COMPETITIVE STEEL PRODUCTION

ENZO RUSCIO
EVP
DANIELI

19TH MIDDLE EAST IRON & STEEL CONFERENCE
14-16 DECEMBER 2015
ATLANTIS, THE PALM
DUBAI, U.A.E
STEELMAKING ROUTES DEPENDING ON THE RAW MATERIAL AVAILABILITY

EAF
Hot metal in metallic charge: 0-40%

BOF
Hot metal in metallic charge: 75-95%

ALLOTHERMIC CONVERTER
Hot metal in metallic charge: 50-75%

RAW MATERIAL FLEXIBILITY: KEY TO SUCCESS
EXAMPLE OF A MINI MILL LAYOUT

RAW MATERIAL FLEXIBILITY: KEY TO SUCCESS

IRON MAKING AREA

- Blast furnace
- Pig iron casting machine
- Material handling

STEEL MAKING AREA

- GCP gas cleaning plant
- LF ladle furnace
- BOF/Allothermic converter/EAF
- CCM bloom casting machine

DANIELI
## RAW MATERIAL FLEXIBILITY: KEY TO SUCCESS

### MINI BLAST FURNACE: PERFORMANCE DATA

<table>
<thead>
<tr>
<th>MBF working volume</th>
<th>m³</th>
<th>175</th>
<th>215</th>
<th>250</th>
<th>350</th>
<th>450</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charcoal (Coke) &amp; ore</td>
<td>Ton/day production</td>
<td>350/385</td>
<td>430/475</td>
<td>500/550</td>
<td>700/770</td>
<td>880/950</td>
</tr>
<tr>
<td>Charcoal (Coke) &amp; ore + sinter/pellets</td>
<td>Ton/day production</td>
<td>405/445</td>
<td>490/550</td>
<td>580/635</td>
<td>800/890</td>
<td>1280/1350</td>
</tr>
<tr>
<td>Make up water</td>
<td>m³/h</td>
<td>50</td>
<td>60</td>
<td>65</td>
<td>80</td>
<td>92</td>
</tr>
<tr>
<td>Specific power consumption</td>
<td>kWh/tHM</td>
<td>130</td>
<td>130</td>
<td>125</td>
<td>120</td>
<td>116</td>
</tr>
<tr>
<td>Maximum power demand</td>
<td>kW</td>
<td>2100</td>
<td>2590</td>
<td>2870</td>
<td>3900</td>
<td>4500</td>
</tr>
<tr>
<td>Avg power demand</td>
<td>kW</td>
<td>1970</td>
<td>2400</td>
<td>2700</td>
<td>3650</td>
<td>4180</td>
</tr>
<tr>
<td>Blast Furnace size, ton</td>
<td>Blast Furnace production, Mton/year</td>
<td>EAF size, ton</td>
<td>Max liquid steel production, Mton/year</td>
<td>EAF Max Power, MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------</td>
<td>--------------</td>
<td>---------------------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>0.2</td>
<td>50</td>
<td>0.514</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>0.5</td>
<td>130</td>
<td>1.337</td>
<td>93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assuming optimal 35% of hot metal in metallic charge.
RAW MATERIAL FLEXIBILITY: KEY TO SUCCESS

MINI BLAST FURNACE-EAF ROUTE OF STEELMAKING

ELECTRICAL ENERGY

CHEMICAL ENERGY
<table>
<thead>
<tr>
<th>Blast Furnace size, ton</th>
<th>Blast Furnace production, Mton/year</th>
<th>Allothermic converter size, ton</th>
<th>Max liquid steel production, Mton/year</th>
<th>Coal consumption, Kg/heat</th>
<th>Max O2 Flow Rate, Nm³/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0,2</td>
<td>40</td>
<td>0,38</td>
<td>3600</td>
<td>12000</td>
</tr>
<tr>
<td>500</td>
<td>0,5</td>
<td>100</td>
<td>0,95</td>
<td>9000</td>
<td>30000</td>
</tr>
</tbody>
</table>

Assuming 50% of hot metal in metallic charge
Allothermic Converter is a combined O2 blowing - lime and coal injections based upon Maxhuette and NSENGI know-how

ADVANTAGES:

- Maximum liquid steel yield
- Low (Fe) in slag
- Low dust generation
- Shortest Blowing Times (lime injection)
- O2 blowing rate: 4-5 Nm³/t*min -> high productivity
- Low lime consumption, no undissolved lime in slag
- No bottom stirring (Ar/N2) applied
- Lowest [O] content, alloy savings
- High off-gas credit
ADVANTAGES:

