HISmelt melting-reduction iron-making technology development
I. HISmelt Technology Introduction

II. HISmelt Technical Features

III. HISmelt Technical Improvement and Optimization

IV. HISmelt Process Production Practice and Application Prospect

V. Conclusions
I. HISmelt Technology Introduction

Fine ore -> Sinter
Fine coal -> Coke

BF iron-making
HiSmelt is a direct smelting reduction iron-making process that directly smelts preheated iron ore fines and other suitable iron-bearing raw materials and injects pulverized coal as the system's source of reducing agents and heat.
I. HISmelt Technology Introduction

HISmelt smelting reduction process flow
II. HISmelt Technical Features

1. Short process flow, less floor space and less investment
II. HISmelt Technical Features

2. Raw material, fuel has good adaption

- Non-coking coal
- Bituminous coal
- Anthracitic coal
- Fine coal
- Oxygen-rich hot blast
- Iron-bearing raw material
- Iron bath pool
- Gas
- Hot metal

- Common iron ore powder
- Vanadium titano-magnetite
- High phosphorus iron ore powder
- Scale
- Fine dust recovery
3. The quality of hot metal is good and meets the need of producing high-quality pig iron

Molong HISmelt smelting reduction process typical components of hot metal and industry standard / wt% of high purity pig iron for China C04 No. casting

<table>
<thead>
<tr>
<th>Element</th>
<th>Molong HISmelt hot metal component</th>
<th>Special class</th>
<th>Class 1</th>
<th>Class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4.15</td>
<td>&gt; 3.0</td>
<td>&gt; 3.0</td>
<td>&gt; 3.0</td>
</tr>
<tr>
<td>Si</td>
<td>0.08</td>
<td>&lt; 0.50</td>
<td>&lt; 0.50</td>
<td>&lt; 0.50</td>
</tr>
<tr>
<td>Ti</td>
<td>-</td>
<td>&lt; 0.02</td>
<td>0.02-0.03</td>
<td>0.03-0.04</td>
</tr>
<tr>
<td>Mn</td>
<td>0.002</td>
<td>&lt; 0.05</td>
<td>0.05-0.15</td>
<td>0.15-0.25</td>
</tr>
<tr>
<td>P</td>
<td>0.03</td>
<td>&lt; 0.02</td>
<td>0.02-0.03</td>
<td>0.03-0.04</td>
</tr>
<tr>
<td>S</td>
<td>0.101</td>
<td>&lt; 0.015</td>
<td>0.015-0.025</td>
<td>0.015-0.025</td>
</tr>
<tr>
<td>Pb+Sn+As+Sb+Bi</td>
<td>≤0.0013</td>
<td>≤0.017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Low emission of pollutants and prominent environmental protection advantages

◆ Reduce SO$_2$, NO$_x$, and CO$_2$ emission
◆ No dioxin, tar and phenol production
◆ Dust emission reduction
◆ Significant reductions on emissions and environmental advantages.
II. HISmelt Technical Features

5. Low production cost

The production cost of Molong is lower than that of some domestic blast furnace.
III. HISmelt Technical Improvement and Optimization

1. Original HISmelt process issue analysis

- **Process**
  - hearth lining erosion problem
  - cooling stave water leakage
  - Spray gun damage

- **Equipment**
  - The first application of new equipment - fluidized bed
  - Equipment design capabilities do not match
  - Unreasonable design - slag hole

- **Operation**
  - Foam slag problem
  - Furnace condition monitoring

- **Control**
  - Automation interlocking control requirements

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![Diagram with production faults](image)

- Communicating pipe freeze
- Foaming slag
- Hearth burnt out
- Fine ore preheating
- SRV furnace
- Water cooling stave
- Hot ore conveying
- Steam system
- Kwinana plant production fault distribution diagram
Based on the experience of Kwinana factory, in the process of localizing the HISmelt process, in order to overcome the deficiencies of the original process, the project participants improved some of the process flow and equipment, mainly in the following aspects:

- Fine ore preheating system
- SRV high temperature gas treatment system
- Cast house system
- Slag treatment system
- Main utility system
III. HISmelt Technical Improvement and Optimization

◆ Fine ore preheating system optimization

➢ To address the impact on process stability from the original fluidized bed fault rate, taking into account the investment cost

CFB fluidized bed process

2-stage type rotary kiln process
SRV furnace high-temperature gas treatment system

