9.88 | 9.92 |
| Sulphur (%) | 0.53 | 0.61 | 0.53 | 0.52 | 0.52 | 0.52 | 0.53 | 0.54 | 0.54 |
| Ash, dry basis (%) | 8.19 | 9.08 | 8.08 | 8.07 | 8.05 | 8.05 | 8.04 | 8.14 | 8.16 |
| V.M., dry basis (%) | 27.02 | 27.47 | 27.56 | 27.64 | 27.72 | 27.76 | 27.84 | 28.28 | 28.65 |
| Fluidity (ddpm) | 413 | 421 | 418 | 398 | 410 | 410 | 406 | 400 | 405 |

that consists of different maceral groups (carbon forms), minerals and variable porous structure. Further, it often displays significant heterogeneity in any metrics used for characterization. Table 4 shows the coal blend properties and cake moisture.

Bulk density was maintained in the range of 1.05 t/m³. Coal cake moisture is targeted in the range of 10%. With increase in plastics addition in the blend, blend volatile matter content increases from 27.02 % to 28.65% in 2% waste plastic addition in the combination. Coal Sulphur is within the range for all the cases. Coal ash is also in the acceptable range. The blend fluidity varies between 398-421 ddpm. This shows that the waste plastic addition does not hamper coal rheological property.

## RESULTS & DISCUSSION

Plastics unlike coal is a synthetic material made from natural materials such as cellulose, coal, natural gas, salt and crude oil through a polymerization/ poly condensation process. Plastics are processed from polymers. Polymers are long chain hydrocarbons. Polymer chains are made by of mostly Carbon-Hydrogen bonds. At high temperatures, they break their bonds to form simple monomers. Monomers are mostly Ethylene ($C_2H_4$) and Propylene ($C_3H_6$) gases.

These gases escape from the furnace on heating at temperature above 200°C creating void in the coal blend. So, adding more plastics to coal blend will lead to loss in final yield as all plastics decomposes to ethylene and propylene gases at 200°C, eventually leads to drop in coke yield.

Table 5 indicates typical coke properties after carbonization (CSR & CRI).

**Table 5: Properties of Coke Produced**

| | % of Waste Plastics addition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **0.0** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** | **1.0** | **1.5** | **2.0** |
| Moisture (%) | 0.47 | 0.51 | 0.49 | 0.52 | 0.52 | 0.52 | 0.53 | 0.51 | 0.54 |
| Sulphur (%) | 0.45 | 0.46 | 0.45 | 0.46 | 0.46 | 0.46 | 0.47 | 0.46 | 0.45 |
| Ash, dry basis (%) | 11.3 | 11.4 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.6 | 11.8 |
| V.M., dry basis (%) | 0.96 | 1.01 | 1.03 | 1.05 | 1.02 | 1.05 | 1.09 | 0.91 | 0.91 |
| CSR (%) | 67.06 | 66.80 | 66.84 | 66.80 | 66.78 | 66.75 | 66.73 | 66.0 | 65.5 |
| CRI (%) | 22.65 | 22.80 | 22.75 | 23 | 23.25 | 23.28 | 23.43 | 25.9 | 26.5 |
| Yield (%) | 72.2 | 71.5 | 71.4 | 71.3 | 71.2 | 71.2 | 71.1 | 69.9 | 68.7 |

**Effect of plastic addition on Coke yield**

As waste plastic addition percentage is increased in the coal blend, there is a significant loss in yield of final coke. With the addition of higher amount of plastics, there is significant drop in yield of final coke (from 72.2% to 68.7%). Higher plastic addition (1.5 & 2.0%) leads to higher volatile matter content in coal blend (up to 28.65%). This presence of morevolatile matter and less fixed carbon generates more coke oven gas, which drastically reduced the final coke yield. Hence, can be concluded that at higher plastics addition in coal blend,excess blend V.M. reduces the final yield contributing to more gas generation. Upto 1.0% plastic addition, no significant changes in the coke yieldwas observed.

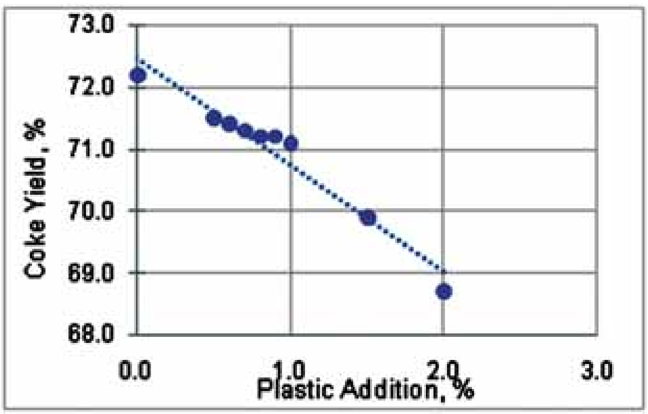



**Fig. 2: Relation between plastic addition & coke yield percentage**

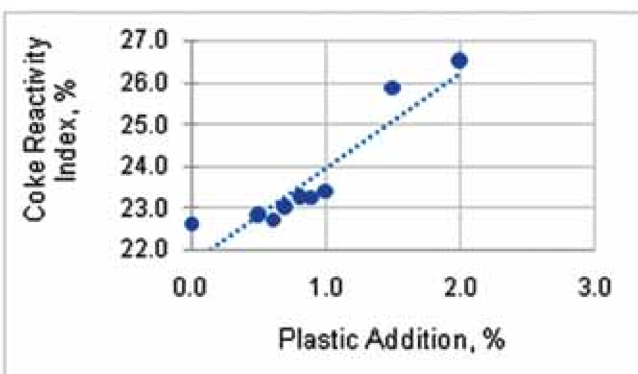



**Fig. 3: Relation between plastic addition & coke reactivity index**

**Effect of plastic addition on Coke Reactivity**

Coke reactivity is an important parameter to be measured for the quality of coke. It is defined as the reaction rate of coke with an oxidizing agent such as carbon dioxide (CO2). Coke reactivity affects the strength and size of the coke particle. Coke reactivity is used to measure the overall chemical kinetics of heterogeneous coke reactions($C+CO_2=2CO$), takes the form normalized rate of mass loss. Coke Reactivity Index (CRI) is the percentage weight loss during gasification. CRI is increasing with increase in plastic percentage as shown in Fig.3. Similarly, average CRI was found to be 23.02 %. At 1.5 & 2.0% plastic addition, CRI found to be 25.9% & 26.5% respectively. From the experiments, it was seen that CRI was increasing with increasing plastic percentage. Standard Blast furnace coke corresponds to CRI of less than or equal to 24.0%.

**Effect of plastic addition on Coke Strength after Reaction**

Coke Strength after Reaction (CSR) is measured on the residue coke after CRI test (reaction with $CO_2$) in a tumbler rotating at 20 rev/min.At 1.5 & 2.0% plastics addition, CSR found to be 66% & 65.5%. Fig.4 indicates that CSR value was decreasing with increasing plastic percentage. Average CSR is found to be 66.82% as shown in Fig.4. Coke with higher CSR breaks down more slowly than low CSR coke and thus in a blast furnace, the permeability of gas and liquid is better and the productivity is increased and the specific coke consumption of the blast furnace is decreased. StandardBlast furnace coke corresponds to CSR>= 66.5%.

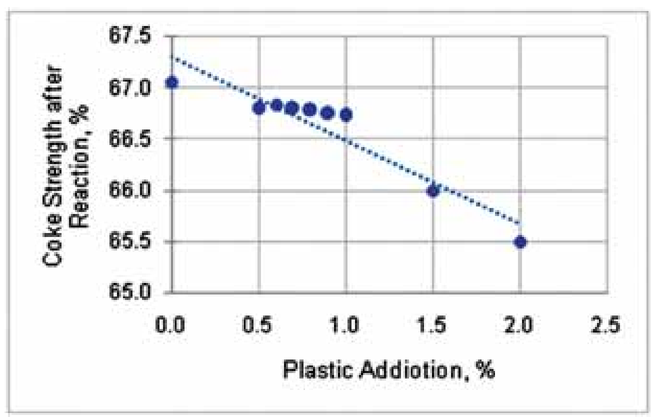



**Fig.4: Relation between plastic addition & coke strength after reaction**

**CONCLUSION**

- Disposal of plastic waste is global problem. Use of waste plastic in coke making is a promising way of recycling.
- It was found that any form of plastic waste can be

mixed to coal blend. In the present work, we have taken combination of mixed plastics.

- Based on the pilot coke oven study,it can be concluded that 1.0% waste plastic addition in coal blend is safe to use without any significant change in CSR & CRI values.

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# A Science-Fiction Route to Green Steel

* A. K. Das

### Foreword

Albert Einstein once said – “Imagination is more important than knowledge”. This has never been so relevant as it is now. With technology changing faster than the society can digest, with processed information and scholarly views literally available at fingertips, this is a different world. A world where power of imagination is out performing knowledge as organisational or individual asset.

This is not a technical article in the conventional sense but an extrapolation of technical ideas into future. The objective is to stimulate imagination among students, young professionals and may be captains of industry.

### A Brief Background

The change process started about forty or fifty years ago at a gentle pace but now in 2065 the engineering education would look nearly unrecognizable to old-timers. There is one common Engineering course called BEM meaning Basic Engineering and Mathematics. Having completed this three-year curriculum, students get a choice to visit industries they wish to get a feel of. Then they have options for hundreds of specialisations such as “Humanoid Engineering”, “Non-invasive Diagnosis and Cure Implement Engineering”, “Weather Intervention Engineering”, “Ocean Floor Engineering” and so many. The age-old Civil Engineering however still exists but with a suffix ET, meaning Extra-Terrestrial. They are into designing and making Space-Stations or Lunar Buildings. Earlier students had to get certificate from a particular Institute but now-a-days they are free to take courses from whichever Global Institute they want.

In spite of so much transformation, the Anthropologists sound quite stubborn. They still say that after the Old-stone age, New-stone age and Bronze Age, the Iron Age still continues. Advent of Iron Age was around 1500 BCE and if at all the name may be modified to Steel Age. The Anthropologists use the “Technology Minus” model as a proof. This a highly complex gigantic computer model which can simulate the absence of any particular technology or industry. The output is a number signifying the drop in Quality of Life of Humanity as a result. The sharpest drop is seen if Steel Technology suddenly ceases to exist. The effect is many times severe than digital imaging or communication technologies.

Maybe driven by this curiosity a group of students opted to visit Steel Industry or maybe they know this is one industry that has responded to the Climate Change challenge very aptly. So much so that steel today is greener than most materials.

The tour was from Ore Mines to the Steel Plant. Their day started as they alighted from a vertical landing-take-off aircraft on a flat hill top.

### The Ore Mining and Preparation Complex

The place appeared hilly in the midst of a dense forest area. Except for a few geometrical shaped structures no factory like construction could be seen. The place looked more like a National Park than a typical Industrial Complex. The tour coordinator welcomed the group and the visit started. They heard a feeble thud and the coordinator said that blasting was going on in the North Eastern bench –“you can see the cracks and fissures on the rock face. However we are having a problem with our blasting method, owing to too much noise.” The group looked surprised. There was hardly any explosion like sound. He explained – “Noise is in the subsonic range, we humans cannot hear it but the elephants can. There are evidences that elephant herds get scared and they might even change there migration corridor. The Apex Court has given us two years time to rectify – we are working with two Universities on subsonic shielding technology."

The ore mass, mostly in the form of huge boulders were being dug out and brought to the EMWT. They could see a large, maybe 3 m wide tunnel like equipment. EMWT meant Emolliating Micro Wave Tunnel. In the past centuries the manual rock breaking industry, in fact, used a similar principle. They used to lit fire around large hard rocks overnight. Then they put water on them to induce thermal cracks which made their job easier. In EMWT, thermal stress got generated in the rockbody by beaming high energy microwave resulting in internal cracks.

The power consumption must be very high – someone commented. –"No, it is not.They use short pulses and not continuous power." Said the coordinator.[1,2]

The technology seemed excellent as they saw large rocks breaking almost silently like fragile biscuits in the Jaw Crushers.

The second tunnel after Jaw Crusher was LAMWT – Liberation Aiding MicroWave Tunnel, a precisely controlled Microwave equipment. The power and pulses were controlled to generate cracks at the interface of mineral body and gangue materials. –"Liberation characteristics are much better with this. However being of natural origin, the ore bodies are very inhomogeneous and change from a rock to the other. There is a "Dielectric Laboratory" on that hill top which studies the samples and advises the microwave recipe with regard to pulse and power. Frequency is usually not touched – anyway not so much scope either because frequency bands have to be within the Government Regulated Width." Explained the coordinator.

They had a short visit to the Lab on hill top. It looked very sophisticated – equipment were mostly for electrical measurements unlike old mineral assessment facilities.

The output from LAMWT were fed to a crusher to reduce the size to less than 2mm and then conveyed into FBMT – Fluidised Bed Magnetisation Tower. It used flue gas from a captive Natural Gas fired power station for fluidisation. The coordinator explained – "Hematite to magnetite transformation can take place at very low concentrations of reducing gas like carbon monoxide or hydrogen. A temperature of 250 or 300 C is good enough. Being magnetic a LIMS, Low Intensity Magnetic Separator which is an age-old process, nicely separates out gangue from mineral[3,4,5,6]".

The whole process was dry but there was no dust emission seen because of the 'Electroseeding Technology' meaning injection of electrically charged particles which attracted gangue particles and developed 2 or 3 mm agglomerates with a typical half-life of one hour. A spray of polymer solution stabilised the agglomerates. They saw sand like particles on a conveyor.

Anticipating the obvious question the coordinator explained – "These are used as sand with or without cement. Our Landscape Engineer uses such materials for doing up the barren mine faces."The team felt that the landscape engineer was doing a good job, the place never looked like having rock blasting and mineral processing activities.

**Transportation of Ore**

The last rail or truck transport took place some twenty years back.They were told that every gramme of ore was transported through Maglev Pipeline. Principle-wise these pipelines were same as the Maglev trains that first came up some fifty years ago in Japan and China. Ore particles, being magnetite, are easily amenable to magnetic levitation. The pipeline was designed to convey levitated particles, the propulsion was also electromagnetic. The group wondered the power consumption would be enormous for this 300 km line. However, it was not so. The line was mostly self-powered by intermittent solar panels, the residual demand being supplemented from the grid. The excitation was sequenced both on the length and time dimensions. When excitation was on say in the nth segment, it was off till n+3 segments. On any particular segment the excitation was pulsed.The amplitude and pattern were adjusted according to the reology of the material, such as the gravity-settling characteristics. Someone was curious to know the capital cost involved because of the electrical winding running over hundreds of kilometres. The coordinator said – "The Hot Rolling Mills make ICSC (meaning Insulated Copper Strip Cladded) plates or coils. As the coils or plates are welded into pipes spirally or lengthwise, the copper strips provide necessary winding for electromagnetics. With levitated transport picking up everywhere, this kind of copper printed steel products are in high demand."

The control room for the pipeline had visual monitors and controls for every segment of the line. Mean time between breakdowns or disruptions appeared to be quite impressive.

**The Steel Plant**

The group was interested upto the stage of liquid metal production because traditionally most the energy consumption and emissions were from these units. Having flown to the Steel Plant 300 km from the ore mines they resumed the study-tour. The coordinator said that the skyline of the Plants changed unrecognisably over the last decade. Pellet Plants, Direct Reduced Iron (DRI) Units had all gone. The look of Blast Furnace was quite different and some new units like Fluid-Bed MTI Reactor came up.

The Fluid-Bed MTI Unit looked a very 'peaceful' kind of equipment because being one of the primary facilities for ironmaking, there were no radiating heat nor sound nor dust floating around. It was a tower with inlets and outlets on the upper half. As they were looking at the battery of four Reactors in operation, the process engineer arrived to help the group understand the technology.

"Magnetite", he showed the equilibrium diagram superimposed with the $H_2$-$H_2O$ line, "can be theoretically reduced straight to iron at low or even at ambient temperatures. This had been known for ages but the difficulty is twofold. At low temperatures, the time needed for hydrogen to diffuse into and the resultant water molecule to migrate out from a magnetite piece is exceptionally long. This can be countered by using small sized particles. The second difficulty is maintaining very high $pH_2/(pH_2O+pH_2)$ ratio for the reaction to proceed. This is managed by using higher reactor pressure that helps condensing out $H_2O$ from gas phase. Also, a series of dehumidifier candles are used which absorb any residual $H_2O$ in the gas phase. The surface to gas phase mass transfer is very favourable with fluidised particles. A residence time of 7.5 minutes is enough to reduce magnetite particles to iron. The reactor temperature is 250 C only.[7,8]

"Hydrogen comes for a series of Electrolysers. Unreacted hydrogen is converted into power in a battery of Fuel Cells making the energy balance and economics workable."

In the control room they could see the interior of the reactor through camera captured live images. Some in the group had the impression that iron ore reduction had to be necessarily a high temperature process. The process engineer added - "So many advantages of low temperature reduction –heat losses are low, reactor construction and linings are simple, sensors and closed loop controls are less expensive yet precise.

"The reduced iron particles are conveyed into nitrogen sealed bins. Induction heaters heat up the particles very rapidly as they are fed to a Roller Briquetting Machine.You can see the briquettes there, each about 10 kg. This process is same as the old Hot Briquetted Iron Technology for DRI Modules. However, from DRI modules the briquetting mix used to be at around 600 0C, hence no flash heating was necessary."

A little away from the Fluid-Bed Reactors, there stood a Blast Furnace - it looked a bit different from what it used to be fifty-sixty years ago. The group was told that this furnace used hydrogen enriched natural gas and recycled plastic granules at very high rates. Some 150-200 kg coke was used but compared to conventional coke this was lighter and stronger, thus providing necessary gas passages in the Blast Furnace. They used pelletised high volatile coal in the coking blend so that the coke had low bulk density.

There was an open area of some 150 X 250 metres where a large diameter down comer from the Blast Furnace was seen to be terminating. The Blast Furnace engineer explained -"This a technology being developed by the Research and Technology Development (R&TD). They have an underground bed of olivine sand through which BF gas is passed. They are trying to make olivine sand absorb $CO_2$. Interestingly, one of the products of the reaction is water which seeps into the water table. They have reclaiming facility for used sand to be sent for normal constructural usage"[9,10].

A battery of ultra-high power Electric Arc Furnaces (EAF) were fed with Hot Metal, Scrap and Iron Briquettes. The Steel Shop looked clean and dust free. – "Not much change in EAF over the decades expect for the scrap preheating conveyor which uses waste gas. Our furnaces are equipped with bottom stirring elements and facilities for injecting calcium-ferrites when deep dephosphorisation is needed." Said the person in-charge.[11]

**Discussion Session**

The group had a discussion with the Steel Plant Staff, representing Process Technology, Energy Management, R&TD, Cost Analysts and General Management.

Why Blast Furnace? Someone asked.

"It is a proven practice for maybe 70/80 years to charge Hot Metal in EAFs. It helps smoother power in-take, better molten bath condition, faster melting, better nitrogen control etc. Though EAFs can be run with either scrap or briquettes or both, Hot Metal as the third partner helps a lot. Therefore Blast Furnace."[12]

"How is the economics with scrap, after all you need to buy it."

"The scrap availability in the country has steadily gone up over the years. In earlier days India was a developing country with less scrap getting recycled. Now the situation is different. Scrap melted steel is by far the greenest steel you can make. The government is giving incentives to scrap usage."

"Fossil fuels are cheapest source of energy and carbon anyway.Is steel produced with so much hydrogen really cost effective?"

"At one point of time electrolysed hydrogen used to be expensive. However, with introduction of high conductivity synthetic electrolytes and cells designed with superconductive components, the efficiency has gone up considerably. Cheaper Solar Power and high efficacy Fuel Cells also help the cause. The combination works"

And the final words came from the Managing Director of the Plant who joined the session towards the end; "My dear young friends, even if the cost is higher it is worth incurring that extra bit to protect the planet. We like you to believe in this principle because you are the future warriors to take the efforts forward!"

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*Dr A K Das had worked in Tata Steel, Essar Steel and was an Advisor to M N Dastur Co.

# Efficient Use of CBM Gas in a Soaking Pit of Blooming & Billet Mill

*I. N. P. Gupta, A. K. Jha and P. Banerjee*
Research & Development Centre for Iron & Steel, SAIL, INDIA

**Abstract**

This paper describes about the modifications carried out to improve the performance of the existing dual fuel burner capable of firing Coke Oven (CO) gas or oil separately in a soaking pit of a Blooming & Billet Mill (BBM) at a steel plant. Due to reduced availability of CO gas, Coal Bed Methane (CBM) gas as fuelwas being fired through the same CO gas nozzle of existing dual fuel burner resulting in its improper combustion and poor heating of stocks. To take care of this, a new CBM gas nozzle was designed, fabricated and installed. The modifications include removal of the existing dummy pipe along with oil gun and insertion of CBM gas nozzle in its place. CBM gas and CO gas are to be fired through the central CBM gas nozzle and existing outer annular pipe respectively. Further, CBM gas flow measuring instruments were also installed. The above modifications have resulted in reduced specific CBM gas consumption by about 16.7 %.

**Keywords:** CBM, Soaking pit, Dual fuel burner

## INTRODUCTION

Soaking pits of BBM are used for heating ingots before rolling to blooms or billets. Each soaking Pit, where the modification took place, was provided with a dual fuel burner capable of firing CO gas or oil separately. Whenever, availability of CO gas gets reduced, CBM gas is used as fuel in soaking pits and furnaces of other primary mills. The CBM gas is supplied to the steel plant at about 1,100 mmWG pressure. The Net Calorific Value (NCV) of CO gas and CBM gas are about 4,200 and 8,400 kcal/Nm$^3$ respectively. In case of non-availability of CO gas, CBM gas is fired through the same existing CO gas burner resulting in its improper combustion and poor heating of stocks in the furnaces.

## About the Soaking Pit

Maximum 10 ingots weighing 4 t each are heated up in each soaking pit. Heat is supplied through a dual fuel burner located on one of the two smaller side walls and placed horizontally at the middle and vertically near to the top. In the dual fuel burner, the oil gun has been provided in the centre through a dummy pipe. CO gas is fired through the outer annular pipe. The preheated combustion air is supplied through multi-holes at the burner tip.A cross-sectional view of the pre-modified dual fuel burner is given in Figure 1. Two flue ports are located at bottom level of the same side wall. A recuperator is provided in each pit to pre-heat combustion air to about 550$^0$C. At the flue gas outlet of soaking pit, a dilution air blower is provided to dilute the flue gas, whenever the temperature of flue gas on exit from pit reaches 900$^0$C. The operation of dilution air valve, i.e. its opening and closing is done by a controller. The capacities of combustion air blower and dilution air blowers are 250 Nm$^3$/minute at 700 mmWG and 50 Nm$^3$/minute at 150 mmWG respectively.

Since many years, use of oil firing in soaking pits has been stopped. CBM gas, whenever used, was fired through the existing CO gas pipe line connected to the

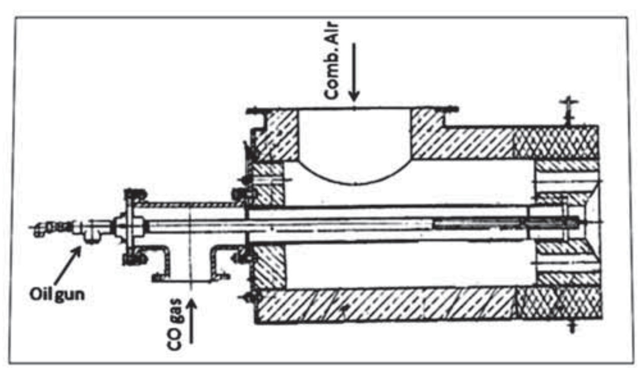


**Fig. 1: Cross-sectional view of pre-modified dual fuel burner for CO gas or oil firing**

burner after stopping CO gas flow. The maximum CO gas flow rate during heating period is about 750 $Nm^3/h$. Average consumption of either CO gas or CBM gas in each soaking pit were about 6,500 $Nm^3$/day and 3,500 Nm3/day, respectively. During CBM gas firing, flame shooting thorough the gap between pit opening and its cover were observed.

