Recent technological advancements in high capacity pellet plants

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Agenda

- Outotec and Samarco in brief
- Industry megatrends and drivers
- Outotec technological advances
- Samarco 4 case study
- Summary
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A technology leader for over a century

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

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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>
</tbody>
</table>
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

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

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

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

Operation and maintenance
- Equipment life assessment
- Upgrades
- Process optimization
- Modernizations
- Training
WE ARE SAMARCO.

A BRAZILIAN COMPANY THAT SUPPLIES IRON ORE TO THE WORLD STEEL INDUSTRY.

- Founded in 1977
- Eighth largest exporter in Brazil, pursuant to the Foreign Trade Department of the Ministry of Development, Industry and Foreign Trade (January 2013)
- Second largest supplier of iron ore pellets on the seaborne market (2012)
- Private company, controlled in equal parts by two shareholders: Vale S.A. and BHP
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Source: World Steel Dynamics
## Industry trends - demand for sustainable technology

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore grade</td>
<td>Ore grades are declining and in order to meet the increased demand, more ore needs to be processed with more advanced technology.</td>
</tr>
<tr>
<td>Energy</td>
<td>Making metals requires a lot of energy and energy costs are constantly climbing. More energy-efficient processes are needed.</td>
</tr>
<tr>
<td>Emissions</td>
<td>Mining and metallurgical industries are major emitters of CO₂ and ecotoxic substances. Cleaner solutions must be developed.</td>
</tr>
<tr>
<td>Water</td>
<td>Water availability and pollution are critical issues. Advanced solutions for water cleaning, conservation and recycling are needed.</td>
</tr>
<tr>
<td>Oil peak</td>
<td>Oil peak is approaching. Oil is expected to run out by 2050 with current production rates, thus alternative sources are needed.</td>
</tr>
<tr>
<td>Recycling</td>
<td>The need for recycling is growing, thus requiring new technologies for turning scrap and waste into products.</td>
</tr>
</tbody>
</table>
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Introduction

- Two industrial systems dominate the iron ore pelletising industry
  - Outotec’s travelling grate (accounting for over 2/3 global production)
  - Grate-Kiln pelletising system
  - Note: low capacity shaft furnaces have only regional relevance

- The Outotec travelling grate is unique
  - Plant capacity available from 1.0 to 9.25 Mtpy in a single machine
  - Market leader and capable of handling all types of iron ore
    - Magnetite, hematite and weathered ores

- Outotec has installed 46 pellet plants around the World
  - Ongoing development of the technology by Outotec continues with the most experienced pellet plant operators in the World
    - LKAB, Vale and Samarco

- Extensive Research and Development facilities in Frankfurt, Germany
  - In house R&D providing leading edge design concepts for the future
  - Specific process solution solving for our global customer base
High plant availability

- One straight grate indurating machine versus the Grate Kiln’s three “in line” processes 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
  - A travelling grate reference in Europe recently concluded a ten year campaign without major shutdown!
  - Outotec travelling grates machines result in significant increases in plant production and reduction of operating expenses
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Recent/future production capacity development

2002 – 2012:
124.5mtpy

2008 – 2012:
86.6mtpy

2008 – 2015:
156.9mtpy

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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 the prerequisite process guarantees:

- Determination of required pellet feed mixture
- Determination of required green pellet moisture level
- Determination of achievable grate factor (specific capacity) and pellet quality
- Determination of design data for the indurating machine, especially its firing and cooling zones
Significant years of development/optimization of plant layout has taken place

- Right angle plant arrangement of green pelletizing and induration
- Minimization of green pellet transfer points
- Single deck roller screens at each balling disc
- Long collecting conveyor with reciprocating head
- Single deck roller screen at machine feed area
Pelletizing discs

- Well proven, robust 7.5m disc
  - Standard design
  - One single drive
  - Mitigation of multiple drive synchronisation problems

- Designed for advanced green pelletizing control
  - Frequency controlled drive
  - Automated inclination control
Optimized zone distributions

- Expansive experience of preheating/firing/cooling configurations for the processing of virtually any type of raw material (High LoI, High S)
- Tailored temperature profiles can also be modified for variation in raw materials over plant lifetime
- Equal heat treatment in all process zones
- Discharge of homogenously cooled product pellets reduces risk of damaging downstream equipment
CFD optimization

