HBIS Group DRI-EAF (HyMEX®) Low-Carbon Emission Steel Production Process

Dr. Menglong LI, Chief Researcher of Sustainable Development Research Center
Dr. Hongqiang LIU*, Vice President of Materials Technology Research Institute

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01 Overview of Low-Carbon Development of HBIS Group

Committed to becoming the most competitive steel enterprise

HBIS is accelerating its development in high-end, intelligent, green, and internationalized directions, driving the transformation of steel products from raw materials to advanced materials and the company's evolution from a manufacturer to a comprehensive service provider, fully committed to completing the' second half' of its transformation and upgrading.

- **worldsteel Sustainability Champion for three consecutive years**
- **China Industrial Carbon Peak "Leader" Enterprise**
- **China National Green Factory**
- **China National Demonstration Factory of Intelligent Manufacturing**
- **China National Digital Pioneer Enterprise**

Rank 229 in Fortune 500

Rank 66 in China 500

Rank 43 in Chinese Multinational Corporations 100

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A systematic low-carbon strategic planning framework of "Philosophy-Strategy-Path-Actions"

Philosophy

Adhering to the philosophy of "harmonious coexistence of people, steel, and environment", HBIS Group embraces the vision of manufacturing green steel for human civilization. It implements a low-carbon & green action plan, and clarifies the path for the enterprise's green, low-carbon, and sustainable development.

Strategy

- **Clean Production (2013-2016)**
- **Ultra-low Emissions (2016-2020)**
- **Green & Low-Carbon (2020-)**

A systematic green and low-carbon development strategy of energy conservation, pollution reduction, CO_2 reduction, circulation, and coordination has been formed

Path

Three major innovations

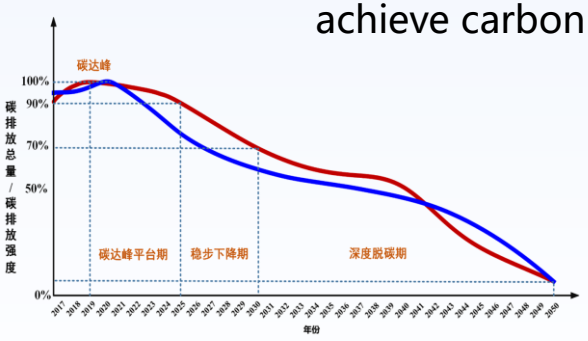
Focus on process structure, energy structure and material technology

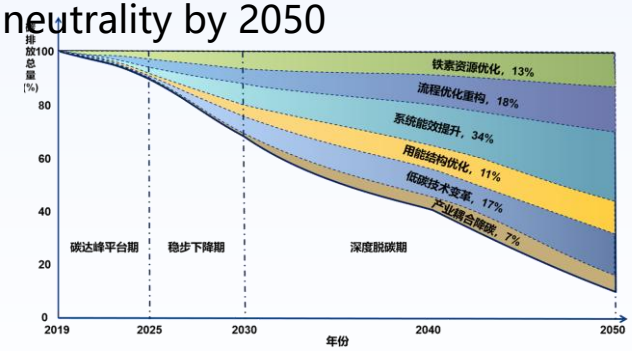
Implementation approach

Six Technical Paths and Two Management Platforms

Development goals

To achieve a 10% reduction in carbon emissions from peak years in 2025, a 30% reduction in carbon emissions from peak years in 2030, and strive to achieve carbon neutrality by 2050





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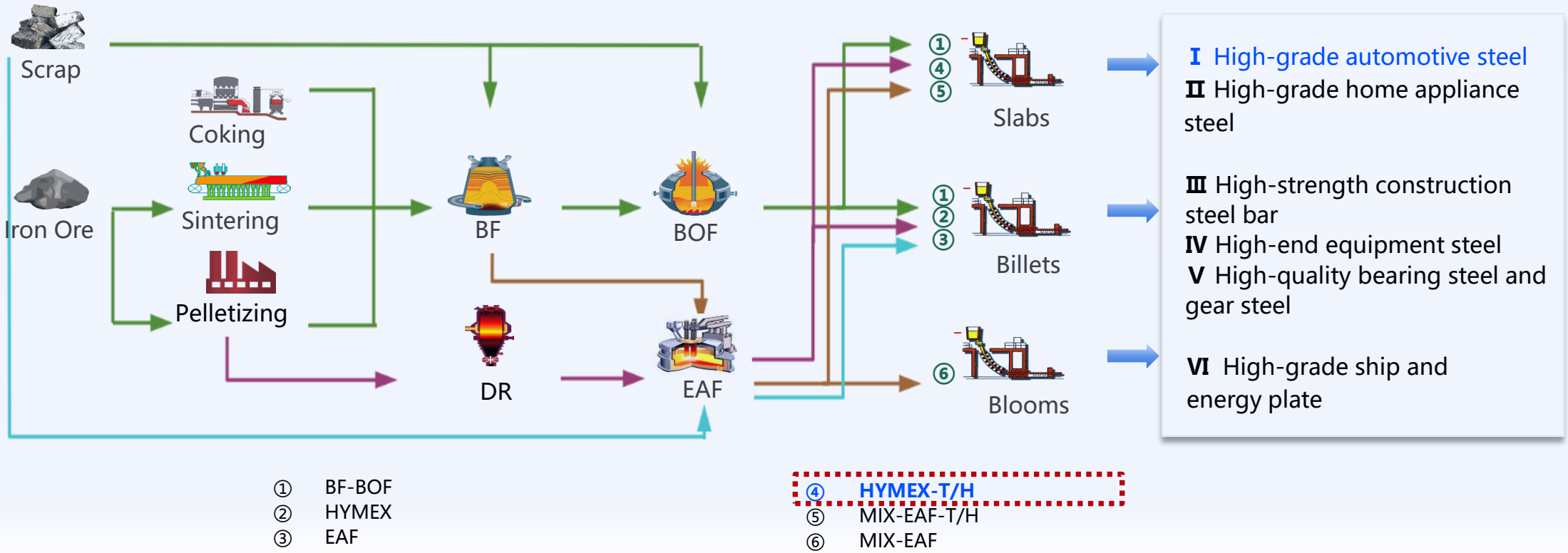
A systematic low-carbon strategic planning framework of "Philosophy-Strategy-Path-Actions"

HINEX Steel®, the Low Carbon Brand

HINEX® Steel

- Building a product matrix of low-carbon emission steel, green steel, and near-zero carbon emission steel.
- Focus on 6 core processes(production lines) and 6 catogaries of steel, 5 levels of CO_2 emission.



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The COG zero-reforming technology based industrial DRI project

Milestones

Dec 2022

- The project phase I was fully completed and started hot commissioning at HBIS.

Mar 2024

- The Hydrogen-based Shaft Furnace–Near Zero-carbon Emission Electric Arc Furnace new-process technical project was officially launched, to achieve three dimensions of "near-zero CO2" in energy sources, raw material production, and smelting processes.

Dec 2024

- The continuous casting line for automotive steel based on DRI-EAF process started hot commissioning.

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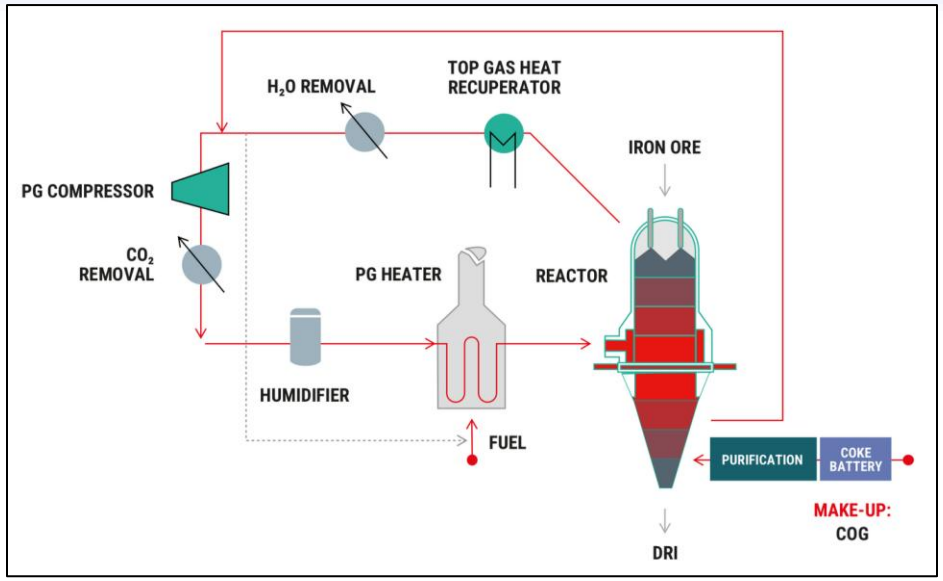
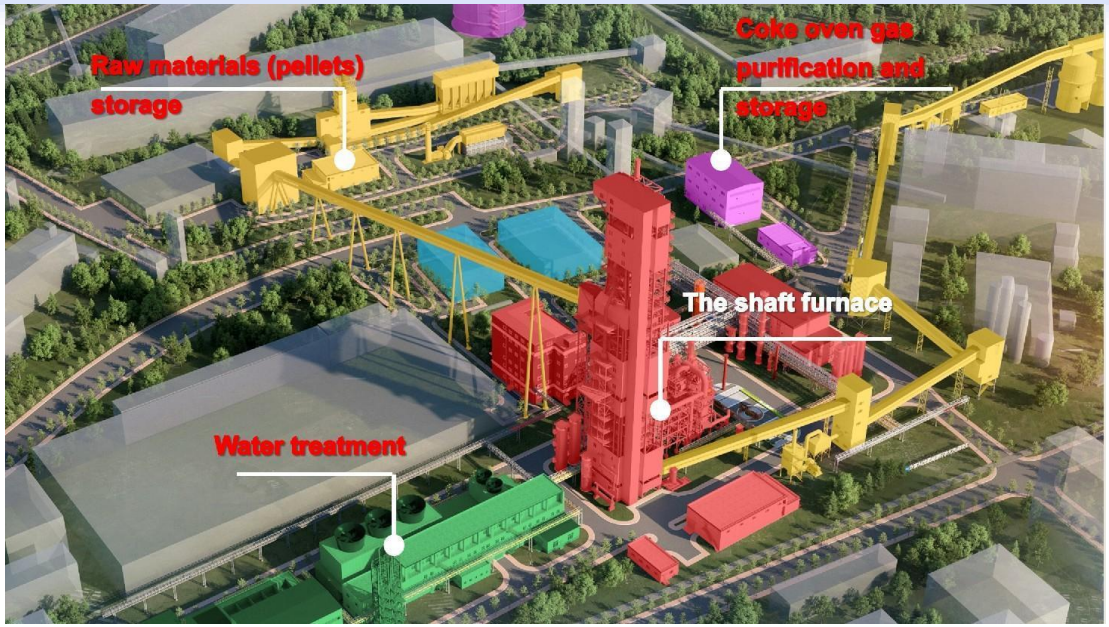
The COG zero-reforming technology based industrial DRI project