### Existing Burner Performance with CBM Gas

Since NCV of CBM gas is almost double than that of CO gas, CBM gas flow rate becomes half in comparison to CO gas flow rate for the same given heat input. Hence, CBM gas velocity through the existing gas nozzle reduces drastically leading to improper combustion of CBM gas and poor thrust of flame generated. When, CBM gas is fired through the existing CO gas pipeline, the controllability of existing gas control valve also reduces leading to more CBM gas flow through the burner than that desired. More CBM gas flow than that required for stoichiometric combustion air flow leads to flame shooting causing frequent damage of pit cover.

### Design of New CBM Gas Burner

The maximum designed flow rate of CO gas in each soaking pit is about 750 Nm3/h. Hence, maximum CBM gas flow rate has been designed as 375 $Nm^3/h$ keeping same heat load and considering NCVs of CO gas & CBM gas. Requirement of combustion air flow with 10 % excess air for complete combustion of CBM isgiven by (Eq. 1):

$$V_{AIR} = 4.76 \times 2CH_4 \times 1.1 / 100 \qquad (1)$$

Where,

$V_{AIR}$ = Requirement of air ($Nm^3/Nm^3$ of CBM gas)

$CH_4$ = dry volume% of Methane

Considering typical composition of CBM gas (by dry volume) as $CH_4$: 97.3 %, $CO_2$ = 0.8 %, and $N_2$ =1.9 %,combustion air requirement will be about 10.2 $Nm^3/Nm^3$ of CBM gas. With above parameters, a new CBM gas nozzle was designed. Considering similar velocity, the pressure requirement of CBM gas near the soaking pit will be about 250 mmWG.

### Performance Evaluation

The new CBM gas burner was fabricated and installed in a soaking pit of BBM. In order to minimize the modification in the existing dual fuel burner, the existing dummy pipe along with oil gun was removed. The New CBM gas nozzle was inserted at the centre of burner for firing of CBM gas. CO gas was designed to be fired separately through the existing outer annular pipe as shown in Figure 2. A new CBM gas line (100 mm NB size) was laid upto the existing dual fuel burner for the soaking pit. Additional equipment / instruments like isolation valves, shut-off valve, control valve, orifice plate, pressure reducing valve, differential pressure transmitter etc. were also installed. Further, modifications in the existing controllers were also incorporated for measurement of CBM gas flow rate.

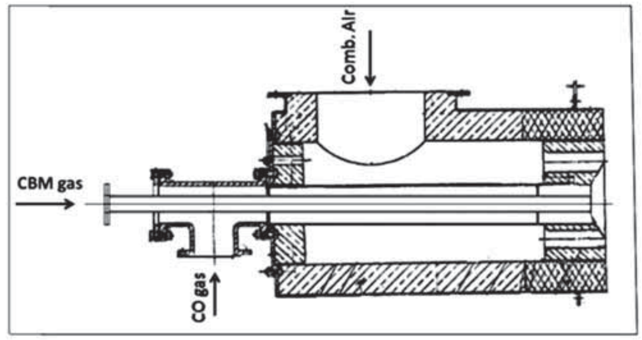


**Fig. 2: New dual fuel burner for CO gas or CBM gas firing**

The performance of new CBM gas nozzle was observed from 1st week of May '20 to 1st week of July '20, when CBM gas was fired in two different soaking pits of BBM and the same is given in Table 1.

**Table 1: Performance of soaking pits of BBM**

| Specific fuel consumption (Gcal / t of charge weight) | | Charge weight (t) | |
|---|---|---|---|
| Soaking pit with modified burner | Soaking pit with pre-modified burner | Soaking pit with modified burner | Soaking pit with pre-modified burner |
| 0.624 | 0.749 | 763 | 770 |

### CONCLUSION

Modifications were incorporated in the dual fuel burner of one soaking pit of BBM. It can be seen from Table 1 that specific fuel consumption in the soaking pit fired with CBM gas through modified burner has reduced by about 16.7 % in comparison to soaking pit with pre-modified burner.

Contact : E-mail: inpgupta@sail.in

# Medium Manganese Steel: A Promising Candidate for Automotive Applications

*Avanish Kr Chandan, Biraj Kr Sahoo and Gaurav Kr Bansal
CSIR-National Metallurgical Laboratory, Jamshedpur, INDIA

**Abstract**

Over the last decade, research in the field of advanced high strength steels (AHSS) for automotive applications has undergone a paradigm shift from low manganese (Mn) transformation induced plasticity (TRIP) aided and high Mn twinning induced plasticity (TWIP) steels to medium Mn (3-10 wt.% Mn) TRIP and/or TWIP aided steels. This is primarily due to the unique combination of strength and ductility obtained in medium Mn steels. Medium Mn steels represent the 3rdgeneration class of advanced high strength steels (AHSS). These steels supersede the 1st Gen AHSS which shows dismal performance with respect to the requirement of the modern carmakers, at the same time, medium Mn steels are significantly cheaper and are easy to process as compared to the 2ndgeneration AHSS. These advantages have led to an upsurge in the research of these 3rd Gen AHSS- medium Mn steels since last 10 years. The present article aims to showcase the prowess of medium manganese steels in terms of mechanical performance and therefore its applicability for automotive applications. An overview of composition, suitable heat treatment and the associated parameters, different processing routes, microstructure, mechanical properties and factors influencing it are presented.

**Keywords:** AHSS; TRIP; TWIP; Medium Mn Steel

## INTRODUCTION

Major developments on the material for automotive applications focus primarily on enhancing fuel efficiency and thereby reducing the associated carbon footprint. Such endeavors are directly or indirectly related to materials with high strength to weight ratio, a decent combination of strength and ductility, low cost, easy processing, corrosion and wear-resistance etc. In this regard, steels continue to remain the most dominant material in the automotive industry. Over the years, steelmakers are striving to develop various new grades of steel, which are lighter and stronger. This is requiredin order to survive the competition being put up by various alternative materials such as aluminum alloys, magnesium alloys, plastics, composites etc. Amidst this competitive environment, steel is still a winner material for the automotive applications as it accounts for about 68% of the vehicle weight. In this regard, the evolution of advanced high strength steels (AHSS) has a major role to play. Various grades of AHSS have kept steel in the competition and as of now, it seems impossible to replace steels from various components of a vehicle. AHSS is the upgraded version of high strength steels (HSS). As per the WorldAutoSteel[1], "HSS and AHSS are parts of steel family that share common behaviours. In general, AHSS differs from various HSS (such as IF, BH, HSLA) in the sense that the former was developed for increased strength and decent ductility in order to achieve enhanced formability. There is no discrete distinction between the strengths of HSS and AHSS, rather these steels fall into a continuum of strengths. For the sake of definition, steels with yield strength (YS) levels in the range of 210 to 550 MPa are termed as HSS and anything stronger as AHSS."

### 1. Evolution of AHSS

AHSS is a class of steel that covers a wide spectrum of steel grades differing in composition, processing, microstructure and properties. Accordingly, different grades of AHSS can be found to be a part of the vehicle depending upon the suitability of their usage. AHSS constitutes a significant part of the body in white (BIW) components of a car. AHSS has evolved from 1stgeneration (Gen) to 3rd Gen over the years.The 1st Gen AHSS primarily includes dual phase (DP) steels, martensitic steels, transformation induced plasticity (TRIP) aided steels, ferrite-bainite(FB) steel etc. With the strength levels of ~ 400-600 MPa and ductility ~ 10-20%, the 1st Gen steel lacks the strength-ductility combination as required by modern carmakersin the context of ever-increasing safety standards of the passenger. Such caveats in the 1st Gen AHSS and further stringent safety demands led to the development of 2nd Gen AHSS. 2nd Gen AHSS are basically high manganese(Mn) (>15-20 wt.% Mn) TRIP or/and twinning induced plasticity (TWIP) steels. Such steel possesses an excellent combination of strength and ductility with uniform strength as high as 1500 MPa along with uniform elongation greater than 50 %.In one hand, the 2nd Gen AHSS exhibit an excellent balance of strength and ductility, on the other hand, this grade of steel suffer major limitations such as extremely high production cost as well as difficult processing, both related to their high Mn content. Additionally, the 2nd Gen grade steels suffer weldability issues, again due to heavy alloying. These factors have certainly hampered the mass production and industrial utilization of TWIP steel and therefore these are not the first choice of budget carmakers.Over the prevailing situation of under performance by the 1st Gen AHSS and high cost of 2nd Gen AHSS, there was a need for further development of some grade of steel which has properties as par withthe requirement of modern car safety standards as well as comes at low cost. In the pursuit of this development, AHSS evolved to its 3rd Gen grades which include medium Mn steels, quench and partition (Q&P) steels, $\delta$-TRIP steels etc. Medium Mn steels being one of the important part of 3rd Gen AHSS has been seen as a prospective BIW material. These steels have been the topic of discussion since its inception as these steel if processed suitably can overcome the so-called strength-ductility trade-off at the same time keeping a check to the cost of the steel. In the following section, detailed discussion on the medium Mn steel, the interrelation between the composition, suitable heat-treatment and the associated parameters, microstructure and final mechanical properties will be done.

## 2. Medium Manganese Steel

Medium Mn steels are said to be the ones having Mn concentration in the range of 3-10 wt. % along with other alloying elements such as C, Al, Si[2]. Medium Mn steels are such processed that the final microstructure possesses a significant amount of retained austenite, generally greater than 15-20 volume %. The other major phases being intercritical ferrite and martensite. The simplest way to stabilize austenite phase (i.e. the retained austenite) is to isothermally hold the steel specimen in the intercritical phase-field (i.e. between Ac1 and $Ac_3$) after the homogenization treatment, followed by cooling[3], but this process would give a rather soft large-grained ferrite matrixand retained austenite. The schematic of the above mentioned heat treatment is depicted in the Figure 1 (a). The large grain sized ferrite phase would certainly limit the mechanical properties that could have been achieved with fine grained microstructure (like that of martensite) along with the required amount of soft austenite phase in-between. The superfine grained austenite-ferrite/martensite duplex structure can be alternatively obtained by intercritical heat treatment of the martensitic structure (obtained by hot rolling and subsequent quenching) through the so called austenite reverted transformation (simply called as ART annealing). There are two types of ART annealing treatment done for austenite stabilization at room temperatures. The first one is intercritical tempering, in which the fully martensitic steel specimen is held at the temperature just above Ac1, i.e. in the lower part of the two phase region for a prolonged duration, and subsequently cooling to room temperature (Figure 1 (b)). The second route is intercritical annealing, in which the steel is held at just below the $Ac_3$ temperature, i.e. in the upper part of the two-phase region (Figure 1 (c)). Both the intercritical tempering and intercritical annealing treatments would result in retained austenite stabilization. The retained austenite stabilization process is the result of the partitioning of the solute elements such as C and Mn from the intercritical ferrite to the intercritical austenite phase during the holding of the steel specimen at the intercritical temperature. These solute elements being austenite stabilizer, stabilizes the austenite phase and at the same time decreases the martensitic start (Ms) temperature of the intercritical austenite phase. Therefore, a part of the intercritical austenite phase gets retained in the microstructure after the final quenching treatment. However, both the cases suffer the major drawback of retention of a too small amount of austenite phase. In the case of intercritical tempering, the amount of intercritical austenite to be enriched with the solute elements is too low and hence, the amount of retained austenite is low as well. On the other hand, during the intercritical annealing at a temperature just below the $Ac_3$, only small amount of intercritical ferrite is present in the microstructure and austenite in this case, gets little source (ferrite phase) of solute enrichment and thus after cooling to room temperature, most of the austenite get transformed to martensite. These limitations of the two processes suggest that there must

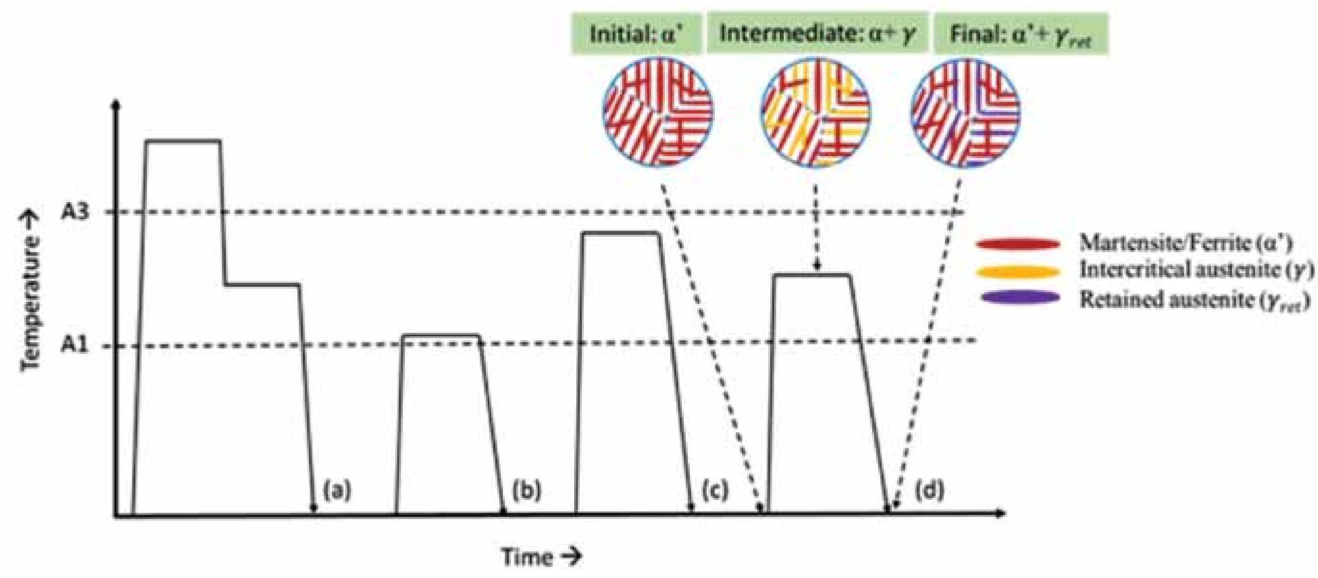


**Fig.1: Various heat treatment routes of medium Mn steel**

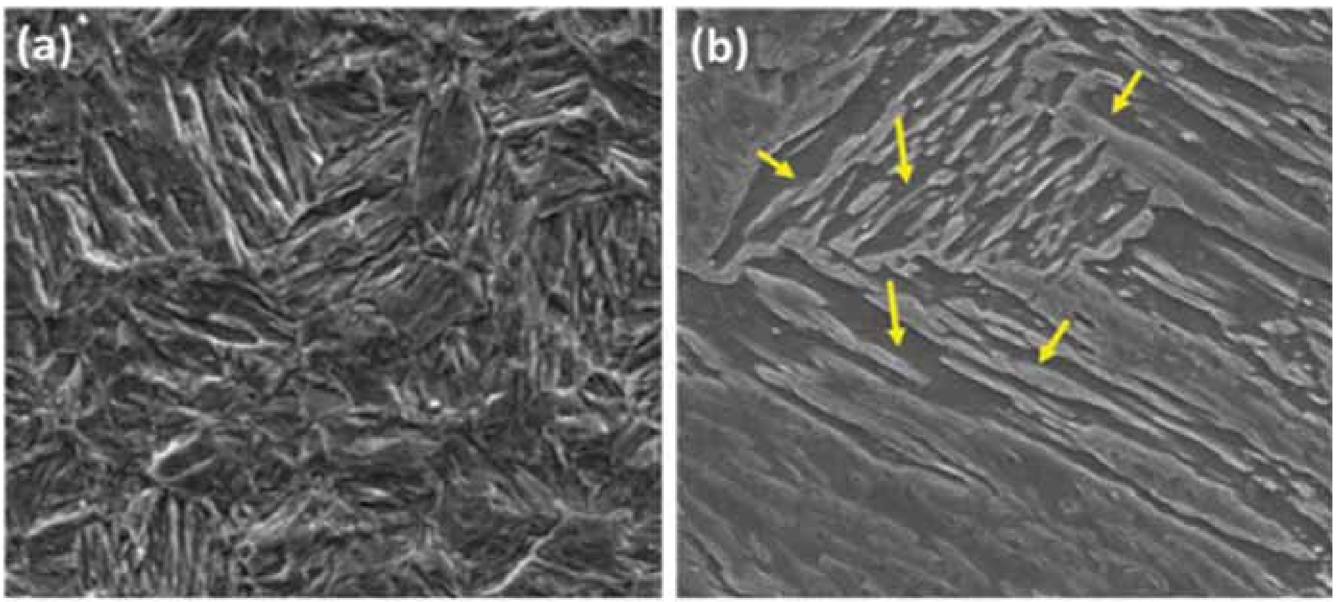


**Fig. 2:Microstructure of medium Mn steel (a) before and (b) after the intercritical heat treatment**

be an intercritical temperature at which, when the steel specimen will be held, can fetch the maximum amount of retained austenite (Figure 1 (d)). The schematic of microstructural evolution during the intercritical heat treatment is also presented in Figure 1.It is evident from the schematic that it is desirable to obtain retained austenite in the inter-lath regions of the martensite phase. Figure 2 presents the microstructure of a Fe-5Mn-0.2C steel microstructure, before and after the intercritical heat treatment. The initial fully martensitic microstructure (Figure 2 (a)) evolved into martensite and retained austenite (Figure 2 (b)).This ultrafine microstructure can provide great strength, along with that the required ductility is achieved by the presence of retained austenite in between the martensite/ferrite laths. Apart from the ultrafine microstructure, maximization of retained austenite volume fraction is the primary aim when one requires to obtain the best strength-ductility combination. Therefore, the next pertinent question is what should be the correct intercritical temperature which would fetch the maximum retained austenite in the microstructure and the subsequent question is how to determine that particular temperature. One way, though rigorous, would be to perform the actual heat treatment at some interval of intercritical temperature and then to measure the retained austenite using some suitable technique such as x-ray diffraction (XRD). Given the intensive nature of this procedure, it is not encouraged. Rather, a simple thermodynamic model developed by moor et al.[4], has been extensively utilized by the research community to predict the amount of retained austenite in the final microstructure. The model is described in the following section.

### 2.1. Thermodynamic model for prediction of retained austenite

In the following, the working steps of the model is discussed taking the example of a simplistic medium Mn composition Fe-5Mn-0.18C-0.5Si-0.5Al (all in wt. %). The required thermodynamic information is obtained from the thermodynamic package Thermo-CalcTM[5]. The approach consists of the following steps:

(i) Prediction of equilibrium amounts of phases as a function of temperature. For this, ThermoCalc program was used and phase fraction evolution with respect to temperature was obtained (Figure 3 (a)).

(ii) Prediction of austenite compositions with respect to temperature, assuming equilibrium condition. Again, ThermoCalc program was employed for the prediction. Equilibrium composition of the austenite phase would be different for different intercritical holding temperature, which is shown in Figure 3 (b&c).

(iii) Using the composition of the austenite phase, predicted above by ThermoCalc, the martensitic start (Ms) temperature was obtained by using the following formula[6]:

$$Ms= 539 - 423*\%C - 30.9*\%Mn - 7.5*\%Si + 30*\%Al \quad (i)$$

Ms temperature would vary with intercritical holding temperature as the solute content of austenite phase was varying with intercritical holding temperature and the Ms temperature depends upon the solute content as per the above equation. The amount of martensite which would form after quenching the sample to room temperature, initially held at some intercritical temperature was estimated using the famous empirical Koistinen-Marburger (KM) equation:

$$f_m=1-\exp(-0.011(Ms-QT)) \quad (ii)$$

Where, $M_s$ is the martensitic start temperature and QT is the final quenching temperature.

(iv) Subtracting the amount of fresh martensite predicted to form upon final quenching from the austenite fraction would give the final retained

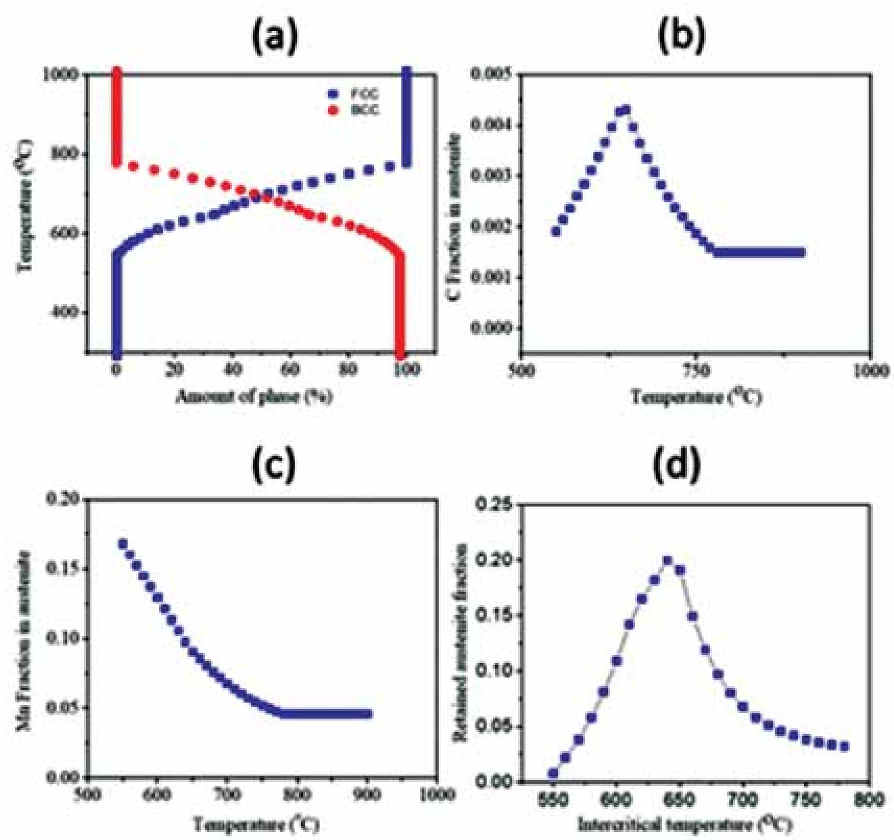


**Fig. 3: (a) Evolution of phase fraction with increasing temperature, (b) Carbon, (c) Manganese and (d) variation of Retained austenite as a function of intercritical holding temperature**

austenite fraction in the microstructure at room temperature (Figure 3 (d)).

### 2.2. Factors affecting retained austenite fraction

It is clear from the above exercise of prediction of the fraction of retained austenite that the same is dependent on various factors such as the intercritical annealing temperature and alloy composition. It is to be noted that the above exercise does not take into account the kinetics of the elemental partitioning during the intercritical holding treatment. In actual practice, it takes a certain amount of time to reach the equilibrium condition, which depends on various microstructural factors such as initial state of the alloy (forged, hot rolled or cold rolled), initial microstructural constituent, annealing temperature etc. In the following section, the various factors affecting the amount of retained austenite in the final microstructure will be discussed:

(i) **Alloy Composition:** It is very clear from the above mentioned model calculation that the austenite stabilizer elements (C, Mn) has the major role to play for the stabilization of retained austenite. These elements partition to the intercritical austenite phase during the intercritical holding and thereby decreases the Mstemperature of that austenite (see equation (i)). This way the retention of austenite becomes possible. It is therefore straight forward that increasing the concentration of the alloying elements like C and Mn will help in austenite stabilization. However, increasing the C content in the alloy also increases the cementite phase field and therefore care must be taken during the intercritical annealing treatment in order to avoid the cementite phase. In this regard, Si and Al additions are done in order to avoid the cementite precipitation and keep the C and Mn free to be available for the partitioning to the austenite phase. Al addition comes with an added advantage of increasing the Ac1 and Ac3temperatures and hence the intercritical temperature for the heat treatment also increases. The higher intercritical temperature facilitates increased kinetics of partitioning and less time is required for reaching the equilibrium. Additionally, Al addition will lead to decrease in the density of the alloy. However, care must be taken during steel making process for Al addition, as Al addition leads to detrimental nitrides and oxides inclusions in the steel.