- Development
  - Verification/optimization of critical duct systems for temperature distribution, gas velocities and pressure drop

- Application
  - Samarco 3 & 4, Brazil
  - LKAB MK 3, Sweden

- Benefits
  - Reduction of ductwork pressure drops and consequently reduction of electrical energy consumption
  - Improvement of plant operating conditions and efficiency of “gas flow-sensitive” equipment, such as ESP’s and process fans

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April 2013
Energy efficiency

- Various recuperation principles tailored to specific customer requirements
  - Reduced overall energy consumption
  - Reduced offgas volumes to be cleaned and released to the atmosphere resulting in reduced environmental impact
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## Lower energy consumption

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Grate Kiln</th>
<th>Grate Kiln</th>
<th>Grate-Kiln</th>
<th>Travelling Grate</th>
<th>Travelling Grate</th>
<th>Travelling Grate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Location</td>
<td>Europe</td>
<td>Europe</td>
<td>South America</td>
<td>Europe</td>
<td>South America</td>
<td>South America</td>
</tr>
<tr>
<td>Iron Ore Type</td>
<td>Magnetite</td>
<td>Magnetite</td>
<td>Hematite</td>
<td>Magnetite</td>
<td>Hematite</td>
<td>Hematite</td>
</tr>
<tr>
<td>Electrical Energy</td>
<td>26.7 kWh/t</td>
<td>14.5 kWh/t</td>
<td>25.0 kWh/t</td>
<td>27.5 kWh/t</td>
<td>14.7 kWh/t</td>
<td>17.2 kWh/t</td>
</tr>
<tr>
<td>(Induration/Fans)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Energy</td>
<td>67,800 kcal/t</td>
<td>69,500 kcal/t</td>
<td>280,900 kcal/t</td>
<td>47,500 kcal/t</td>
<td>240,600 kcal/t</td>
<td>220,000 kcal/t</td>
</tr>
<tr>
<td>(Gas/Oil+Carbon)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Energy</td>
<td>105.5 kWh/t</td>
<td>95.3 kWh/t</td>
<td>350.6 kWh/t</td>
<td>82.7 kWh/t</td>
<td>294.5 kWh/t</td>
<td>273.0 kWh/t</td>
</tr>
<tr>
<td>Consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total energy consumption of travelling grate is only 77-86% 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

Pellets remain undisturbed during the complete heat treatment process!
High pressure burners

- **Development**
  - Substitution of traditional low pressure oil atomizers by high pressure oil atomizers

- **Application**
  - LKAB, Sweden
  - Samarco 3 & 4, Brazil
    - Dual fuel burner to provide the option to swap over to natural gas in the future

- **Benefits**
  - Reduction of atomizing air volumes and consequently reduction of oil consumption
  - Better atomization of the oil, forming a controlled flame shape to avoid contact with the refractory, which causes erosion
  - More equal temperature distribution of the flame
Pallet cars

- 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 significant 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, 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 (instead of 120 °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
Our reference list tells the whole story …

<table>
<thead>
<tr>
<th>Operator</th>
<th>Location</th>
<th>Startup</th>
<th>Capacity (Mtpy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-GOK</td>
<td>Stary Oskol, Russia</td>
<td>2013</td>
<td>6.0</td>
</tr>
<tr>
<td>Samarco</td>
<td>Plant #4, Ponta de Ubu, Brazil</td>
<td>2013</td>
<td>9.25</td>
</tr>
<tr>
<td>Bhushan Power &amp; Steel Ltd.</td>
<td>Rengali, India</td>
<td>2012</td>
<td>3.85</td>
</tr>
<tr>
<td>Tata Iron &amp; Steel Co.</td>
<td>Jamshedpur, India</td>
<td>2010</td>
<td>6.0</td>
</tr>
<tr>
<td>Caofeidian</td>
<td>Caofeidian, China</td>
<td>2010</td>
<td>4.0</td>
</tr>
<tr>
<td>Brahmiani River Pellets</td>
<td>Kalinga Nagar, Orissa</td>
<td>2010</td>
<td>4.0</td>
</tr>
<tr>
<td>MBR</td>
<td>Nova Lima, Brazil</td>
<td>2008</td>
<td>7.0</td>
</tr>
<tr>
<td>Samarco</td>
<td>Plant #3, Ponta de Ubu, Brazil</td>
<td>2008</td>
<td>7.25</td>
</tr>
<tr>
<td>Vale</td>
<td>Tubarão VIII, Vitória, Brazil</td>
<td>2008</td>
<td>7.0</td>
</tr>
<tr>
<td>Gol-e-Gohar Iron Ore Co.</td>
<td>Sirjan, Iran</td>
<td>2007</td>
<td>5.0</td>
</tr>
<tr>
<td>LKAB</td>
<td>MK3, Malmberget, Sweden</td>
<td>2006</td>
<td>2.5 – 4.0</td>
</tr>
</tbody>
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Project background

