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The clean minerals phase transformation by hydrogen reduction

An easy way to process hard-to-beneficiate Iron Ore

R & DEVELOPMENT HISTORY

Since 2007

The research team formed and began to study HMPT technology

2015

Build up pilot test base

2017

HMPT was ready for commercial promotion

2018

Parent Company was founded and conducted the first industrialized project

2019

Listed as one of the top ten technical news in world steel industry

2020

World's first HMPT production line finished and succeeded

2021

Entering foreign markets (Africa)

2022

Hainan Mining Project started
Took over Yichuan plant

2023

Self-invest project with HMPT is about to construct

SRPEF pilot test succeeded

2023

Potential projects from South America and MENA


ChaoYang
ShenYang
Chaoyang Experimental Base
Shenyang Research & Design Base
Yangzhou Manufacturing Base
YangZhou
Shanghai Business Center
ShangHai
长春市
黑河市
哈尔滨市
营口市
朝阳市
沈阳市
大连市
丹东市
秦皇岛市
北京市
天津市
唐山市
威海市
烟台市
韩国
日本海
函館
廊坊市
潍坊市
青岛市
黄海
保定市
沧州市
淄博市
日照市
济南市
聊城市
泰安市
临沂市
连云港市
济宁市
枣庄市
菏泽市
商丘市
宿州市
亳州市
蚌埠市
扬州市
泰州市
南通市
南京市
镇江市
常州市
苏州市
淮南市
马鞍山市

WHAT IS HMPT

- Hydrogen Mineral Phase Transformation (HMPT) involves hard-to-beneficiate iron ores (like *limonite,* and *siderite*) under a ***Suspension State*** and ***certain temperature***, encounter with Nitrogen (N), Hydrogen (H_2) or Carbon Monoxide (CO). ↓
  - ➢ This leads to ***reduction→*** non-magnetic minerals (like *limonite,* and *siderite*) **converting** to →weakly magnetic minerals (***hematite)*** and then **into** →strongly magnetic minerals (***magnetite or maghemite)***.
- **Reductant agent** (like Natural Gas) is used.

➢ Followed by *Low Intensity Magnetic Separation* (LIMS), high grade concentrate can be obtained from the materials processed by HMPT.

MILESTONE TECHNOLOGY 逢石科技

HOW DOES MINERAL PHASE TRANSFER

"Pre-oxidation>Heat Accumulating-Reduction>Re-oxidation" Multi-stage Processing Method