(ii) **Intercritical Temperature:** The intercritical heat treatment temperature needs to be appropriate such that during the heat treatment optimum amount of intercritical austenite and intercritical ferrite are formed. The amount of intercritical ferrite phase decides the amount of alloying elements available for partitioning to the austenite phase. Additionally, the intercritical annealing temperature should be carefully chosen in order to avoid the formation of other carbides and intermetallics.

(iii) **Intercritical Annealing Time:** The kinetics of austenite phase evolution during the intercritical holding and the subsequent partitioning of elements is highly dependents on various associated factors such as the initial microstructure and initial state of the specimen (hot rolled or cold rolled). One of the aim is to maximize the amount of retained austenite in the final microstructure and the amount of retained austenite is dependent on the amount of intercritical austenite, the amount of elemental partitioning, the morphological evolution of the intercritical austenite etc. All these above factors are time dependent phenomena and directly influence the retained austenite content in the final microstructure. It is therefore important to carry out the intercritical annealing treatment for a suitable time duration in which the above time dependent factors could be well taken into account.

### 2.3. Structure – Property Correlation

Medium Mn steels have been seen as a suitable candidate for various parts of BIW of automobiles. This is primarily due to the superior mechanical properties which could be achieved in such steels. In the earlier sections, a detailed discussion has been made on the correct microstructure, the required heat treatment procedure to obtained the same and the factors on which the evolution of the correct microstructure depends. In this section, an interrelation between the microstructure and the mechanical properties has been discussed. Various reviews on medium Mn steel showcased the superiority of tensile properties being exhibited by these alloys in comparison to the 1st Gen AHSS grades (Figure 4). Further, Medium Mn steels are not far behind the 2nd Gen AHSS in terms of strength or ductility, with an added advantage of relatively very low alloying content and thus low in cost and relatively easy processing. Medium Mn steels can have tensile strength as high as 1200-1500 MPa and can possess a ductility greater than 50%. The high strength in such alloys is the direct consequence of ultrafine microstructure with the martensite/ferrite laths and the austenite film thicknesses in the order of ~200-500 nm. The austenite phase embedded in between the laths of martensite/ferrite provides the required ductility. A scatter in the properties of medium Mn steel in Figure 4 is associated with the vast range of austenite composition being tried with variation in the amount of retained austenite and differences in the sizes and morphologies of the phase constituents. In general, the lower the lath thicknesses, the greater will be the strength. The evolution of lath thicknesses in turn is dependent on various factors such as the initial martensite lath thickness i.e. before the intercritical heat treatment, the prior austenite grain size etc.[7]. In addition, the amount of alloying elements also directly influences the strength of the alloy as a part of solid solution strengthening. The ductility is mainly guided by the retained austenite present in the microstructure. It is generally accepted that, greater the amount of retained austenite in the microstructure, higher will be its ductility as austenite being face centered cubic crystal structure which is a close packed structure having a large number of slip systems and thus canbe deformed easily. This is true but there is an extension to this theory. Apart from slip, the austenite phase can also deform via twinning and/or martensitic transformation. Both the twin and martensitic transformation are known to provide exceptional work hardening during the deformation and the associated phenomena are commonly known as TWIP and TRIP effects, respectively. Therefore, the presence of austenite not only can provide ductility but can contribute significantly to the strength of the alloy as well. The onset of TRIP or TWIP effect is dependent on the stacking fault energy (SFE) of the austenite phase. It has been found that the austenite phase with SFE less than 18-20 mJ/m$^2$ deform primarily via TRIP effect, while TWIP effect is prominent in the austenite phase having SFE in between 20-45 mJ/m$^2$. Austenite phase with SFE greater than 45 mj/m$^2$ deforms via slip. TWIP effect is known to exhibit superior work hardening effect during the deformation. Therefore, SFE of the steel should be such, that it could provide progressively high work hardening during deformation. SFE of the austenite phase can be tuned to suit the mechanical property requirement as it depends on austenite composition, morphology, grain-size and temperature.

From the present section, it becomes clear that the mechanical properties of the medium Mn steels are tunable as per the end requirement. This can be done by tuning various microstructural parameters.

### 2.4. Current status and prospect

Despite the advantages of medium Mn steel over the first generation and second generation steels, these steels find restricted use till now because of several

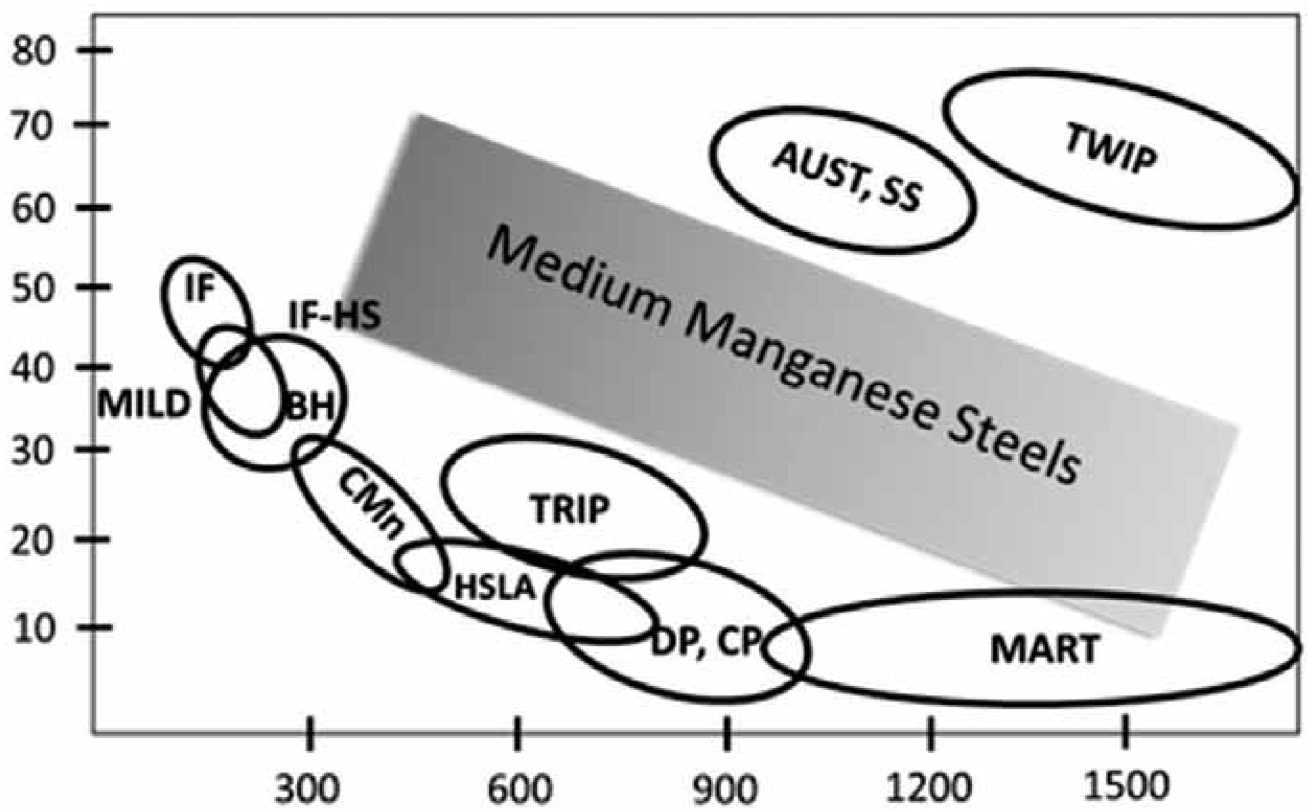


**Fig. 4: Schematic of tensile strength – elongation map for medium Mn steels, superimposed on the strength – elongation map for automotive steel grades**

limitations. First, the requirement of significant alloying content increases the cost of production as well as poses manufacturing challenges in industrials scales. Production of medium Mn steels requires special liquid steel making practices to control the level of phosphorus, sulphur and nitrogen in steel and thereby minimize the inclusions especially MnS. Ca treatment can be suitably applied during the secondary steel making stage to improve steel casting ability, minimized slab surface defects arising from inclusions and modify the sulfide inclusion morphology to improve its compatibility with the matrix during hot rolling. The cold rolling of these steel also poses challenges like achieving the desired dimension (width, thickness, flatness) as the steels exhibit higher cold strain hardening and there is a risk of cold roll cracks at higher reduction rates. However, with the optimization of cold rolling schedules especially reduction rates at each pass and suitable lubrication, higher thickness reduction can be achieved. In regard to the coating, because of its high Mn, Al and Si content, there are problems of selective oxidation during annealing treatment. However, using a suitable annealing atmosphere ($N_2$ and $H_2$) and dew point control, the extent of selective oxidation can be reduced to ensure good coatability. During the forming stage of medium Mn steel, one of the severe difficulties encountered is the high spring-back effect, due to their high strength. Several investigations are ongoing in this direction to understand the formability and bending ability of these steels. While medium Mn steels offer superior mechanical properties, it requires specialized welding techniques for its application in automotive structure. The heat produced during welding alters the microstructure of the base material and therefore the mechanical properties. Advanced welding techniques like resistance spot welding and laser welding have emerged recently to join AHSS without much alteration in the properties.

Regardless of the above stated caveats which can be addressed by applying respective specialized techniques, the requirement of lighter and safer vehicles will drive the development of medium Mn steels design philosophy. The design of new generation medium Mn steel also takes into consideration the lowering of the density of the alloys, by addition of a substantial amount of light elements like Al in range of 3-12 wt.%. With every 1% addition of Al, there is a decrease in density of 1.3% and a reduction in bulk density of 5-15% can be achieved in medium Mn high Al steels. The Al added low-density medium steel gives an additional weight saving opportunity and a consequent reduction in fuel consumption and emissions. The mechanical properties obtained in these steel are quite outstanding, having a product of strength-elongation in the range of 40-70 GPa%. Keeping in view the stringent vehicle safety regulations and environmental norms to reduce emission, the requirement for medium Mn high strength low-density steels will continue to rise in the coming future. The strong demand for energy saving is considered to lead the change in automotive power train from internal combustion engines to HEVs (Hybrid Electric Vehicles), EVs (Electric Vehicles) and FCVs (Fuel Cell Vehicles). Crashworthiness will be one of the key performances of automobiles even though advances in automation/sensor technologies to avoid traffic accidents. These technologies can be effective only when the automation/sensor and material manufacturing industries work together from the beginning of the new development.

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*Corresponding Author: Avanish Kumar Chandan, Scientist, Materials Engineering Division,
CSIR-National Metallurgical Laboratory, Jamshedpur, INDIA.
E-mail: avanish@nmlindia.org Tel (o): +91 657 234 5071, Mo: +91 8102723400

# Energy, Environment & Ecology

### Carbon Dioxide ($CO_2$) Emissions & Mitigation in Steel Industry

With the rapid expansion in coal-based power generation in India, the sector's coal consumption had almost doubled between 2006- 07 and 2017-18; so had its carbon dioxide ($CO_2$) emissions. India's coal-based power sector accounts for approximately 2.4% of global greenhouse gas (GHG) emissions, one-third of India's GHG emissions, and around 50% of the country's fuel-related emissions.

Experts opine that despite the growth in renewable power, coal-based power will continue to play a crucial role in India's energy security, with the capacity expected to rise from 205 GW in 2020 to 266 GW in 2030. Beset with problems ranging from poor quality coal to slow progress on technical and institutionalreforms, India's coal power sector is one of the most inefficient in the world. But there is huge scope of reducing the sector's $CO_2$ emissions footprints and, in turn, augment its climate change mitigation potential.

Energy experts claim that in the next 20 years fossil fuels will be challenged by renewables and fission, thus keeping hydrocarbon prices very low and countries relying on their exports being forced to sell at rock bottom prices.

### Steps for Reduction of $CO_2$ Emission

China will determinedly slash the production of crude steel and ensure it drops year on year in 2021. Efforts will be made to endorse low-carb on industrial improvement and green manufacturing in 2021, stated Minister of Industry and Information Technology Xiao Yaqing at a work meeting.

China formerly declared that it will attempt to peak carbon dioxide releases by 2030 and attain carbon neutrality by 2060.

In the next five years, China will chase high-quality national development by further upgrading its systems for environment protection to realize a fundamental transformation in its economic, industrial and energy structures, Ministry of Ecology and Environment (MEE), will need to push the transformation of the country's industrial, transportation and construction sectors toward low-carbon development models, efficiently controlling fossil fuel energy consumption, promoting renewable energy, and proceeding with the replacement of coal and gas for electricity in daily life. The regulation of the scattered and small-sized coal mining operations will also be intensified. Low-carbon lifestyle should be publicized too across China.

Among the efforts citizens will be strongly proposed to make in their daily lives, they will be encouraged to use public transportation, reduce food waste, and to drive new energy vehicles. To reduce carbon emissions to zero from their climax in 30 years will be a large challenge for China, and the pledge is a clear illustration of China's resolution and commitment to a lowcarbon future. In the coming years, China will need to strictly control coal consumption including limiting the coal power generation capacity within the reasonable range, and to accelerate the construction of non-coal energy generation facilities. China will continue to impose tough restrictions on the operations of those industries generating greenhouse gases to reduce their impact on climate change. By the end of 2019, non-fossil energy contributed 15.3% of the country's total energy consumption.Over 2016-2019, the efficiency enhancement in power consumption was equivalent to a reduction in carbon emissions by 1.4 billion tonnes. In China, officials are encouraging steelmakers to replace blast furnaces with electric arc counterparts as environmental regulations grow stronger.

## Solar on Track to Become China's No. 3 Power Source

Things are looking bright for solar power in China, which is on track to edge past wind to become the nation's third largest electricity source by the end of 2020 with around 240 gigawatts of solar capacity, representing about 16.2% growth from the end of 2019. Both solar and wind currently supply about 11% of China's total electric capacity, while hydropower is No. 2 at 18%. Dirtier coal-fired power is still the clear leader, accounting for about half of China's 2,100 gigawatts of capacity.

Solar has surged in recent years as maturing technology makes the clean energy source increasingly efficient while also bringing down prices. The China Photovoltaic Industry Association predicts China could add as much as 70 GW to 90 GW of new capacity annually over the next five years, as the country tries to reduce its dependence on fossil fuels that produce $CO_2$ and contribute to global warming.

Chinese President Xi Jinping said China, the world's biggest carbon-dioxide emitter, would cut emissions per unit of GDP by 65% from 2005 levels and increase the share of non-fossil fuels in primary energy consumption to around 25% by 2030.

Japan's JFE Steel will spend over 100 billion yen ($955 million) during the next decade to install equipment at the company's mills nationwide, looking to reduce their output of $CO_2$ by at least 20%. JFE will replace BOFs with updated versions that are more energy efficient. This will let mills use more ferrous scrap as raw material. The change will reduce the ratio of steel made from iron ore, a process that consumes coal and releases $CO_2$. JFE also will adopt technology that makes use of catalysts to dissolve iron. Nippon Steel, Japan's leading steelmaker, will release its first ever carbon-cutting plan later this fiscal year. The company intends to expand the number of overseas mills with electric arc furnaces, which use only iron scraps as raw material. Electric arc furnaces emit just one-quarter the amount of carbon as conventional blast furnaces.

European steelmaker ArcelorMittal emitted 188 Mt of carbon in the 2018 fiscal year, roughly double that of Nippon Steel's 97 Mt. ArcelorMittal's steel output also was roughly twice that of its Japanese counterpart. Both the European Union and Japan aim to achieve net-zero emissions of greenhouse gases by mid-century. Steelmaking processes that use hydrogen are being developed to that end. But the steel industry appears to need further technological innovation to approach carbon reduction goals.

## Mitsubishi Heavy to Build Biggest Zero-Carbon Steel Plant

Japan's Mitsubishi Heavy Industries will soon complete in Austria the world's largest steel plant capable of attaining net-zero carbon dioxide emissions.

Mitsubishi Heavy, through a British unit, is constructing the pilot plant at a complex of Austrian steelmaker Voestalpine. Trial operation is slated to begin in 2021.

The plant will use hydrogen instead of coal in the reduction process for iron ore. The next-generation equipment will produce 250,000 tons of steel product a year.

The global steel industry generated about 2 billion tons of $CO_2$ in 2018, according to the International Energy Agency -- double the volume in 2000. The steel sector's share among all industries grew 5 percentage points to 25%.

Iron ore reduction accounts for much of the $CO_2$ emissions in steelmaking. Japanese steelmakers including Nippon Steel are developing hydrogen-consuming reduction processes based on the conventional blast furnace design.

Mitsubishi Heavy's plant adopts a process called direct reduced iron, or DRI. New blast furnaces require trillions of yen (1 trillion yen equals $9.6 billion) in investment. Although DRI equipment produces less steel, the investment is estimated at less than half of blast furnaces.

For DRI to attain the same level of cost-competitiveness as blast furnaces, low-cost hydrogen will be key. Market costs for hydrogen now stand at around 100 yen per normal cu. meter, estimates the Ministry of Economy, Trade and Industry.

The government aims to get the hydrogen costs down to 30 yen per normal cu. meter by 2030, mainly via mass production.

But for DRI to be feasible in the steel industry, "the level needs to go below 10 yen," said an executive at a large steelmaker.

Germany's SMS, the world's leading supplier of steelmaking equipment, is pursuing the hydrogen-fueled steelmaking process, along with runner-up Danieli of Italy. Among steelmakers, Luxembourg-based ArcelorMittal plans to build a German pilot hydrogen steel plant in 2021. Competitors such as Germany's Thyssenkrupp and Salzgitter are investing in DRI.

Mitsubishi Heavy, the world's third-largest steelmaking equipment supplier, is also securing a hydrogen supply chain. In October, the company bought a stake in a Norwegian outfit that makes hydrogen-producing equipment.

Elsewhere, Mitsubishi Heavy has decided to acquire stakes in hydrogen producers in such places as Australia. The group will oversee supply of hydrogen, together with equipment construction and engineering.

The European Union announced in July an initiative to invest 470 billion euros ($572 billion) in hydrogen by 2050. Hydrogen steel plants are anticipated to receive support. Europe is home to a growing number of businesses that deal in hydrogen. Mitsubishi Heavy will capture the steel industry's demand for hydrogen to offset the softer growth prospects for thermal power plant equipment.

**Prime Minister Boris Johnson outlines his Ten Point Plan for a Green Industrial Revolution for 250,000 jobs.**

The Prime Minister sets out his ambitious ten point plan for a green industrial revolution which will create and support up to 250,000 British jobs.

Covering clean energy, transport, nature and innovative technologies, the Prime Minister's blueprint will allow the UK to forge ahead with eradicating its contribution to climate change by 2050, particularly crucial in the run up to the COP26 climate summit in Glasgow in 2021.

The plan, which is part of the PM's mission to level up across the country, will mobilise £12 billion of government investment to create and support up to 250,000 highly-skilled green jobs in the UK, and spur over three times as much private sector investment by 2030.

The Prime Minister's ten points, which are built around the UK's strengths, are:

1. **Offshore wind:** Producing enough offshore wind to power every home, quadrupling how much we produce to 40GW by 2030, supporting up to 60,000 jobs.
2. **Hydrogen:** Working with industry aiming to generate 5GW of low carbon hydrogen production capacity by 2030 for industry, transport, power and homes, and aiming to develop the first town heated entirely by hydrogen by the end of the decade.
3. **Nuclear:** Advancing nuclear as a clean energy source, across large scale nuclear and developing the next generation of small and advanced reactors, which could support 10,000 jobs.
4. **Electric vehicles:** Backing our world-leading car manufacturing bases including in the West Midlands, North East and North Wales to accelerate the transition to electric vehicles, and transforming our national infrastructure to better support electric vehicles.
5. **Public transport, cycling and walking:** Making cycling and walking more attractive ways to travel and investing in zero-emission public transport of the future.
6. **Jet Zero and greener maritime:** Supporting difficult-to-decarbonise industries to become greener through research projects for zero-emission planes and ships.
7. **Homes and public buildings:** Making our homes, schools and hospitals greener, warmer and more energy efficient, whilst creating 50,000 jobs by 2030, and a target to install 600,000 heat pumps every year by 2028.
8. **Carbon capture:** Becoming a world-leader in technology to capture and store harmful emissions away from the atmosphere, with a target to remove 10Mt of carbon dioxide by 2030, equivalent to all emissions of the industrial Humber today.
9. **Nature:** Protecting and restoring our natural environment, planting 30,000 hectares of trees every year, whilst creating and retaining thousands of jobs.
10. **Innovation and finance:** Developing the cutting-edge technologies needed to reach these new energy ambitions and make the City of London the global centre of green finance.

**Germany Backs Green Hydrogen Pilot in Saudi Arabia Future City**

German state has handed over 1.5 million euro grant to steelmaker Thyssenkrupp'sUhde Chlorine Engineers' unit for the development of a prototype of a 20MW alkaline electrolyser for the production of green hydrogen and ammonia in Saudi Arabia. The grant is part of Germany's national hydrogen strategy that seeks to source green hydrogen from abroad given Germany's limited space for domestic hydrogen production from renewables. Germany under the scheme earlier this month had handed out a first grant for a synthetic fuel project in Chile.

The Thyssenkrupp unit in a first phase dubbed 'Element One' is slated to develop the electrolyser for a hydrogen innovation and development centre in the model region of Neom at the Red Sea, where Saudi Arabia is building as a futuristic high tech city and region. Neom among other things will host massive green hydrogen and renewables projects to make the desert Kingdom less dependent on oil. Yet to be built solar and wind power arrays in a second phase are slated to feed an industrial scale electrolyser plant at Neom to produce up to 650 tonnes of green hydrogen and 3,000 tons of ammonia per day by 2025. Once completed, Helios plant will be one of the world's largest green hydrogen production facilities. The ammonia, which is easier to store and transport than gaseous hydrogen, will be shipped overseas for reconverting to hydrogen for use as an alternative fuel in transportation.

Neom, a combination of the Greek neos, new, and the first letter of the Arabic word for future, mustaqbal is planned to be a luxury city 33 times the size of New York, with flying cars and taxis, robot servants, holographic teachers, artificial rain, and a giant artificial moon. The development, which will sprawl over 26,500 square kilometers near the Red Sea, was initiated by the Saudi crown prince Mohammed bin Salman bin Abdulaziz Al Saud as part his Vision 2030 project. Helios also involves Saudi firm ACWA Power, Air Products & Chemicals and Danish chemical catalysis producer HaldorTopsoe.

### Hydrogen Key to Produce Green Steel

Steel is an essential part of our future with global demand set to double in the next 30 years, yet it's a big carbon emitter – accounting for 9% of carbon dioxide emissions already. With many countries committing to ambitious carbon neutrality targets, clearly this is not sustainable. Traditional steelmaking involves the use of coking coal in blast furnaces, resulting in huge carbon dioxide emissions.

With the age of fossil fuels coming to an end, and COVID-19 accelerating thinking among captains of industry and governments that we can and need to build a better world for future generations, the role of hydrogen is in the spotlight. We know hydrogen provides the key to a carbon-neutral steelmaking process and can be used in place of coking coal as a reducing agent to produce sponge iron – with the by product being water, i.e. emitting $H_2O$ rather than $CO_2$.

However, hydrogen has its problems too. In addition to its challenge of bringing down cost of production, it is also difficult to store and difficult to transport – adding significantly to its cost.

Currently, the hydrogen supply chain is costly and challenging. Each stage of storage, liquefying, shipping and re-gassing, adds to the cost of a tonne of hydrogen – and that's on top of the capital cost of the plants and infrastructure required.