- After the successful implementation of the 7.25mtpa Samarco 3 project, Samarco commissioned Outotec to complete a study for the implementation of Samarco 4

- In 2010, Samarco approved the study and a LoA was issued, the contract was ultimately signed in March 2011

- Outotec commenced the engineering in a task force based in Belo Horizonte, with the implementation on a "fast track" basis, namely 31 months until the first pellet is produced

- Scope of Outotec contract
  - Basic and detail engineering
  - Steel structural design, boiler, and electrical and mechanical equipment
  - Civil and construction, electro-mechanical assembly and plant commissioning
Samarco pelletizing plants

Ponta de Ubú, Espírito Santo

Samarco 1 (1977)

Samarco 2 (1997)

Samarco 3 (2007)

Samarco 4 (2013)

Outotec

Kvaerner-Davy

(Year of Start-up)
Contract details

- Total Samarco investment: 700 million BRL (USD 350 million)
- Outotec contract value: ca. 200 million Euro (USD 266 million)
- Project implementation: 31 months
- Date of production of first pellet: 14. October 2013 (start-up)
- Plant capacity: 9.25 million tonnes of pellets per year
- Furnace size: 816m² - the World’s largest pellet plant
Engineering – status

- Design engineering is 100% complete
- Engineering disciplines involved: process, mechanical, structural steel, civils, piping, electrical and instrumentation and control
- The entire engineering has been developed in 3-D (PDMS, Tekla, TQS, Inventor)
- In 16 months 5,500 drawings and documents have been produced by Outotec and its partners and subcontractors
- Internal and external document communication peaked in September 2012 at approximately 10,000 per month
- Project taskforce comprises
  - Local Outotec engineering team: 22 personnel
  - CRA and IHM team partners: 80 personnel (peak)
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Procurement status (January 2013)

- The current progress of procurement/supply is at 93%, including purchasing, manufacturing, inspection and on-site delivery
- Types of supplies: mechanical and electrical equipment, automation system, steel structure and piping
- 85% of the equipment has already been procured in 120 orders
  - 90% of suppliers are Brazilian
- 22,700 tonnes of material have already been delivered to the site
Construction status (January 2013)

Contractor: PARANASA
- Manhours estimate: 660,000
- Personnel: 400 (peak)
  - Direct: 316 + Indirect: 84
- Progress: 81% against forecasted 73%

- Construction data
  - 66,500 m³ of excavating
  - 1,100 tonnes of steel
  - 15,000 m² of formwork
  - 11,900 m³ of concrete
Electro-mech. assembly status (January 2013)

- Electro-mechanical assembly
  - Contractor: NIPLAN
  - Manhour estimate: 2,240,000
  - Personnel: 1,040 (peak)
    - Direct: 910 + Indirect: 130

- Refractory installation
  - Contractor: RIP
  - Manhour estimate: 342,000
  - Personnel: 260 (peak)
    - Direct: 220 + Indirect: 40

- Total estimated for construction: **3,242,000 Man-Hours**
- Current physical advancement: 11% of the forecasted 12%
Construction: Furnace View (January 2013)
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- The travelling grate is, and will remain, the dominating technology of choice for the iron ore pelletising industry
  - Plant capacity currently available from 1.0 to 9.25 Mtpy
  - Future capacity may well be higher than this!
- Process flexibility of the travelling grate
  - Magnetite, hematite and weathered ores
  - Profiles can be modified for variation in raw materials over plant lifetime
- Ongoing development of the technology continues with the most experienced pellet plant operators in the World
  - LKAB, Vale and Samarco
- Extensive Research and Development facilities in Frankfurt, Germany
  - In house R&D leading to upgraded designs
  - Specific process solution solving for global customer base
Sustainable use of Earth’s natural resources

Thank you for your attention!
Any questions?

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