A look back at the Industry & Pathway forward for a healthy successful year

April 27th, 2015
Refractories for Cement & Lime Industries

Agenda

- Who is Magnesita
- Cement Production Overview
- Cement Process
- Refractory for Cement Industry
- Challenges to Refractory Industry
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- Who is Magnesita
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Company overview

Magnesita is a global leader in refractories solutions and industrial minerals

- More than 100 years of experience in refractories and industrial minerals
- 3rd largest player in the refractory sector worldwide
- #1 in the steel and cement applications in Brazil and South America
- #1 in cement applications in North America
- Highest vertical integration level in the industry (~80%), fully self-sufficient in high-grade magnesite
- Best, largest and lowest-cost magnesite mine in the world outside China
- Significant number of unexplored mineral rights in Brazil
- Solid financial fundamentals

Magnesita in numbers

- Revenues of R$ 2.66 billion in 2013
- Production in 4 continents, supplying globally to almost 1,000 clients worldwide, in 90 countries
- 6,250 employees
- 28 industrial facilities with more than 1 million tons/year of refractories sold in 2013
Refractory industry overview

Refractories are crucial consumables for manufacturing processes with high temperatures

**Industry overview**

- **Refractories** are fireproof materials consumed within various production processes, providing heat, chemical and mechanical resistance in industrial furnaces.
- Their **raw material** are minerals with high melting points, including magnesite, dolomite and alumina.
- **Crucial**, but represents only ~3% of COGS in steel manufacturing and less than 1% in cement.
- **Refractories are consumables**: ~10Kg per ton of steel; ~0.6Kg per ton of cement.

**Types of refractories**

- Monolithic
- Bricks
- Pre castables, valves and slide gates

**Main end markets worldwide**

Source: Freedonia. estimates 2013

- **Steel** ~60%
- **Nonmetallic** (cement, glass, lime) ~15%
- **Non-ferrous** (aluminum, copper, nickel, silver, zinc) ~10%
- **Other** (pulp&paper, petrochemical, ceramic, other) ~15%

**Refractories are continuously consumed during steel production...**

- **Blast Furnace**: 900 tonnes ~15 years
- **Torpedo car**: 200 tonnes ~2 years
- **BOF**: 800 tonnes ~6 months

- **Steel ladles**: 800 tonnes ~6 months
- **Continuous casting**: 1 ton of steel demands ~10-15 Kg of refractories

**...and other industrial processes**

- **1 ton of cement demands** ~1 Kg of refractories
- **1 ton of glass demands** ~4 Kg of refractories
- **1 ton of aluminum demands** ~6 Kg of refractories
- **1 ton of copper demands** ~3 Kg of refractories
Unique global footprint

Global scale, with local presence in key markets, with an integrated supply chain.

- York Dolomite Mine (USA)
- York Production Unit (USA)
- Clay Mine (Uberaba – BRA)
- Magnesite Mine (Brumado – BRA)
- Chromite Mine (Santa Luz – BRA)
- Talc Mine (Brumado – BRA)
- Aratu Port
- Sinterco Dolomite JV (BEL)
- Valenciennes and Flaumont Production Units (FRA)
- Hagen-Halden, Oberhausen and Kruft Production Units (DEU)
- Dalian Production Unit (CHN)
- Qingyang Dolomite Mine (CHN)
- Chizhou Production Unit (CHN)
- Taiwan JV’s Production Unit (CHN)

- Aratu Port
- Headquarters
- Production Units
- Mines
- Sales Offices and Sales Representative
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Cement Production Overview

Production Worldwide

Cement Production 2015 Forecast (Mton)