By using hydrogen to make steel in-situ i.e. immediately where it is produced, the storage and transport problems can be solved. This coupled with bringing down cost by using large scale renewable energy in key locations with favourable renewable resources, will allow to produce competitive 'greensteel' totally free of fossil fuels. In addition it will enable large and effective consumption of hydrogen allowing the hydrogen industry to develop rapidly.

Australia is well positioned with its natural resources to become a world leader in a new hydrogen economy. It will be economical for Australia to produce and export green steelthan to export hydrogen.

Liberty Steel is working on this idea of producing green steel at the Whyalla Steelworks, in South Australia. It has the best conditions for solar and onshore wind energy anywhere in the world (hence their 280MW Cultana Solar Farm initiative), abundant magnetite iron ore reserves which enable new, less carbon intensive technologies and processes to be used,

The potential benefits, with hydrogen production established, go well beyond steel and would position South Australia as a global hub for fuel cell technology, research and development and advanced manufacturing.

China has built the world's largest electrolysers and is pouring billions into fuel cell technology, Germany has committed to spending €9bn on hydrogen development and France wants to have the largest hydrogen production capacity in Europe by 2030. Sweden has already built a pilot plant producing what they describe as emissions-free steel using hydrogen. But none of these countries have the same degree of natural advantages and resources that Australia has for hydrogen and hydrogen steel production.

### thyssenkrupp works on 'Green Hydrogen' Joint Feasibility Study

Essen-based energy company STEAG, Duisburg-based steel producer thyssenkrupp Steel and Dortmund-based thyssenkruppUhde Chlorine Engineers, specializing in electrolysis technology, are working on a joint feasibility study. The study deals with the construction of a water electrolysis plant at the STEAG site in Duisburg-Walsum by thyssenkruppUhde Chlorine Engineers, the structuring of energy supply and operation of the electrolysis plant by STEAG and the supply of green hydrogen and oxygen to thyssenkrupp Steel's steel mill in the neighboring Duisburg district of Bruckhausen.

The immediate proximity of the sites allows optimum transport connections to the steelworks: The project includes the construction of two new pipelines to transport hydrogen and oxygen from Walsum to the steel mill less than three kilometres away. The connection to the extra high-voltage grid ensures the supply of green electricity for the electrolysis; large-scale battery systems ensure grid stability. The approximately 15-hectare site in Duisburg-Walsum offers the possibility to erect electrolysis units with a total capacity of up to 500 MW. It also has a connection to the existing natural gas network, which in the future could be used for the transport of hydrogen.

The water electrolysis system, says thyssenkrupp, will be installed by the company's Uhde Chlorine Engineers' Green Hydrogen product division. It consists of pre-fabricated standard modules. This modular system makes it easy to scale up a plant to several hundred megawatts or gigawatts. This is why the technology is particularly suitable even beyond green steel production for an industrial-scale decarbonization on the path towards sustainable value chains and $CO_2$ reduction. This kind of sector coupling enables new business models and a sustainable circular economy, which is to be completely powered by renewable energy sources in the future. Together with the Business Unit Chemical and Process Technologies, thyssenkrupp in Dortmund is able to supply the entire range of green chemicals, from hydrogen to ammonia, methanol and synthetic natural gas, thus contributing significantly to a climate-neutral industry.

The project development is planned to start as soon as the feasibility study delivers a positive result.

## POSCO to expand Hydrogen Production to 5 Mt by 2050

POSCO has unveiled a new vision of becoming a green hydrogen enterprise that leads a transition to a decarbonized hydrogen economy. To attain the vision, the company plans to expand its hydrogen production capacity to 5 Mt a year by 2050.

It will seek to secure core technologies for hydrogen production through water electrolysis and establish hydrogen production facilities by 2030, and foster the hydrogen business as one of its growth engines. Currently, POSCO produces 7,000 tons of hydrogen annually using by-product gas generated from a steel manufacturing process, and LNG. It extracts about 3,500 tons of by-product hydrogen and use it to control temperature and prevent oxidation during steel production. In addition, the steelmaker has developed the world's first steel product for hydrogen fuel cell separators and supplies it to hydrogen car producers in Korea.

POSCO plans to strengthen its capabilities to research the hydrogen reduction steel production method which is a steel production technology using hydrogen, develop steel products needed to produce, transport, storage and utilize hydrogen, increase facilities for production of hydrogen, and develop core technologies for hydrogen production among others going forward. On top of that, the company plans to pursue large-scale investments while seeking various business opportunities such as green hydrogen distribution, infrastructure construction, and participation in green hydrogen projects. By doing so, the company plans to jack up its production capacity of by-product hydrogen to 70,000 tons by 2025, and to produce up to 500,000 tons of blue hydrogen in cooperation with global companies by 2030. At the same time, it plans to complete a 5 Mt green hydrogen production system by 2050 including the establishment of a 2 Mt green hydrogen production system by 2040.

Blue hydrogen is produced by using fossil fuels such as natural gas, and carbon dioxide generated at this time is collected and stored in the ground. Green hydrogen is produced by the electrolysis of water based on new and renewable energy. POSCO also plans to usher in a carbon-phase out era by realizing a hydrogen reduction steel mill based on green hydrogen by 2050. If the hydrogen reduction steel construction method is commercialized, it will require up to 3.7 Mt of green hydrogen a year, which is expected to make POSCO the largest hydrogen demand company and producer. It will also develop technology to extract hydrogen from ammonia considered key technology for hydrogen transportation and storage. Ammonia is a combination of hydrogen and nitrogen and is considered the best material for the efficient and economical transportation of hydrogen.

# Economy & Steel Market Scenario

## GLOBAL ECONOMY

As the COVID-19 vaccine started rolling out in many countries, the World Bank expects that the global economy will expand 4% in 2021, but will still remain more than 5% below its pre-pandemic trend.

Although the global economy is growing again after a 4.3 % contraction in 2020, the pandemic has caused a heavy toll of deaths and illness, plunged millions into poverty, and may depress economic activity and incomes for a prolonged period.Top near-term policy priorities are controlling the spread of COVID-19 and ensuring rapid and widespread vaccine deployment. To support economic recovery, authorities also need to facilitate a re-investment cycle aimed at sustainable growth that is less dependent on government debt.

The big winners are likely to be countries like China and South Korea that succeeded in suppressing COVID-19 early. China's economy is projected to grow in 2021 by 8%, over twice that of the most successful western countries even before the pandemic.China's export-led economy has actually benefited from lockdowns in western countries. Western demand for services like entertainment and travel may have declined, but demand for household consumer goods and medical supplies has increased. Chinese exports to the US have reached record levels despite the high tariffs imposed by the Trump administration.

China is also expanding its economic influence throughout Asia, with a new free trade area in the Pacific and huge infrastructure projects along its trade routes to Europe and Africa. It is investing in advanced technologies to reduce its dependence on western supply chains for components such as semiconductors. China could now overtake the US as the world's largest economy within five years, twice as fast as previously predicted.

## GLOBAL STEEL SCENARIO

China's domestic steel market is likely to see higher prices in 2021, especially in the first half of the year, given the possibility of a relatively tight supply and demand balance. Raw materials prices would provide steel market support too.

China issues revised steel 'capacity swap' guidance draft for the domestic steel industry on installation of all the new domestic iron- and steelmaking capacities. This covers removal of old or inefficient iron- or steelmaking capacities by steelmakers and the installation of new facilities of similar capacity. The guideline encourages Chinese mills to switch from BF-based steelmaking to more eco-friendly steel production employing technologies such as EAF, Corex, Finex and HIsmelt-based steelmaking.

The strong recovery in South Asia's steel markets have surprised despite the extent of widespread economic damage inflicted via lockdown imposition at the start of the pandemic. The sustenance of this recovery or a further uptick hinges on effective management of spike in infections post festivals; receding of pent-up demand after an initial reflex; strong raw material prices; fiscal constraints on infrastructure push; political and social stability; economic reforms as well as global growth. With a strong GDP outlook for South Asian economies in 2021, steel companies stand on strong footing when it comes to their domestic markets, with an added attraction to boost export realizations.

Regarding the new capacities due to come online, the current steel capacity of 89.5 Mt in the ASEAN region will increase to 157.2 Mt, while demand only increases by 5% each year. This will create a huge imbalance. And bring down profitability in the region.

Rising steel prices and surging demand in China arenot helping the profits of steel mills, due to surging iron ore prices.

The price of cold-rolled sheet, used in manufacturing and the vehicle sector, rose to  $867.58/t from last year's low of $584/t on April 29.

**INDIAN ECONOMY**

Indian economy is estimated to contract 7.7% in 2020-21. There will be a contraction in almost all sectors with the exception of agriculture.

The economy contracted by 23.9% in the first quarter and 7.5% in the second quarter pushing India into its first recession. India's economy was already in trouble when the pandemic hit. The real GDP growth had moderated from 7% in 2017-18 to 6.1% in 2018-19 and to 4.2% in 2019-20, the lowest in a decade. The sharp fall in GDP growth this year will be the first contraction in four decades (after 5.24%contraction in 1979-80) and the steepest one since independence.

**INDIAN STEEL SCENARIO**

The Indian steel industry, which suffered severe adverse effects of the drastic fall in domestic demand in the first five months, staged a surprising comeback in the latter part of the year. Large integrated steel players are likely to see their market dominance increase this year, with both prices and volumes picking up since September and expected to hold stable till the March quarter. This would make them stand apart in a manufacturing sector that has been battered by covid-19. For integrated players, the recent performance is a far cry from April, when they were reeling under the side effects of a national lockdown. Blast furnaces were either shut or kept running without any actual production of liquid. By May, with domestic demand for steel continuing to be negligible, Indian mills started producing solely for low-margin exports, to keep the furnaces operational. With a proof of a more broad-based pickup in economic activity with every passing quarter, the recovery in domestic steel demand will sustain in the near term at least.

The share of the top six domestic steel producers in total crude steel production rose to 65% in recent months, compared to a historical average of 55%. Their capacity utilization was 85%, against a long term industry average of 78%. Smaller secondary steel producers are operating at capacity utilization rates of about 65%, indicating the rising dominance of large steel players in the domestic industry and an adverse impact of pandemic on the business performance of some smaller steel producers, which would find it difficult to operate at pre-Covid levels in the near term.

The credit ratings agency revised its FY21 steel demand forecast to a contraction of around 12%, significantly better than its initial forecast of 23% in April. ICRA Senior vice president & group head corporate sector ratings Mr Jayanta Roy said "The revival in demand has been surprising, and the steel industry's ability to claw back to the pre Covid levels of demand within six months of the pandemic has been remarkable."

Lower coking coal price and surge in iron ore prices have helped Indian steel plants, especially integrated plants. China's ban on Australian coking coal has made it cheaper.The production cost of India's steel producers using the blast furnace route would come down by approxRs 1800/t due to reduced cost of coking coal per tonne of around Rs.7,300. It is expected that Australia premium hard coking coal (HCC) CNF prices would be around $120 per tonne over remaining FY21, except for any weather-related supply disruptions in Australia. Higher iron ore price has led to increased international prices of steel items.

Tata Steel CEO and Managing Director Mr TV Narendran said that the steel demand in India should grow at least at the rate of GDP growth or higher in 2021-22. He expressed optimism about the demand for steel in India in 2021, backed by inflow of funds from across sectors and an uptick in the overall consumption. He said "Government's efforts to improve infrastructure coupled with the Atmanirbhar Bharat' policy and the Production Linked Incentive initiative. Additionally, the government's focus on rural infrastructure projects will also give an impetus to the steel demand. We are optimistic about the overall demand for steel and hence the performance of the steel industry and Tata Steel."

He added "Globally, steel prices were likely to stay firm as China was not expected to export large volumes owing to a better balance in their domestic market, and there were no other very significant exporters in the world market."

Ms Soma Mondal, Chairman SAIL explained that domestic prices were impacted by international prices besides the forces of demand and supply. "There is an increase in demand in the international market. Iron ore prices are at around $150 a tonne, which has an impact on global prices. Indian prices cannot be insulated from that," She also pointed out that because of the perked-up demand in the domestic market, steel companies had reduced exports substantially. The industry expects the strong demand to continue for the next few quarters. Most companies in the first quarter posted losses; SAIL recorded a loss in the first quarter, but had a profit in Q2. The third quarter will also be good, given the good market conditions.

**Surge in Prices of Steel, Scrap and Iron Ore**

Steel prices have been on the rise since July 2020 in line with international prices. International prices for HRC increased from $397 a tonne to $750 tonne. Domestic steel prices have touched a record high, adding to cost pressures on automobile and consumer durable makers at a time when demand is starting to rebound from the impact of the pandemic.Prices of hot rolled coil (HRC), a key indicator of the price trend in flat steel, have risen to their highest-ever of Rs. 58,000/ tonne on average. Local steel prices move in tandem with the global average, which is influenced by Chinese demand.

The Chinese government's $550 billion stimulus to revive its economy has swelled the nation's appetite for steel at a time when steel exporting nations such as Japan and South Korea have curtailed production. This mismatch in demand and supply has sent global steel prices rocketing. Steel prices are likely to increase further in the coming months due to high prevailing iron ore price and continued demand.

While domestic steelmakers ensure prices stay below the cost of imported steel, the recent price hike saw domestic steel at a 6% premium to the imports from South Korea and on a par with China for the first time since April.However, given the lead time for imports stretches well into the June quarter, steelmakers are confident that imports won't threaten domestic sales.

The rebound of steel production globally has caused both iron ore and ferrous scrap prices to spike in the final two months of 2020. Prices of iron ore, a principle raw material for the steel industry, has increased by over 100% in the last few months. Iron ore prices started the new year with a bang due to unprecedented demand from China due to lower off take from Australia and curtailed production in Brazil. In December, the steelmaking raw material hit its highest level since September 2011 after gaining nearly 80% during the year. The benchmark 62% Fe fines imported into Northern China were $165.29 a tonne in the first week of January.China is importing more iron ore from India to meet demand for its infrastructure projects and also because it has stopped importing the ores from Australia following fissures in their bilateral relations. China's import of iron ore from India rose 73% during April-November period of the current fiscal compared with the year-ago period.

The demand has forced government-owned National Mineral Development Corporation to hike ore price twice since last month.NMDC iron ore prices increased from Rs 1,960 a tonne in June to Rs 4,610 a tonne in December

The Union Government is considering imposing floor prices for export of iron ore to ensure that high-grade ores are not shipped out in the garb of ore fines.

In line with iron ore prices, another input for steel production viz scrap is also getting dearer. Scrap prices have soared to well above US$450/t.

Industry bodies representing these sectors, medium and small enterprises, and Union minister Nitin Gadkari had complained to the Prime Minister's Office in December on the repeated increases in steel prices, which is affecting production, consumer demand and implementation of infrastructure projects.

Steel industry's representative body Indian Steel Association (ISA) urged the PMO to impose a temporary ban on exports of iron ore for six months to tide over the present supply crisis which is resulting into price rise of the raw material and causing steel price hike.The Steel Minister assured to look into imposing a short-term ban on exports of iron ore in wake of domestic shortage

The Federation of Indian Mineral Industries (FIMI), in its letter to the PMO on December 31, said the ISA letter was obfuscating the whole issue and justifying the unjustifiable increase in steel prices. They are calling for withdrawal of import and other duties meant for shielding the domestic steel industry which, they believe, has indulged in 'profiteering' taking undue advantage of the current market situation. "Duplicity of steel producers about shortage of iron ore is well exposed as some of the primary steel producers are themselves exporting iron ore. The very fact that steel companies are exporting iron ore means that there is no shortage of iron ore, otherwise they would have utilised it in their steel plants," FIMI said.

Above all, almost all major steel players now have their captive sources where iron ore is available to them at transfer prices. FIMI said while the Indian steel industry fixes its prices almost at par with the international level; Indian ore prices are always much lower than the international prices.

FIMI said there was no need to ban iron ore exports as in future, steel will be produced through recycling. The production could increase gradually once ample scrap is generated for reuse.FIMI said India recycled 25 Mt of steel last year, accounting for 28% of 90 Mt of crude steel produced in the country.

# Special Features

## Sustainable Steel - Indicators 2020 and Steel Applications

worldsteel published Sustainable steel - Indicators 2020 and steel applications. The publication features the steel industry's sustainability performance via its 8 sustainability indicators and focuses on 3 key steel applications from a life cycle perspective: automotive, construction and packaging.

A life cycle assessment (LCA) of a product provides a full picture of its environmental performance as it accounts for resource and energy consumption as well as all emissions to air, water and land. LCA also considers all stages of a product's life, from the raw material extraction stage to its end-of-life stage, including reuse and recycling. An LCA approach must therefore be considered for the development of appropriate legislation to ensure that the true environmental impact of products is assessed correctly and consistently, avoiding any unintended consequences.

Construction, automotive and packaging are examples of three key steel market sectors where life cycle thinking is being incorporated into regulations or standards. A more widespread use of LCA in other applications is crucial to minimise the overall environmental impact of products throughout their whole life.

Nine steel companies were recognised by worldsteel as Steel Sustainability Champions for their work in 2019; ArcelorMittal, BlueScope, China Steel Corporation, JSW Steel Limited, Nippon Steel Corporation, Tata Steel Europe, Tata Steel Limited, Tenaris and Ternium. Not only did they provide data for each of the indicators and for worldsteel's life cycle inventory (LCI) database, but also a programme or initiative of these companies was shortlisted for one of the 5 categories of the annual Steelie Awards, or Safety and Health recognition programme.

worldsteel uses 8 indicators to measure key aspects of the steel industry's economic, environmental and social sustainability performance. A total of 104 steel companies representing 1.1 billion tonnes of crude steel production contributed data – this covers nearly 60% of global crude steel production.

| Sr. No. | Environmental performance | Unit | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|
| 1 | $CO_2$ emissions | Tonnes $CO_2$/tonne crude steel cast | 1.84 | 1.81 | 1.83 |
| 2 | Energy Intensity | GJ/tonne crude steel cast | 19.85 | 19.54 | 19.84 |
| 3 | Material efficiency | % of materials converted to products & co-products | 96.49 | 96.33 | 97.49 |
| 4 | Environmental management systems (EMS) | % of employees & contractors working in EMS-registered production facilities | 96.55 | 97.08 | 97.15 |
| | **Social performance** | | | | |
| 5 | Lost time injury frequency rate | Injuries/million hours worked | 0.97 | 0.84 | 0.83 |
| 6 | Employee training | Training days/employee | 6.26 | 6.36 | 6.89 |
| | **Economic performance** | | | | |
| 7 | Investment in new processes and products | % of revenue | 5.76 | 6.10 | 7.07 |
| 8 | Economic Value Distributed | % of revenue 95 | 95.36 | 93.84 | 98.02 |

## Potential Impact of COVID-19 on Steel Industry Trends

The COVID-19 outbreak has already given a significant boost to both technological progress and the green transition which are the two main transformational forces of this century.

The accelerated speed of change is not likely to stop.

Increased adoption of e-commerce and online services, online work and education tools will support the development of new enhanced technological tools and services, creating a self-reinforcing cycle for technological progress.

Concerning the green transition, the COVID shock-induced increase in awareness of the looming environmental risks will almost certainly lead to increased public pressure on governments and businesses for an acceleration in mitigation of risks. It will increasingly be required of them to take the necessary adaptation measures to protect people (preparedness).

We already see some countries announcing “green recovery packages” that place supporting renewable energy development and decarbonisation technology development at the centre of their plans for economic recovery from the pandemic.

Let’s now consider the resulting industry-specific consequences of an accelerated green transition and a technologically progressive environment for the global steel industry.

1. **Increased focus on decarbonisation**

   Our efforts towards decarbonisation are likely to receive a boost from the COVID-19 pandemic.

   Investments in energy efficiency, electrification and higher scrap use, and efforts towards the development of breakthrough low CO2 emission steelmaking technology are likely to be accelerated.

2. **Accelerating product portfolio evolution**

   Our product portfolio has always evolved in response to changing requirements of steel-using industries.

   However, the pandemic most likely accelerated some of the changes we expected to see in our customers’ requirements.

   So, we will need to accelerate our efforts in providing steel solutions for zero-emission mobility, smart & green buildings, solutions for climate change adaptation projects and infrastructure modernisation.

3. **Increased focus on the life cycle and circular economy characteristics of steel**

   The pandemic is likely to underpin the global steel industry’s efforts towards studying the life cycle and circular economy characteristics of its products, towards improving these characteristics and communicating the superior attributes of its products very strongly.

4. **Increased focus on collaboration: sustainability partnerships**

   The massive scale of the climate change challenge will require increased collaboration with the following partners:

   - **energy and chemical companies:**

     for decarbonisation in carbon capture and use projects and hydrogen steelmaking, and the use of steel co-products and recycled gases.

   - **steel-using industries:**

     in the design phase for the development of the appropriate steel solutions for smart and green applications.

   - **our supply chain:**

     for meeting ESG standards and transparency, better management of steelmaking materials involving sorting and beneficiation processes that will result in a smaller environmental footprint.

     worldsteel is setting up a membership expert group to review in detail how the five identified key megatrends will shape the global social and economic landscape and the steel industry value chain in the years and decades to come.

*Source : Worldsteel*

# Technology, Product Development and Application

### JFE Steel's 1.5 GPa CR Steel Adopted in Vehicle Structural Parts

JFE Steel Corporation announced that its 1.5 GPa grade, 1470 Mega Pascal, high tensile strength cold rolled steel sheets are now being utilized in vehicle body structural parts, the world's first such adoption in a cold press forming application. This constitutes the highest strength of vehicle body structural parts obtained through cold press forming. The steel sheets are being utilized in several applications by automakers, and JFE Steel has begun supplying these sheets to auto parts suppliers.

In order to protect vehicle occupants in the event of a collision and improve fuel economy through weight reductions, efforts are on going to increase the strength of vehicle body structural parts. JFE Steel's 1.5 GPa grade high-tensile strength cold-rolled steel sheets are already being utilized in parts with simple shapes, such as bumpers and door impact beams. However, the adoption of high tensile strength cold-rolled steel sheets for vehicle body structural parts with complex shapes has been limited to the 1310MPa grade until now, because increasing the strength of sheets can result in decreased cold press formability and delayed fracture resistance. To overcome with these issues, the adoption of 1.5 GPa grade high-tensile strength steel sheets through a hot press forming process2 is becoming more widespread. However, this requires the steel to be heated to high temperature and then maintained at constant temperatures for cooling, which decreases the number of parts that can be pressed per unit of time. Improvements have therefore been desired from a number of perspectives, including manufacturing costs.

With the new 1.5 GPa grade steel sheets, the high cooling capacity of the proprietary water quenching method based continuous annealing process line located at JFE's West Japan Works in Fukuyama District was used to reduce the addition of alloy elements and minimize non uniformity of the steel sheet microstructure. As a result, particularly high yield strength and delayed fracture resistance were simultaneously realized even with the 1.5 GPa grade high tensile strength steel sheets while maintaining cold press formability equivalent to that of 1310 Mega Pascal grade sheets. This enabled the utilization of the 1.5 GPa grade high tensile strength steel sheets in vehicle body structural parts through a low cost cold press forming process.

*Source: SteelGuru Business News*

### Baosteel Develops 2100 MPa Bridge Cable Wire

Baosteel has recently developed and trial produced 2100 Mega Pascal and 2160 Mega Pascal multi alloy coated bridge cable wires. All of the performance indexes, as appraised by scientific and technological achievements in Shanghai, meet the engineering application standards and reach the international advanced level and will better meet the needs of large-span high tech bridge construction.

This is another success after Baosteel's 2060 Mega Pascal bridge cable wire reached the highest strength grade in the world. 2060 Mega Pascal grade steel was developed by Baosteel in 2020, which completed the second batch of 800 tonnes of cable steel wire trial production and passed the evaluation. Baosteel has signed a supply contract of nearly 10,000 tonnes of wire rods and wires for Lingdingyang Bridge of the Shenzhen Zhongshan Transportation Project.