Limonite, Siderite

Hematite+
Magnetite

Magnetite

Magnetite
+ Maghemite

i) Heating and Pre-oxidation Stage

$Fe_2O_3 \cdot nH_2O = \alpha\text{-}Fe_2O_3 + nH_2O$

$4FeCO_3 + O_2 = 2\alpha\text{-}Fe_2O_3 + 4CO_2$

$3FeCO_3 = Fe_3O_4 + 2CO_2 + CO$

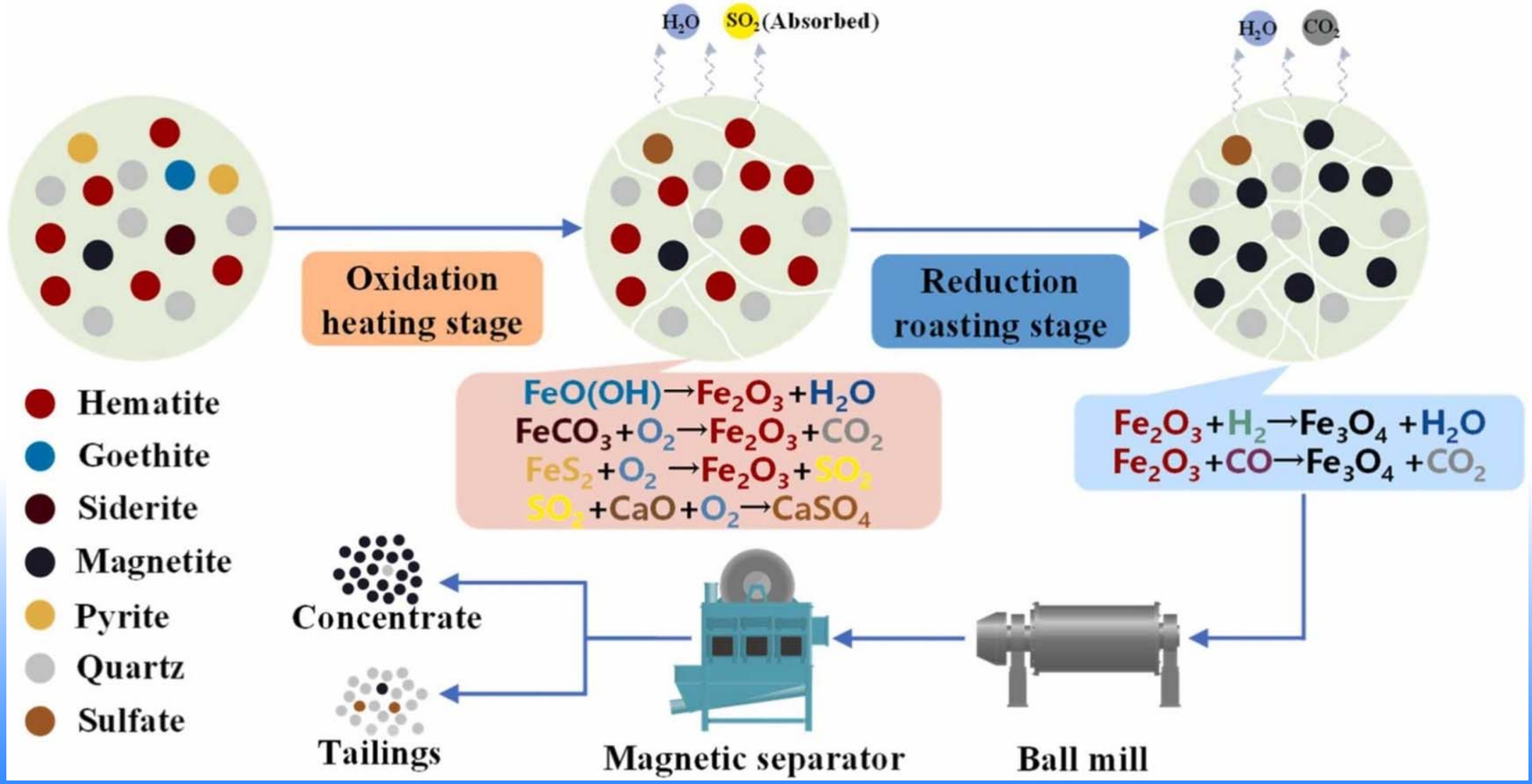
ii) Heat Accumulating Reduction Stage

$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$

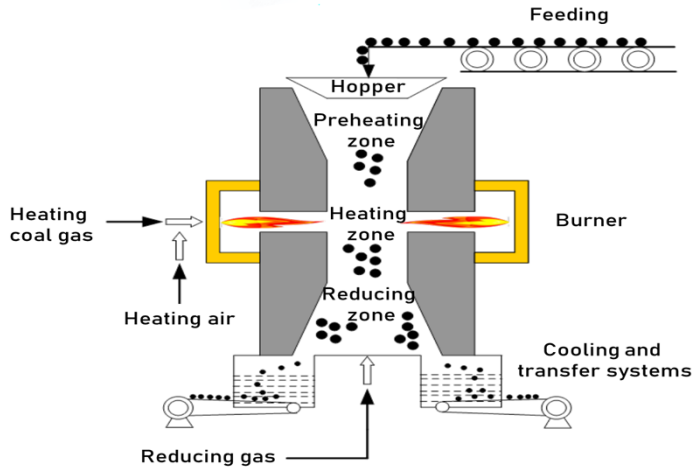
$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$

