Agenda

1. Introduction / Basis for Discussion
2. Refractories: Commercial & Technical Impact
3. Refractory Assessment + Services
4. Conclusion
1. Introduction

Saint-Gobain Group – established in 1665

Operations in 64 countries

<table>
<thead>
<tr>
<th>2013</th>
<th>€Bn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>42.0</td>
</tr>
<tr>
<td>Operating income</td>
<td>2.8</td>
</tr>
<tr>
<td>Recurring net income</td>
<td>1.0</td>
</tr>
<tr>
<td>Capital expenditure</td>
<td>1.4</td>
</tr>
<tr>
<td>Cash flow from operations</td>
<td>2.5</td>
</tr>
</tbody>
</table>

About 193,000 employees

15 R&D centers

+400 patents in 2012

Saint-Gobain in Gasification:

- Worldwide sales for more than 60 years
- Alumina, chromia-aluminas and chromia product lines for slagging and non-slagging reactor types
- Refractory engineering and design with/for customers
- Refractory product engineering to develop adapted products
- R&D support
- Worldwide production facilities
- Refractory supply to more than 50 gasification sites
1. Introduction / Basis for Discussion

A structured approach for evaluating potential refractory suppliers for near term needs and long-term relationships is proposed based on technical and commercial impact related to specific gasifier requirements.

Refractory linings operating at high temperatures require

- **Significant expertise in ceramic engineering** to achieve life and performance goals in gasifier operations
- **Design capability** for shapes to fit the gasifier structure throughout the operating temperature range
- **Manufacturing expertise** for large or complex shapes
- **Quality control and analytical capabilities** for understanding product performance.
2. Commercial Impact

Refractories impact commercial operations of the plant:

- Refractories are ‘critical’ equipment
- Refractory design and performance impact operations and finances
- Consistent refractory performance required as feedstock varies
- Refractories represent <<% of plant CAPEX, but have a large impact on OPEX (based on performance)
- Project commercial viability has to include the calculation of refractory lifetime (downtime cost, replacement cost, disposal), in frequency and time effort
- Refractory stock management to match maintenance needs and available funds
2. Commercial Impact

Cost structure of refractory products:

- Main cost: raw material
- Other costs: Labor, Mixing, Forming, Firing, Machining, Yields, Shipping

<table>
<thead>
<tr>
<th>Refractory product type</th>
<th>Relative Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low duty castable</td>
<td>1-2</td>
</tr>
<tr>
<td>Low duty bricks</td>
<td>2-3</td>
</tr>
<tr>
<td>High alumina castable</td>
<td>3-5</td>
</tr>
<tr>
<td>High alumina bricks</td>
<td>5-10</td>
</tr>
<tr>
<td>Chromia-alumina/chromia bricks</td>
<td>10-18</td>
</tr>
</tbody>
</table>

Castables → Brick Shapes
2. Technical Impact - Refractory Choice
(Based on commercial and technical specifications)

- **Overall plant design** (number of reactors + spare reactors, syngas volume, …)
- **Type of gasification system** (GE, E-Gas, Siemens, OMB, etc.)
- **Type of feedstock / flux**
  - Slagging / non slagging
  - Type of slag and flux
- **Design of reactor**
  - Different reactor volumes may use different refractory types
- **Reactor operations**
  - Reactor load (% of nominal)
  - Outage frequency concerted with outage of up/downstream equipment
  - Thermal cycling
  - Stock policy
2. Technical Impact—Refractory Supplier Tasks

- **Close contact** between customer & refractory supplier from the early stages of a project
  - *Refractory design and engineering* to be addressed very early in the complete reactor design
  - *Refractory choice*
    - Slag compatibility testing
    - Selection of right product from product range
    - Product development ➔ to fit with customer’s requests
  - *Long lifetime support* (post mortem analyses, product & design developments)

- **Consistent Reliability**
  - Better / faster if: best fitting, no lifting equipment, design easy to install, less rework, design of lining and bricks have better / faster heating/cooling performance.....
3. Refractory Assessment Program - Product Choice Off the Shelf

Discussion with customer
- Identify needs
- Understand process
- Understand design
- Understand operations

Slag analysis
- Chemical composition
- Viscosity
- Softening point
- Wettability

Material proposal
- Choice of corresponding existing material
- New product development

Lab performance test
- Corrosion resistance
- Thermal shock resistance

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3. Refractory Assessment Program - Product Development

Lab performance tests II
- Infiltration kinetics
- Structural stability

Pilot Production
- Industrial feasibility
- Mix validation (compared to lab results!)

Test panel with customer
- Performance in operations
- Several months

Performance evaluation
- Corrosion resistance
- Thermal shock resistance

Final evaluated product ready for commercial operations
3. Refractory Supplier Services 1

Refractory Lining Design

- Complete shape and overall design based on vessel design, operation parameters, EHS compliance (size of bricks, design of bricks easy to lift, easy to install, fast installation),
- Thermal calculations
- Thermo-mechanical calculations
- Wear pattern

Life-long Support

- Continuous/individual follow-up of refractory performance
- Post-mortem analyses
- Trouble shooting
- Root cause identification
  - Material defects? (e.g. lamination)
  - Installation errors? (e.g. expansion joints)
  - Impact of operations (e.g. spalling)
3. Refractory Supplier Services 2

**Refractory Installation & Supervision**
- On-site technical support during installation
- Own material – best know material
- Installation log-book
- Equipment
- Experienced manpower
- Retention samples & data logging
- Drying and curing

**Stock Management**
- Order and installation history
- Identification of replacement zones and frequency
- Stock management on site / at supplier
- On time delivery
- “Count bricks”
3. Refractory Suppliers Additional Checklist

**EHS – Environment Health & Safety**

- What are your *company commitments* to HSE?
- Suppliers’ HSE commitments?
  - Production cycle
  - Raw materials
  - Hexavalent chromium (Cr\(^+6\)) issue!
  - Recycling?
  - Waste water

**Supplier evaluation criteria and rating sheet**

- DIN / ISO certification
- Long-term relationship
- Customer data management and protection
- Customer auditing

**Supplier production capacity**

- Stock planning
- Outage planning
- Long-term supply and delivery possibilities
- Location
4. Conclusions

Refractory is key equipment for gasification units

Refractory design to be taken into account in early planning stages

Refractories can have significant impact on finances (OPEX, production availability…)

Refractory supplier can help you improve process performance

There are few supplier or material standards in the refractories industry, so supplier assessment is critical toward success
Thank for your attention!

matthias.schumann@saint-gobain.com