Circular Pelletizing Technology

A revolutionary solution

18th Middle East Iron & Steel Conference 2014 – Dubai, U.A.E.
Joint venture between two partners with complementary strengths

<table>
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<tr>
<th>Siemens</th>
<th>Mitsubishi Heavy Industries (MHI)</th>
<th>Joint Venture Company</th>
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<tr>
<td>• Comprehensive technology and service portfolio in iron- and steelmaking, casting, automation and environmental solutions (Siemens VAI)</td>
<td>• Technological leadership in hot and cold rolling, processing lines and manufacturing (Mitsubishi-Hitachi Metals Machinery)</td>
<td>• Formation of a new metallurgical plant-building company with expected commencement of operations in January 2015</td>
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<tr>
<td>• More than 130 years of metallurgical, engineering and plant-building experience</td>
<td>• More than 2,200 plants installed worldwide with proven record of reliability and cost-effectiveness</td>
<td>• Ownership: 51% Mitsubishi-Hitachi Metals Machinery Inc.; 49% Siemens AG*</td>
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<tr>
<td>• Strong emphasis on R&amp;D and introduction of numerous innovations</td>
<td>• In-house machinery-manufacturing expertise</td>
<td>• Headquarters: U.K. with principal business locations in Tokyo, Hiroshima, Linz and Erlangen</td>
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<tr>
<td>• Worldwide sales organization and global engineering network but main focus in Europe</td>
<td>• Strong sales setup and engineering competence, particularly in growing Asian countries</td>
<td>• Global business focus: supplier of advanced processes, technologies, plants, products and services for the iron, steel and aluminum industries</td>
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(*) subject to approval of the relevant authorities.
Siemens VAI
over 45 years experience in pelletizing

Milestones

- 1966 Siemens VAI enters pelletizing business (VOEST-Alpine)
- 1977 License Agreement with LURGI (today Outotec)
- 1978 Mandovi Pellets India 1.8 Mt/a Limonite
- 1978 SIDOR Venezuela 2 x 3.3 Mt/a Limonite
- 1979 Tubarao 1 Vale, Brazil 2.0 Mt/a Hematite
- 1973 Tubarao 2 Vale, Brazil 3.0 Mt/a Hematite
- 1981 Delta Steel Nigeria 1.5 Mt/a Hematite
- 1976-2011 Primary focus on Sinter Plants
- 2004 LURGI Pelletizing License terminated
- 2001 Pelletizing Plant modernization studies
- 2010 Acquisition of Circular Pelletizing Technology
- 2011 First Circular Pelletizing Plant contracted in India Pro Minerals 1.2 Mt/a
- 2013 Second Circular Pelletizing Plant contracted in India Surana 1.2 Mt/a

References

- 2001 Pelletizing Plant modernization studies

Circular Pelletizing Technology
Global Trends in the Mining Industry
Circular Pelletizing Technology
Industry Trends – Lack of lump ore

Strong tendency towards mining of fine ore / ultra fine ore grades

- **1940-1960**: Coarse hematite
  - Lump Ore >200mm

- **1960-1980**: Coarse / fines
  - Lump Ore 12-75mm

- **1980-2000**: Fines
  - Lump Ore 10-37mm

- **2000-Future**: Fines – Ultrafines
Why Pelletizing is inevitable?

- **Global decrease of Lump and Sinter Feed Ores**
  This tendency makes the utilization of fine and ultrafine ores more important, for which pelletizing is the only industrial scale proven process.

- **Productivity increase in downstream process**
  Good Bed Permeability and Reducibility

- **Uniform chemical analysis**
  By beneficiating of ultrafines a very constant quality is achieved leading to constant operation conditions.