> No slopping, 100% “quiet blowing”, nearly no lance scull
> Easy Operation Procedure - lance positioning constant, O2 flow constant
> Scrap Rate up to 50%
> Independence from HM-Quality and scrap rates
> Max. liquid steel yield
> High Desulphurization Rate
> Efficient Dephosphorization
> Ultra Low Carbon contents possible

Allothermic Converter is a combined O2 blowing - lime and coal injections based upon Maxhuette and NSENGI know-how.
> Hot metal is an excellent metallic source for downstream processes (alternative/complement to scrap/HBI/DRI).

> Hot metal use improves (as HBI/DRI) the quality of finished product.

> Hot metal can be treated (in different percentages in the charge mix) by all downstream processes (Allothermic, BOF, EAF).

> The Allothermic process provides a substantial flexibility both in terms of productivity and charge mix as well as Capex/Opex advantage with respect to the EAF process route.

> The Allothermic process minimizes the need for electric power.
SIMULATION, KNOWLEDGE, SAFETY

Can software reshape metals?

ENZO RUSCIO
EVP DANIELI

19TH MIDDLE EAST
IRON & STEEL CONFERENCE
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DUBAI, U.A.E
SIMULATION TOOLS
• TO TEST SOFTWARE
• TO TRAIN PERSONNEL
• TO TEST NEW PRODUCTS
• TO TEST NEW CYCLES
UNDERSTANDING PROCESS DATA
> BIG DATA FOR PROCESS SIMULATION
> BIG DATA FOR QUALITY & TREND PREDICTION
> KNOWLEDGE IN THE AUTOMATION CONTROL
SAFETY PROCEDURES AS VALUABLE ASSET TO IMPROVE PRODUCTIVITY

> NO MAN ON THE FLOOR
> ADVANCED PULPITS AND CONTROLS
> ARTIFICIAL VISION SYSTEMS
> ROBOTICS
iSTAND

3D Simulation platform and virtual training
3Q PULPIT

No man on the floor
Single and remote pulpit for more plants
3Q ROBOT MELT

For EAF sampling
REMOTE COMMISSIONING

In Year 2015 DANIELI AUTOMATION commissioned a rolling mill for bars, located in a dangerous area in the Middle East, in remote mode, from a pulpit in our Headquarters in Buttrio.
3Q MOBILE
Equipment devices

Solutions for modern technology

The plant on your smartphone
SAFESTAR
Integrated communication system for safety supervision

- Improvement of safety supervision
- Reduce assistance response time
- Improves staff management
- Integration with business processes applications
- Integrated communication
- Full resources localization
### EAF TECHNOLOGICAL FEATURES

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EAF TYPE</td>
<td>AC, full platform, EBT</td>
</tr>
<tr>
<td>BOTTOM SHELL DIAM.</td>
<td>7.0 m</td>
</tr>
<tr>
<td>TAPPED STEEL</td>
<td>150 ton</td>
</tr>
<tr>
<td>HOT HEEL</td>
<td>50 ton</td>
</tr>
<tr>
<td>TRANSFORMER</td>
<td>130 MVA + 20%</td>
</tr>
<tr>
<td>ELECTRODES</td>
<td>710 mm</td>
</tr>
<tr>
<td>MATERIAL HANDLING</td>
<td>Continuous feeding from roof: Hot DRI (Hytemp® system)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cold DRI, Lime, Dololime, Carbon</td>
</tr>
</tbody>
</table>

**REFERENCE DRI CHARGE FURNACE-EMIRATE STEEL**

![Diagram showing EAF and Hytemp® tower](image)

- Hot DRI → pneumatic transport
- Hytemp® tower
**INJECTION PACKAGE**

**OXGENJETS**
- 5 x 2,500 Nm³/h

**CARBON INJECTORS**
- 4 x 40 kg/min

**INJECTORS LAYOUT**

![Image of injection package layout]
PLANT #2 CAPACITY ENHANCEMENT

2011

EAF initial design:
196 t/h
46 min TtT

2014

EAF NEW TARGET ACHIEVED:
237 t/h
38 min TtT

EAF POWER-OFF
9 min > 6 min

> Gunning robot
> Increased EBT diameter

EAF POWER-ON
37 min > 32 min

> Oxygen plant revamping
> Increased DRI plant productivity
> Increased chemical energy utilization
> Power input maximization
# EAF Results after Up-Grade