### POSCO to Expand Supply of Steel for LNG Fuelled Vessels

POSCO is focusing on liquid natural gas powered vessels as global demand for these eco friendly ships is expected to grow fast. The fuel tanks of these vessels are built with special steel as they store ultra low temperature LNG. POSCO expects the LNG fuel tank market to grow in earnest staring from 2021. So it is considering expanding the supply of 9% nickel steel and high manganese steel used for LNG fuel tanks. Nine percent nickel steel is the most commonly used steel for production of LNG fuel tanks. It is characterized by excellent strength: It does not break even at minus 163 degrees Celsius. POSCO has supplied 9% nickel steel products for the construction of the world's first LNG fuelled bulk carriers, which were built by Hyundai Samho Heavy Industries.

High manganese steel is also used for LNG fuel tanks. POSCO has developed high manganese steel on its own. High manganese steel is not much different from 9% nickel steel in terms of quality. But it has an advantage as manganese is cheaper than nickel and its reserves are more abundant. POSCO started research on high manganese steel in 2008 and completed the development of mass-production technology in 2013.

Originally, the International Maritime Organization had allowed only four types of steel to be used for LNG fuel tanks- nickel alloy steel, stainless steel, nine percent nickel steel and aluminium alloys. But high manganese steel was added two years ago. In December 2017, POSCO supplied high manganese steel for the construction of the 50,000 tonne Green Iris, the world's largest LNG fuelled bulk carrier at the time.

The POSCO Research Institute predicts that the global market for LNG-fuelled ships will grow from 20 trillion won in 2020 to 130 trillion won in 2025. It forecasts that 2,500 to 3,000 LNG fuelled ships will be ordered by 2029. It also predicts that 60% of the ships built in Korea will be LNG-fueled in 2030.

*Source: Steelguru*

**Intelligent Qualification for Stainless Steel by Fives**

AcciaiSpeciali Terni, an integrated cycle stainless steel manufacturer, has entrusted Fives, an industrial engineering group, with a quality qualification project for its flat production facility in Terni, Italy. The project is an essential part of the digital technology improvement plan, prioritized by AS Terni.

Fives has proposed a digital solution - EyeronTM, a real-time quality qualification system that automatically captures and analyses data from different steel processes to give operators a clear view of product quality.

**Smart tracking**

Bringing together data from the laboratory, steel making, surface inspection, production orders and quality claims, Eyeron™ replaces the need for separate software tools and allows smartly to track any quality issues:

- Control automatically the quality of each coil in real time
- Recommend coil reassignment based on the end-customer quality target
- Predict occurrence of surface defects according to specific process conditions on upstream lines

AcciaiSpeciali Terni decided to opt for the EyeronTM system due to its fully automatic features of product qualification and ability to adapt to their complex operational needs. "We appreciate its flexibility to interconnect our databases into a single platform and implied advantages," says Antonio Iaia, Innovation Manager at AcciaiSpeciali Terni. "Eyeron™ will allow us to extract useful information from an automatic visual inspection system to control more precisely product and process quality and take thoughtful decisions. It will help us to reduce considerably downgraded and scrap coils and decrease a time-consuming process to track production quality issues."

In 2018, Eyeron™ was successfully installed in the steel shop, the hot rolling mill 2000 and the plate rolling shop N2 of Severstal, a leading Russian steelmaker. It also received an award as a breakthrough digital solution at the French-Russian forum "Industry of the Future" in 2019.

**POSCO Implementing Smart Technologies to Make Steel Plants Safer**

Posco has implemented various smart technologies to prevent industrial accidents and ensure safety for its employees. Posco recently introduced drones to its plants. In the past workers had to use ladders and climb about 100 meters to check sinter plants for defects, but now drones take care of that task. Drones are useful not only for risky tasks, but have also improved efficiency for work that needs to be done in small, closed spaces.

Posco also uses robots to achieve efficiency in production while protecting its workers from injury. Automated robots clean off the impurities and residues that build up on the steelmaking equipment, protecting employees from exhaustion and from accidents that could cause suffocation or burns.

In addition, Posco is sharing the smart technologies with partner firms in the interest of synergy across its supply chain. Posco had established a task force at the end of last year, and worked with 15 partner companies and seven foundries to develop an automatic product recognition system using image recognition technology. The company has also advanced the data management system so that product orders can be processed promptly and accurately,

*Source: Steelguru*

**A $500 billion Smart City Project at NEOM, Saudi Arabia**

NEOM means “new future”. This is a $500 billion project in the northwest of Saudi Arabia. It will be a new model for sustainable living, working and prospering.

The project can be described as a “living laboratory”, where entrepreneurship will make the new future through investment and research on various fields that will bring about a promising future of sustainability and development. The city’s energy will be 100% through renewable energy, especially by solar and wind energy on which Saudi Arabia is currently investing heavily.

It is an ambitious project that Muhammad Bin Salman, the crown prince of Saudi Arabia, has announced to build a car-less, zero-carbon city with 1 million inhabitants and no roads, laid out as a 170km-long belt with services and transport infrastructure built underground so that there is no pollution, traffic and human congestion.

The absence of roads, and vehicles, will not inconvenience the city’s inhabitants since all essential daily services, such as schools, medical clinics, leisure facilities and well as green spaces will be located within a five-minute walk. A graphic produced by Neom shows trains and autonomous freight vehicles running in an invisible layer of infrastructure beneath the city.

For longer distance travel, inhabitants will have access to ultra-high-speed transit and autonomous mobility solutions with no journey longer than 20 minutes.

The city, which is being badged as part of the kingdom Vision 2030 strategic plan, will be run by artificial intelligence, enhanced by machine learning and 5G systems, that predicts ways to make life easier.

Construction of The Line will begin in the first quarter of this year and it will create 380,000 jobs and add $48 bn a year the kingdom’s GDP by 2030.

# News Watch

## Indian Steel Plants

**India Finalises Production Linked Incentive for Special Steels**

India's steel ministry has finalised a plan for specialty steel manufacturing under the Production Linked Incentive scheme. The ministry has proposed a three incentive slab of 3%, 6% and 9%. The PLI per company will be subject to a ceiling of INR 200 crore and the outlay for specialty steel is marked INR 6,322 crore for the five year period.

The highest rate of a 9% incentive will be made available for commencing production of steel products that are entirely being imported into the country, like pipes and tubes for the oil and gas industry and head-hardened steel rails.

The second incentive level of 6% will be offered for achieving incremental domestic production of electro-galvanized steel and tin-coated steel products and with the potential of achieving export capabilities within the period of the next five years.

The third level of incentive of 3% will be available for incremental production of aluminium-zinc coated steel and heat-treated hot rolled coils.

Producers of rebars, stainless steel and alloy steel products have also approached the government to be made eligible for the PLI, but the ministry is yet to take a decision on creating incentive levels for this segment.

Indian government has approved INR 1.45 lakh crore plans in November under the PLI for 10 sectors for a period of five years to augment domestic manufacturing and enhance export capabilities. The 10 sectors include Pharmaceuticals, Telecom, Automobile, Textile, food processing, solar, white goods, specialty steel amongst others.

**Primary Steelmakers to offer Preferential Pricing to MSMEs**

Indian primary steelmakers have introduced new schemes to supply steel at preferential prices to micro, small and medium enterprises (MSMEs), amid complaints from MSMEs and the Engineering Export Promotion Council (EEPC) about rising price of the raw material.

JSW Steel, Tata Steel and Jindal Steel and Power Ltd have introduced exclusive pricing schemes for MSMEs, while ArcelorMittal Nippon Steel (AMNS) said that they always supply steel at export-parity prices for MSMEs.

**Steep hike in Steel Prices to steer Indian Steel Plants to a Record Financial Performance**

Indian steel mills are estimated to report record high earnings in the December quarter and the rest of the year due to skyrocketing steel prices and a visible rebound in infrastructure and consumption demand. It is expected that the steel sector will stage a splendid turnaround on the back of a price uptick, the operating profit per tonne for ferrous is likely to be near the peak of the previous cycles in the past 15 years.There is Ebitda growth of around 152% year-on-year on an average. Prices rose by an average Rs 7,300/tonne to Rs 49,000 - Rs 52,000 per tonne in Q3.

A rally in steel prices to an all-time high has resulted in a stellar showing for bankrupt steel assets that were among the earliest to be auctioned under the Insolvency and Bankruptcy -- Tata Steel BSL (formerly Bhushan Steel) and JSW Ispat Special Products (formerly Monnet Ispat& Energy) and Vedanta-owned ESL Steel. Tata Steel BSL has posted a profit of Rs 913.19 crore in the December quarter, its highest since its acquisition by Tata Steel in 2018.

**Main Features in Budget 2021-02-01 for Iron & Steel Sector**

MSMEs and other user industries have been severely hit by a recent sharp rise in iron and steel prices. Therefore, Customs duty has been reduced uniformly to 7.5% on semis, flat, and long products of non-alloy, alloy, and stainless steels. To provide relief to metal re-cyclers, mostly MSMEs, duty on steel scrap has been exempted for a period up to 31st March, 2022. Further, the budget also revoked ADD and CVD on certain steel products.

Thus, Iron and Steel melting scrap, including stainless steel scrap upto 31.3.2022 custom duty will change from 2.5% to Nil. Primary/Semi-finished products of nonalloy steel from 10% to 7.5%. Flat products of non-alloy and alloy-steel from 10%/ 12.5% to 7.5% and Long products of non-alloy, stainless and alloy steel from 10% to 7.5%.

## STEEL AUTHORITY OF INDIA LTD. (SAIL)

### Smt. Soma Mondal assumes charge as Chairman, SAIL

Smt. Soma Mondal has taken over as Chairman of Steel Authority of India Limited (SAIL)w.e.f. 01.01.2021. She was the Director (Commercial) of SAIL prior to this. Before joining SAIL as a Director, Smt. Mondal was the Director (Commercial) at NALCO.

After assuming the charge on the first day of the year, she addressed the SAIL collectiveand said, "SAIL has a rich legacy with enormous contributions from its employees and leadership over the decades. It has been at the forefront of the nation building."There's a little bit of SAIL in everybody's life" isan apt description of SAIL's importance as a trusted steel maker to the nation."She added, "SAIL is a colossal organization, with multi-locationproduction units &mines, wide ranging product basket and diverse workforce.People are its greatest strength and with synergized efforts of the entire Team SAIL, we will strive to attain higher summit". "Our immediate focus is to improve the top-line and the bottom-line of the company. We are charting out all strategies to improve value for all our stakeholders and make it structurally stronger", she asserted.

Smt. Mondal was instrumental in introducing new marketing strategies and products at SAIL enriching the company's product basket. Under her able leadership, the company launched niche branded products like NEX (Structural) and SAIL SeQR(TMT bars). Both these products have emerged as best-in-class in their respective categories.

### SAIL reports Net Profit of Rs 1,468 crore in Q3

SAIL reported a net profit of Rs 1,468.20 crore during the December quarter of FY 21, as against a net loss of Rs 343.57 crore during the same period last year, mainly on account of increased steel demand.

SAIL has shown overall improvement during the current financial year despite all the challenges. The Company is confident of improving the performance further in the remaining period of the financial year.

Company's revenue from operations increased 20% to Rs 19,835 crore during the December quarter, while total expenses amounted to Rs 16,406 crore, a reduction of around 5.2% y-oy.

During the quarter under review, hot metal production was recorded at 4.8 Mt, growth of 12% y-o-y and saleable steel production at 4.15 Mt, growth of 6% y-o-y. Total sales including domestic and exports were at 4.15 Mt, growth of around 1% y-o-y.

In sectors like infrastructure, construction, manufacturing and automobiles, there has been a relatively rapid recovery. As these sectors are major steel consumers, the recovery in them has helped the up-rise in demand in the domestic steel sector," the company said in a statement.

The company's earnings before interest, taxes, depreciation and amortization was at Rs 5,294 crore, as against an EBITDA of Rs 1,186 crore.

SAIL achieved the best ever quarterly production of Hot Metal, Crude Steel and Saleable Steel during the quarter ended 31st Dec-20, and witnessed a handsome growthover CPLY.

The sales volume of the company has also registered a growth. The total sales (including domestic and exports) grew by 5.6% during the Q3 FY'21 over CPLY. The total sales in the 9M period of April – December 2020 also increased marginally.

Smt. Soma Mondal, Chairman, SAIL commented, "During this financial year, the company has continuously enhanced its production volumes. The first quarter was impacted due to the onset of the pandemic but gradually we have scaled up our performance

**Production Performance in FY21**

| | Q3:FY21 | Q3:FY20 | % Growth | 9M: FY21 | Q2:FY21 | Q1:FY21 |
|---|---|---|---|---|---|---|
| Hot Metal (Mt) | 4.80 | 4.30 | 12% | 11.60 | 4.13 | 2.70 |
| Crude Steel (Mt) | 4.37 | 4.00 | 9% | 10.60 | 3.82 | 2.50 |
| Saleable Steel (Mt) | 4.15 | 3.90 | 6% | 10.20 | 3.75 | 2.30 |

*Mt is Million Tonnes

**Sales Performance in FY21**

| | Q3: FY21 | Q3: FY20 | 9M: FY21 | Q2: FY21 | Q1: FY21 |
|---|---|---|---|---|---|
| Total Sales (MT) | 4.32 | 4.09 | 10.76 | 4.21 | 2.24 |
| Home Sales (MT) | 4.05 | 3.73 | 9.28 | 3.54 | 1.7 |
| Exports (MT) | 0.27 | 0.36 | 1.48 | 0.67 | 0.54 |

by enhancing the volumes. It is heartening that the pre-covid levels have already been reached and the production has grown over CPLY in the last quarter". She added, "The consistent growth reflects that SAIL is poised to grow steadily in future. The domestic steel consumption has a positive outlook as the economy is reviving and all sectors have started to pick-up. We are confident of seizing the unfolding opportunities in the steel market".

**Sale of Iron Ore Fines:** The Ministry of Mines, GoI has allowed SAIL to sell 25% of its total Iron ore production calculated on the basis of cumulative production of all captive mines in a state, as well as sub-grade minerals lying at the mine pit heads.In compliance of this notification, SAIL has already sold approximately 2.16 Mt of Fresh Fines through auction during the current financial year from its various mines. Around 0.3 Mt of Dump Fines and Tailings have also been successfully auctioned during this period. This has helped to alleviate, to some extent, the shortage of Iron Ore in the market.

**Deleveraging:** SAIL has significantly reduced the net debt from a peak of Rs 52,290 crores on 30th Apr-20 to Rs 44,308 crores on 31st Dec-20 – a reduction of Rs 7982 crores. The company continues its efforts to deleverage further.

### SAIL awarded with Golden Peacock Environment Management Award 2020

SAIL has been awarded with the prestigious Golden Peacock Environment Management Award for the year 2020 in the Steel Sector by the Institute of Directors.

Shri Anil Kumar Chaudhary, Chairman, SAIL lauded the efforts of SAIL collective and said, "SAIL has been the winner of this award for successive two years and this bears testimony to the efforts made by the Company for sustainable and environmentally responsible steel making. This award is one of the most coveted awards in the category. Considering various environmental issues leading to global warming and climate change, the award encourages corporates to enhance their environmental performance and to compete with peers to set benchmarks".

SAIL, as its Corporate Responsibility for Environment Protection continuously focuses on adopting various environmental measures including, upgrading of pollution control facilities, treatment & recirculation of wastewater from individual units & outfalls, enhancement in the green cover in & around Plants & Units, efficient handling of different solid wastes (viz. process waste, hazardous waste, canteen/township waste), carbon sequestration through afforestation, eco-restoration of mined out area, among others. Also, the impact of SAIL's initiatives and best practices on improving cleaner environment, reducing emissions & discharges, mitigating impacts of climate change and helping the Company to conduct its operations in environmentally benign manner has been recognized.

### SAIL recognizes Outstanding Employees for Extraordinary Efforts in SAIL Corporate Awards for Excellence 2020

SAIL gave away the SAIL Corporate Awards for Excellence 2020 by Shri Anil Kumar Chaudhary, Chairman, SAIL, in presence of the Functional Directors and CEOs.

Felicitating the award winning employees, Shri Anil Kumar Chaudhary said, "SAIL Corporate Awards for Excellence have been formulated with the objective to create a Company level platform for recognizing and awarding the exemplary performance and extraordinary contribution of the SAIL employees in various areas of operation.

The awards are given in three distinct levels viz. Best CEO of the year Award, Best ED of the Year Award and SAIL Corporate Awards for Excellence in ten categories. Shri DipakChattaraj, CEO, RSP was awarded the Best CEO of the Year Award for his exemplary vision and commitment towards taking the Plant to newer heights and setting benchmarks. The Best ED of the year award was jointly shared by Shri LN Mallik, ED (L&I) and Shri PK Dash, ED (Works), RSP. The other ten employees who received the SAIL Corporate Awards for Excellence in the ten categories were from various steel plants under SAIL.

## TATA STEEL

### Tata Steel's Sales Momentum Continues as Q3 Production grows 3% Y-o-Y

Tata Steel India reported a 3% y-o-y growth in its crude steel production at 4.60 Mt for the third quarter of the current fiscal with momentum continuing in sales, though constrained by lower opening inventory post a stronger sales during the second quarter of the fiscal.

Deliveries were 4.66 Mt in the third quarter, lower by 8% q-o-q and 4% y-o-y. Domestic deliveries sharply ramped up to 4.16 Mt. Exports shrank below 11% of overall deliveries.

Automotive & Special Products' segment deliveries grew 48% q-o-q on the back of improved demand, increased share of business from existing customers and new product approvals. Branded Products & Retail' segment deliveries grew by 5% q-o-q with B2C brands, Tata Shaktee and Tata Tiscon achieving best-ever quarterly sales. The company launched a new B2ECA brand "Galvanova" to serve the need of appliances, false ceiling and solar segments.

Industrial Products & Projects' segment deliveries were marginally lower. It achieved a 47% q-o-q delivery volume growth in high-end segments as it continued focusing on product mix catering to sub-segments like oil and gas, lifting and excavation and pre engineered buildings.

Gross revenue generated through 'Aashiyana', the online platform for individual home builders surged to Rs 222 crores in the third quarter, registering a growth of 40% q-o-q and 134% y-o-y.

During the quarter, despite planned maintenance shutdowns, the company was able to ramp-up steel production at Tata Steel Europe by 22% q-o-q and y-o-y. This was aimed at replenishing inventory ahead of improving market conditions and seasonally a better fourth quarter. While the third quarter steel sales volume declined 7% q-o-q and 10% y-o-y due to lower opening inventories and Covid-19 impact at beginning of the quarter, the mix of deliveries saw further improvements in the automotive and the engineering sectors.

### TSLP Consolidation aimed to Create Synergies for Growth

In line with the Chairman's vision to drive scale, synergies and simplification, and resolve to create value for all stakeholders, there has been reorganisationfor companies in Indiacovering listed and unlisted subsidiaries into four clusters. These business clusters are Long Products, Downstream, Mining and Utilities & Infrastructure. A step in this direction was taken recently with the Boards of Tata Steel Long Products, Tata Metaliks and Indian Steel and Wire Products approving the merger of the latter two companies into Tata Steel Long Products. Tata Steel Long Products Ltd, formerly Tata Sponge Ltd, is the lead entity for long products business. Tata Steel Downstream Products Ltd is the flagship for the downstream activities.

The proposed consolidation will create significant synergies and position the company towards future growth in the long products segment. The process is expected to be completed in the next 6-9 months.

### Tata Steel Reorganises 2 Downstream Business to TSDPL

Tata Steel has transferred its 51% stake it holds in Jamshedpur Continuous Annealing and Processing Company Private Ltd and 50% stake in Tata BlueScope Steel Private Ltd to wholly owned subsidiary Tata Steel Downstream Products Ltd, as part of reorganising its India footprint. The transactions were carried out on a non cash basis and Tata Steel Downstream Products Ltd issued shares to Tata Steel as consideration for acquiring the stakes.

Set up in 2012, Jamshedpur Continuous Annealing and Processing Company Private Ltd has an installed a capacity of 600,000 tonnes of cold rolling sheets targeting the auto sector.

Set up in 2005, Pune headquartered Tata BlueScope Steel Private Ltd manufactures Coated Steel, Roof & Wall Cladding Products and Pre-engineered Building Solutions. It has its manufacturing units in Jamshedpur, Sriperumbudur, Bhiwadi and Pune. Tata BlueScope Steel has an annual metallic coating capacity of 250,000 tonnes and colour coating capacity of 150,000 tonnes.

As on March 31, 2020, the net worth of Jamshedpur Continuous Annealing and Processing Company Private Ltd was INR 428.60 crore, while the same for Tata BlueScope Steel Private Ltd was INR 469.97 crore. While Nippon Steel of Japan is the other shareholder in Jamshedpur Continuous Annealing and Processing Company Private Ltd, BlueScope Steel of Australia is the partner in Tata BlueScope Steel Private Ltd.

### Tata Steel and CII Green Business Centre to develop GreenPro framework for Steel Rebars

Tata Steel has collaborated with CII Green Business Centre and relevant stakeholders in the Indian Steel sector to develop GreenPro framework for steel rebars, for first time in India. GreenProEcolabel enables the end-users to make an informed choice about buying steel having the lowest environment impact. The products with GreenPro label are guaranteed to be made of the highest quality standards and are sustainable as per the GreenPro standard. GreenPro certified products are also recognised in Indian Green Building Council (IGBC) green building rating system.

Steel rebars are key construction materials and have significant impact on the sustainability of buildings. There is a need for the Indian steel industry to reduce the environmental footprint during the manufacturing of steel products and supply steel having lowest environment impact for the Indian building sector.

GreenPro is a Type-1 Ecolabelling programme offered by the Confederation of Indian Industry (CII) Green Business Centre. So far, more than 125 building products and materials manufacturing companies have adopted GreenProEcolabel for 1800+ products and are available in the market for construction of Green Buildings.

Buildings and construction together account for nearly 36% of global energy use and 39% of energy related carbon dioxide emissions. Embodied carbon accounts for 11% of the building's emissions and is primarily from materials like steel, cement, concrete, glass, etc. The use of Green or low carbon materials has the potential to reduce the life cycle environmental impacts in the construction sector. Material efficiency strategies can reduce emissions due to construction, operations, and dismantling of homes by up to 50% to 70% in India by 2050.

Climate change is 'as real as daylight' and it is imperative for countries to strike a balance between economic development and protect the environment. Economy and ecology can coexist and green buildings are the need of the hour for this coexistence.

Tata Steel ensures that the technologies and processes used to manufacture products must optimise resources and be efficient. The Company aspires to develop Product Disclosures that complies to the leading Green Building Certification programs globally.

**Tata Steel launches 'Galvanova', a new generation steel**

Tata Steel has launched a new coated product brand named 'Galvanova,' a 55%Aluminium-Zinc alloy coated product, to address the evolving and unmet requirements of the Medium and Small Scale Enterprises (MSMEs) - Emerging Corporate Accounts (ECAs).

Sanjay S Sahni, Chief of Marketing & Sales (Branded Products & Retail), Tata Steel, said: "Over the last few years, Tata Steel has leveraged its technological capabilities to build a strong value-added steel product portfolio. The Company has introduced innovative products for a wide range of applications such as home appliances, the panel industry, and the automotive industry. The launch of Galvanova, a new generation steel, is part of the Company's portfolio-building plan focused on the appliances and the solar industry. This product has been created to meet the evolving needs of the micro-segments."

Galvanova is an all-weather durable product with superior corrosion resistance, and has distinctive white metallic sparkle in appearance. This environment friendly product is scratch protective and has cut-edge protection. Itsanti-finger print coating and brand marking adds to the brand's authenticity. The product's double layered protection coupled with excellent heat insulation properties enables longer life span of up to four times when compared to ordinary galvanised steel.

The product is suitable for various segments including Appliances, Heating Ventilation and Air Conditioning (HVAC), False Ceiling, Solar Applications, enabling a better yield while harnessing the power of endurance.