- **Easy handling and transportation**
  Excellent strength of pellets for further handling and processing.
Circular Pelletizing Technology
A smart combination
Circular Pelletizing Technology
Characteristics and Design Criteria

CPT is based on proven straight grate induration process

Design Criteria

- **Simple and robust** plant equipment
- **Circular design** and **small footprint**
- Capacities between **0.6 - 3.0 Mio. tons / year**
- **Flexibility on location** - not necessarily at mine site, but also at steel works or direct reduction plants
- **Energy efficiency** – recuperation principles, flexibility in fuels
- **Fully automated operation** for plant safety, availability, product quality
- **Lowest CAPEX** solution for top quality Production of Blast Furnace and Direct Reduction pellets as well as Manganese pellets

CPT combines proven process with reliable mechanical system
Siemens VAI Sintering Technology
Mechanical design of a circular dip rail cooler
The Challenge of making iron ore pellets
Typical Flow Sheet of a Pelletizing Plant

Balling section

Storage and mixing section

Intensive mixer

Hearth and side layer

Screening and feeding section

Circular induration furnace

1 Iron ore  2 Concentrate  3 Coke and limestone  4 Bentonite  5 Dry dust
Straight Grate Pelletizing Technology
Induration Process
Circular Pelletizing Technology

Temperature and Processing Zones

Indurating Furnace Temperatures and Seven Processing Zones

- Drying Section
- Heating Section
- Heat Recovery Section

Key Processing Zones:

1. Updraft Drying
2. Downdraft Drying
3. Pre-heating
4. Firing
5. After-firing
6. First Cooling
7. Second Cooling

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Circular Pelletizing Technology
The Induration Process in Circular Arrangement

Induration Zones:
1. Up-draft drying
2. Down-draft drying
3. Preheating
4. Firing
5. After-firing
6. First cooling
7. Second cooling

Ω 22m
Circular Pelletizing Technology
A SMART combination

A SMART combination:

<table>
<thead>
<tr>
<th>Straight grate induration process</th>
<th>Mechanical system of SVAI circular dip rail cooler</th>
<th>Circular Pelletizing Technology</th>
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<td>• well-proven travelling grate process</td>
<td>• robust mechanical design from the circular dip rail cooler</td>
<td>The result is the revolutionary:</td>
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<td></td>
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<td>• Circular Pelletizing Technology</td>
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By careful design of the pallet cars and the drive system combined with a detailed stress analysis of the complete system a reliable and easy maintainable indurating machine could be realized.
By simulating the process gas flows inside the indurating hood the optimum arrangement and specific power of the burners could be defined.
Circular Pelletizing Technology
Induration Furnace - Cross Section - Firing Zone
Circular Pelletizing Technology
Dual Fuel Burner Principle Scheme

Indigenous Coal
Air
Coal Gasif.
Ash
Flare
Primary Air
HFO

Fuels can be mixed in every ratio.
Circular Pelletizing Technology

Layout and Plant Features
Circular Pelletizing Technology (CPT)
Standard Plant Layout CPT 1.2M

1. Raw material dosing & balling
2. Additive storage & grinding
3. Mixing Station
4. Induration Furnace
5. Product classification
6. Product storage pile
7. Process gas cleaning
8. Coal gasification plant
Circular Pelletizing Technology

Impressions
Circular Pelletizing Technology
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Circular Pelletizing Technology
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Top View of a CPT 1.2M in a Steelworks

1. Iron ore grinding
2. Additive storage & grinding
3. Dosing & Mixing
4. Green balling
5. Induration furnace
6. Product classification
7. Product intermediate bin
8. Process gas cleaning
Advantages of CPT
CPT vs Straight Grate
Comparison of Induration Furnace

CPT: Side view

Straight Grate: Side View

CPT: Top view

Pallet cars usage of only:

Pallet cars usage of:

Circular Pelletizing Technology
CPT vs Straight Grate
Comparison of Induration Furnace

CPT Plant:
- 1/3 of Straight Grate in plant length
- 30% less plant height

Result:
- Lower concrete foundation
- 30% weight reduction
  - less pallet cars
  - less steel structure
  - lower height of induration platform
Circular Pelletizing Technology
Plant Layout CPT 2.5M + Midrex 1.7 Mtpa DRI Plant

CPT Plant Combinations:

By the production of DR-grade pellets the next generation module size of CPT plants is the ideal basis for a MIDREX® 1.7 Mtpa DRI plant.

