RIST’s New Continuous Thermal Reduction Process for Magnesium Production

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RIST

Various Magnesium Production Process

<table>
<thead>
<tr>
<th>Field</th>
<th>Process</th>
<th>CAPE X</th>
<th>Operation</th>
<th>Cost</th>
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<tr>
<td>Thermal Reduction</td>
<td>Silico-thermal (Retort)</td>
<td>Pidgeon process</td>
<td>Low</td>
<td>1200°C (Gas) Batch</td>
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<tr>
<td></td>
<td>Silico-thermal (El. Furnace)</td>
<td>Magnetherm, MINTEK, Zuliani (on development)</td>
<td>Mid</td>
<td>1500–1700°C (Electric) Batch / Continuous</td>
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<tr>
<td></td>
<td>Carbo-thermal (on development)</td>
<td>Magnetherm, MINTEK, Zuliani (on development)</td>
<td>Mid</td>
<td>1500–1700°C (Electric) Batch / Continuous</td>
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<tr>
<td></td>
<td>Electric Reduction</td>
<td>Single-electrode, Multi-electrode, SOM (on development)</td>
<td>High</td>
<td>1000–1500°C (Electric) Continuous</td>
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</table>

Pidgeon process: Most competitive for magnesium production

Pidgeon Process for Producing Magnesium

Pidgeon process: most competitive in costs and quality

- about 88% of world magnesium produced in China via Pidgeon process in 2013

Background for RIST’s New Process Development

To innovate the existing Pidgeon process for high productivity, low cost and automated operation
- Retort Type (unreacted slag adhesion to retort) Retort Free
- Batch Process (w/ low productivity) Continuous Process
- Labor Intensive (w/ low automation) Automated System
- External heating (w/ low efficiency) Internal Heating

Concept for the Retort Free CTRP (Continuous Thermal Reduction Process)

Vertical Pidgeon CTRP Effect

Heating External Internal E. Efficiency ≥ 15%
Chamber Preheating-Reduction Preheating, Reduction & sintering Productivity ≥ 30%
Distribution system for Briquette Batch / manual Continuous / automated Labor cost ≥ 30%
Briquette packing Retort Briquette Box Retort-free reduction ratio ≥ 60%
Condenser type Batch Continuous Recovery ratio ≥ 10%

Concept of CTRP (Continuous Thermal Reduction Process)
**Concept of CTRP: Retort Free & Internal Heating**

- Retort free & Internal Heating: Heating time for Retort & Briquette Box (Furnace Temp: 1200℃, Heating Temp: 1150℃, Briquette Charging Thickness: 15mm)
- Separation of Preheating and Reduction Zone
- Retort Free & Internal Heating: Heating time for Retort & Briquette Box

**Process Conceptual Design**

- Continuous Condenser
- Heating time for Reduction Temp by using briquette box
- Continuous operation of the system by using briquette box

**Concept of CTRP: Preheating, Reduction Zone Separated**

- Preheating & Reduction Chamber of CTRP
- Charging & Distribution of the Briquette
- Heating rate increase and E. reduction by separating the preheating and reduction zone

**Concept of CTRP: Basic Component of the Chambers**

- Basic component of the preheating and reduction chamber of CTRP
- Desk越高越
- RT Burner
- C. Condenser
- Heating zone (Mg evaporation)
- Radient tube

**Concept of CTRP: Design**

- Design criteria for CTRP
- Min temp. in reduction chamber allowable ≤ 800℃
- Surface temp of briquette box ≤ 150℃
- Basic vacuum (excluding P_{inp}) ≤ 1 Torr
- Surface temp of Mg condenser 450–550℃
- Surface temp of vacuum chamber ≤ 50℃

**Main issue for lab scale CTRP apparatus**

- High temp & high level vacuum system with tight sealing
- Continuous operation of gate valves w/ condensation of Mg vapor
- Refractory and Radiant tube w/good durability for Mg vapor
- Easy operation of briquette distribution system
Experimental Results of Lab Scale CTRP

- Modified shrinking unreacted core model
- Activation E. of reduction reaction of Mg briquette for CTRP: \( \Delta G^\circ = 140.8 \text{kJ/mol} \)

Conclusion

- Simultaneous application of the retort-free and internal heating concept for CTRP resulted in shorter reduction time and superior reduction ratios compared to the current Pidgeon process.
- A core elemental technologies to commercialize the Mg CTRP such as high temperature vacuum system, continuous operation of the gate valve, and other core technologies were achieved and verified.
- The potential of RIST’s innovative Mg smelting process would show the significant cost reductions and competitiveness from the current Pidgeon method in subsequent scaling up to pilot and commercial plant.
Thank you for your attention!