iii) Re-oxidation Stage

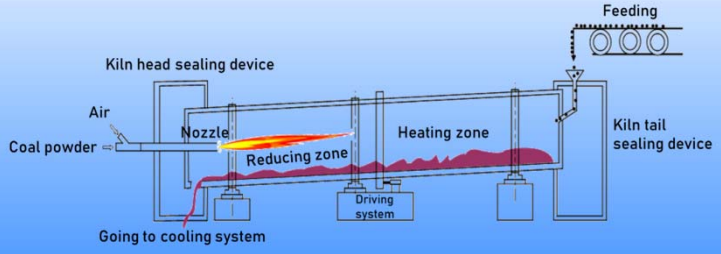
$4Fe_3O_4 + O_2 = 6\gamma\text{-}Fe_2O_3$


H_2O
SO_2(Absorbed)
H_2O
CO_2
Oxidation heating stage
Reduction roasting stage
Hematite
Goethite
Siderite
Magnetite
Pyrite
Quartz
Sulfate
$FeO(OH) \rightarrow Fe_2O_3 + H_2O$
$FeCO_3 + O_2 \rightarrow Fe_2O_3 + CO_2$
$FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$
$SO_2 + CaO + O_2 \rightarrow CaSO_4$
$Fe_2O_3 + H_2 \rightarrow Fe_3O_4 + H_2O$
$Fe_2O_3 + CO \rightarrow Fe_3O_4 + CO_2$
Concentrate
Tailings
Magnetic separator
Ball mill

TECHNICAL COMPARISON



Shaft Furnace Roasting



Rotary Kiln Roasting

Traditional Magnetization Roasting

OUT OF PRODUCTION

Slow Reaction Rate
Lump Particle Size

Low Heating and Reduction Efficiency
One Chamber

Impossible Reduction for All Various Mineral Phase

High Energy Consumption
High Pollution
Non-exquisite Equipment

Sticking Matter
Instable Operation

HMPT

TECHNICAL REVOLUTION

Fast Reaction Rate
Fine Particle Size

Higher efficiency
Precise Heating & Reduction Control
Multi-stages and Chambers

High Recovery Rate
Consistency for Various Mineral Phase

Low Energy Consumption
Low OPEX
Low Pollution

Smart Tech.,
High Automation
Few Labors

TECHNICAL ADVANTAGES

Higher

Fe and Mass Recovery Rate

Save

Using urban recycled water and No flotation reagents

Low/Zero Carbon

Using natural gas or 100% green hydrogen

Ultra-low Emission Standard

PM ≤10 mg/Nm^3, SO_2 ≤35 mg/Nm^3, NOx ≤50 mg/Nm^3

Clean Utilization

Tailings as building materials

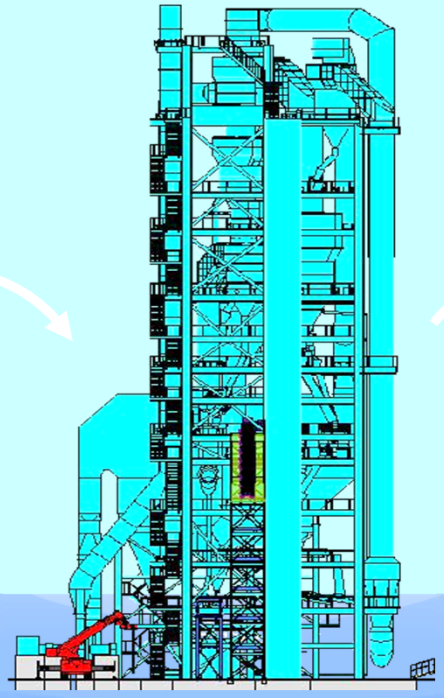
High Automation

Computer control whole system

ZERO CARBON PROCESS ROADMAP

GREEN H_2

GREEN ELECTRICITY



HMPT

GREEN IRON ORE

GREEN STEEL

GLOBAL EXPERIMENTAL DATA

COMPLETED EXPERIMENTS

Initial statistics of overseas (for China) hard-to-beneficiate iron ore resources that can be processed by HMPT.