**Tata Steel features amongst the Top Five Companies in the Steel Industry in Dow Jones Sustainability Indices Corporate Sustainability Assessment 2020**

Tata Steel has ranked amongst the top 5 steel companies in Dow Jones Sustainability Indices (DJSI) Corporate Sustainability Assessment 2020. The results of the Assessment were declared by S&P Global in the second week of November 2020. The Company has retained its position in the DJSI Emerging Markets (EM) Index for the 9th year in a row. Tata Steel is one of the 11 companies from India and one amongst only two steel companies from Emerging Markets that have made it to the EM Index (comprising 100 companies).

Tata Steel Limited has been participating in the Corporate Sustainability Assessment (CSA) since 2012 and has been a member of DJSI Emerging Markets Index for nine consecutive years.

The DJSI Corporate Sustainability Assessment (CSA) is an annual evaluation of companies' sustainability practices since 1999. Each year over 7300 companies around the world are assessed on Economic/ Governance, Environmental and Social dimensions focusing on criteria that are both industry-specific and financially material.

**Tata Steel awarded the CII National Award for Excellence in Water Management 2020**

Tata Steel receives two recognitions at the 14th edition of CII National Award for Excellence in Water Management 2020 for its continuous efforts and commitment to water sustainability. Tata Steel Jamshedpur plant has been honoured with excellence in water management in 'Within the Fence' category. The CRM Bara Pond Project at Jamshedpur, East Singhbhum, has been identified as a 'Noteworthy Project in Water Management in the 'Beyond the Fence' category.

Tata Steel is committed to play a leading role in conservation of water and significantly reduce its impact on water. While the Jamshedpur operations has more than doubled its capacity from 5 Mt to 11 Mt over the last decade, the fresh water consumption has reduced to 62% in the last six years. The rejuvenation of the CRM Bara pond in the Bara area of Jamshedpur town now serves as a source of rainwater harvesting accumulating 82,320 $m^3$ of rain water while also reducing pollution, and playing a pivotal role in maintaining the biodiversity of the surrounding area. Besides, the ground water table has seen a rise post implementation of the project.

Tata Steel's continued commitment to sustainability has helped reduce freshwater consumption in Jamshedpur by 50% over the last 10 years. The Company's plans to rejuvenate waterbodies in the steel city will not only help in water harvesting but also reduce water pollution in the coming years.

**Tata Steel BSL Bags Apex India Green Leaf Award 2019**

Tata Steel BSL has bagged four Apex India Green Leaf Awards 2019 in Metal and Mining sector given by the Apex India Foundation in the category of Environmental Excellence, Energy Efficiency and Water Stewardship. Its plant located in Dhenkanal, Odisha made the company proud by bagging the Gold Award for outstanding achievement in Environmental Excellence. While its Khopoli plant in Raigad district of Maharashtra got the Platinum award for its outstanding achievement in Energy Efficiency and the Gold Award for outstanding achievement in Environmental Excellence and its Sahibabad plant in Ghaziabad district of Uttar Pradesh received the Platinum Award for outstanding achievement in Water Stewardship.

In its Dhenkanal plant in Odisha, it has been recognized for successfully installing CDQ and 250 TPH gas-fired boiler to increase green power. Besides interventions including waste management of hazardous elements, water conservation and re-cycling, improvement in ambient air quality in and around the plant, creation of site-specific rain water harvesting structures, rapid afforestation using Miyawaki method of plantation, etc helped the company bag the awards.

With the deployment of Sustainable Framework and Environment Policy, the steel major strives to build a culture of zero tolerance to environmental non-compliances with focus on reduction of carbon emissions, specific energy consumption, freshwater intake, waste generation, etc.

Its Khopoli plant in Raigad district of Maharashtra has shown immense competency in energy conservation and innovation in solid waste management, hot water generation systems, and installation of solar heating systems in the nearby colonies, efficiency improvement of Nitrogen Plant, installation of air amplifier reducing 25% air consumption, more use of LED lights, reduction in power consumption, Miyawaki plantation, etc. have improved the overall environment management of the plant drastically.

Similarly, appreciated for its incredible water stewardship, its Sahibabad plant in Ghaziabad district in UP has been efficiently harvesting 5.7 lakh cubic metres per annum rainwater and recharging the harvested rainwater underground to replenish the water aquifer. Besides stopping the waste of water, adoption of 9 ponds for recharge of ground water around the plant, artificial recharge in water scarcity zones, introduction of water-mist tap and water-free urinals have been highly appreciated.

## OTHER STEEL PLANTS

### JSW Steel's Net Profit Jumps 13 times to Rs 2,669 crore in Q3

JSW Steel recorded a 13 times growth in consolidated net profit for the third fiscal quarter compared to a year earlier on the back of better demand and restocking from automotive, machinery, construction and infrastructure sectors aided by increased government spending, the company said.

The Company posted a net profit of Rs 2,669 crore for the December quarter, compared with Rs 187 crore a year earlier. In the September quarter of FY 21, it had reported a 37% fall in net profit at Rs 1,595 crore. Consolidated revenue from operations rose 21 % y-o-y to Rs 21,859 crore, while standalone revenue grew 22% to Rs 19,239 crore. Operating earnings before interest, tax and depreciation expanded 142% to Rs 5,946 crore.

On the back of this strong demand environment, JSW Steel improved average capacity utilisation level of 91% for the quarter vs. 86% in 2Q FY 2021.

During the quarter under review crude steel production during the period stood at 4.08 Mt and standalone saleable steel sales at 3.90 Mt.

While the India operations reported the highest ever net profit in almost 10 quarters, the company's overseas businesses in the US and Italy reported EBITDA losses. The US based Plate and Pipe Mill in Texas facility reported an EBITDA loss of US $ 8.45 million for the quarter, US based HR coil manufacturing facility, Acero, reported a loss of US $ 21.26 million and the Italy based business reported an EBITDA loss for the quarter was US$ 21.26 million.

The company commenced production from the last of the three recently acquired mines in Karnataka on 10th December 2020.Overall volume from captive mines in the third quarter constituted 49 % of iron ore receipts of the Company.

The company said that the expansion project at Dovi from 5 Mtpa to 10 Mtpa steel making capacity is nearing completion, with the majority of operations to be commissioned in the current quarter. In Vijaynagar one out of two continuous galvanising lines (CGL) has been commissioned, and the second will be commissioned by the first quarter of FY 22.

### New Danieli Reheating Furnace in Operation at JSW Toranagallu

Danieli Centro Combustion India completed the scheduled start-up of the new, 220-tph walking-beam reheating furnace at wire rod mill #2 of JSW's Toranagallu site.

The furnace heats up cold billets with excellent temperature uniformity thanks to tailor-made burners along with proprietary Proportional High Low - PHL technology in the combustion control system.

Electrical and automation controls were provided by Danieli Automation India. Furnace dry-out was performed before the startup of the rolling mill.

Most of the commissioning was executed using remote connection. Very limited presence of Danieli experts for the last few days of hot commissioning was enough to complete tuning of the system and to achieve the first hot billet.

This 220-tph furnace is the third reheating furnace supplied by Danieli Centro Combustion operating at JSW and the second in Toranagallu. The 245-tph walking-beam furnace in operation at Dolvi since 2014, is the largest billet reheating furnace in operation in India.

**AMNS's Presentation to the Steel Minister on its Expansion plan at Hazira**

ArcelorMittal Nippon Steel India (AMNS India) welcomed India's Steel Minister Mr Dharmendra Pradhan at its Hazira manufacturing facility on January 4, 2021. AMNS India leadership made a presentation on the company's future plans. Mr Pradhan said "The Company has plans to expand its capacity at Hazira and is actively engaging to come up with a steel plant in Odisha. I am happy that AM/NS India has evinced interest for expanding its investment in Odisha, especially in the areas of value added & special steels."

AMNS India CEO Mr DilipOommen said "It is encouraging to receive the government's support to deliver on our promise of providing better steel to New India. AM/NS India is confident of sustainably meeting the growing steel demand through various products and significantly contributes to the Prime Minister's vision of an Atmanirbhar Bharat."

AMNS India's long-term production intention is to expand upstream and downstream capacity in a phased manner, and make a notable contribution to the country's steel needs by providing a spectrum of diversified and superior products.

AMNS is keen on expanding its current capacity to around 8.5 Mtpa from its current level of 7.5 Mtpa by debottlenecking its existing operations in the coming years."Our long-term production intentions to reach between 12 and 15 Mt of annual production still stands. In the short-term, the focus will be on debottlenecking our existing operations so we can increase annual production to around 8.5 Mt," stated the corporate's Chairman Aditya Mittal.

The slowdown following the March lockdown was safely and effectively managed, as was the ramp up as lockdown measures eased, enabling us to be again at full manufacturing ranges by mid-May, solely six weeks after the lockdown was initially initiated, Mittal stated.

In November the Company set a new monthly production record in Hazira. On the sales and marketing side, the national network of retail outlets, Hypermart, was extended, and two new high-strength steel brands, Stallion and Maximus, were launched.

AMNS can be planning to develop its downstream capabilities and enhance its capability to provide increased worth added auto merchandise in addition to introducing different high-value merchandise.

ArcelorMittal has now set a web zero 2050 goal and is continually trialing applied sciences that can scale back emissions.

"While this may not feel like the most pressing issue in India today, if we are to set new standards in Indian steelmaking we need to be as conscious of the long-term trends which will shape our industry as we are of the short-term challenges which occupy our thoughts daily," Mittal stated.

AMNS is also operating a 12 Mtpa capacity iron ore pelletization facility in Paradip. They are planning additional capacity addition of 8Mtpa for the pelletization plant and are also actively engaging to come up with a 12 Mtpa steel plant in Odisha.

**JSPL Posts Record Production & Sales in December**

Jindal Steel and Power Ltd has posted a record 30% jump in its standalone production and 25% growth in sales during December 2020. JSPL's total production from its plants in India was at 0.727 Mt in December 2020, up from 0.559 Mt in December 2019. Its standalone sales were at 0.711 Mt in December 2020 as against 0.567 Mt in December 2019.

For October-December 2020, JSPL has posted 1.926 Mt standalone production, up 20% YoY from 1.610 Mt in October-December 2019. During this period, the sales were at 1.876 Mt, up by 12% YoY compared to 1.671 Mt in October-December 2019.

The consolidated net profit after tax (PAT) is Rs 2,432 crore for Q3 2020 as compared to net loss of Rs 257 crore in December quarter of 2019. The company's earnings before interest, taxes, depreciation, and amortisation (EBITDA) surged by 170 per cent to Rs 4,252 crore from Rs 1,574 crore in the year ago period. "All operational assets except Australia reported positive EBITDA in Q3 FY21," JSPL said.

During the quarter under review, pellet production increased 3%y-o-y. External sales of pellets, however, reduced to 0.40 Mt (down 38%y-o-y) on higher internal consumption as steel volumes continue to ramp up.

**Indian Railways awards Regular Supplier Status to JSPL for 880 grade Rails**

Indian Railways has awarded the regular supplier status to steelmaker Jindal Steel & power limited (JSPL) to supply 60kg 880 grade (90UTS)Rails.

JSPL rails have been used in special freight corridors and High-speed Train projects. Soon, JSPL is planning to supply grade 1175 HT for heavyweight traffic rail tracks conceived by the Indian railway.

**Liberty Group buys SBQ Steels in its Second Bankruptcy Acquisition**

The UK based Liberty group has acquired the bankrupt 0.25 Mt SBQ Steels, culminating a three year process in which the Company was put into liquidation after initial efforts to sell it failed.

Liberty paid Rs 262.45 crore plus interest of Rs 8 crore to take the Nellore based steel company, its second acquisition through the bankruptcy process after acquiring the bankrupt AdhunikMetaliks and its associate Zion Steel in February 2020 under the insolvency law in a Rs 425 crore cash deal.

“Liberty outbid Switzerland based IMR Metallurgical Resources to emerge the highest bidder during liquidation with a Rs 262 crore offer. For Liberty this acquisition gives a foothold into the Southern market but only after investments in plant and machinery to get the company up and running.

The Liberty Steel Group has total rolling capacity of 18 Mtpa across UK, US and India. The late revival in interest by both IMR and Liberty came due to the upturn in the Indian steel market on the back of higher global demand.

SBQ Steels owned by the Chennai based RKKR Group, manufactures pig iron, sponge iron, steel billets, bars, and wire rods, catering to the requirements of automobile and engineering sectors, and also to the nuclear power industry. However, it has no direct iron ore linkage.

Located 15 km away from the Krishnapatnam Port in a 675 acre facility it gives Liberty the opportunity connect the plant with its facilities and iron ore from abroad. The steel plant also has two power plants with 45MW capacity each.

**Vedanta pledges to Carbon Neutrality & drives ESG best practices across the group**

Vedanta has signed a declaration on climate change by pledging to move towards carbon-neutrality at the Second India CEO Forum on Climate Change.

The mission is to take the country to net zero emission goal through specific emission measures, including the promotion of renewable energy, enhanced energy efficiency, water-efficient processes, green mobility, planned afforestation, and waste management & recycling.

Mr. Sunil Duggal, CEO, Vedanta Group said, “We as a company remain fully supportive of the govt. initiative to work towards a net zero emission goal and are committed to minimize our carbon footprint. At Vedanta we have a philosophy of ‘Zero Harm, Zero Waste & Zero Discharge’. We are well on course to substantially de-carbonize our operations over the next decade.”

Vedanta’s in-house Carbon Forum and Innovation Cells comprise of Global experts who are actively working on solutions that can help the company reduce its carbon footprint.

With a continuous focus on responsible mining, as of March 2020, the company has successfully reduced their GHG emissions by almost 14% from 2012 baseline levels, this will help reduce more than 9 Mt of $CO_2$ from the atmosphere. They generated 582 Million Units of Renewable Energy last year and have achieved 6 Million Giga Joules of Energy savings in the last 3 years. 70 projects have been implemented across various locations for the conservation of energy. In addition to setting up 40 Mega Watt solar project, wind farms with capacity of 274 MW were installed in 5 states across India.

**Jindal Stainless (Hisar) Ltd Merges into Jindal Stainless Ltd**

The Board of Directors of Jindal Stainless Limited and Jindal Stainless (Hisar) Limited have approved the merger of Jindal Stainless (Hisar) Limited into Jindal Stainless Limited. As per the proposed structure, the mobility business of JSL Lifestyle Limited, a domestic subsidiary of Jindal Stainless (Hisar) Limited, would be merged into Jindal Stainless Limited. Non-mobility businesses would be carved out as a separate new entity, named Jindal Lifestyle Limited. Post restructuring, Jindal Stainless Steelway Limited and Jindal Lifestyle Limited will operate as Indian subsidiaries, while overseas operational subsidiaries of Jindal Stainless Limited in Spain and Indonesia will continue to operate as business units of merged Jindal Stainless Limited. With the appointed date of April 1, 2020, the merger process is expected to be completed in H2 FY22. The merger is subject to approvals from statutory authorities, shareholders, creditors, and NCLT.

**Jindal Stainless (Hisar) Limited (JSHL) awarded the first prize at the prestigious ‘Global Environment Awards 2020’ in the ‘Platinum’ category**

Established in 2010, the Global Environment Awards recognise outstanding contributions by individuals and organisations in the field of sustainable environmental practices.

The virtual award ceremony took place on December 16 and was organised by the Energy and Environment Foundation. Jagmohan Sood, a Director of Jindal Stainless (Hisar) commented, “JSHL is committed to sustainable manufacturing and is seamlessly optimising its energy consumption at the Hisar facility. The company has significantly increased its use of environment-friendly bio-fuel, as part of its total thermal energy consumption, by a margin of 157% in the last two years. As a business philosophy, we believe that environment is a key stakeholder in our industry. This award is a testimony to our efforts in this direction."

JSHL has undertaken several steps in pursuit of sustainable business. The company has successfully reduced its Specific Energy Consumption (SEC) by 6.3% over the last three years. As a consequence, it has successfully reduced its carbon footprint by 16.6kt over the period. The company has undertaken major initiatives aimed at reducing traditional energy consumption, including the replacement of conventional lights with LED lights, the installation of high-efficiency water pumps, and the adoption of a 650 kW rooftop solar PV system. The company claims that these steps have helped it to reap the benefits of clean energy, zero $CO_2$ emissions, and annual power generation of 8.5 lacs kWh. All these efforts led to JSHL becoming the first stainless steel plant in India to receive ISO 50001:2018 certification.

**Mukund Divests in MukandSumi Special Steel to Jamnalal Sons**

The Jamnalal Sons have completed the first tranche of agreement with Mukund on December 31, 2020 by acquiring nearly 1,24,75,723 equity shares of MukandSumi Special Steel Limited, constituting 30% of the issued and paid up equity share capital. The first tranche is completed for consideration of over INR 713.61 crores. Mukund said "After completion of the aforesaid transaction, the Company will continue to, inter alia, retain ownership of its alloy steel manufacturing assets in Ginigera in Karnataka & income derived from the sale of its alloy steel products, manufactured in Ginigera in Karnataka, to its joint venture, MukandSumi Special Steel Limited.".

Mukand Sumi Special Steel Ltd is a joint venture of Mukand Ltd India and Sumitomo Corporation of Japan, with a Special Bar Quality rolling mill for the production of straight round and hexagon bars, wire rod and bar-in-coils near Hospet in Karnataka

**Centre gives nod to Privatisation of Vizag Steel Plant**

The Cabinet has approved strategic disinvestment in Vizag Steel Plant. The Rashtriya Ispat Nigam Ltd. (RINL), is a 'Navratna' PSU that runs with a capacity of 6.3 Mtpa.

The plant has been incurring heavy losses since 2017, except for the financial year 2019 when it achieved a net profit of Rs 96.71 crore. It has no captive iron ore mine which is resulting a loss of at least Rs 5000 on every tonne.

The RINL also runs RINMOIL Ferro Alloys Pvt Ltd, an equal joint venture with MOIL Ltd, and RINL Powergrid TLT Pvt Ltd, also an equal joint venture with Power Grid Corporation of India Ltd.

**Neelachal Executives Seek NINL Merger with PSU**

In view of the uncertainty prevailing over disinvestment of the NeelanchalIspat Nigam Limited (NINL) plant in Kalinganagar, the Neelachal Executive Association has urged the Central Government to reconsider its decision and instead keep all the assets of NINL under a Central PSU. NEA general secretary Mr Ajit Kumar Pradhan said "Since all the present share holders are from State and Central PSUs, the NINL merger with steel PSUs should not create any problem. Hence an alternative model has to be worked out, so as to merge the unit with a steel PSU like SAIL/RINL/NMDC who are in the business of mines and steel making. In such an event MMTC shares can be taken over by a steel PSU. Any delay in restarting the production and sale will lead to loss of revenue to State and Central Governments and will affect the livelihood of 5,000 employees as well as the surrounding beneficiaries."

After decision of strategic disinvestment of 100% shares in the NINL, major promoter MMTC as well as other minor promoters of the plant have stopped further funding for running of the plant, leading to suspension of production of all units since March. The employees have not got their salaries for past nine months leading to restlessness among employees and strikes on several occasions.

Neelachal Ispat Nigam Limited, a company promoted by MMTC Ltd, Industrial Promotion and Investment Corporation of Orissa limited and other government agencies has set up an 1.1 Mt Integrated iron and steel plant at Kalinganagar in Jajpur district of Odisha

**L&T Bags Contract for Bacheli Nagarnar Slurry Pipeline**

The Water and Effluent Treatment business of L&T Construction has secured an EPC order involving design, engineering, supply & installation of plant and equipment to lay 135 km of Slurry Pipeline and Water Pipeline Systems between Bacheli and Nagarnar and associated facilities in the State of Chhattisgarh.

L&T is already executing a pumping facility as part of another package for the same client in the same area that involves the supply of positive displacement pumps and the construction of a slurry pump house.

# Indian Steel Plants Spread Wings

**LIBERTY France and SNCF Réseau approved to supply GREENSTEEL Rails to Europe**

LIBERTY France, and SNCF Réseau have announced that Europe's first GREENSTEEL on the French rail network have been approved. According to Liberty France, this 'significant step' demonstrates SNCF Réseau's contribution to the establishment of a French 'green rail' industrial sector to fully integrate the country's railway infrastructure into a circular economy. The approval also marks the first step in achieving Liberty's ambition for the recently-acquired Liberty Ascoval and Liberty Rail Hayang which is to build a world class GREENSTEEL rail and rail services business with international reach.

Liberty claims that the key focus of its acquisition was to connect Ascoval with the Hayange rail mill so that together they become the leader in the provision of GREENSTEEL rails. It is claimed that this circular economy concept would see Liberty Ascoval melting recycled scrap steel, including recovered scrap rail from Hayange's customers, in its electric arc furnace to produce large rectangular GREENSTEEL 'blooms' which could then be rolled into rails at Liberty Rail Hayange.

This was achieved shortly after the acquisition of Liberty Ascoval when its new modified caster line cast its first square 'billet'. The €17 million modification, which was delivered on time and to budget despite COVID-19 complications, meant that the high quality steelmaking equipment at Ascoval could be deployed to produce a new range of cross-sections, including blooms and billets, suitable for rolling into rails and other steel products in new markets. Ascoval is now running at higher capacity, with the strong prospect of adding more jobs in early 2021 as the plant expands its production.

Rail production specialists at Hayange worked closely with those from SNCF Réseau to manufacture a range of GREENSTEEL rails which will be used across the French rail network. This new production process reduces $CO_2$ emissions by 90% with the traditional processes used in Europe for the production of rail steels. This environmental performance is possible because of the electric arc process rather than traditional blast furnaces. The manufacturing method of GREENSTEEL rails emits 180 kg of $CO_2$ per tonne of steel compared to 1.8 tonnes of $CO_2$ per tonne of steel using conventional blast furnaces. The goal is to make the rails carbon neutral by 2030.

SNCF Réseau has carried out a comprehensive range of homologation tests on the new range of rails and a full audit of the Liberty Ascoval site. Once homologation testing and audit work was completed, SNCF Réseau approved the use of the new rails across its French network. LIBERTY expects to start developing a sustainable GREENSTEEL rail market, initially in France and then more widely across Europe, as rail operators make the transition to carbon neutral networks.

Gerard Glas, President of Liberty Rail Hayange said that the validation of GREENSTEEL rails by SNCF Réseau will drive the company's expansion plan and its move towards producing truly carbon neutral steel rails for operators across Europe. "We look forward to working ever more closely with our colleagues at LIBERTY Ascoval in the future to create a GREENSTEEL champion in France," he said.

**GFG Alliance Completes Purchase of the Hydro Energy-Powered Tasmanian Electro Metallurgical Company Smelter in Tasmania**

GFG Alliance has finalised the purchase of the hydro energy-powered Tasmanian Electro Metallurgical Company smelter in Bell Bay in Tasmania, a significant step forward in its pursuit to be self sufficient in the supply chain. After entering a binding sale and purchase agreement with South32 Limited and Anglo American Plc in August last year, finalisation sees TEMCO join LIBERTY Steel Group as part of the GFG Alliance family. GFG Alliance Executive Chairman Mr Sanjeev Gupta said the acquisition not only secured the jobs of the smelter's 250 workers but would also play a key role in enhancing LIBERTY's drive to be self sufficient in the supply chain. He said "When we entered into the agreement in August, I flagged that our investment in key inputs such as ferromanganese and silico manganese would generate supply chain value to ensure a sustainable and globally competitive steel manufacturing sector. This acquisition is an upstream integration for Whyalla and all our steel plants globally."

The TEMCO facility, which is powered by Hydro Tasmania, has four submerged arc furnaces, including a sinter plant, and has the capacity to produce around 150ktpa of high carbon ferromanganese and 120ktpa of silico manganese used in the production of steel.

