50 Years of Iron Ore Pelletizing Experience and Innovation

Thomas Schwalm – Outotec

World DRI and Pellet Congress, Abu Dhabi, April 29-30, 2013
Agenda

1) Outotec in brief

2) Technology Trends in Pelletizing

3) Summary
A technology leader for over a century

Listing on the Helsinki Stock Exchange

2012
2010
2006
2001
1990
1970
1950
1900

Outotec

Year

OUTOTKUMP TECHNOLOGY

BOLIDEN CONTECH
NORDBERG GRINDING MILLS
KHD ALUMINIUM
AISCO, SUPAFLO
WENMEC

LURGI METALLURGIE

LAROX

AUSMELT

ENERGY PRODUCTS OF IDAHO

Other recent acquisitions:
BACKFILL SPECIALISTS
TMS GROUP
DEMIL MANUTENÇAO
NUMCORE
KILN SERVICES
VPF, ASH DEC
MILLTEAM
EDMESTON
AUBURN

World DRI and Pellet Congress, Abu Dhabi
50 Years of Pelletizing Experience

Marcona 1, Peru, 1962
125m² indurating machine
1 mtpy capacity

Samarco 4, Brazil, 2012
816m² indurating machine
9.25 mtpy capacity
Raw Material Flexibility

Pelletizing capacity ever built
China not fully shown
Status: 07/2012
<table>
<thead>
<tr>
<th>Costumer</th>
<th>Location</th>
<th>Order</th>
<th>Feed</th>
<th>Cap. [mtpy]</th>
<th>Size [m²]</th>
<th>Scope</th>
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</thead>
<tbody>
<tr>
<td>Baotou</td>
<td>Baotou</td>
<td>2013</td>
<td>Mixed Ore</td>
<td>5.0</td>
<td>624</td>
<td>EPS</td>
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<tr>
<td>Gol-e-Gohar 2</td>
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<td>EPS</td>
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<tr>
<td>Samarco 4</td>
<td>Ponta de Ubú</td>
<td>2011</td>
<td>Hematite</td>
<td>9.25</td>
<td>816</td>
<td>LSTK</td>
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<td>Stoolensky GOK</td>
<td>Stary Oskol</td>
<td>2011</td>
<td>Magnetite</td>
<td>6.0</td>
<td>768</td>
<td>EPS</td>
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<tr>
<td>Ternium</td>
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<td>7.0</td>
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<tr>
<td>BPSL</td>
<td>Jharsuguda</td>
<td>2009</td>
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<tr>
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<td>Caofeidian</td>
<td>Caofeidian</td>
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<tr>
<td>BRPL</td>
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<td>ES</td>
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<td>Vale Vargem Grande</td>
<td>Nova Lima</td>
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<td>Hematite</td>
<td>7.0</td>
<td>768</td>
<td>EPS</td>
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<td>Ponta de Ubú</td>
<td>2005</td>
<td>Hematite</td>
<td>7.25</td>
<td>768</td>
<td>LSTK</td>
</tr>
</tbody>
</table>

Last 8 years: >70 million tons designed capacity
Industry trends

- **Ore grade**: Ore grades are declining and in order to meet the increased demand, more ore needs to be processed with more advanced technology.

- **Energy**: Making metals requires a lot of energy and energy costs are constantly climbing. More energy-efficient processes are needed.

- **Emissions**: Mining and metallurgical industries are major emitters of CO₂ and ecotoxic substances. Cleaner solutions must be developed.

- **Water**: Water availability and pollution are critical issues. Advanced solutions for water cleaning, conservation and recycling are needed.

- **Oil peak**: Oil peak is approaching. Oil is expected to run out by 2050 with current production rates, thus alternative sources are needed.

- **Recycling**: The need for recycling is growing, thus requiring new technologies for turning scrap and waste into products.
Technology Trends in Pelletizing

- Plant Sizes – Investment Costs
- Operating Costs
  - Availability - Maintainability
  - Energy Consumption
  - Emissions
- Flexibility on Changing Raw Materials
  - Iron Ore Carriers
  - Fuels
  - Recycled Steel Plant Waste
- Product Quality
Investment Costs

Reference case:
- 675 Million USD for 7.5mtpy capacity (2011)
- 90 USD/t @ 7.5mtpy capacity (2011)