☐ Ligned with China's resource endowments

- China is "poor in oil and gas", but the coke production is about 470 million tons per year, and the by-product coke oven gas, in addition to the plant's own use, still has a surplus of about 100 billion cubic meters, containing 60% hydrogen and a certain amount of methane and CO, which is suitable for reducing gas.
- The 2-million-ton coking and pelletizing facilities at HBIS's original production line provide crucial support for the DRI project.
- This is the first shaft furnace to use COG zero-reforming technology.



Energiron ZR



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Comprehensive Development of Direct Reduction-Electric Arc Furnace Process Technology Innovation

- Focus on innovation in process, energy and materials， to enhance the technical and economic efficiency of the process, and achieve the production of high-end materials with low carbon emissions.

Shaft furnace Direct Reduction

Low-carbon raw materials

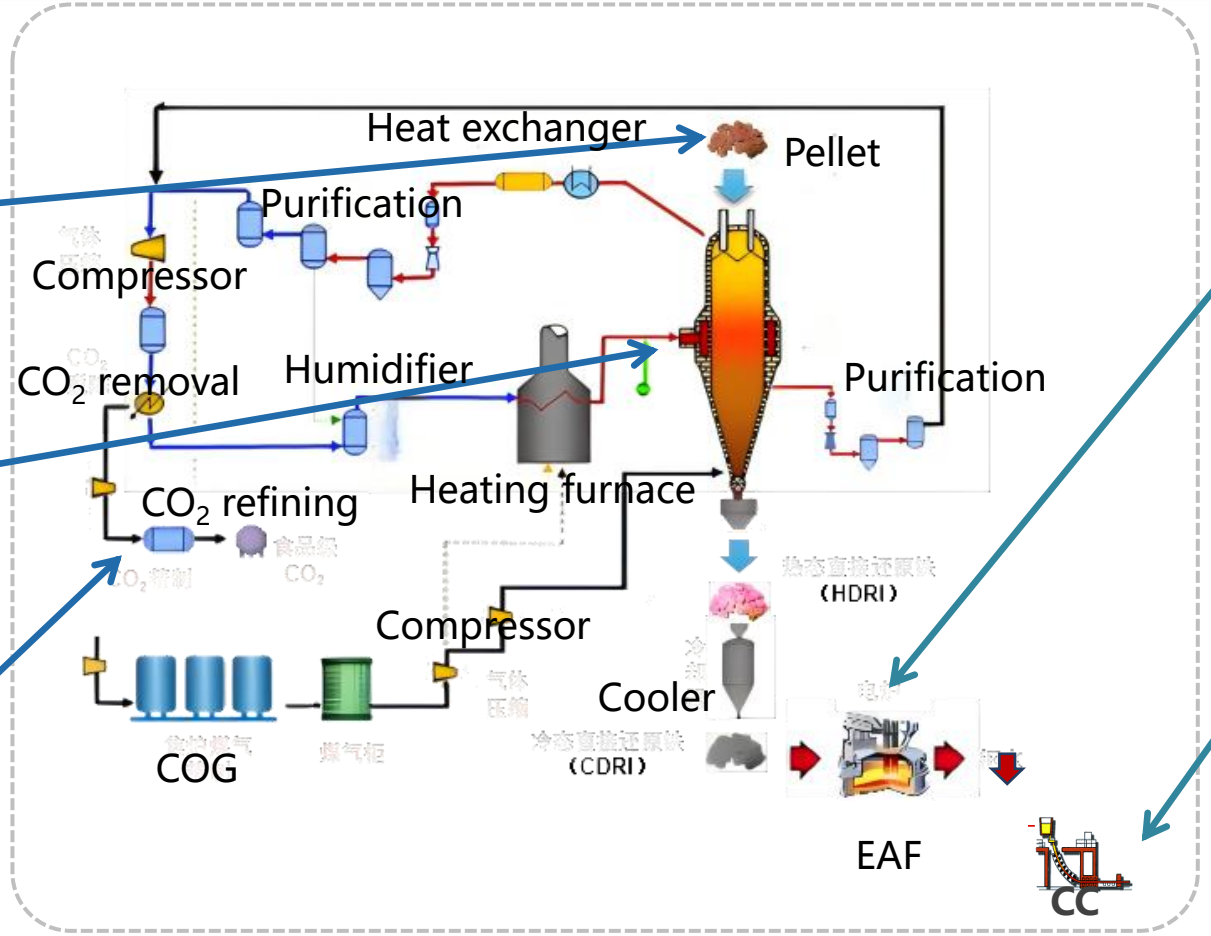
Expand use of lower grade iron ore

Reducing gas

First to make full use of COG, and the future

CCUS

CCU combined with COG DR process



DRI-EAF process

High efficient, clean, and low-carbon steelmaking

Near zero emission EAF process

High quality steel

DRI-EAF steels and the new automotive steel line

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02 The COG ZR shaft furnace DRI process

2.1 Reducing gas

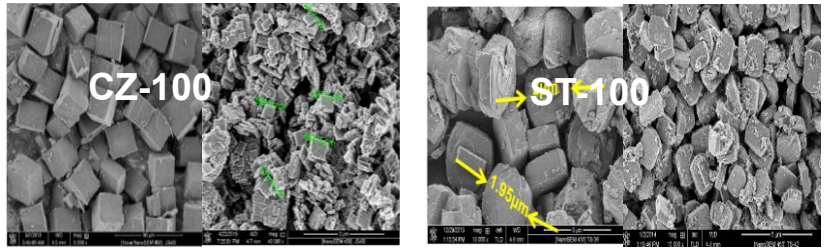
Low-cost deep purification of coke oven gas

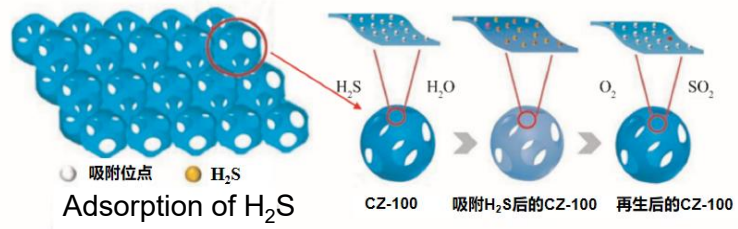
- Based on the concept of low-cost and precise adsorption, the high-efficiency purification process of coke oven gas based on high adsorption performance polycrystalline material has been optimized.
- The removal rates of H_2S, hydroxyl sulfide, SO_2 and aromatic impurities are 98%,85%,80% and over 80% respectively, and the low-cost purification is achieved at 0.1 yuan/Nm^3.

The results of coke oven gas purification

No.	Content	unit	Before	After
1	H2S	mg/m³	1000~2000	≤1
2	hydroxyl sulfide	mg/m³	200~400	≤5
3	CS2	mg/m³	20~30	≤5
4	**Total Sulfur**	**mg/m³**	**1200~2500**	**≤10**
5	Tar	mg/m³	15~25	≤2
6	Naphthalene	mg/m³	2~4	≤5
7	ammonia	mg/m³	30~50	≤5
8	**benzene**	**mg/m³**	**2000~2500**	**≤50**