**Liberty Powder Metals begins Commercial Powder Production at New Atomiser Facility in UK**

Liberty Powder Metals, part of GFG Alliance's Liberty Steel Group, has started commercial production at its new high-tech powder metal facility in Teesside, UK, targeting the demand for Additive Manufacturing materials.

With the new facility, Liberty Powder Metals will produce a range of stainless steel and nickel superalloy powders aimed at the market for precision components within the automotive, aerospace, and engineering sectors. The company states that its powder production process cuts carbon emissions by 85% compared with the traditional steel manufacturing route, and is part of its CN30 strategy to become carbon neutral by 2030.

In the powder production process, spherical powder particles are processed to the highest specifications in a vacuum induction argon gas atomiser, the only one of its kind in the UK, with a unique anti-satellite facility to increase productivity. Atomising Systems Ltd and Consarc Engineering worked closely with Liberty Powder Metals on equipment design for the facility.

The facility launch is the culmination of a two-year collaboration with the Tees Valley Mayor Ben Houchen and the Combined Authority, which provided £4.6 million of funding, and the Materials Processing Institute, which housed the atomiser within its own research facilities. Installation and commissioning have successfully overcome significant challenges caused by the coronavirus pandemic in 2020, which has restricted the number of contractors able to work on-site and impacted on the delivery of equipment.

Commissioning of the atomiser includes a series of 'acceptance melts', which Liberty Powder Metals must perform before the plant is handed over for full operation. The atomiser enables the company to melt a range of defined chemistries and pour the liquid stream through an aperture, using inert gas to break it into fine droplets which then solidify into a powder which is secured and confined to avoid contamination from outside sources.

Powders then undergo further processing, including optimisation and characterisation, before final testing and dispatch to customers. The same post-atomisation processing activities are deployed for all metal powders in the company's portfolio, which includes aluminium, titanium and cobalt alloys.

**JSW Steel Italy Acquire Total Control of GSI Lucchini**

JSW Steel announced that its Italian subsidiary JSW Steel Italy Srl has signed a share purchase agreement with South Africa based Industrial Development Cooperation, owned by the Government of South Africa to acquire the remaining 30.73% share in forged steel producer GSI Lucchini SpA for EUR 1 million. The balance share capital of 69.67% of GSI Lucchini is already held by JSW Steel Italy Srl.

The manufacturing unit of GSI Lucchini is located in Piombino in Tuscany Region of Italy, providing easy access to export markets through the port of Piombino. The location of the plant allows specific advantages in terms of lead time, service level, and logistics cost in its target markets. The port based facility also gives GSI Lucchini the access to import raw materials, bars, blooms & billets to supplement supplies as when required. GSI Lucchini is a producer of forged steel balls used in grinding mills with predominant application in mining processing. The high Carbon alloyed steel bars are forged into balls and processed to give a uniform metallurgical structure. The high hardness structure combines excellent abrasion resistance with the toughness needed to resist breakage during the milling operation. Chemistry and heat treatment can be customized to best fit the application needs of the end users. The brand is widely recognised in Europe and Africa, and is among the prominent supplier in African mines.

The transaction is subject to fulfilment of conditions precedent and other terms mentioned in the share purchase agreement.

*Source: SteelGuru Busine*

# International Steel

## NEWS ITEMS

### Chinese Steel Sector Urged to Limit Steel Output in 2021

China's Industry and Information Technology Minister Mr Xiao Yaqing has called on the Chinese steel sector, as an energy intensive industry, to resolutely reduce output and ensure there is a year-on-year decline in 2021. Mr Xiao noted "China has managed to reach its goal of shutting 150 Mt of annual steel capacity ahead of schedule in the current Five Year Plan period covering 2016-20 and achieved a significant drop in carbon intensity. However, low carbon operations, energy saving and green manufacturing remain priorities in the year ahead A new set of measures on implementing capacity swaps in the steel sector would be released in 2021."

In China, steel mills are unable to launch any new capacity unless an equal or bigger volume of old capacity has been shut.

China is set to churn out more than 1 billion tonnes of crude steel for the first time in 2020 and a government consultancy recently estimated output would rise a further 1.4% in 2021 amid rapid economic growth and increased fixed-asset investment.The last time annual steel output in China fell was in 2015

### SMS group Plans Global Adjustment of its Corporate Structure, Reaffirms Strategy and Long-Term Goals

The Covid-19 pandemic has impacted numerous industries, and the steel market is among those facing reduced forecasts and order volumes. After the 2019 financial year, in which both order intake (EUR 3.15 billion) and sales (EUR 2.94 billion) rose once more, SMS group is lowering its outlook for the coming years. The global market leader in metallurgical plant construction expects this year's order intake to be around one third below the level originally planned, but reaffirms its growth strategy and realignment towards areas of future growth.

The area most severely affected by the current decline is Plant Construction, where a long-term reduction in order intake is expected. The Service and Digitalization business is proving much more stable and will continue to grow, thanks to a combination of big data technologies and new business models such as Equipment as a Service, which allows customers to turn their capital expenses into operating expenses.

Besides strengthening the growth areas of Service, Digital and Electrics/Automation, the growth strategy of SMS group is based on establishing global leadership in the decarbonization of industry. Key elements of this strategy include the use of hydrogen in CO2-free steelmaking and priority projects in the recycling of batteries and electronic scrap.

A profitable core business provides the basis for all the growth areas as well as establishing new technologies in the metals industry, such as 3D metal printing and the recovery of precious metals from electronic scrap, SMS group transfers its expertise to other industries. Examples include generating environmentally friendly synthesis gases from sewage sludge, which have numerous uses including fuel and energy production. Through this "New Horizon" strategy, SMS is diversifying its product portfolio outside its core business. The most recent example is the commissioning of a highbay storage system for shipping containers in Dubai. This facility of the SMS joint venture BOXBAY not only offers three times the capacity of a typical container storage facility on the same area, it also boasts a far higher handling speed, improved worker safety and a carbon-neutral footprint.

To further strengthen its ability to act quickly and effectively in the market, SMS group will continue to supplement its organic growth with acquisitions of suitable start-ups or established specialists.

To optimize the conditions for future market success, SMS group will adjust its corporate structure. Key components of the planned new organizational structure are a cross-divisional and international focus on customer projects. In contrast to the present structure, six regions will assume project responsibility for sales and execution. In place of the current business units, Centers of Excellence (CoEs) will be created that will deliver their services and technologies to the projects. The entire organization will be served by Global Support Functions. Consultations about the new organization, which will be implemented worldwide from spring 2021, will be held with the relevant committees in the coming weeks.

**Former Ilva, the Return of the Italian State in the Steel Business**

A new agreement between ArcelorMittal and State-owned Invitalia was signed on December 10, 2020. Thanks to this deal, Invitalia, which is wholly owned by the Italian's Treasury, will become the main shareholder of former Ilva steelworks.

The agreement, which marks the return of the Italian State in the steel business after a 25-years long hiatus, provides for "an articulated plan of environmental and industrial investments". The industrial plan aims at reaching 8 Mt/year of steel production in 2025. This goal will be achieved through reactivation of Blast Furnace 5 (stopped since 2015, which alone could cover for more than 60% of production), the use of Blast Furnace 4, and the debut of a new EAF dedicated to the production of low carbon steels up to 2.5 Mt/year. The implementation of EAF is part of a wider decarbonization process to make Ilva the largest "green" plant in Europe.

The takeover will be articulated in two distinct phases: in a first step, Invitalia has planned a capital increase of 400 million euros for joint control of AmInvest Co. Italy Spa (currently owned by ArcelorMittal). This investment, it is understood, is subject to antitrust authorization from the European Union. In May 2022, Invitalia will then become the main shareholder with a second capital increase of up to 680 million to raise its stake at 60%. ArcelorMittal will invest up to 70 million euros, to the extent necessary to retain a 40% shareholding.

**PROJECT NEWS**

**Metalloinvest Modernized Blast Furnace No 2 at Ural Steel**

Metalloinvest has launched modernized blast furnace No 2 at Ural Steel, undertaken at an investments of 2.5 billion rubles. The main process equipment supplier is Danieli Corus. In comparison with a traditional blast furnace, the advantage of blast furnace No 2 is the ability to operate on a charge using up to 95% of iron ore pellets in the charge. The maximum productivity of the new furnace is up to 7,60,000 tonnes of pig iron per year. The warranty period without costly overhauls is more than 15 years. The patented technology of the lining and cooling system allows, in the event of a burnout of a copper horizontal refrigerator, to quickly replace it without a long stoppage of the furnace. Blast furnace No 2 is also equipped with an expert system for analyzing and regulating the technological process, which makes it possible to determine the optimal technological regime and control blast furnace smelting in an automatic mode, controlling and analyzing many parameters.

Metalloinvest's large-scale investment project is being implemented as part of the strategic comprehensive program for the development of Ural Steel. Its activities will improve the efficiency of the enterprise and reduce the burden on the environment. The Company plans to start reconstruction of blast furnace No 3 in February 2021.

**Tenova Received the Order for a Hydrogen DRI Plant from Salzgitter Flachstahl in Germany**

Salzgitter Flachstahl GmbH has commissioned Tenova for the construction of μDRAL, a demonstration plant for the production of Direct Reduced Iron (DRI), using up to 100% hydrogen as reducing agent. The plant is based on the ENERGIRON® technology and will be installed on the premises of the Salzgitter steel mill at Salzgitter, Germany.

The μDRAL will have a nominal production capacity of 100 kg/h and will be operated with hydrogen and natural gas showing the flexibility of the technology in terms of fluctuating availabilities of reducing agents, including 100% hydrogen. The DRI produced by µDRAL will be both used in the blast furnace process to save injected coal and in the electric arc furnace of the Peine plant.

The ENERGIRON® process, jointly developed by Tenova and Danieli, represents the base for the plant design and is the most feasible high-intensity $H_2$ DR system available, already designed for extremely low $CO_2$ emissions while processing iron ore pellets. This enables Salzgitter to achieve the long-term $CO_2$ reduction targets, defined with SALCOS® approach.

The ENERGIRON® solution has been also recently selected by HBIS Group for the first ever gas-based DR plant in China and by OMK in Russia for the production of the highest quality of steel grades.

**First Hydrogen based ENERGIRON DRI Plant for Tenova in China Castellanza,**

Tenova has signed a contract with the HBIS Group for the implementation of the Paradigm Project, a High Tech Hydrogen Energy Development and Utilization Plant. The project includes a 600,000 ktpy ENERGIRON DRI plant. This will be the world's first DRI production plant powered by hydrogen enriched gas, which will make use of the most advanced, competitive, eco-friendly and reliable technology of the Tenova process portfolio, which includes advanced digital models for equipment and metallurgical behavior prediction.

It will be the first gas-based DRI plant in China. The HBIS DRI plant will use make-up gas with approximately a 70% Hydrogen concentration. Due to the high amount of $H_2$, the HBIS plant will be the greenest DRI plant in the world by producing only 250kg of $CO_2$ per ton of DRI. The carbon dioxide will be selectively recovered and part of it will be reutilized in downstream processes, with a final net emission of just about 125kg of $CO_2$ per ton.

To be installed at HBIS facilities in the Hebei province, the new Energiron DR plant will produce 600,000 tpy of quality DRI starting from the end of 2021.HBIS selected EnergironDirect Reduction technology to achieve the highest targets in terms of energy efficiency, product quality and environmental compliance.

Energiron DR technology allows great flexibility in the mixture of gas used as a make-up, so it will be possible to reach 100% hydrogen as reducing agent.

The gas mixture to be used by HBIS will be composed approximately by 30% of coke oven gas available from the existing integrated plant and approximately by 70% of hydrogen from external sources.With a $CO_2$ release as low as 250 kg/ton of DRI, the HBIS plant will be the greenest DRI plant in the world.

Furthermore, the carbon dioxide will be selectively recovered by a $CO_2$ removal unit included in the basic Energiron DR technology process scheme, and part of it will be reutilized in downstream processes (carbon capture and use or storage CCU/CCS).

This would lead to a final net emission of just about 125 kg of $CO_2$ per ton of DRI.

**Tenova's Flameless SmartBurner: Enabling Hydrogen-based Decarbonization of Industrial Furnaces**

Tenova is ready to supply megawatt-size flameless combustion system burning any mixture of natural gas and hydrogen, up to 100% hydrogen, integrated with Tenova's advanced digital solutions. Its TSX SmartBurner for reheating furnaces is to be installed in industrial plants with potentially zero $CO_2$ emissions, working in a full range of $H_2$ and natural gas mixtures. It is the first flameless burner of a megawatts family that has been tested with 100% of $H_2$ successfully. This allows to maintain NOx emissions well below the next future strictest limits – releasing less than 80 mg/ $Nm^3$ @ 5% of oxygen with furnace at 1250°C – also working with 100% $H_2$ and maintaining an optimal heat transfer uniformity within the furnace. The quantity of hydrogen can be simply regulated through the burner control logic, allowing steel producers to adapt the fuel mixture to contingent needs without any mechanical intervention.

**Danieli Hydro Mab to take a Step Ahead in Green Steel**

The new, Danieli Centro Combustion hydrogen multi-air burner operates with a methane and hydrogen mixture to reduce $CO_2$ emissions

Through recent decades $CO_2$ emissions have been reduced by increasing thermal efficiency.

Nowadays, the use of hydrogen in combustion processes could bring the steel industry towards full decarbonization.

CFD simulations and laboratory tests led the Danieli Centro Combustion R&D team to the development of HYDRO MAB – a new hydrogen multi-air burner - as the answer for burning a natural gas/hydrogen mixture that results in further $CO_2$ reduction.

In addition to $CO_2$ reduction, HYDRO MAB burners maintain the lowest levels of NOx emissions and the optimal flame pattern.

**Bashundhara Group Orders Danieli Mida Green Steel Minimill Plant**

1 Mtpy of long products produced in endless casting-rolling with just one casting strand

The largest private Bangladeshi company, Bashundhara Group, ordered from Danieli a MIDA endless-casting rolling minimill to produce 1 Mtpy of rebar and wirerod for the local market.

To be installed at Bashundhara industrial park in Mirsarai, nearby Chittagiong, Bangladesh, it will be most productive single-strand minimill for long products in the world.

Danieli MIDA endless casting rolling minimills are the most energy-efficient, green and competitive plants to produce long products thanks to patented Digimelter and QLP-DUE® - Danieli Universal Endless technologies.

Scrap will be continuously melted by a 100-t Digimelter, which will operate at a productivity of 150 tph. Featuring a Q-One power unit, Q-Melt intelligent controller and ECS continuous scrap charging, Digimelter runs the melting processes automatically, in a stable and adaptive way, with minimal impact on the electric network.

The single-strand FastCastPlus machine equipped with high-performance FCC oscillator and the newly patented Octocaster mould will deliver endless billets to the mill at casting speeds exceeding 7 m/min.

The rolling mill consisting of 20 AC-driven housingless stands in H and V configuration feeds two lines for bars in bundles and wirerod, which include two 6-pass pre-finishing plus one 4-pass finishing blocks, QTB and QTR quenching lines.

Danieli Automation equipment and process control systems will guarantee a continuous and reliable production of the technology areas together.

The startup of the new Green Steel MIDA minimill is expected by early 2023.

DUE®, Danieli Universal Endless technology is the Danieli endless-casting rolling technology to produce long products (QLP-DUE®) and flat products (QSP-DUE®) in a green, competitive way. .

**Tenova's New EAF and Consteel® Evolution Plants for Guangdong NanfangDonghai Iron & Steel Co., Ltd. Castellanza**

Tenova has been contracted by Guangdong NanfangDonghai Iron & Steel Co to supply two Electric Arc Furnace (EAF) and Consteel® Evolution plants equipped with Consteerrer™ technology for the customer's melt shop plant.

Tenova's EAF Consteel® Evolution fulfills the need to reduce pollution and $CO_2$ emissions thanks to its operational reliability as well as advantages such as savings in electrical consumption, improved productivity, high-quality steel, and greater environmental protection and workplace safety. In addition to Consteel®, the project introduces the Consteerrer™ technology. This innovative electro-magnetic stirring system, jointly developed with ABB, brings the advantage of lower operating costs, providing more reliable and safer operations, higher steel quality and more precise logistics. Consteerrer™ enhances the Consteel® Evolution process with ABB's ArcSave® non-contact electromagnetic stirring of the furnace's liquid bath, and can be customized to match the needs of different EAF process steps.

**Endless Billet Welding and Bar Spooling for Nucor Plymouth by Danieli**

Nucor Steel awarded Danieli the order for a new billet welder and spooler line to be installed at Plymouth, Utah. Thanks to this upgrade the line will process 250,000 tpy of rebar from #3 to #8, in compact coils up to 5.5 tons.

The project also includes the extension of the existing reheat furnace to allow billet discharging at a higher temperature and in line with the mill. Commissioning of the newly upgraded line is expected in the last quarter of 2021.

The combination of billet welding and spooling technologies maximize the yield (up to 99%) because of the endless production process.

Twist-free spooled coils add value to final products because they do not require uncoiling and recoiling operations before downstream processing.

This will be first billet welder and third spooler line supplied to Nucor Steel in the past two years.

**CMC Steel Arizona Minimill receives Solar Energy and Becomes even More Green**

Commercial Metals Company announced that CMC Steel Arizona has begun receiving renewable energy from Salt River Project's (SRP) new "Saint Solar" electricity generation plant.The Saint Solar plant, located in Coolidge, Arizona, is a 100 MW utility-based solar array that will provide renewable energy to CMC Steel Arizona and others in the SRP community.

Constructed in 2009, CMC Steel Arizona is one of the most efficient and green steel producing facilities in the world. By using recycled scrap for 98% of the raw material, the need for natural resources is reduced. $CO_2$ Scope 1 green-house gas emissions and energy consumption intensities are approximately 8 times less than the global steel making average.

On August 13, 2020, CMC announced plans to build its third micro mill, AZ2, adjacent to CMC Steel Arizona. The mill will be the first in the world to produce merchant bar quality (MBQ) products through a continuous-continuous production process. AZ2 will feature Danieli's "Q-One" technology which will allow CMC to have a direct connection between the EAF and Ladle Furnace to renewable energy sources. This technology reduces electricity transmission losses as compared to traditional methods and associated operating costs.

**Danieli MiDa Minimill Starts at Nucor Steel Florida**

On December 18th, thanks to the joint efforts of Danieli and Nucor teams, Nucor Steel Florida safely started on schedule, melting, casting and rolling in endless mode from the first heat.

The new MIDA minimill has a rated capacity of 380,000 tpy and will produce rebar ranging from 9.5 to 35.8 mm in straight bars up to 60 ft, and spooled coils up to 5 tons. Featuring the latest energy-saving and environmentally friendly melting, the MIDA casting and rolling technologies significantly reduce the overall $CO_2$ emissions thanks to the absence of the reheating furnace.

In January 2020, the first MIDA minimill for Nucor, Sedalia, Missouri also started up quickly, having the endless casting and rolling operations in place on third day and a "more than 1 km" long billet produced on the fifth day.

The MIDA endless casting-rolling process route includes the Danieli ECS® scrap preheating and continuous charging system, able to feed hot scrap continuously into a 40-t, side-charging, Fastarc AC EAF; and then a ladle furnace ensures the proper refining of the steel.

A single-strand, high-speed continuous casting machine is the core of the endless casting-rolling section. It is equipped with the Danieli Fast Cast Cube (FCC) and a 130 x 130 mm square section Power-mould copper tube directly connected, through a 4 MW induction furnace, to an 8 + 8 stands ultra-compact rolling mill.

The finishing facilities consist of an apron roller line, for the larger sizes, the Danieli-patented Direct Rolling and Bundling system (DRB) for the smaller range and a spooler line based on the "K-Spool" technologies, able to produce coils from rebar #3 to #8 in coils up to 5 tons.

**Italian steel producer Duferco commissions SMS group to supply Medium Section Mill powered exclusively by Renewable Energies**

Duferco Steel, Italy, has placed an order with SMS group for a new medium section rolling mill. This flagship project will focus on core components of digitalization and automation in production and logistics, and on sustainability. With the new mill Duferco will be able to reach a yearly output of 1.5 Mt of long products.

SMS is going to supply the complete new medium section mill, including electrics and automation systems up to Level 2. Moreover, a SMS DataFactory will be implemented, combining the information from the product tracking system with all available data in the plant, from the sensor level up to the higher-level automation systems. In this way, a product genealogy will be created, which is the basis for digitalizing the complete production process and – through the use of artificial intelligence – will be setting new benchmarks in digitalization. Thanks to the first green PPA (Power Purchase Agreement) signed by the Italian steel company, the whole power supply of the new rolling mill will be covered by renewable energy.

The mill will be equipped with the latest generation of CCS® (Compact Cartridge Stand) tandem mill stands, featuring strengthened guide holders, a new chock design and the new Technological Control System

TCS plus. By implementing TCS plus, Duferco will have additional productivity reserves and will be able to minimize the hydraulic power consumption. Moreover, the new tandem mill will be supplied fully prepared for low-temperature rolling which will allow savings on valuable resources such as alloying elements. The laser-based PROgauge light section measuring device, including the SurfTec surface defect detection system, from SMS will enable Duferco to measure the sections inline and to detect and analyze surface defects that may occur during the rolling process.

The project is scheduled to be implemented during a period of only two years, with commissioning planned for the end of 2022.

**Severstal awards Danieli with Order for New Special Steel Rolling Mill**

Russian steelmaker AO Severstal awarded Danieli with an order for the supply of a new rolling mill for special steels to be installed in Cerepovec.

The new plant will produce 1 Mtpy of 5.5 to 32-mm-dia smooth wirerod and coiled bars for the engineering and automotive industries and 8 to 16-mm-dia quenched rebar for construction purposes.

Danieli will provide all the technological equipment, automation and advisory services.

A Danieli Centro Combustion walking beam reheating furnace will bring to rolling temperature 12-m-long, 150-mm square-billets, at a pace of 170 tph. A single-strand high-speed roughing mill made of horizontal and vertical housingless stands will feed two independent wirerod lines and a garret coiler to produce the bigger diameters.

The intermediate mill is composed by horizontal housingless stands while the finishing stand group consists of cantilever stands and two separate fast-finishing blocks (six plus four passes) in order to achieve better macrostructure.

Two oil-film bearing laying heads will lay wraps on a 100-m cooling conveyor designed for sorbitezed process.

All coils will be processed along a Sundbirsta vertical trestle system. The entire mill will be powered by Danieli Automation electrical motors and drives, and controlled by L1, L2 and Q3 technologies. Mill startup is planned within end of 2022.

**Primetals Technologies achieves Successful Remote Commissioning of Process Automation of Continuous Caster for Outokumpu in Tornio**

In June 2020, Primetals Technologies successfully completed the online commissioning of the new software for optimizing the Level 2 process automation for the CCM1 continuous caster at Outokumpu's plant in Tornio, Finland. The remote commissioning used empirical values gained from commissioning the similar CCM2 continuous caster at the same location in December 2019. As well as upgrading the process optimization software for the CCM2, Primetals Technologies also installed a TPQC (ThroughProcess Quality Control) caster system, which records all the quality data of the entire production process in a long-term archive. The new process optimization solution offers Outokumpu more options for flexible quality evaluation and a "digital twin" for offline simulation of the casting process. The casting speed can also be controlled via Level 2 with the "Speed Expert" process model, which also covers start of casting and casting situations.

The hardware and software for optimizing the processes of Outokumpu's CCM1 continuous caster in Tornio had become outdated and individual spare parts difficult to procure. Outokumpu consequently engaged Primetals Technologies in the middle of 2019 to upgrade the process optimization solution for the CCM1 line. The original operation on physical servers has now been replaced by operation on virtual servers in Outokumpu's VM infrastructure. The operators of the continuous caster can now use the "Quality Expert" module themselves to create and maintain rules for evaluating the quality of the strands. The "Speed Expert" module has been controlling casting speed, including start of casting and casting situations, since the first batch after the upgrade. The "Dynacs 3D" model is used to optimize secondary cooling. The "Process Intelligence Cockpit (PIC)" is a digital twin of the line and enables offline simulation of the casting process.