## EAF Best Daily Results

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2014 After revamping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HOT / COLD DRI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DRI – Tot Fe</td>
<td>90 / 10 %</td>
<td>90 / 10 %</td>
</tr>
<tr>
<td>DRI - % MTZ</td>
<td>92.3 %</td>
<td>92.4 %</td>
</tr>
<tr>
<td>DRI - % C</td>
<td>95.7 %</td>
<td>95.7 %</td>
</tr>
<tr>
<td></td>
<td>2.18 %</td>
<td>2.01 %</td>
</tr>
<tr>
<td><strong>TAP TO TAP</strong></td>
<td>45 min</td>
<td>37 min</td>
</tr>
<tr>
<td><strong>POWER ON</strong></td>
<td>36 min</td>
<td>31 min</td>
</tr>
<tr>
<td><strong>POWER OFF</strong></td>
<td>9 min</td>
<td>6 min</td>
</tr>
<tr>
<td><strong>AVERAGE POWER</strong></td>
<td>105 MW</td>
<td>109 MW</td>
</tr>
<tr>
<td><strong>ELECTRIC ENERGY</strong></td>
<td>412 kWh/t</td>
<td>378 kWh/t</td>
</tr>
<tr>
<td><strong>OXYGEN</strong></td>
<td>33 Nm³/t</td>
<td>34 Nm³/t</td>
</tr>
<tr>
<td><strong>ELECTRODES</strong></td>
<td>1.28 kg/t</td>
<td>1.05 kg/t</td>
</tr>
</tbody>
</table>

## Revamping

- **High DRI quality**
  - T > 510 °C at EAF
- **Melting practice improv.** (114 MW)
- **Hot DRI EAF**
  - 5,800 kg/min
- **O₂ EAF**
  - 12,500 Nm³/h
- **Gunning robot**
  - EBT 200 mm
- **Power-On**
- **Power-Off**
- **Heat Losses**
- **Electric Energy**
  - -34 kWh/t
CHR CLEAN HEAT RECOVERY
FROM EAF HOT FUMES INTO ELECTRIC ENERGY WITH CONSEQUENT FUEL SAVING AND REDUCTION OF GREEN-HOUSE GAS EMISSION
<table>
<thead>
<tr>
<th><strong>HIGH ENTHALPY</strong></th>
<th><strong>LOW ENTHALPY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Water Temperature: 220° C</td>
<td>Max Water Temperature: 110° C</td>
</tr>
<tr>
<td>Design pressure: 40 bar</td>
<td>Design pressure: 16 bar</td>
</tr>
<tr>
<td>CHR™ Efficiency: 17%</td>
<td>CHR™ Efficiency: 8%</td>
</tr>
<tr>
<td>Primary FTP cooling application</td>
<td>EAF and Primary FTP cooling application</td>
</tr>
<tr>
<td>PED standard required</td>
<td>PED standard NOT required</td>
</tr>
<tr>
<td>Re-design of FTP Water cooling ducts, piping and water stabilization to work at higher pressure - suitable for GREENFIELD</td>
<td>Light revision of EAF and FTP water cooled elements to optimize the interface with ORC – suitable for REVAMPING</td>
</tr>
<tr>
<td>Medium CAPEX</td>
<td>Low CAPEX</td>
</tr>
</tbody>
</table>

**COOLING WATER SAVINGS**

<table>
<thead>
<tr>
<th><strong>HIGH ENTHALPY</strong></th>
<th><strong>LOW ENTHALPY</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>REDUCTION of Cooling Water flow-rate (40%)</td>
<td>NEGLIGIBLE Cooling Water consumption (Closed Circuit)</td>
</tr>
<tr>
<td>NEGLIGIBLE Cooling Water consumption (Closed Circuit)</td>
<td>NEGLIGIBLE Chemicals consumption for cooling water treatment</td>
</tr>
<tr>
<td>NEGLIGIBLE Chemicals consumption for cooling water treatment</td>
<td></td>
</tr>
</tbody>
</table>
ROI $\frac{3}{5}$ years depending on:

> EAF Melting process (ex. Carbon or Stainless steel)
> EAF size
> Greenfield plant or Revamping project
> Energy cost
> Presence of public financing
The Organic Rankine cycle (ORC) is named for its use of an organic, high molecular mass fluid (ex. air-conditioning application) with a boiling point occurring at a lower temperature than the water-steam phase change.