Polycrystalline material

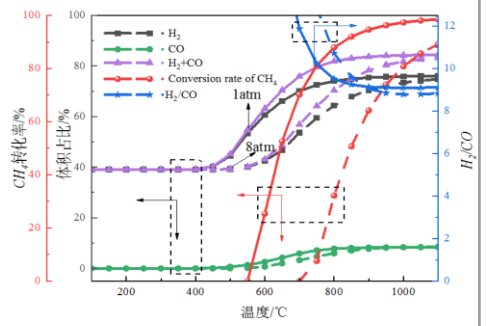




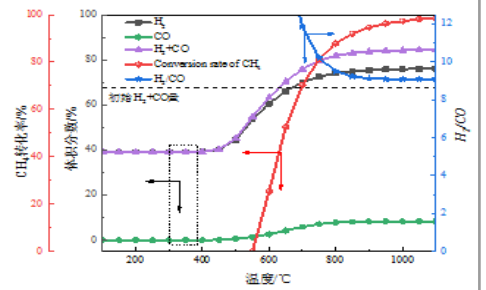
2.1 Reducing gas

Dynamic adjustment of gas composition in vertical furnace process

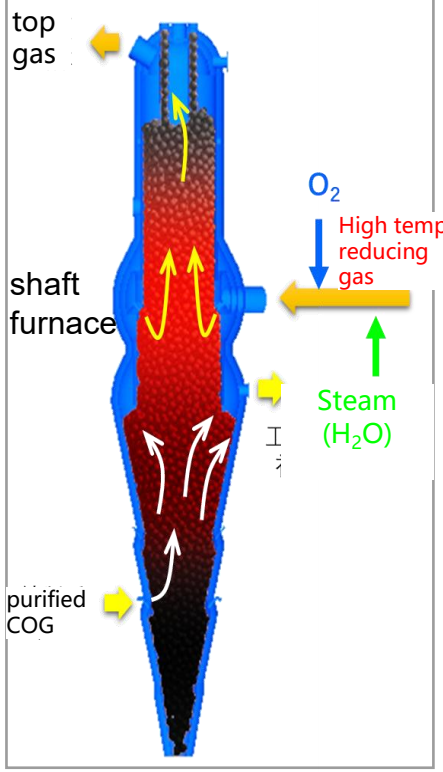
- Based on the study on influence of temperature, pressure, composition and other factors on the process reducing gas in the shaft furnace and the reforming mechanism of the reducing gas, the dynamic control model of the process reducing gas humidification and local oxygen injection was established.
- The dynamic temperature of the process gas in the furnace was stabilized at 1050℃ and $H_2/CO>8$.

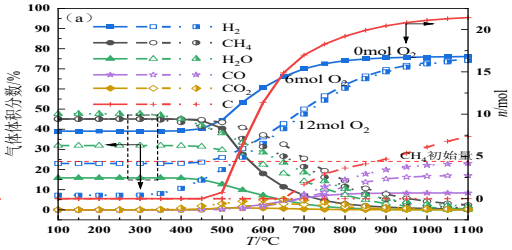


Effect of Pressure on the Conversion of Reducing Gas Composition

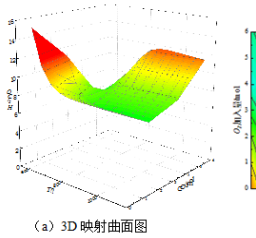


Effect of Temperature on the Conversion of Reducing Gas Composition

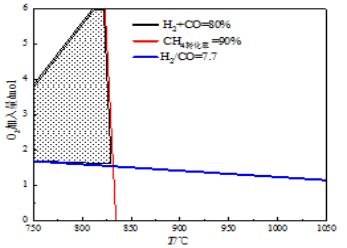




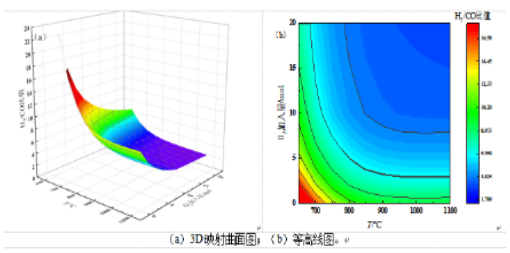
Effect of Oxygen Injection on Gas Composition



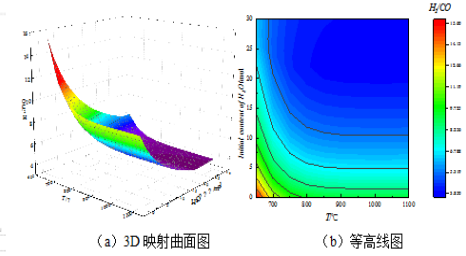
Effect of Oxygen Injection on H_2/CO Ratio



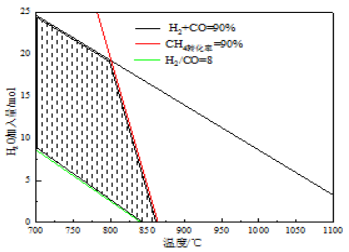
Optimization range for O_2 injection volume



Effect of Steam on $CO+H_2$ Conversion



The Influence of Steam on the H_2/CO Ratio

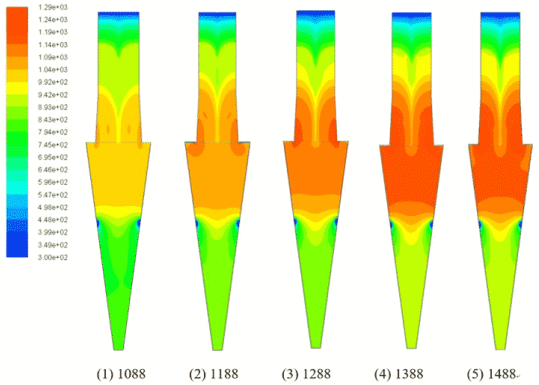


Optimization range for steam injection amount

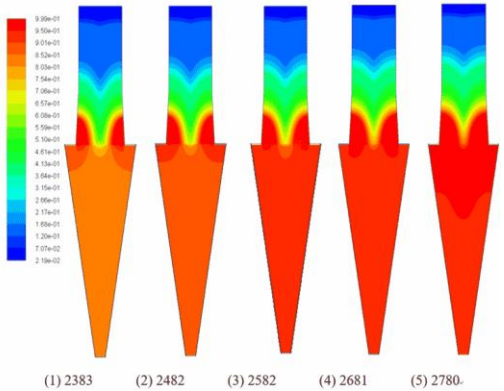
2.1 Reducing gas

Multi-parameter coordinated control of shaft furnace production

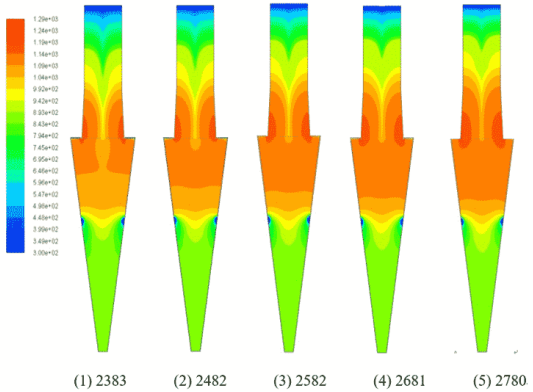
- The temperature of reducing gas 1030℃~1050℃, and the minimum process gas volume at 120000 m^3/h, can meet the requirements of DRI high efficiency production with 94% metallization rate and 2%~4% carburizing amount at the lowest energy consumption.



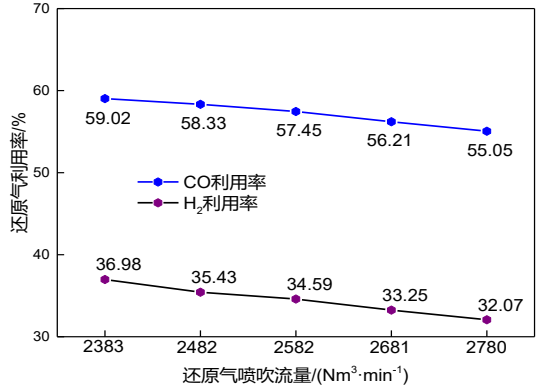
Reducing gas temperature and shaft furnace temperature



Reducing gas flow rate and metallization rate



Reduced gas flow & top temperature



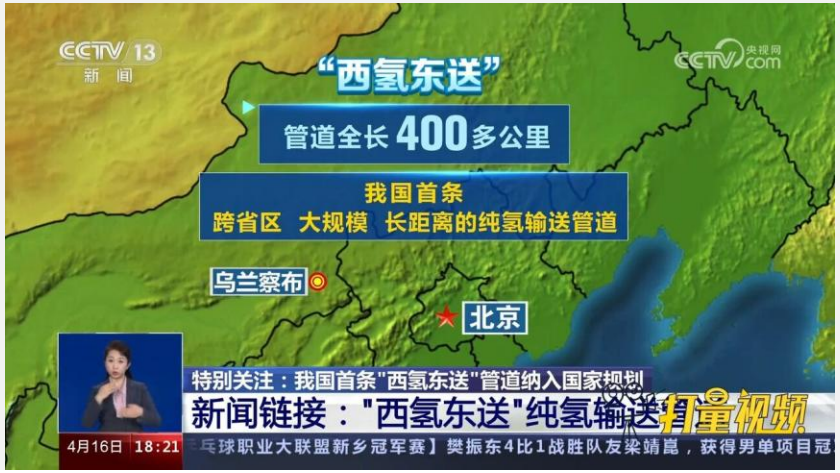
Reduced gas flow rate & gas utilization rate