Investment cost acc. to Kolbel-Schuize:

\[ K_2 = K_1 (X/X_0)^m \]

with:
- \( K \): CAPEX
- \( X \): capacity
- \( m \): degression exponent
  - 0.6 - 0.8
  - 0.62 - 0.65 for pelletizing plants

Plant Capacity [mtpy] vs. Total Investment Cost [Million USD] and Specific Investment Costs [USD/t].
Samarco pelletizing plants

Ponta de Ubú, Espírito Santo

Samarco 1 (1977)
Samarco 2 (1997)
Samarco 3 (2008)
Samarco 4 (2013)

(Kvaerner-Davy)

(Outotec)

(Year of Start-up)
Construction: Furnace View (January 2013)
### Iron Ore Pelletizing in India

<table>
<thead>
<tr>
<th>State</th>
<th>[Mtpy]</th>
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<tbody>
<tr>
<td>Orissa</td>
<td>22.7</td>
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<tr>
<td>Karnataka</td>
<td>15.1</td>
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<tr>
<td>Jharkhand</td>
<td>9.0</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>7.0</td>
</tr>
<tr>
<td>Chhattisgarh</td>
<td>3.8</td>
</tr>
<tr>
<td>Goa</td>
<td>2.3</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>1.2</td>
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</table>

**Map of India showing the locations of iron ore pelletizing facilities.**

**Pie chart showing the distribution of pellet production methods.**

- **Shaft Furnace:** 12%
- **Traveling Grate:** 2%
- **Grate/ kiln:** 1%
- **Others:** 85%
Standard Pellet Plant 1.2mtpy
One straight grate indurating machine leads to significant upsides, proven in plants designed/built by Outotec:

- **Plant availability**
  - Design: 330 - 345 days/year
  - Achieved: up to 355 days/year

- **Plant operating campaigns**
  - Planned: > 2 years
  - Achieved: > 5 years

Outotec travelling grate machines result in significant *increases in plant production* and *reduction of operating expenses*. 
Low CO2 emissions

Emissions in Pellet Plants
Carbon Dioxide@ LKAB

Grate
Kilns

Travelling
Grate

<table>
<thead>
<tr>
<th>Year</th>
<th>Malmberget</th>
<th>Svappavaara</th>
<th>Kiruna</th>
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<tr>
<td>2008</td>
<td>38.0</td>
<td>41.0</td>
<td>43.0</td>
</tr>
<tr>
<td>2009</td>
<td>39.0</td>
<td>42.0</td>
<td>44.0</td>
</tr>
</tbody>
</table>
Energy efficiency

- Various recuperation principles to
  - Reduce overall energy consumption
  - Reduce offgas volumes to be cleaned and released to the atmosphere resulting in **reduced environmental impact**
Flexibility on Raw Materials

Several Burners in Preheating and Firing Zone

easy adaptation of temperature profile to raw material requirements

![Graph showing temperature profile for different raw materials](image-url)
Flexibility on Fuels

- Heavy Fuel Oil
- Light Fuel Oil
- Natural Gas
- Coal Tar
- Mixtures of coke-oven and blast furnace off-gas
- Mixed off-gases from steel plants with net calorific value of >2.500 kcal/Nm³
- Coal Gas ad mixed with Heavy Fuel Oil
Dedicated in-house R&D facilities

In-house test facilities and the associated knowledge/expertise for testing representative iron ore samples and analysing results in order to offer tailored process plant solutions and process guarantees.

Pelletizing Test Campaigns

- South Africa: 3%
- Kazakhstan: 3%
- China: 6%
- Sweden: 6%
- Iran: 5%
- Canada: 5%
- Australia: 5%
- Mauretania: 3%
- Mexico: 3%
- Brazil: 25%
- India: 22%
- Russia: 14%
# Technological Advantages

<table>
<thead>
<tr>
<th>Feature</th>
<th>Advantage</th>
</tr>
</thead>
</table>
| Three recuperation principles                | 1. Low specific energy consumption  
                                      |   Low operating costs  
                                      |   2. Low emissions (CO₂)                                                    |
| Arrangement of several burners in the preheating and firing zone | 3. Temperature profile easily adjustable, ensuring flexibility  
                                      |   4. Adaptation of different firing profiles for changing feed materials  
                                      |   5. Adjustment to various pellet qualities  
                                      |   6. Significant turn-down ratios possible                                  |
| Accentuated after firing zone                | 7. Uniform heat distribution  
                                      |   8. Uniform fired pellet qualities                                        |
| Undisturbed pellet bed                       | 9. Minimized dust and fines generation  
                                      |   10. No need for minimum strength, thus reduced binder consumption  
                                      |   11. No compaction of pellets, maintaining high porosity                  |
| Stationary refractory Grate maintenance off-line | 12. Low maintenance costs, high availability, longer equipment life   |
Sustainable use of Earth’s natural resources