ADVANTAGES
> Simple completely automatic machine
> No influence on the steelmaking process
> No flammable fluid can be used
> Low operation and maintenance costs
POLYMER INJECTION TECHNOLOGY

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Injection of a blend of rubber crumb from end-of-life tyres, and coke, in the Electric Arc Furnace (EAF) as a slag foaming slag agent.
**The main benefits are:**

- superior slag foaminess
- reduction in the amount of carbon injectant (rubber crumb / coke blend) required compared to 100% coke.

**The practical consequences of a better foaming slag are:**

- reduction of electrical energy consumption
- productivity increase with reduced power on time
- savings in injected oxygen consumption
Polymer + coal combination produces a higher slag volume than just coal.
<table>
<thead>
<tr>
<th>POLYMER INJECTION TECHNOLOGY</th>
<th>FOAMING SLAG PHENOMENA</th>
<th>DANIELI</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% COKE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t = 0 sec</td>
<td>t = 120 sec</td>
<td>t = 180 sec</td>
</tr>
<tr>
<td>t = 240 sec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POLYMER BLEND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t = 0 sec</td>
<td>t = 120 sec</td>
<td>t = 180 sec</td>
</tr>
<tr>
<td>t = 240 sec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ENVIRONMENTALLY SUSTAINABLE

All of these benefits, including the reduction in total carbon injectant required, have been proven using Six Sigma statistical analysis, during implementations at Celsa Group EAFs.

In addition, Polymer Injection Technology is an environmentally sustainable practice, contributing to diversion of end-of-life tyres from land fill and, due to the reduced coke consumption, also results in decreased CO2 emissions.

Tests performed at Celsa Group EAFs have confirmed that there are no deleterious impact on emissions.
ECOGRAVEL® PROCESS CAN SOLVE WITH PROFIT THE SLAG PROBLEM COMING FROM EAF - BOF - LADLE
Dust, noise and pollution from the wheel loaders and trucks

Costs for the slag disposal in authorized landfills

Chaotic management of surface areas
Finish products near slag storages

ENVIRONMENTAL PROBLEMS

ECONOMICAL PROBLEMS

MANAGEMENT PROBLEMS
ECOGRAVEL® PROCESS  GREEN STEEL ABS PROJECT
CRUSHING AREA STAGES:
> DEFERIZZATION
> CRUSHING
> SCREENING

1. DEFERIZZATION UNIT
2. JAW CRUSHER
3. HAMMER MILL
4. VIBRATING SCREENS
Ecogravel is a CE-marked product in compliance with the following standards:

> EN 12620: “Aggregates for concrete”
> EN 13242: “Aggregates for hydraulically bound materials for use in civil works and road construction”
> EN 13043 “Aggregates for bituminous mixes and surface treatments for roads, airports and traffic areas”
ECOGRAVEL® ACHIEVEMENTS

APPLICATIONS

> Pre-fabricated items
> Aggregate for concrete

> Aggregate for bituminous conglomerate
> Road construction
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FUME DUST RECOVERY
THE EAF DUST WAYS

MELTSHOP 1Mt/y

EAF dust 15 - 25 kg/ton of liquid steel
15 - 25% zinc content, 14 - 18 % iron content

<table>
<thead>
<tr>
<th>LANDFILL</th>
<th>TRADITIONAL WAY WAE LZ FURNACE</th>
<th>INNOVATIVE WAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANDFILL (regulation)</td>
<td>REUSE (certification)</td>
<td>INDUTEC® CZO (CRUDE ZINC OXIDE)</td>
</tr>
<tr>
<td>ZINC PLANTS</td>
<td>EZINEX®</td>
<td>SHG ZINC</td>
</tr>
</tbody>
</table>
THE INDUTEC PLANT AND PRODUCTS

1 PROCESS

EAF DUST

INDUTEC®

Pig Iron
Inert slag

CRUDE ZINC OXIDE

EZINEX®

Zinc ingots
Alkaline Salt (NaCl+KCl)
Lead cement
2 PROCESS CONTROL

THE PROCESS MASS BALANCE

- EAF Dust (15% Zn)
- Coal: 90 Kg/t
- Natural gas: 20 nmc/t
- Oxygen: 90 nmc/t

INDUTEC®

27% Crude zinc oxide

37% Pig iron

36% Inert slag
THE INDUTEC PLANT FURNACE AND EQUIPMENTS

3 EQUIPMENT