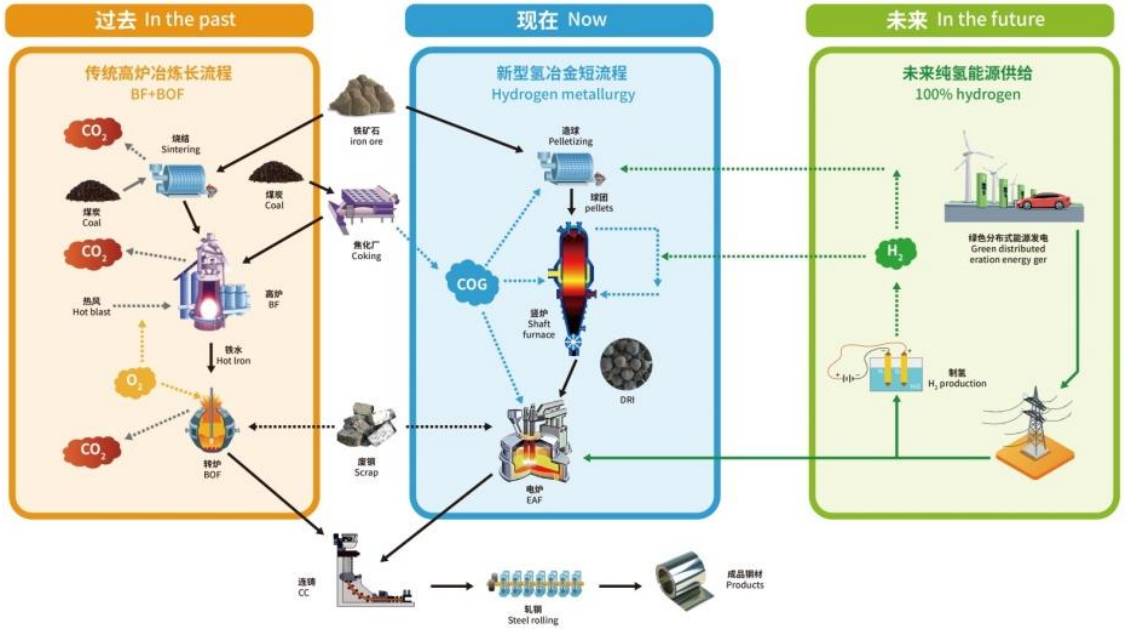
2.1 Reducing gas

- Compared with natural gas and pure H_2, coke oven gas is the preferred gas source for China's shaft furnace DRI before the emergence of more affordable hydrogen energy.
- Based on the green hydrogen resources in China's northwest region, the transition is gradually shifting to direct reduction with green hydrogen.

Signed with Sinopec "Strategic Cooperation Framework Agreement on Building a Green Hydrogen Energy Industry Chain"

- **Build a Green Hydrogen Energy Industry Chain**
- **Promote scientific and technological cooperation in hydrogen energy engineering materials**



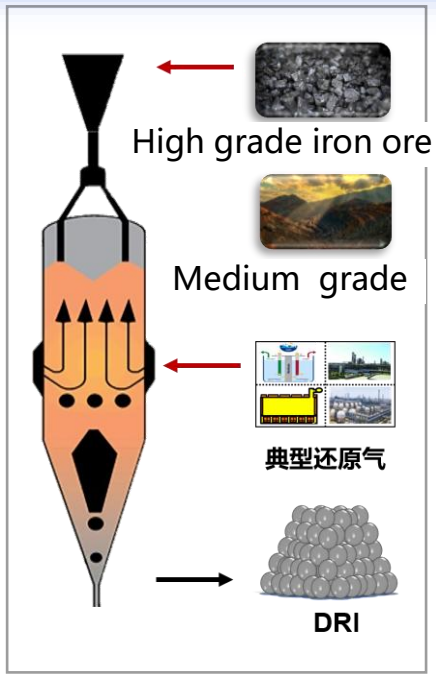


From COG to green hydrogen

2.2 Low-carbon raw materials

Synergistic application of different grade multi-source iron ore

- The integrated control of basic characteristics of **high grade ore**, pellet preparation and direct reduction was carried out. The pellet strength was controlled at 2500-3500 N, the reduction expansion rate was less than 15%, and the metalization rate of DRI product was more than 94%.
- The synergistic application of multi-source **medium and low grade iron ore** has been tested, and the strength of pellet was 2000-3000 N, the metalization rate of the product after reduction was more than 90%, and the pulverization index of low temperature reduction $LTD_{-3.2}$ was less than 10%.



Crushing strength/N		2500-3500
Metallurgical performance	reduction expansion rate/%	< 15
	caking index/%	< 20
	low-temperature reductive pulverization rate/%	$RDI_{+6.3}$ > 90
		$RDI_{-3.2}$ < 10
	metalization rate/%	≥94

Technical specifications for high-grade ore pellet production

Industrial test and verification of medium grade ore

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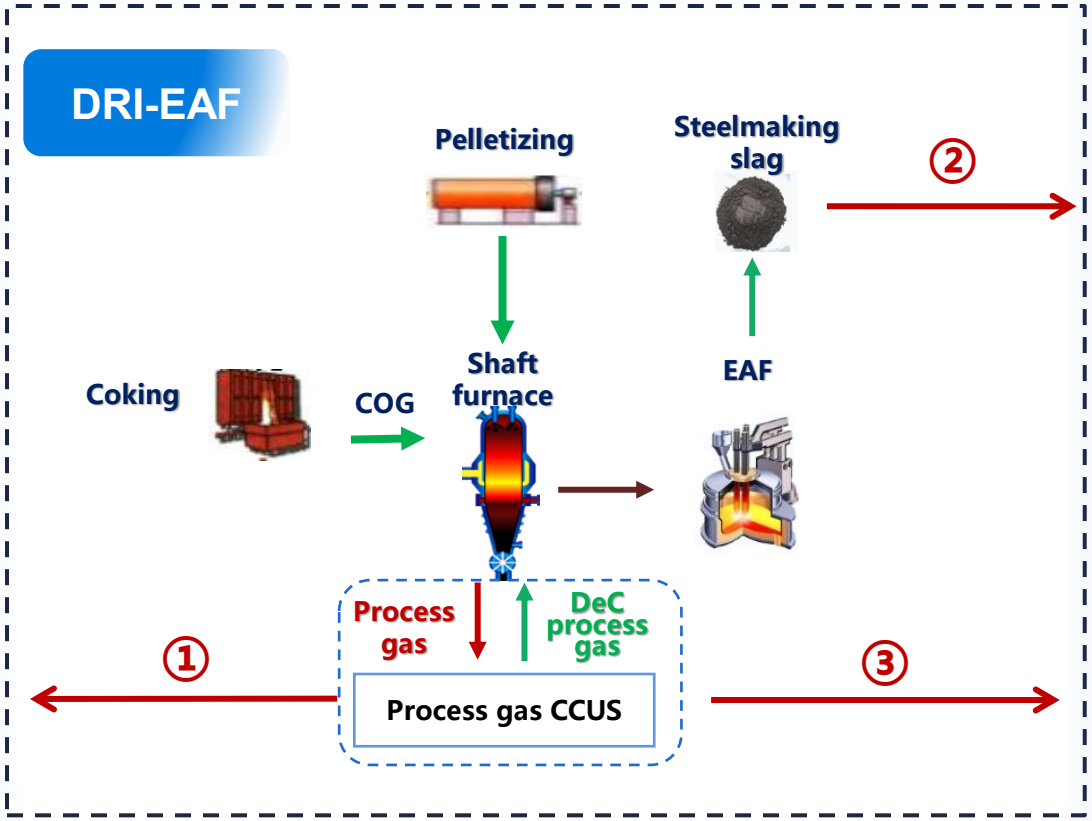
2.3 Integration of CCUS and DR process

- Develop an integrated technology system combining CCUS with DRI project, covering CO_2 internal circulation in the steel industry and cross-industry utilization pathways to transform CO_2 into high-value-added products.

Top gas CO_2 capture and refining

Exploration of CO_2 Utilization in Industrial and Food Grade

- CO_2 60000t-70000t/a
- Optimized MDEA method, > 80% capturing rate of tail gas.
- CO_2 refined to >99.999%



Carbon fixation and utilization of steel slag at the scale of 1000 tons

- 7,200 hours annually
- processing 5,000 tons of steel slag and 1,000 tons of CO2

Microbial carbon fixation to ptoduce protein from Steel Flue Gas

- 1m³ pilot was completed in the field with the flue gas, and the protein production rate was more than 10 kg/m³/d, and the protein content of the product was higher than that of fish meal.

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2.4 Technical and economic indicators of the demonstration project

- The technical indicators of COG zero reforming shaft furnace direct reduction process has reached the advanced level of gas-based shaft furnace DRP, and has more advantages in energy consumption.
- It further indicates that, compared with natural gas and pure H_2, coke oven gas is the preferred gas source for China's shaft furnace DRP before the emergence of more affordable hydrogen energy.

Indicator	Y2023	Y2024
Metallization/%	93.5-94.5	94.0-95.0
COG consumption/(m^3/t)	**650-750**	**550-600**
Pellet consumption/(t/t)	1.37-1.40	1.35-1.37
Power consumption/(kWh/t)	250-300	200-250

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03 High quality steel production technology of DRI-EAF process

Green process technology with "DRI-EAF" as the Core

2x tenova Consteel® EAF

- Successfully commissioned in February and June 2023.