Thank you for your attention!

thomas.schwalm@outotec.com
Agenda

More Details
Life cycle solutions creating best value to customers

Conceptual design
- R&D services
- Modeling & simulation
- Testwork
- Feasibility studies

Operation and maintenance
- Plant operation
- Spare parts
- Preventive maintenance
- Auditing
- Testwork
- Shutdown services

Construction and commissioning
- Plant construction
- Equipment installation
- Start-up and ramp-up services
- Training

Decommissioning
- Refurbishment of equip. for re-use
- Plant decommissioning
- Permanent shutdown of the plant
- Land reclamation

Engineering and supply
- Flowsheet development
- Basic/detail engineering
- Supply of process and plant equipment
- Operability & maintainability optimization
- Spare parts

Operation and maintenance
- Equipment life assessment
- Upgrades
- Process optimization
- Modernizations
- Training

24  29.04.2013  World DRI and Pellet Congress, Abu Dhabi
Four business areas providing sustainable solutions

<table>
<thead>
<tr>
<th>Ferrous Solutions</th>
<th>Non-ferrous Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>For processing iron ores and other ferriferous materials in the entire value chain from ore to metal</td>
<td>For processing copper, nickel, zinc, lead, gold, silver and platinum group metals in the entire value chain from ore to metal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy, Light Metals and Environmental Solutions</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>For sulfuric acid production, off-gas handling, alumina refining, roasting, calcining, biomass, oil shale and oil sands processing as well as industrial water treatment</td>
<td>Providing life cycle services to Outotec’s customers</td>
</tr>
<tr>
<td>Plant Type</td>
<td>Grate Kiln</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Plant Location</td>
<td>Europe</td>
</tr>
<tr>
<td>Iron Ore Type</td>
<td>Magnetite</td>
</tr>
<tr>
<td>Electrical Energy</td>
<td>26.7 kWh/t</td>
</tr>
<tr>
<td>(Induration/Fans)</td>
<td></td>
</tr>
<tr>
<td>Thermal Energy</td>
<td>67,800 kcal/t</td>
</tr>
<tr>
<td>(Gas/Oil+Carbon)</td>
<td></td>
</tr>
<tr>
<td>Total Energy</td>
<td>105.5 kWh/t</td>
</tr>
<tr>
<td>Consumption</td>
<td></td>
</tr>
</tbody>
</table>

Total energy consumption of travelling grates is only around 80% of competing systems.
Higher reducibility

- No compaction of pellets required to maintain a high porosity for downstream reduction processes
- >80% of pellets processed by Midrex Direct Reduction plants worldwide are produced on travelling grates

Photo: Hadeed – Module E (photo credit: Midrex)

**Pellets remain undisturbed during the complete heat treatment process!**
Pallet cars and grate bars

- Significant upside to pallet car/travelling grate concept
  - Pallet car maintenance carried out offline
  - **No disturbance to production**
  - Bed height flexibility
- Pallet car concept
  - Designed for purpose based on comprehensive operating experience
  - Optimised for reduced side wall consumption
- Grate bars
  - Increased bed permeability (+45 %) - **lower energy consumption**
  - Modified alloy for higher temperature and wear resistance - **lower grate bar consumption**
Dry lintels

- Development
  - Elimination of longitudinal and transverse water cooled lintels of the indurating hood to support separation walls
  - Substitution with adapted refractory and steel structure design

- Application
  - MBR, Tubarao VIII, Brazil
  - Tata, India

- Benefits
  - Elimination of the entire water cooling on the furnace (approx. 800m³/min)
  - Reduction of investment costs due to smaller cooling tower, piping and cooling water pumps
  - Reduced plant operating expenses
Better insulation

- Development
  - Improvement of the inside refractory and/or outside thermal insulation to achieve surface temperatures of furnace and ductwork below 80 °C

- Application
  - Samarco 3 & 4, Brazil
  - MBR, Brazil

- Benefits
  - Reduction of energy losses and consequently reduction of thermal energy consumption
  - Improvement of working conditions for operation personnel