<table>
<thead>
<tr>
<th>Region</th>
<th>Capacity Utilization 2015 Forecast (%)</th>
<th>2015 Cement Production (Mton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>83%</td>
<td>4,125.3 / +4%</td>
</tr>
<tr>
<td>China</td>
<td>68%</td>
<td>2,566.1 / +3%</td>
</tr>
<tr>
<td>Asia Ex-China</td>
<td>74%</td>
<td>636.3 / +4%</td>
</tr>
<tr>
<td>MEA</td>
<td>63%</td>
<td>311.2 / +6%</td>
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<tr>
<td>EU - 28</td>
<td>70%</td>
<td>140.3 / +2%</td>
</tr>
<tr>
<td>CIS</td>
<td>68%</td>
<td>111.8 / +6%</td>
</tr>
<tr>
<td>United States</td>
<td>66%</td>
<td>83.8 / +6%</td>
</tr>
<tr>
<td>Non - EU</td>
<td>68%</td>
<td>84.6 / +6%</td>
</tr>
<tr>
<td>Brazil</td>
<td>70%</td>
<td>75.6 / +5%</td>
</tr>
<tr>
<td>SAMOB</td>
<td>65%</td>
<td>55.4 / +7%</td>
</tr>
<tr>
<td>Mexico</td>
<td>65%</td>
<td>37.1 / +4%</td>
</tr>
<tr>
<td>Germany</td>
<td>65%</td>
<td>32.1 / +3%</td>
</tr>
<tr>
<td>Canada</td>
<td>65%</td>
<td>12.7 / +5%</td>
</tr>
<tr>
<td>Oceania</td>
<td>65%</td>
<td>10.4 / +3%</td>
</tr>
</tbody>
</table>

Capacity Utilization 2015 Forecast:

- Oceania: 96%
- Canada: 65%
- Germany: 65%
- Mexico: 65%
- SAMOB: 65%
- Brazil: 65%
- Non - EU: 65%
- CIS: 65%
- EU - 28: 65%
- MEA: 65%
- Asia Ex-China: 65%
- China: 82%
- World: 82%

Source: CW Group – GCVFR – 2H2012
Cement Production Overview

World Production

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country/Region</th>
<th>mil Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>People's Republic of China</td>
<td>2,300</td>
</tr>
<tr>
<td>2</td>
<td>India</td>
<td>280</td>
</tr>
<tr>
<td>3</td>
<td>United States</td>
<td>77.8</td>
</tr>
<tr>
<td>4</td>
<td>Iran</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>Brazil</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>Turkey</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>Russia</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>Viet Nam</td>
<td>65</td>
</tr>
<tr>
<td>9</td>
<td>Japan</td>
<td>53</td>
</tr>
<tr>
<td>10</td>
<td>Saudi Arabia</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>South Korea</td>
<td>49</td>
</tr>
<tr>
<td>12</td>
<td>Egypt</td>
<td>46</td>
</tr>
<tr>
<td>13</td>
<td>Mexico</td>
<td>36</td>
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<tr>
<td>14</td>
<td>Indonesia</td>
<td>58</td>
</tr>
<tr>
<td>15</td>
<td>Thailand</td>
<td>35</td>
</tr>
<tr>
<td>16</td>
<td>Germany</td>
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</tr>
<tr>
<td>17</td>
<td>Pakistan</td>
<td>32</td>
</tr>
<tr>
<td>18</td>
<td>Italy</td>
<td>29</td>
</tr>
<tr>
<td>19</td>
<td>Spain</td>
<td>20.7</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>597</td>
</tr>
<tr>
<td></td>
<td><strong>2013 World Production</strong></td>
<td><strong>4000</strong></td>
</tr>
</tbody>
</table>

- **China:**
  - 57.5% of world total
  - Was 29% in 1994
  - 1.4 ton per inhabitant