Scrap and DRI as raw materials

- To produce low P, S and O content high quality steels

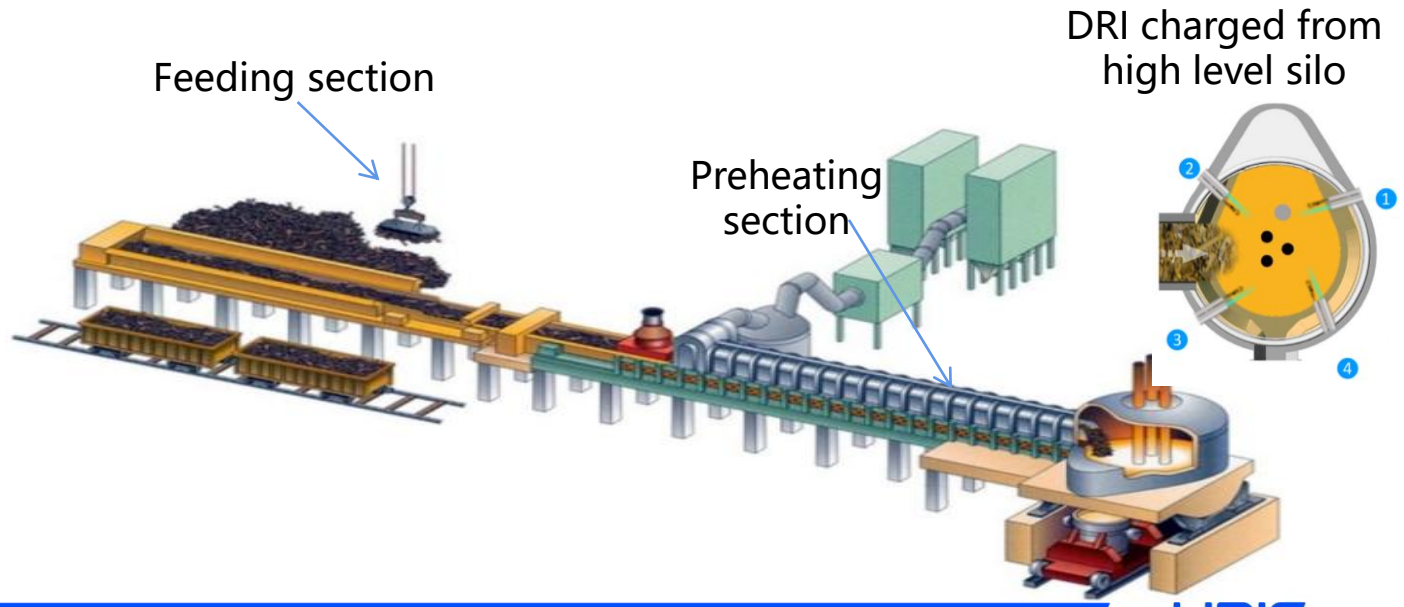
Flue gas treatment system

- The preheating section hood was specially designed to improve the efficiency of secondary combustion.

Injection system

- 4 KT oxygen lance (max. 3500Nm^3/h) and 4 KT carbon injection lance (35kg/min), to form a powerful composite stirring.

Nominal capacity	120 t
Diameter	7000 mm
Tapping mode	EBT
Electrode diameter	700 mm



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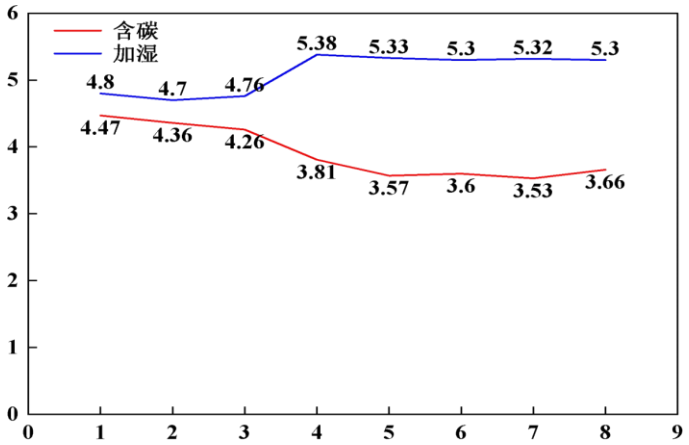
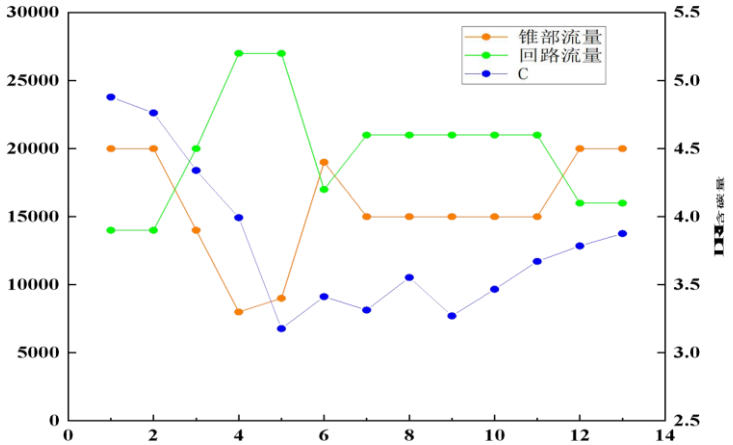
3.1 Stable preparation of high quality DRI containing carbon

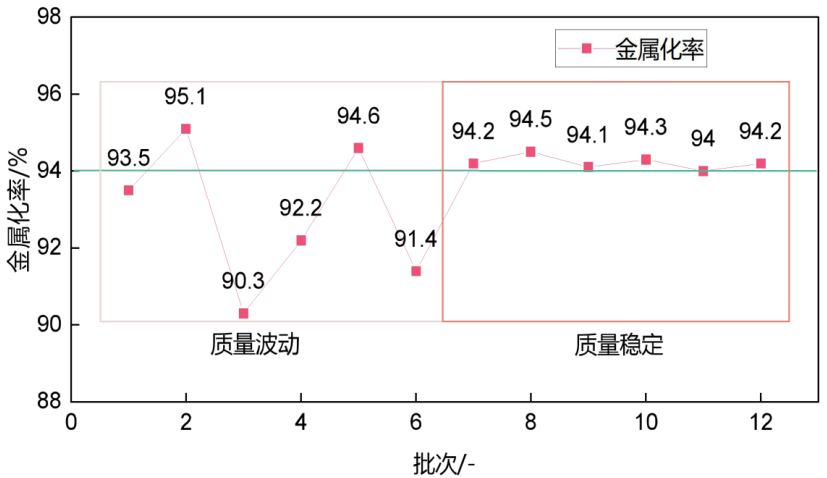
- The carbon content of DRI is the main factor affecting the heat of EAF，in view of the problem of the large fluctuation of carbon content of COG DRI, to achieve a synergistic control of DRI carbon content by methane desorption from process gas, DRI carburizing of gas in the cone section and humidification, at 2.5-3.0%
- By the integrated regulation of process gas flow, furnace top temperature and DRI output, the metallization rate of DRI was controlled at over 94%.



Humidification



Flow volume



Integrated control

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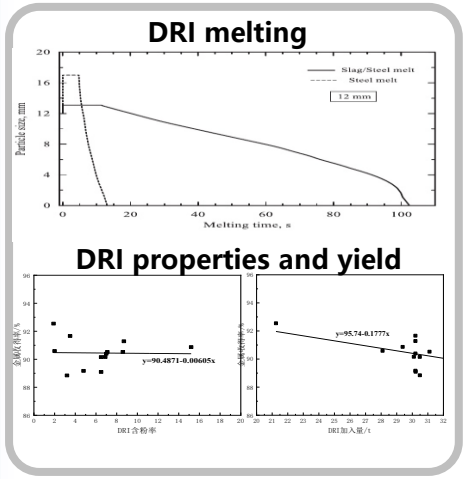
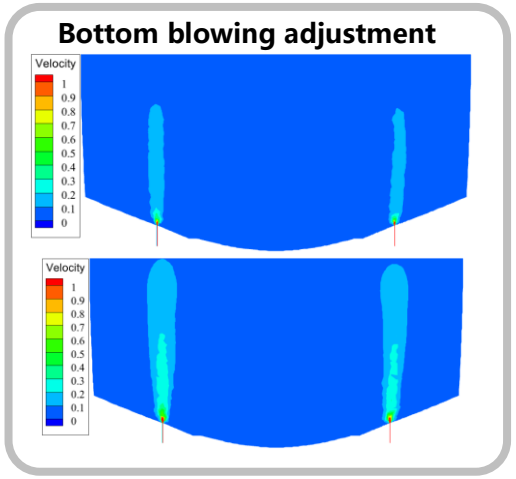
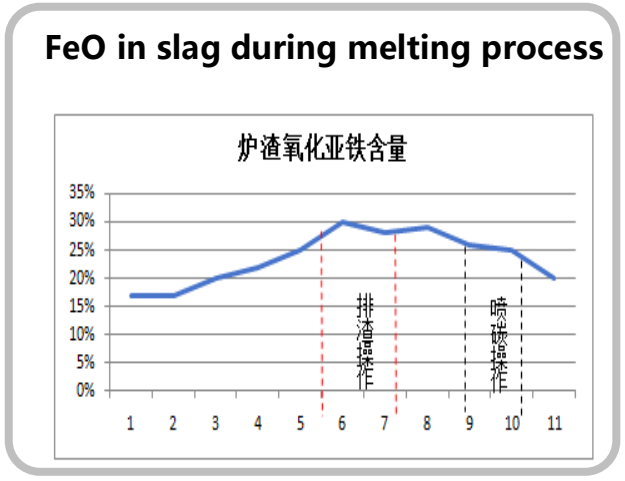
3.2 High efficiency melting of DRI in EAF

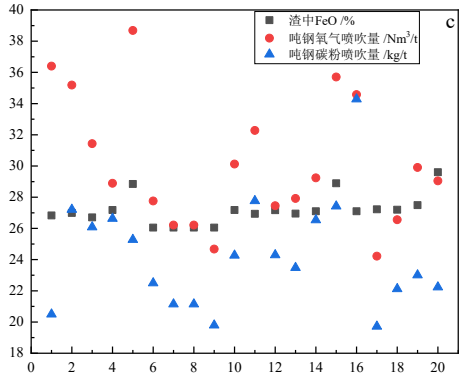
- The control model of bottom blowing was divided into several parts to enhance the stirring capacity of melting pool and increase the melting rate of DRI.
- Adjust the carbon injection mode and optimize the slag discharge timing to achieve dynamic control of the slag layer throughout the entire process.
- DRI yield ＞82%.