Ore Sample	Ore Category	Raw Ore Fe grade (%)	Previous Process Technology (%)		HMPT		Results Comparison	
			Concentrate (%)	Recovery Rate (%)	Concentrate (%)	Recovery Rate	Concentrate (%)	Recovery Rate (%)
Ansteel eastern tailings	-	11.48	inapplicable	-	65.69	55.33	-	+55
Ansteel Donganshan ore		31.74	63 ~ 64	63 ~ 65	66.60	88.56	+3	+23
Brazil Vale S.A. hard-to-beneficiate iron ore	Hematite -Limonite	47.45	inapplicable	-	65.32	97.06	+5	+32
Australia FMG iron ore	Hematite -Limonite	54.78	58	65	64.00	98.33	+6	+33
Sierra Leone Tonkolili iron ore	Hematite -Limonite	42.85	inapplicable	-	65.50	96.88	+22	+97
South Africa Thabazimbi iron ore	Hematite -Limonite	40.00	inapplicable	-	65.70	95.00	+25	+95
Iran Chadormalu iron tailings	Hematite	28-33	inapplicable	-	66.42	85.00	+33	+85
Algeria Gara Djebilet iron ore	Hematite Magnetite	56.00	inapplicable	-	64.13	89.59	-	+89

Zambia Iron-bearing Manganese Ore

Raw Ore Grade

44.71 Fe%

17.86 Mn%

Fe in form of Hematite

Manganese minerals: Pyrolusite (MnO_2) and Braunite $\{(Mn^{2+}Mn^{3+}_6(SiO_4)O\}$