- **India:**
  - 227 kg per inhabitant

- **USA:**
  - 244 kg per inhabitant
Cement Production Overview

Consumption per Capita vs GDP

Many countries are approaching a GDP per capita that could favor faster growth in cement consumption.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Company/Group</th>
<th>Country</th>
<th>Capacity (Mt/yr)</th>
<th>No. of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lafarge</td>
<td>France</td>
<td>225</td>
<td>166</td>
</tr>
<tr>
<td>2</td>
<td>Holcim</td>
<td>Switzerland</td>
<td>217</td>
<td>149</td>
</tr>
<tr>
<td>3</td>
<td>CNBM</td>
<td>China</td>
<td>200</td>
<td>69</td>
</tr>
<tr>
<td>4</td>
<td>Anhui Conch</td>
<td>China</td>
<td>180</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>HeidelbergCement</td>
<td>Germany</td>
<td>118</td>
<td>71</td>
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<tr>
<td>6</td>
<td>Jidong</td>
<td>China</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Cemex</td>
<td>Mexico</td>
<td>96</td>
<td>61</td>
</tr>
<tr>
<td>8</td>
<td>China Resources</td>
<td>China</td>
<td>89</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>Sinoma</td>
<td>China</td>
<td>87</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>Shanshui</td>
<td>China</td>
<td>84</td>
<td>13</td>
</tr>
<tr>
<td>11</td>
<td>Italcementi</td>
<td>Italy</td>
<td>74</td>
<td>55</td>
</tr>
<tr>
<td>12</td>
<td>Taiwan Cement</td>
<td>Taiwan</td>
<td>70</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Votorantim</td>
<td>Brazil</td>
<td>57</td>
<td>37</td>
</tr>
<tr>
<td>14</td>
<td>CRH</td>
<td>Ireland</td>
<td>56</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>UltraTech</td>
<td>India</td>
<td>53</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>Huaxin</td>
<td>China</td>
<td>52</td>
<td>51</td>
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<tr>
<td>17</td>
<td>Buzzi</td>
<td>Italy</td>
<td>45</td>
<td>39</td>
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<tr>
<td>18</td>
<td>Eurocement</td>
<td>Russia</td>
<td>40</td>
<td>16</td>
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<td>19</td>
<td>Tianrui</td>
<td>China</td>
<td>35</td>
<td>11</td>
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<tr>
<td>20</td>
<td>Jaypee</td>
<td>India</td>
<td>34</td>
<td>16</td>
</tr>
</tbody>
</table>

Global cement companies 1-20 ranked by capacity.

Source: Annual reports of respective companies and their websites and the Global Cement Directory 2013.
Cement Production Overview
Production Trends - USA

- Dynamic regional market conditions driving production demands
- Pressure to meet Tightening Air-Quality Environmental Standards
- Continued Modernization of “Older” production equipment
- Widespread requirement for Low Alkali Cements
- Cost pressures encouraging trials of low-cost imported refractories

PCA Market analysis 2014
Refractories for Cement & Lime Industries

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Refractory for Cement Industry

Overview

PREHEATER
- 60% shaped products
- 30% unshaped products
- 10% insulation materials

Rotary Kiln
50% basic bricks
20% high alumina brick
25% fireclay brick
5% castables

Tertiary air duct
- 75% shaped products
- 10% unshaped products
- 15% insulation materials

Kiln Hood
10% shaped
75% unshaped
5% insulation

Cooler
5% shaped
80% unshaped
15% insulation
Cement Process
Different Process Types

Various Cement Processes

US & Canada – Units per Process Type

- 5 Stage Preheater
- 4 Stage Preheater
- 4 Stage Calciner
- Dry (Long)
- Preheater
- Wet (Long)
- Dual 4 String Calciner
- 2 Stage Preheater
- 1 Preheater
- Trav. Grate
Cement Process
Process Profile 2005 x 2014

- Average consumption 1.21 kgs/1000 mtn of production
- 44,000 mtn of Basic consumed yearly
- Installed Rated Capacity of 110 Mmtn/yr
Average consumption down from 1.21 kgs/mtn(x000) to 0.43 kgs/mtn (x000)
Cement Process - Fuels
Process Profile 2005 x 2014

Production Process Type
Fuel and Fuel Mix
- Natural Gas
- Coal
- Pet Coke
- Bunker C Oil
- Whole Tires

Production Process Type
Fuel and Fuel Mix
- Natural Gas
- Coal
- Pet Coke
- Whole Tires
- Shredded Tires
- SWDF
- Engineered Fuels
- Car Chaff
- Glycerol
- Waste Oils
- Asphalt Shingles
- Creosote Wood
Cement Process
Alternate Fuels

Relative Specific Fuel Consumption [%]

Year


Chlorine / Sulphate
Phosphate
Sulphur / Zinc
Mercury / Cadmium

Sewage Waste
Municipal Waste
Animal
Meat / Bone / Fat
Plastic
Other Industrial Waste
Solvents
Waste Oil
Tyres

Pulp / Paper / Cardboard

Merc

Chlorine

This is our Way
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Refractory for Cement Industry
Operational Impacts to Refractory Life

- Solid Fuel / AF Program
- Uncoated Exposure
- Reducing Atmosphere
- Condensation of Clinker Materials