- Oxygen blow 25-30Nm^3/t, carbon injection 20-26 kg/t，to achieve stable FeO control at 20-30% in the slag.
- Average tap to tap 48.5min, power supply time 31.5min，to achieve high efficiency EAF steelmaking.

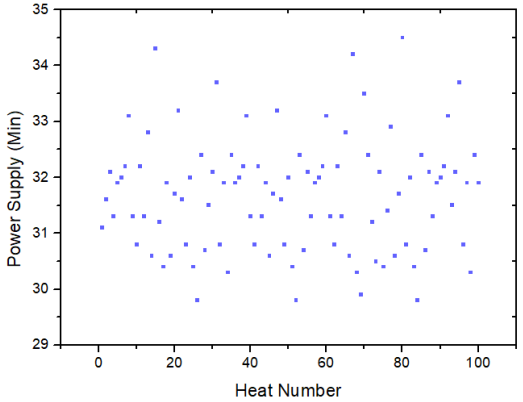




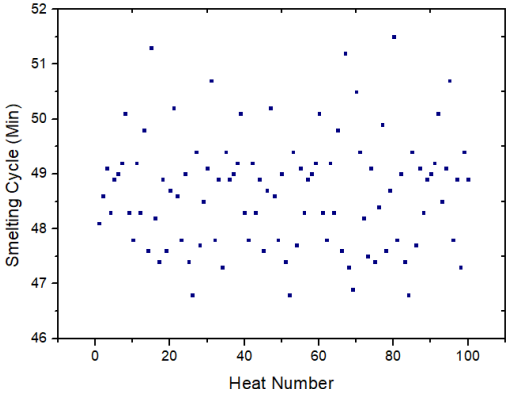




O2 blowing/Carbon injection/FeO



Power supply



Tap to tap

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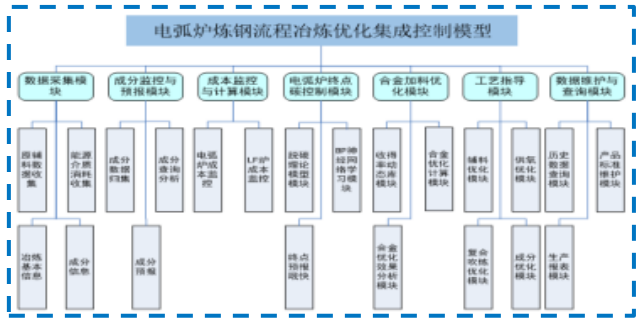
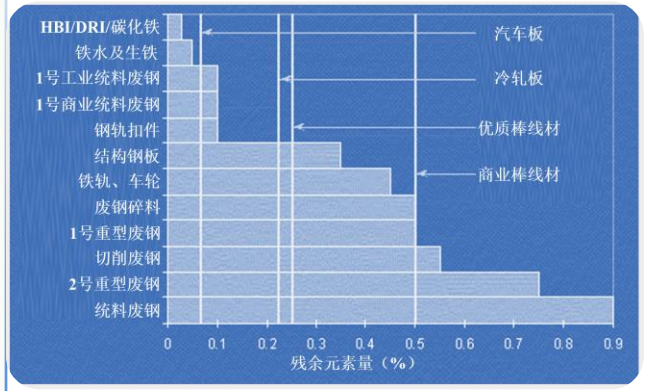
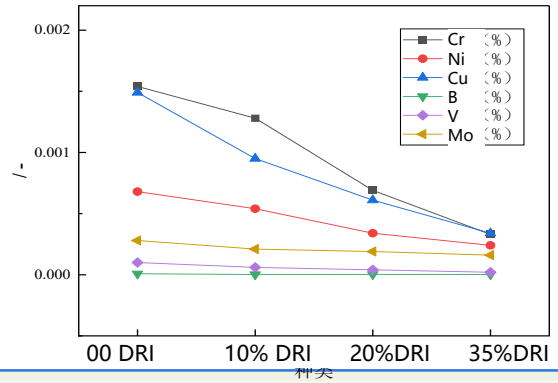
3.3 Hierarchical control of residual elements in EAF Steels

- Based on the demand for residual elements in steel grades and cost optimization, an intelligent control model was developed to achieve graded control of residual elements in EAF steel.
- By adjusting the proportion of DRI added and smelting parameters, the stable control of residual elements such as Cu, Ni, Cr in molten steel was achieved, to produce clean steels.

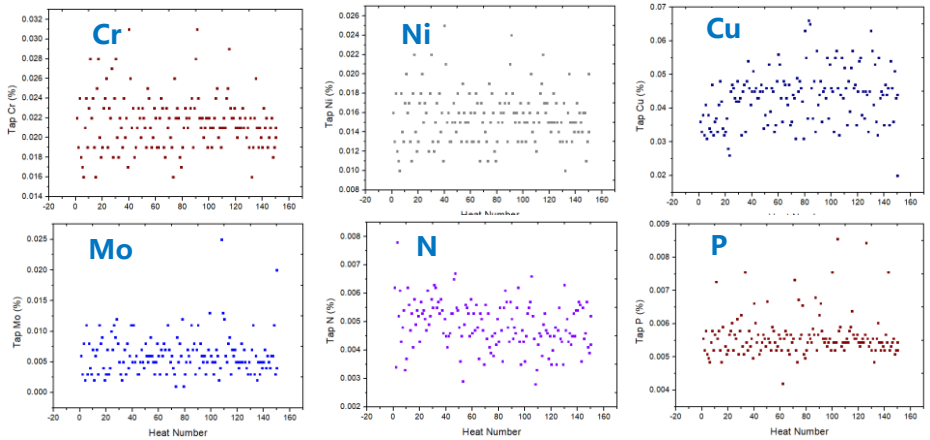
Intelligent charging model







Classification and control of residual elements in EAF steel by steel type



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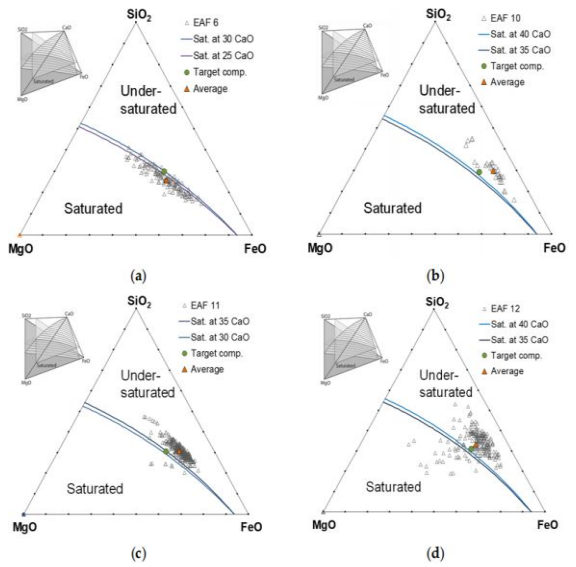
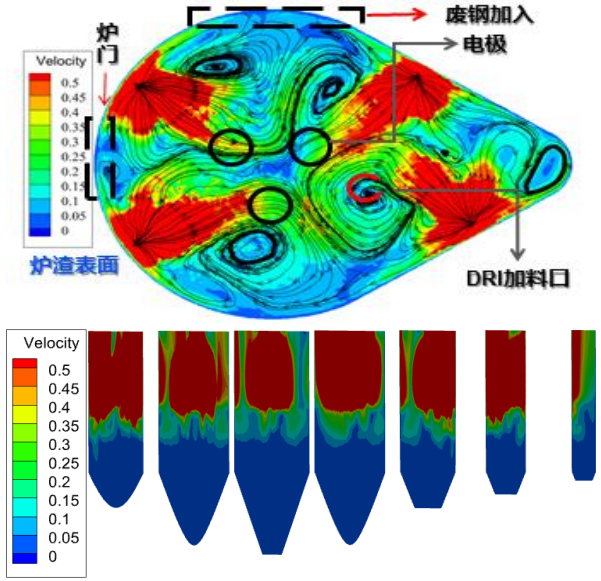
3.3 Hierarchical control of residual elements in EAF Steels

- Based on the optimization of the whole process high quality foaming slag and dynamic conditions, the nitrogen control technology suitable for DRI EAF smelting was developed, and the nitrogen content can be controlled below 30ppm, which opens up the process path of high quality steel.
- Increasing the DRI charge significantly improves the purity of steel, with marked reductions in final nitrogen content and trace elements such as Cr, Cu, and Ni.

Slag composition study

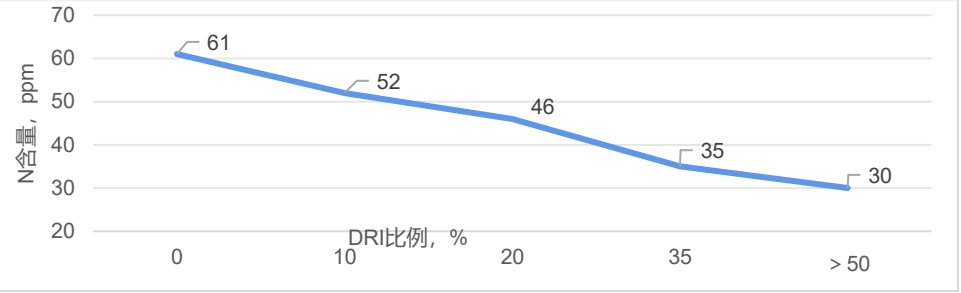


Dynamic conditions optimization



[N] content control

方案	1#氧枪流量 Nm3/h	3#氧枪流量 Nm3/h	4#氧枪流量 Nm3/h	5#氧枪流量 Nm3/h	钢渣界面速度m/s	钢渣界面死区比例	钢渣界面速度提升/%	钢渣界面死区比例降低/%
原工艺	1700	1700	1700	1700	0.058	41.42		
优化工艺	2000	2000	2000	2000	0.072	29.02	24.14	12.40
	1700	1700	2000	2000	0.07	30.57	20.69	10.85
	1700	1700	2300	2300	0.092	15.1	58.62	26.32
	2300	2300	2300	2300	0.1027	13.76	77.07	27.66



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3.4 Effect of DRI on EAF steelmaking

- The charge of DRI significantly improves the cleanliness of molten steel, while also substantially increasing energy and material consumption.
- When the DRI charge increased from 0 to 45 tons (30%), the power consumption increased by 24.89 kWh/t and the oxygen consumption by 1.49 Nm^3. The consumption of pulverized carbon, slag-forming additives and ferrous charges consumption also increased significantly, leading to higher costs. It is necessary to optimize the process to balance economic efficiency and production capacity.