Conventional Method

Fe: 0%

Mn: 0%

HMPT

Fe: 67.46% Mn: 50.18%

Fe RR: 97.23% Mn RR: 88.68%

Capacity

0.6 million t/a

Built In

2021.12

Hainan Mining Project

Raw Ore Grade **40.6** Fe%

Fe in form of

Hematite and Magnetite

Conventional Method

Fe: 61~62%

Fe RR: 60~61%

HMPT

Fe: **65.68%**

Fe RR: **85.56%**

Capacity

2.0 million t/a

Built In

2023.7

DAFENG PROJECT

Raw Ore Grade **50.51** Fe%

Fe in form of

Hematite

Conventional Method

Fe: 63.39%

MRR: 31.46%

HMPT

Fe: **65.00%**

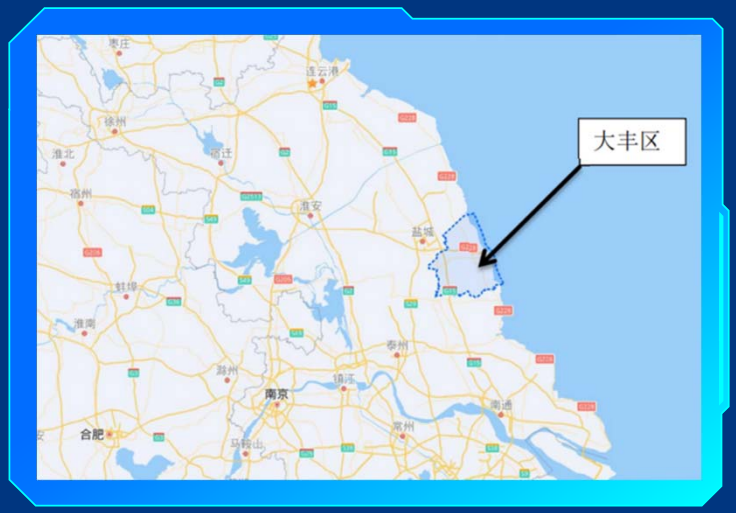
Fe RR: **94.96%**

Capacity

2.0 million t/a

About to build in

late **2023**



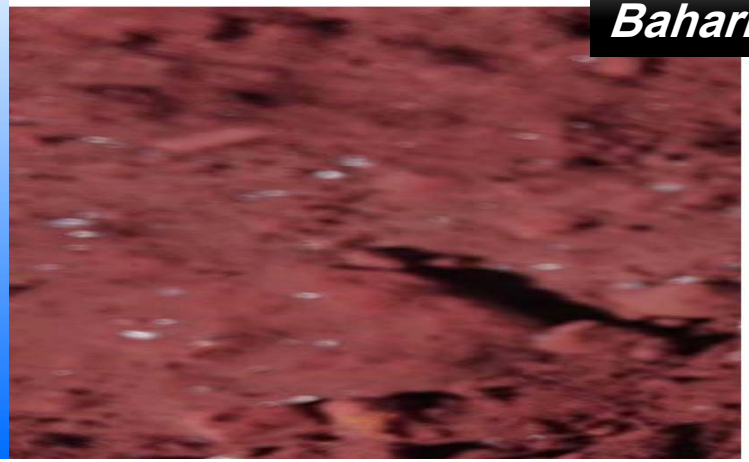
EGYPTIAN IRON ORE DEPOSITS

Iron Ore Deposit of Sedimentary Nature (Ironstone) Phanerozoic age

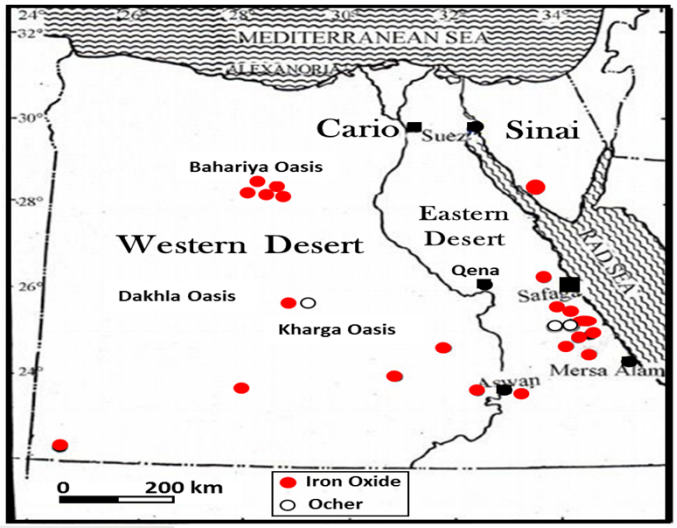
2) Bahariya Oasis
(Middle Eocene):
i) El Harra
ii) Nasser
iii) Ghorabi
iv) El Gedida

Gabal Halal (Sinai)
(lower Cretaceous)

1) Aswan (East of Aswan)
[Upper Cretaceous (Senonian)]:
Main Occurrence:
i) Kom-Ombo
ii) Lake Naser
Minor occurrence:
i) Kalabsha
ii) Garf Hussein
iii) Kurusko
iv) Abu Simbil
v) Wadi Qena



East Aswan Iron Ore



Conclusions

- ***Suspension (Fluidized) bed Magnetization Roasting*** is recognized as the most effective and promising technology due to
  - Its high reaction efficiency, low energy consumption and large processing capacity.

i) ease of control due to absence of moving parts within the reactor,
ii) homogeneity of discharge products,
iii) ability to handle fine particles (<0.8 mm),
iv) high efficiency of heat transfer and mass transfer.
v) HMPT technology also become step into phosphorus removal from iron ore.

- Hydrogen-base ore conversion technology can improve the grade of inferior Fe-ore by up to 25% points.
- Fore every **1%** increased of Fe-ore in furnace reduce 20 kg CO_2 consumed by the production of 1.0 ton of molten Fe can.
- Hydrogen-based technology can achieve 100% green hydrogen heating and reduction which can make ***Zero-Carbon process a reality.***
- Single industrial production line can process 2 Mt/y and the annual output volume exceeds more than 2 million yuan.

Thank You For Your Attention !