- Gas sensible heat cannot be used
- Wet dust removal burden, high gas moisture content
- It is difficult to use high-water-containing clean gas
- Influence the efficiency of subsequent hot blast stoves, power generation and other equipments
- Poor system stability, low continuous production capacity

Molong HISmelt high-temperature gas treatment system

- Recover SRV high temperature gas sensible heat
- Reduce gas scrubbing and sludge treatment pressure
- Moisture content of gas is reduced from 15% to 3%, expanding the use of net gas
- Improve process stability, production continuity
Recycling of residual iron is done through the increase of residual iron recovery bay, the residual iron recovery bay is provided with residual iron receiving facilities, and an 80t hot metal ladle electric flat car leading to PCM is set up so that the residual iron from the SRV furnace can be casted in PCM. It facilitates the reuse of residual iron.
The original Hlsmelt slag was treated with dry slag, which influenced the continuity of production and caused a loss of 28,000 ton of metal iron per year.

Molong Hlsmelt slag treatment process, water slag granulation and metal ferromagnetic separation recovery, 90% metal iron in slag can be extracted and recovered;
III. HISmelt Technical Improvement and Optimization

Utility and power systems

- Condenser
- New added power generation
- Flue gas boiler
- Boiler water supply
- Gasification flue channel
- Saturated vapo
- Steam turbine drive blower & power generation
- Steam driven oxygen plant
- Electric blower
IV. HISmelt Process Production Practice and Application Prospect

1. HISmelt process production practice

- In the localization process of HISmelt, various technological innovations have been made in the process flow, process equipment, operation technology, and resource and energy utilization of the original process, and significant progress has been made in process stability and equipment durability.

### Shandong Molong HISmelt smelting & reduction process index

<table>
<thead>
<tr>
<th>Item</th>
<th>Molong index</th>
<th>Date</th>
<th>Kwinana index</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max monthly production, t</td>
<td>51714</td>
<td>Dec. 2017</td>
<td>37345</td>
<td>May. 2008</td>
</tr>
<tr>
<td>Min coal consumption, t/tHM</td>
<td>0.780</td>
<td>March. 2018</td>
<td>0.810</td>
<td>August. 2007</td>
</tr>
<tr>
<td>The max weekly operability, %</td>
<td>100</td>
<td>November. 2017</td>
<td>99</td>
<td>June. 2008</td>
</tr>
<tr>
<td>Continuous production record, day</td>
<td>116</td>
<td>Jan-April 2018</td>
<td>68</td>
<td>April-June 2006</td>
</tr>
<tr>
<td>Furnace lining corrosion</td>
<td>Already produced for 0.45MT, furnace lining is not changed</td>
<td>Produced for 0.388MT, changing furnace lining for 5 times</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IV. HISmelt Process Production Practice and Application Prospect

1. HISmelt process production practice

- HISmelt cumulative output exceeds 450000 t;
- The maximum output reaches 80% designed capacity, namely 80t/h;
- HISmelt Equipment continuous operation rate exceeds 95.8%.
IV. HISmelt Process Production Practice and Application Prospect

1. HISmelt process production practice

- The higher unit production of Molong HISmelt is, the lower the consumption of pulverized coal per ton of iron will be, the current production output is about 75 tons per hour, the unit coal consumption is about 0.89; when the hourly output reaches 90 tons, coal consumption of iron per ton is expected to reduce to 0.7 to 0.8 In between, which can greatly reduce production costs;

- In general, the more daily hot metal output is, the lower the cost per ton of iron will be;
IV. HISmelt Process Production Practice and Application Prospect

1. HISmelt process production practice

<table>
<thead>
<tr>
<th>Typical value</th>
<th>BF</th>
<th>HISmelt</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>4.5%</td>
<td>4.4 ± 0.15%</td>
</tr>
<tr>
<td>Si</td>
<td>0.5 ± 0.3%</td>
<td>&lt;0.01%</td>
</tr>
<tr>
<td>Mn</td>
<td>0.4 ± 0.2%</td>
<td>&lt;0.02%</td>
</tr>
<tr>
<td>P</td>
<td>0.09 ± 0.02%</td>
<td>0.02 ± 0.01%</td>
</tr>
<tr>
<td>S</td>
<td>0.04 ± 0.02%</td>
<td>0.08 ± 0.05%</td>
</tr>
<tr>
<td>five-harmful elements</td>
<td>0.001%-0.01%</td>
<td>0.0001%-0.001%</td>
</tr>
</tbody>
</table>

The main products are cast high-purity pig iron, high quality and high purity special pig iron.