DRI t	Power consumption kwh/t	Oxygen consumption Nm^3/t	Injected carbon kg/t	Lime kg/t	light-burned dolomite kg/t	ferrous charges consumption kg/t	FeO	R
0	397.44	25.45	20.90	18.19	14.61	1092.9	26.54	1.52
20	400.27	25.88	20.60	19.84	16.78		23.32	1.58
30	404.78	26.22	20.88	21.10	16.58	1122.3	21.33	1.64
45	422.33	26.94	21.59	27.69	17.89		30.03	1.51

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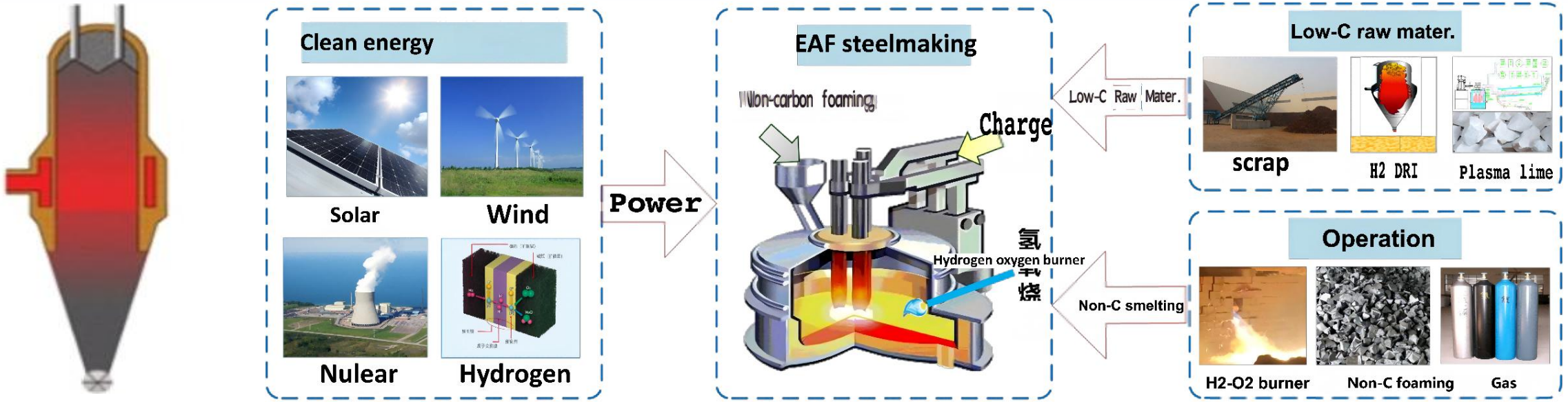
3.5 Low-carbon EAF steelmaking

DRI-near zero CO_2 emission EAF technology

- Partnering with the University of Science and Technology Beijing, we are deploying optimized combinations of green technologies and renewable energy. By utilizing carbon-free clean energy, low-carbon raw materials, and non-carbon smelting techniques, to achieve near carbon-neutral steel production.
- Our goal is to establish a near-zero carbon emission production line centered on the 'DRI-EAF' process.



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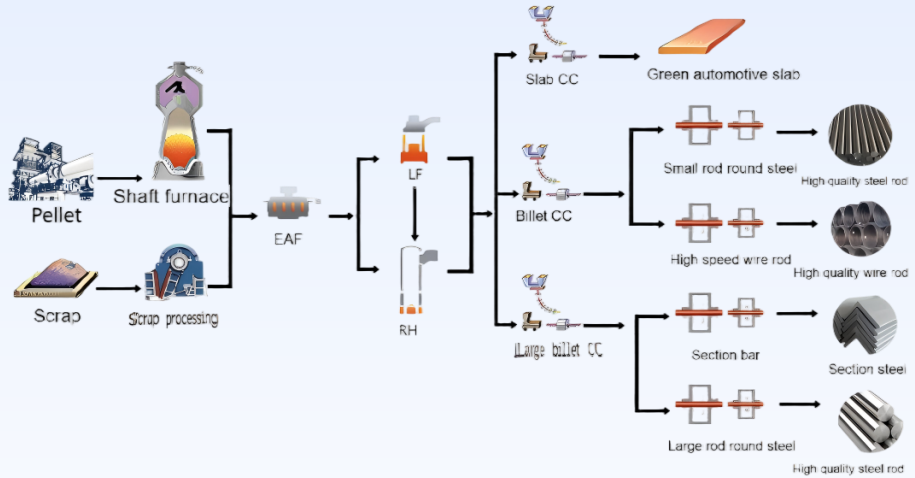
3.6 Use DRI-EAF process to produce high quality steel

HyMEX®

Develop a series of DRI-EAF green and low-carbon products with significant brand value

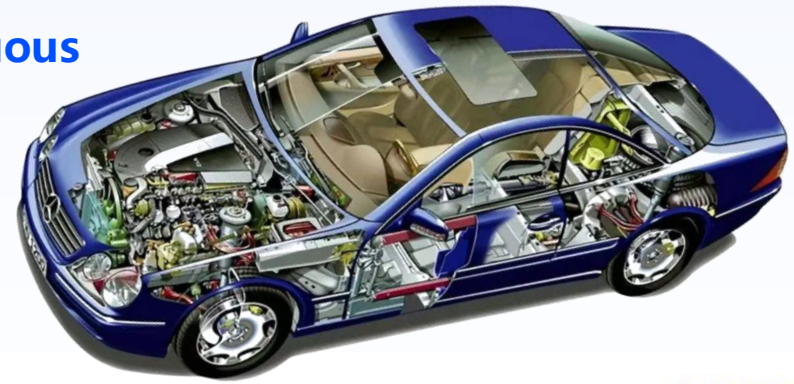
- The company has 11 green and low-carbon final production processes, including finishing, heat treatment, and silver brightening, and has developed production capabilities for high-quality steels such as long steel, section steel, and flat steel(slab).



- **High-end machinery and automotive special steel**
- **Green automotive sheet**
- **Power tower steels**
- **High-end aerospace-grade new materials**
- **… …**

December 2024, hot commissioning of automotive plate continuous casting production line

Focuses on the R&D of 9 series and 62 steel grades, such as automotive structural steel, wheel steel, beam steel, cold rolled/galvanised steel, etc.



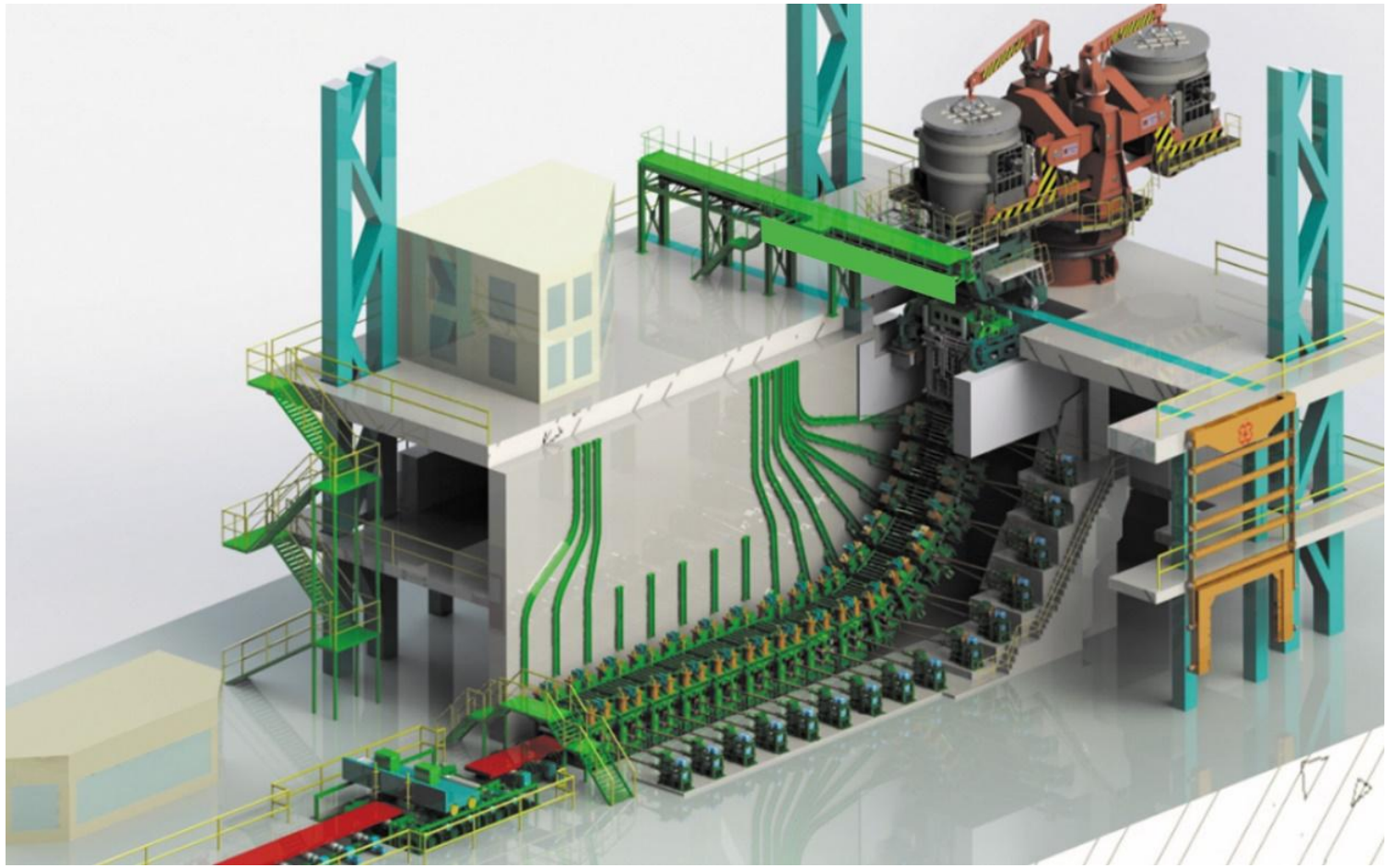
3.6 Use DRI-EAF process to produce high quality steel