The new module can also be combined with a 1.5 Mtpa COREX® plant for the production of hot metal.

The complete combined plant solutions can be offered by Siemens VAI.
Circular Pelletizing Technology
Plant Layout CPT 1.2M including Beneficiation Plant

Beneficiation Plant  Circular Pelletizing Plant CPT 1.2M
Modular CPT Concept – 3 CPT Modules

Advantages of modular concept

- Specific investment costs at same level of large pellet plants
- Production ramp-up with lower capital exposure
- Flexibility in production
  - Different pellet qualities (DR-grade, BF-grade, fluxed pellets, …) at the same time
  - Capacity variation as per market situation
- Planned / unplanned maintenance shut downs: no complete stop of production
SIMETAL MEROS
State of the Art Gas Cleaning Technology

MEROS = 4 in 1

- Lowest investment!
- Lowest operation costs

Easily expandable to DeNOx (first reference in LINZ)
SIMETAL MEROS –
Maximized Reduction of Emission for Sintering

Typical Situation
• High quantities of dust, acidic gases and metallic and organic components in the sinter off-gas
• Environmental aspects gain more and more significance for design and operation of sintering plants

Saving Potentials & Benefits
• Siemens VAI dry gas cleaning system MEROS – Maximized Emission Reduction Of Sintering
• Meets current and future emission regulations
• Considerable benefits compared to conventional wet dedusting technologies
• Fulfilling BAT requirements
• Easily expandable by DeNO\textsubscript{x}

References:
- Voestalpine Linz, Austria
- MA Steel, China
Circular Pelletizing Technology
Pot Grate Test Facility at Leoben, Austria

- Own pot grate test facility enables quick and reliable test of different raw materials
- Optimization of pellet quality and other parameters like additive addition, fuel consumption, etc.
- Combination with the simulation model for pelletizing allows very accurate up scaling and forecast
SVAl’s Test Facility

Beneficiation:
• Investigation chemistry, mineralogical structure, intergrowth of mineral
• Equipment for all common technologies used in beneficiation plants
• Material handled: up to 200 mm
• Laboratory scale beneficiation
• Pilot scale beneficiation with 1-1.5 t/day capacity

Pelletizing:
• Grinding to pelletizing fineness
• Mixing (Eirich type, horizontal type mixers)
• Green balling on 1.4 m disc
• Pellet firing in modern Pot grate
• Standardized testing of pellet quality incl. all common normed test procedures
Siemens’ Hybrid Flotation addresses the challenges by differing from conventional technologies

Why Hybrid Flotation?

- **First stage (upper section):** Pneumatic principle with 3-phase-ejectors; especially capable to recover “fines” and achieve high enrichment factors
- **The circular movement** in the upper section together with the conical intersection between upper and lower section leads to a centrifugal effect
- **Second stage (lower section):** Column principle with bigger gas bubbles; catch coarse particles not attached in first stage at lower enrichment factors, but increasing total recovery significantly
- **Adjustability of the lower aerators** ensures best possible positioning for optimization of bubble-particle contact
- **Short retention times** lead to a quick discharge of the froth product
- **No stirring device** means no energy required for it and no wear at an agitator system

… because it’s two principles in one machine!
Advanced Level 2 Automation System
Optimized Process Control for Pellet Production

Main Aspects
- Fully integrated system comprising all elements of CPT
- Stable and standardized (shift independent) operation
- Process insight through visualization and reporting

Main Benefits
- Improved quality and capacity
- Safe operation
- Reduced energy consumption
- Increased plant availability
- Transparent and regular management reporting

Circular Pelletizing Technology
Circular Pelletizing Technology Key Facts

- Lowest specific weight, height and space requirements per ton of production in pelletizing resulting in lowest CAPEX
- Highest flexibility in process control by direct firing principle and innovative burner design and arrangement
- Lowest OPEX based on the utilization of low-grade fuels like coal gas (from combined coal gasification plant)