**Continuous Rolling Mill Upgrades at BSRM–Danieli Service Small Revamping Team executes Valuable Projects**

The Danieli Service Small Revamping Team has just commissioned a bar mill upgrade at BSRM Steel Mills, in Chittagong, Bangladesh.

The target of the revamping was to improve the productivity for the smallest bar sizes, by implementing 5-strand slitting and producing 5x8- and 5x10-mm-dia finished products.

The intervention was completed two days ahead of schedule and involved installing the slitting guides, modifying the existing ratios on the stand gearboxes and upgrading shears and QTB along the mill.

Furthermore, for the same plant, in order to meet the request of BSRM to improve the lean management of finished bars from the mill, Danieli is supplying a new offline cutting area.

There, angle bars will be automatically cut in submultiple commercial lengths at a productivity of 36 tons per hour, whilst allowing the main rolling mill to continue producing longer sections of the entire range of profiles at a high-performance rate.

The innovative new area will be able to detect, separate and feed two parallel lines of bandsaws with series of longer products and divide these into shorter products according to market requests.

**Primetals Technologies upgrades Arvedi ESP line at Acciaieria Arvedi in Cremona, Italy to Increase Capacity**

In September, the Arvedi ESP (Endless Strip Production) line at AcciaieriaArvedi in Cremona, Italy was restarted after a major upgrade. The modernization, performed by Primetals Technologies, included changes to the continuous casting machine, resulting in an increase of mass flow, and, consequently production capacity. The upgrade is the first step to raise the overall production capacity of the ESP line to 3 Mtpy. The measures undertaken will also improve product quality.

The first pioneering Arvedi ESP line at AcciaieriaArvedi, Italy has been operating for 10 years. AcciaieriaArvedi has gathered much experience of how to improve quality and increase productivity and charged Primetals Technologies with the design, supply and execution of the upgrade. In this context, the metallurgical length of the line´s caster was elongated to 21.8 meters by adding two caster segments, provisions for an additional segment 13 were also made. This allows an increase of casting thickness to 105 mm, resulting in a mass flow of 450 tons per hour which is the highest mass flow for a thin slab casting plant worldwide. The required space for the additional segments was obtained by moving the first high reduction mill stand R1 downstream of the original R3 to becoming the new R3 stand. The flexibility to increase the metallurgical length, as well as the option to later move the rolling stand R1 to the R3 position, including foundations, was already foreseen in the original plant design of 2006.

The EAF of the ESP melt shop also received an upgrade and a ladle size increase. Accordingly, the ladle turret was replaced, with a larger unit, including new software features, etc. Improved automation models will give further support to serve a higher value added products market directly from the ESP line.

**Big River Steel Successfully Commissions Expansion of SMS group supplied Steel Mill**

U.S. steel producer Big River Steel has successfully commissioned the second construction stage of its steel plant in Osceola, Arkansas, supplied by SMS group.

Also for the mill expansion, which doubles the mill's annual production capacity to approximately 3 Mt of steel, SMS group supplied the mechanical equipment, the electrical and automation systems, and the digitalization technology.

Now, with the second construction stage completed, Big River Steel operates two EAFs and two twin-ladle furnaces. The steelworks has also been equipped with a further gas cleaning system as part of the project. The CSP® plant has seen the addition of a second casting strand, a second tunnel furnace and another downcoiler. Big River Steel's CSP® plant produces up to 1,930 mm wide coil, making it one of the widest CSP® plants in the world.

SMS group's PQA® (Product Quality Analyzer) system is a central element of the process automation implemented in the first phase and it is equally so in the automation of the newly added units and systems. PQA® monitors, documents and assures quality along the complete production process down to the finished cold strip.

Most of the hot coil produced in the CSP® plant is processed into high-grade cold strip in the downstream coupled pickling line/tandem cold mill. As part of the expansion, another coil preparation station was added to the entry end of the PLTCM, and the adjacent continuous galvanizing line received an additional downcoiler at the exit end. For all newly installed plants, SMS group supplied the mechanical equipment and the X-Pact® electrical and automation systems, including level 3.

Since commissioning of the new mill in December 2016, Big River Steel has been producing high-quality steels, including tube grade sheet for pipeline construction, silicon steels for a wide range of uses in energy generation and electric motor manufacturing, and advanced high-strength steels for the U.S. automotive industry.

**HBIS Laoting successfully Commissions High-Performance Hot Strip Mill supplied by SMS group**

The new high-performance hot strip mill supplied by SMS group has successfully started production at HBIS Laoting Iron & Steel Co. Ltd. in China. This has an annual capacity of 4.1 Mt and produces hot coils with widths of up to 1,900 mm. Final thicknesses range between 1.2 and 25.4 mm. The product mix includes, besides low-alloy carbon steels, high-strength automotive grades, weather-resistant structural and container steels, pipe grades, boiler and pressure vessel steels and steels for use in ship and bridge construction.

The hot strip mill comprises as main equipment a roughing mill descaler, a slab-sizing press, a two-high reversing roughing mill, a four-high reversing roughing mill with attached edger, a mandrel-less coilbox and a crop shear, and at the finishing end a descaler, a seven-stand finishing mill and a laminar cooling system. Three downcoilers produce straight-edged coils of finished hot strip. Downcoiler No. 3 has been specifically designed for the challenging task of coiling thick, high-strength strips.

The described system configuration provides HBIS Laoting maximum flexibility in planning and production. For example, the slab sizing press in the entry area of the hot-strip roughing mill enables a width reduction of up to 350 mm.

The two high-performance roughing stands allow a high degree of flexibility in the distribution of pass reductions. The finishing stands come with rolling forces of 52 MN (F1-F4) and 40 MN (F5-F7). All stands - equipped with hydraulic roll gap adjustment – achieve tightest tolerances.

For optimum profile, contour and flatness of the strip, the stands are equipped with the proven CVC®plus system (Continuously Variable Crown) with integrated work roll bending.

A laminar cooling line of the latest generation in the exit area of the finishing mill provides high flexibility and a wide range of cooling rates in setting the required mechanical properties for all grades and dimensions within narrow tolerances. The higher flow rates in the rear part of the cooling section also facilitate the production of multi-phase steels.

**ThyssenKrupp to Slash 11,000 Jobs after Recording $6.5 bn Net Loss**

thyssenKrupp will cut 11,000 jobs, roughly 10% of its workforce, as the conglomerate's beleaguered steel business hemorrhages cash and Germany's government bickers over a possible rescue.

The steel and materials group almost doubled the number of positions it plans to eliminate after recording a 5.5-billion euro ($6.5 billion) net loss for the year that ended in September. The Company forecast another more than 1 billion euro deficit for the current period.

"Once synonymous with German industrial prowess, ThyssenKrupp is now fighting for survival. Its steel division faces severe problems with yawning pension deficits and cheap imports from Asia. The end game for the company is likely to involve a mix of asset sales, restructuring and the ignominy of a taxpayer bailout.

Management has held talks with potential buyers and merger partners for the steel unit to help address chronic overcapacity. They're also in discussions with the German government over an aid package that could be worth at least 5 billion euros. With a workforce of more than 100,000, Thyssenkrupp remains a systemically important employer.

The conglomerate sold its prized elevator division earlier this year for 17.2 billion euros in a bid to buy time to restructure other parts of the business. It now has about 13.2 billion euros of cash and undrawn credit lines.

Excluding proceeds from the elevator sale, Thyssenkrupp burned through 5.5 billion euros in the last fiscal period, triple its prior-year outflow. It's forecasting another 1.5 billion euros of negative free cash flow over the next 12 months. "The outlook for next year is still pretty dire," said Ingo Schachel, senior analyst at Commerzbank.

ThyssenKrupp's guidance for a cash burn of 1.5 billion euros in fiscal 2021 isn't surprising -- given the extent of the restructuring underway at the group, with a further 5,000 job cuts announced during full-year (ended September) 2020 results -- yet the number is higher than consensus and their own scenario analysis, highlighting the execution risk in pulling off a turnaround.

Thyssenkrupp expects to make a "fundamental" decision in the spring on a solution for its steel business, which swung to a 946 million-euro loss in the last fiscal year. The full group's adjusted deficit before interest and taxes was 1.6 billion euros.

# Statistics Revelation

## GLOBAL IRON & STEEL SCENARIO

**Table 1(a): World crude steel production 1950 to 2019-Mt**

| Year | World crude steel prod. | Year | World crude steel prod. | Year | World crude steel prod. |
|---|---|---|---|---|---|
| 1950 | 189 | 2000 | 850 | 2010 | 1433 |
| 1955 | 270 | 2001 | 852 | 2011 | 1538 |
| 1960 | 347 | 2002 | 905 | 2012 | 1560 |
| 1965 | 456 | 2003 | 971 | 2013 | 1650 |
| 1970 | 595 | 2004 | 1063 | 2014 | 1671 |
| 1975 | 644 | 2005 | 1148 | 2015 | 1621 |
| 1980 | 717 | 2006 | 1250 | 2016 | 1629 |
| 1985 | 719 | 2007 | 1348 | 2017 | 1732 |
| 1990 | 770 | 2008 | 1343 | 2018 | 1814 |
| 1995 | 753 | 2009 | 1239 | 2019 | 1869 |

**Table 1(b): Top steel-producing companies 2019 – crude steel production, Mt**

| Rank | Company | Tonnage | Rank | Company | Tonnage |
|---|---|---|---|---|---|
| 1 | ArcelorMittal | 97.31 | 9 | Tata Steel Group | 30.15 |
| 2 | China Baowu Group | 95.47 | 10 | Shougang Group | 29.34 |
| 3 | Nippon Steel Corporation | 51.68 | 11 | Shandong Steel Group | 27.58 |
| 4 | HBIS Group | 46.56 | 12 | JFE Steel | 27.35 |
| 5 | POSCO | 43.12 | 13 | Valin Group | 24.31 |
| 6 | Shagang Group | 41.10 | 14 | Nucor Corporation | 23.09 |
| 7 | Ansteel Group | 39.20 | 17 | JSW Steel | 16.26 |
| 8 | Jianlong Group | 31.19 | 18 | SAIL | 16.18 |

**Table 1(c): Direct reduced iron production 2012 to 2019-Mt**

| Country | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| Russia | 5.1 | 5.3 | 5.4 | 5.4 | 5.8 | 7.2 | 7.9 | 8.0 |
| Mexico | 5.6 | 6.1 | 6.0 | 5.5 | 5.3 | 6.0 | 6.0 | 6.0 |
| United States | - | - | 1.3 | 1.1 | 1.8 | 2.0 | 3.4 | 3.5 |
| Venezuela | 4.5 | 2.7 | 1.4 | 1.4 | 0.9 | 0.5 | 0.4 | 0.4 |
| Egypt | 3.1 | 3.4 | 2.9 | 2.5 | 2.6 | 4.7 | 5.8 | 4.4 |
| Iran | 11.6 | 14.5 | 14.6 | 14.5 | 16.0 | 19.4 | 25.7 | 28.5 |
| Qatar | 2.4 | 2.4 | 2.5 | 2.6 | 2.5 | 2.5 | 2.5 | 2.4 |
| Saudi Arabia | 5.0 | 5.3 | 5.5 | 4.8 | 5.1 | 4.8 | 5.0 | 4.7 |
| UAE | 2.7 | 3.1 | 2.4 | 3.2 | 3.5 | 3.6 | 3.8 | 3.7 |
| India | 23.4 | 22.6 | 24.5 | 22.6 | 24.6 | 29.5 | 34.2 | 36.9 |
| **World** | **76.2** | **78.8** | **80.3** | **75.0** | **75.9** | **88.7** | **104.0** | **107.6** |

**Table 1(d): Major importers and exporters of steel 2019-Mt**

| Rank | Country | Total Exports Mt | Rank | Country | Total Imports, Mt |
|---|---|---|---|---|---|
| 1 | China | 63.8 | 1 | United States | 27.1 |
| 2 | Japan | 33.1 | 2 | Germany | 23.1 |
| 3 | South Korea | 29.9 | 3 | Italy | 20.1 |
| 4 | Russia | 29.5 | 4 | Thailand | 16.7 |
| 5 | Germany | 24.1 | 5 | South Korea | 16.4 |
| 6 | Turkey | 19.7 | 6 | China | 15.5 |
| 7 | Italy | 17.9 | 7 | Vietnam | 15.4 |
| 8 | Belgium | 17.2 | 8 | France | 14.5 |
| 9 | Ukraine | 15.6 | 9 | Indonesia | 13.4 |
| 10 | France | 13.6 | 10 | Mexico | 13.0 |
| 11 | India | 13.4 | 16 | India | 8.9 |

## Global Crude Steel Production: January- December 2020

Global crude steel production reached 1,864.0 Mt for the year 2020, down by 0.9% compared to 2019.

China's crude steel production in 2020 reached 1,053.0 Mt, up by 5.2% on 2019. China's share of global crude steel production increased from 53.3% in 2019 to 56.5% in 2020. India's crude steel production for 2020 was 99.6 Mt, down by 10.6% on 2019. Japan produced 83.2 Mt in 2020, down 16.2% on 2019. South Korea produced 67.1 Mt, down 6.0% on 2019.

Vietnam's production has climbed significantly this year to 19.5 Mt up by 11.6% on 2019. Iran's growth in production of crude steel is also remarkable at 29.03 Mt up by 13.4%.

The EU produced 138.8 Mt of crude steel in 2020, a decrease of 11.8% compared to 2019. In the CIS, production was 102.0 Mt in 2020, up by 1.5% on 2019. Russia is estimated to have produced 73.4 Mt in 2020, up 2.6% on 2019. Ukraine produced 20.6 Mt in 2020, down 1.1% on 2019. Crude steel production in North America was 101.1 Mt in 2020, down 15.5% on 2019. The United States produced 72.7 Mt in 2020, down 17.2% on 2019.

**Table 2: Top 10 steel-producing countries**

| Rank | Country | 2020 (Mt) | 2019 (Mt) | % 2020/2019 |
|---|---|---|---|---|
| 1 | China | 1053.0 | 1001.3 | 5.2 |
| 2 | India | 99.6 | 111.4 | -10.6 |
| 3 | Japan | 83.2 | 99.3 | -16.2 |
| 4 | Russia (e) | 73.4 | 71.6 | 2.6 |
| 5 | United States | 72.7 | 87.8 | -17.2 |
| 6 | South Korea | 67.1 | 71.4 | -6.0 |
| 7 | Turkey | 35.8 | 33.7 | 6.0 |
| 8 | Germany | 35.7 | 39.6 | -10.0 |
| 9 | Brazil | 31.0 | 32.6 | -4.9 |
| 10 | Iran (e) | 29.0 | 25.6 | 13.4 |

(e) = estimate

*Source: worldsteel*

**China's steel exports down and imports up**

China's economy grew by 2.3% in 2020, which is the only major global economy to achieve positive growth in 2020.

Strong steel demand in China also lifted its 2020 steel imports to the highest level since 2005, even as the country maintained its status as the world's biggest steel exporter.

China's steel imports rose by 64.4% from a year earlier to 20.23 Mt in 2020, with exports falling by 16.5% on the year to 53.68 Mt, the lowest level since 2015, when the country exported 112.39 Mt of steel. China's price advantage has waned this year due to high iron ore price. Chinese steel mills are not in an advantageous position in their talks with iron ore suppliers, and prices have surged back which is hovering at over $170 per tonne.

**STAINLESS STEEL**

During the current year there is a significant fall in melting shop output compared to the equivalent period in 2019. The impact of the COVID 19 pandemic was most significant on the industry production in percentage terms in Europe, USA and Asia (excluding China). Stainless steel melt shop production decreased by 7.8% year–on–year to 36.7 Mt.

**Table 3: Stainless Steel production ('000t)**

**Stainless steel melt shop steel production ('000 metric tons)**

| Region | Quarter | | | 9 months | | +/- % |
|---|---|---|---|---|---|---|
| | 1/2020 | 2/2020 | 3/2020 | 2019 | 2020 | y-o-y |
| Europe | 1,790 | 1,341 | 1,414 | 5,233 | 4,546 | -13,1 |
| USA | 627 | 450 | 499 | 2,019 | 1,575 | -22.0% |
| China | 5,989r | 7,455r | 8,496 | 22,490 | 21,941 | -2.4% |
| Asia w/o China and S. Korea | 1,886 | 1,080 | 1,627 | 5,872 | 4,593 | -21.8% |
| Others | 1,322 | 1,215 | 1,520 | 4,186 | 4,057 | -3.1% |
| **Total** | **11,614r** | **11,541r** | **13,557** | **39,800** | **36,712** | **-7.8%** |

Others : Brazil, Russia, S. Africa, S. Korea, Indonesia r : revised, e = estimate

*Source : International Stainless Steel Forum (ISSF)*

**INDIAN STEEL SCENARIO**

**Top 4 Steel Players' Output Rises 6% to about 15 Mt in Oct-Dec'20**

The country's top four steel makers jointly produced 14.95 Mt steel in the October-December quarter of the current fiscal, registering a 6%t year-on-year rise. The total steel output of JSPL, JSW Steel, SAIL and Tata Steel India was 14.09 Mt during the same quarter of 2019-20. During the quarter under review, the total sales of the steel producers - excluding JSW Steel - surged 2.25% to 10.88 Mt, as against 10.64 Mt in the year-ago quarter. Among all four steel players, Tata Steel India was the top producer in the October-December period of FY21. Its total output from India operations was 4.60 Mt during in the quarter. The company's output was 3 % higher compared to 4.47 Mt steel it had produced in the year-ago period. Its sales from India operations slipped 4 % to 4.66 Mt from 4.85 Mt. SAIL's production grew 9% to 4.37 Mt steel during October-December compared to 4 Mt a year ago. Its total sales were at 4.32 Mt, up about 6 % from 4.09 Mt in the same quarter preceding fiscal. JSW Steel's output during the period under review rose 2 % to 4.08 Mt, as against 4.02 Mt in the year-ago period. JSPL's output surged 18% to 1.9 Mt in the October-December quarter from 1.6 Mt a year ago. Its sales increased by 12 % to 1.9 Mt from 1.7 Mt. JSPL, JSW Steel, SAIL and Tata Steel India jointly contribute about 45% to India's total steel production annually.

**Table 4: Performance of Indian steel industry: April-December 2020(Mt)**

| Item | April-December '20 | % Change April-December '20/19 |
|---|---|---|
| Crude steel production | 72.73 | -11.6 |
| Pig iron production | 3.398 | -21.3 |
| Finished steel production | 66.555 | -14.4 |
| Export of finished steel | 8.314 | 27.5 |
| Imports of finished steel | 3.209 | -41.8 |
| Consumption of total finished steel | 64.608 | -15.3 |

*All figures provisional

*Source: JPC*

India's finished steel exports in 2020 has surged significantly while finished steel imports declined by over 40%.

# Forthcoming Events

**STEELTEC's Seminar on Ferroalloys, Raw materials & Future Perspectives, 5th. March, 2021**
Venue: ITC Sonar Hotel, Kolkata, India
Contact: : info@steeltech-india.com/ i_arnab@rediffmail.com

**9th MENA Billet & Flats Conference. 29-30 March, 2021**
Venue: Dubai, UAE,
Contact: events@metalexpert.com

**Ferroalloys Europe 2021 (Including Stainless Steel Scrap), May 11-12, 2021**
Venue: Dusseldorf, Germany
Contact: http://www.events.crugroup.com

**AISTech 2021, May 3-6, 2021**
Venue: Music City Centre, Nashville, TN, USA
Contact: http://www.aist.org

**METEC India Exhibition & Conference, 8-10 September 2021**
Venue: Bombay Convention & Exhibition Centre, Mumbai, India.
Contact: www. metec-india.com

**HTS 2021 - 14th International Exhibition on Heat Treatment, , 29 Sept-1st. Oct, 2021**
Venue: Bombay Exhibition Centre, Mumbai, India
Contact: www.asmindiachapter.org

**MMMM 2022 Exhibition & Conference, 25-27 August 2022**
Venue: Pragati Maidan, New Delhi, India,
Contact:www.mmmm-expo.com


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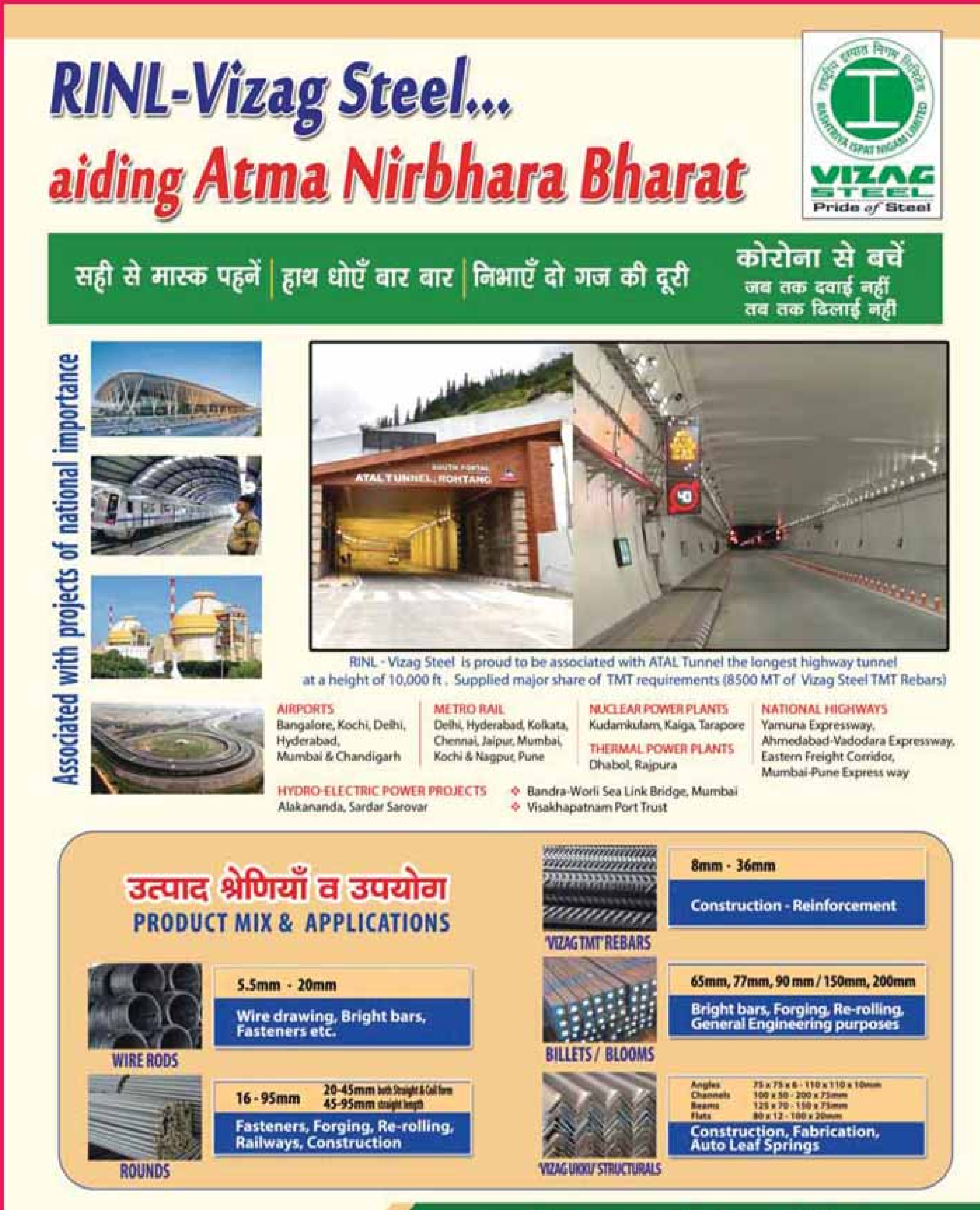



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