High-end automotive sheet production line

- Equipped with the whole process protection casting, large capacity tundish, mold hydraulic vibration, mold expert system, leakage forecast model, 3D secondary cooling dynamic water spray, etc., to achieve high purity, less inclusions, and high slab quality.
- Width: 900-1900mm
- Thickness：230mm, 250mm
- Sizing: 9-11m，4.5-5.3m（partial）
- Main product: LC, ULC, HSLA, DP for auto, and home appliances steel

1900mm slab continuous casting line

PRIMETALS TECHNOLOGIES



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3.6 Use DRI-EAF process to produce high quality steel

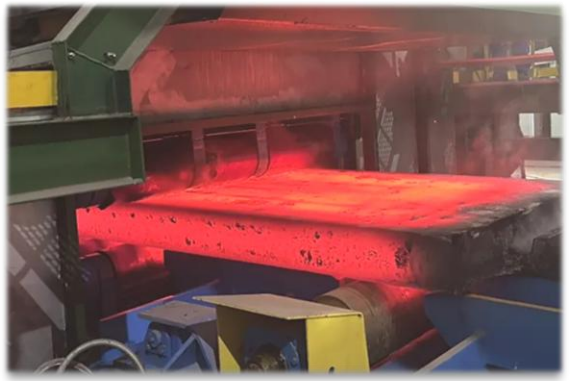
☐ Realize the stable mass production of green automotive plate

- With the goals of high-end, intelligent and green development, aimed to build a diversified low-carbon product structure and target the potential demand market, a new green automotive sheet continuous casting line for DRI-EAF was built and put into operation.

➢ Starting from Jan 2024, preparations for the IATF16949 quality management system certification for automotive steel began simultaneously with construction; Certified in January 2025.

➢ In 2025, the new production line has passed the audit by well-known auto company.

More than 400000 tons have been produced cumulatively, achieving high proportion DRI smelting technology for electric furnaces (up to 50%), and the EPD report shows a 50% reduction in carbon emissions.



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3.6 Use DRI-EAF process to produce high quality steel

Round steel and bar production line

- Small round bar line, Φ20-70mm
- Large round bar line, Φ50-120mm

Product categories: structural steel series, gear steel series, high-strength fastener steel, high-pressure boiler tube steel, crawler steel, bearing steel, valve steel, ball mill steel, free-cutting non-quenched and tempered steel, spring steel, etc.

Section bar production line

- 165×165mm, 200×280mm billets used for section line

High speed wire rod line

- 150mm×150mm billets used for high speed wire rod line, product Φ5.5-14mm

Product categories: ER70S-6 series for welding, prestressed steel wires and steel strands, hose wire, bead wire, etc.

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3.7 DRI-EAF product environmental impact assessment

◘ WesCarber® Digital Platform

- Providing industry users with full-scenario solutions encompassing carbon accounting, carbon footprint, energy-carbon synergy, and supply chain carbon management.
- Over 60 carbon footprint certificates have been issued for global clients.

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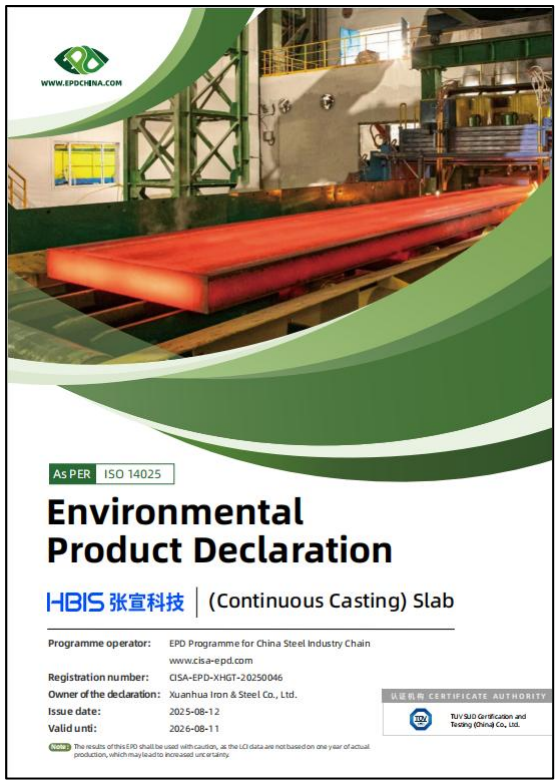
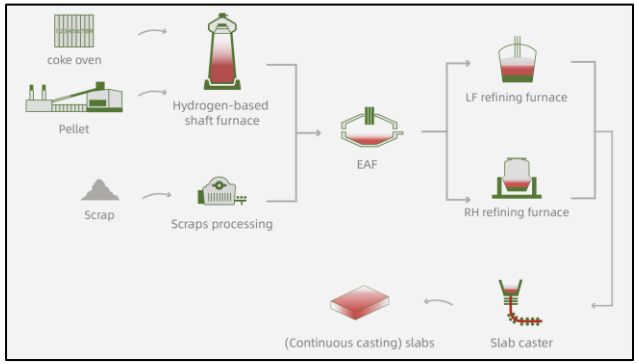
3.7 DRI-EAF product environmental impact assessment

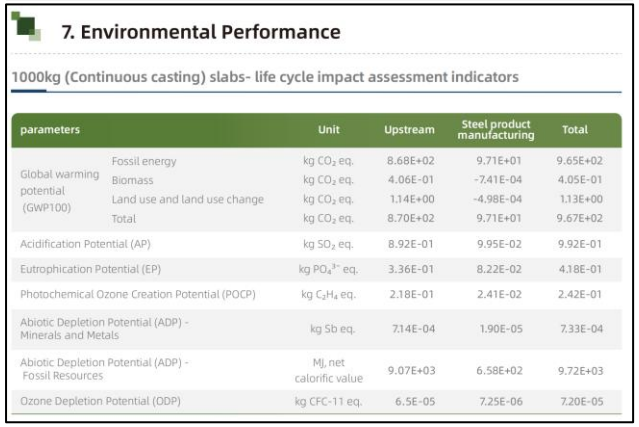
- The EPD for DRI-EAF slabs was released in August 2025.
- Compared with the traditional integrated process of BF+BOF, the process of DRI-EAF of HBIS can reduce the CO_2 emission per ton of steel by about 50%.

Conventional process	Slab/billet Carbon Footprint (LCA)	Shaft furnace + electric arc furnace	Slab Carbon Footprint (LCA)
HBIS Company	1.850t	HBIS Zhangxuan Technology	0.967t (CISA-EPD-XHGT-20250046)
Company A	2.070t		
Company B	1.830t		
Company C	2.140t		

Data source: CISA EPD Platform






7. Environmental Performance

1000kg (Continuous casting) slabs- life cycle impact assessment indicators

parameters		Unit	Upstream	Steel product manufacturing	Total
Global warming potential (GWP100)	Fossil energy	kg CO_2 eq.	8.68E+02	9.71E+01	9.65E+02
	Biomass	kg CO_2 eq.	4.06E-01	-7.41E-04	4.05E-01
	Land use and land use change	kg CO_2 eq.	1.14E+00	-4.98E-04	1.13E+00
	Total	kg CO_2 eq.	8.70E+02	9.71E+01	9.67E+02
Acidification Potential (AP)		kg SO_2 eq.	8.92E-01	9.95E-02	9.92E-01
Eutrophication Potential (EP)		kg PO_4^{3-} eq.	3.36E-01	8.22E-02	4.18E-01
Photochemical Ozone Creation Potential (POCP)		kg C_2H_4 eq.	2.18E-01	2.41E-02	2.42E-01
Abiotic Depletion Potential (ADP) - Minerals and Metals		kg Sb eq.	7.14E-04	1.90E-05	7.33E-04
Abiotic Depletion Potential (ADP) - Fossil Resources		MJ, net calorific value	9.07E+03	6.58E+02	9.72E+03
Ozone Depletion Potential (ODP)		kg CFC-11 eq.	6.5E-05	7.25E-06	7.20E-05

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