- Mainly used for high-speed rail, nuclear power, wind power castings and various low temperature impact castings and ductile iron parts, which can greatly improve the compression resistance, tensile strength, elongation and low temperature impact resistance of the castings.

- High quality ductile iron pig iron and foundry pig iron are widely used in automotive, agricultural machinery, mining metallurgy, machine tools and other equipment manufacturing. The product has the characteristics of high stability, low harmful elements, and easy ball milling of pig iron.
IV. HISmelt Process Production Practice and Application Prospect

2. HISmelt process application prospect--high purity pig iron production

◆ For Molong HISmelt high-purity pig iron, due to the superiority of the technology, the purity of the products is high, which can be used in nuclear power, high-end machining and other fields, the future prospect is promising.
IV. HIsmelt Process Production Practice and Application Prospect

2. HIsmelt process application prospect--high phosphorus ore, vanadium titanium magnetite

- Its unique strong oxidizing atmosphere makes the oxygen potential in the slag high, which effectively inhibits the reduction of TiO$_2$ and the formation of high-melting TiC (TiN), and can also achieve high-efficiency dephosphorization.
- Iron ore undergoes direct reduction in the molten state, the reaction speed is fast, the viscosity of the slag is low, and no large amount of gas remains in the slag, so no serious foam slag is generated in the furnace.
The HISmelt process can treat steel plant recycling waste, and can also handle high Zn, high Pb iron-containing powders. When it is mixed with the ore powder, the iron recovery rate can reach 97%, and the valuable metal resources such as zinc, lead, and indium contained in the dust can be fully utilized. The carbonaceous material contained in the dust of iron and steel enterprises has good reducibility, and the addition of iron and steel enterprise dust can reduce the amount of reducing agent used in the HISmelt process.

Molong HISmelt rotary kiln preheating system dust chemical composition

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>TFe</th>
<th>CaO</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>MgO</th>
<th>Cr₂O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.00</td>
<td>50.00</td>
<td>11.96</td>
<td>9.57</td>
<td>4.77</td>
<td>2.54</td>
<td>0.01</td>
</tr>
</tbody>
</table>

- Molong HISmelt plant dusts are all of self-recovery
- Fully recycle and utilize iron and carbon resources in dust
IV. HISmelt Process Production Practice and Application Prospect

2. HISmelt process application prospect--environmental protection & productivity adaption

Development plan up to 2020 (1st generation) Development plan 2020-2025 (2nd generation) Development plan after 2025 (3rd generation)

Current device

6m SRV (independent) 6m SRV + preheating pre-reduction system 6m SRV + preheating pre-reduction system
0.6MT production capacity 2 MT production capacity 2 MT production capacity

CO2 physical storage

6m SRV + preheater 8m SRV + preheater 8m SRV + preheating pre-reduction system + CCS
0.8 MT production capacity 2 MT production capacity 4 MT production capacity

8m SRV (INDEPENDENT) 8m SRV + preheating pre-reduction system
1.6MT production capacity 2 MT production capacity 4 MT production capacity

Carbon emission close to zero
V. Conclusions

- The HISmelt smelting reduction process is one of the commercial smelting reduction ironmaking processes, and it is the only smelting reduction ironmaking technology that does not use cokes until now. The feasibility of the process is unquestionable through the practice tests of foreign and domestic commercial plants.
The completion and production of Molong HISmelt plant was a complete upgradation and optimization based on the original Australia. It has made significant breakthroughs in the lifespan, operating rate, and production capacity of the SRV furnace, laying the foundation for the further development of the HISmelt process.
With the stable operation of domestic factories, the constant familiarity of professionals with process materials and operations, combined with the strong equipment manufacturing capabilities and technological innovation capabilities of the metallurgical industry, we believe that the HIsmelt smelting reduction process can be used directly from raw ore, without pelletizing, and The advantages of non-coking coal, short flow, and simple operation become the development direction of future smelting reduction iron-making technology.
V. Conclusions

25th May, 2018 Technical Appraisal

Molong HISmelt smelting reduction iron making technology project results

appraisal structure: The stability of production, economy on cost and advanced environmental protection in smelting and reduction field have reached the international advanced level.
Thank you for your listening.

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