- Speed of Rotation
- Drive Pier Location
- Tire Condition (Ovality)
- Tire Span / Overhang
- Kiln Thrust (Movement)

Thermal Effects
- Start-up / Shutdown Procedures
- Operator reaction to Coating failure
- Feed On/Off procedures
- Feed-Speed Ratio's

Mechanical Effects
- Speed of Rotation
- Drive Pier Location
- Tire Condition (Ovality)
- Tire Span / Overhang
- Kiln Thrust (Movement)

Operator Effects
- Secondary Materials input
- Insufflation Practices
- Kiln Dust Return
- Clinker Type changes

Chemical Effects
- Speed of Rotation
- Drive Pier Location
- Tire Condition (Ovality)
- Tire Span / Overhang
- Kiln Thrust (Movement)
Refactory for Cement Industry
Base Brick Components

- Direct bonded Dolomite system’s
  - Chemically compatible with Conditions present in the main sintering zone
  - Increased MgO % reduces coating while increasing corrosion resistance
  - Coating is removed in process only with extreme overheating conditions
  - Coating easily maintained through flame off conditions by reduced $\Delta t$
  - Largest single product used in Sintering zones. (U.S. & Canada)
Refractory for Cement Industry
Base Brick Components

- In-Situ spinel bonding
  - Considered in general as 1st. Generation spinel systems
  - Using coarse Tabular alumina to form spinel under primary firing.
  - Limited on % addition because of expansive reaction in firing.
  - May be added in combination with pre-reacted Spinel
  - More commonly seen in imported refractories (China)
Sintered Spinel Bonding

- Termed as 2nd. Generation spinel systems
- Sintered spinel additions range in size from fine to intermediate
- Sintered spinel overcame issues with addition rates
- This pre-reacted spinel does not have the reaction in-situ
- Improved bonding to fine MgO Matrix
Refractory for Cement Industry
Base Brick Components

- Fused Spinel Bonding
  - Termed also as 2nd. Generation spinel systems
  - Fused spinel additions intermediate through coarse
  - Generally regarded to possess higher thermal resistance
  - Limited surface area to reduce potential CaO·Eutectics
  - Lower potential for matrix bonding
  - Improved expansion mis-match for shock resistance
Refractory for Cement Industry
Base Brick Components

- Ferro-Aluminate spinel bonding Hercynite
  - Considered in general as sub-class of 2nd. Generation spinel systems
  - Fe\cdot Al system to enhance flexibility and encourage coating formation
  - Lower Fe systems more successful because of REDOX reactions
  - May be added in combination with pre-reacted Spinel
  - Limited to coating stable environments
Coating Mechanism FeAl Spinel Systems

- Cyclic Operations created a market for non-hydratable systems
- Recent applications of Fe+ Aluminate spinels were offered to fulfill this requirement
- Under steady-state operations Fuel, Feed, Chemistry these systems provide acceptable performance
- Present operations depend on multiple fuel sources, and variable raw feed structures
- Refractory is compromised when exposed; resulting in reaction on the Fe+ component
- Described as the Kirkendall effect

Kirkendall effect: Formation of intercrystalline voids due to MgFe$_2$O$_2$-reduction in Iron containing spinel systems

Unique MgO’s with Fe phase in the interior of the grain are able to reduce this effect. (Magkor A3)
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Campaign planning is a combined activity between Plant and Magnesita.
Logistic Management allows a better planning to fulfill programmed and unexpected demands.

Kiln Profile → Outage Schedule → Cement Model → Refractory demand: Brand, Shape, Quantity
Advanced technical engineering: focused in performance follow-up for continuous improvement
How Are you positioned for the future

- Current Imported refractory Systems may be based on older Spinel technology
- Lining designs have been compromised to account for lower run factors
- Refractory companies have “Blurred” the lines between Legacy Brands and 3rd Party outsourced brands
- Monolithic Materials are largely sourced through CI network which limits a company's ability to qualify higher quality systems
- Monolithics in General will become the next Corporately controlled commodity
- There will be a natural swing back towards Higher Purity systems to meet this ramp up in performance
- Companies need to continue to monitor refractory installations for quality in all aspects of placement and practices