MMMM 2012
25th - 28th September 2012,
New Delhi, INDIA

Danieli concepts & experiences in Thin Slab Casting and Rolling technology for Hot Rolled Coil Production.

Dr. Carlo P. PIEMONTE
Executive VicePresident
Danieli Wean United - Italy
Conventional process route
Thin Slab Casting Rolling: the beginning

First generation of Thin Slab Caster & Rolling

- Reduced investment and transformation cost
  - Target: commercial products segment

Drawbacks of applied technology in “first generation plants”
- Limitation in product mix & steel grades
- Limitation in production
- Commercial quality

Considering present market status trends, a flat products minimill conceived to target commercial quality market, with limited productivity (below 1.5 / 1.6 Mtpy), as given by “first generation technology”, is not economically sustainable.
Thin Slab Casting Rolling: the evolution

Added Value Production

Productivity

First Generation Technology Plants
Thin Slab Casting Rolling: the evolution

Danieli minimill concept: the new generation of minimill for flat products

- Increasing in production level
- Extended product mix
- “Conventional mill style” coil quality
- High value production
- Ultra thin gauges production
1984 first pilot caster plant based on Danieli original technology

- Productivity: increased output to reduce transformation costs
- New steel grades: AHSS, HSLA, Peritectic, Silicon Steels and API grades (including ARCTIC applications)
- New markets: top quality pipe applications and, as goal, automotive exposed
Productivity chart

Yearly Production per Casting Strand

<table>
<thead>
<tr>
<th>Year</th>
<th>Strands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>0.8 Mtpy</td>
</tr>
<tr>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>2.0 Mtpy</td>
</tr>
</tbody>
</table>

- 0.8 Mtpy
- 1.5 Mtpy
- 2.0 Mtpy
Thin Slab Casting Rolling: the ultimate goal

**Danieli minimill** concept:

the new generation of minimill for flat products.

Close the “vicious gap” between conventional route and TSCR process in production and quality, keeping intact the “virtuous gap” in competitiveness concerning:

- Unbeatable CAPEX (20% advantage) and OPEX (15% advantage)
- Reduced environmental impact and carbon dioxide footprint
State-of-the-art

Tangshan Iron & Steel plant, TISCO (China) has been the first plant in the world able to produce in excess of 3.0 Mtpy of coils adopting thin slab casting and rolling process.
The evolution

With the new Danieli applications of Ultra High Speed casting consolidated in POSCO it is possible to exceed a plant productivity of 4.0 Mtpy.
Essar Algoma (Canada)

The first plant in the world to produce peritectic steel grades adopting thin slab casting and rolling process.

Danieli Thin Slab Casting process is the only technology that ensures the cast of these steel grades.
“The 12” square by 0.250” was the flatest product we have ever seen. There was significant reduction in our scrap rate and less set up time in our mill. As for the scale, if the product had been oiled, I would have believed that the material had been pickled.”

(Jim Clark, Director of Quality, Sonco Steel Tube Inc., Brampton, Ontario)

“The surface was marvelous, almost like cold rolled.”

(Sue Meagher, Maksteel Inc., Missisagua, Ontario)
Essar Algoma developed HSLA grades with HIGH strength

- DSPC 700B/770B is a superior HSLA light gauge grade with minimum yield strength exceeding 700 MPa, for several applications including automotive, weathering grades, drawing quality.
- Surface quality of these steel grades produced in DSPC are reported to be higher than experienced in conventional Essar Algoma mill.
Benxi Iron & Steel plant (P.R. China)

- Pioneering silicon steel production in China using Thin Slab Casting technology
- Several Si grades have been successfully cast at over 4 m/min with a Si content up to 3.2%
Benxi experience: customer reports

<table>
<thead>
<tr>
<th>Inspection Part</th>
<th>Ensured Envi</th>
<th>Steel Making Technical (Ctts)</th>
<th>Inspection Model</th>
<th>N011N02</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>quantity</td>
<td>sample date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rejection Item</td>
<td>V89498-1987</td>
<td>Inspection date</td>
<td>rejected date</td>
<td>Nov-98/98</td>
</tr>
<tr>
<td>sample code</td>
<td>5.1, 5.2, 6.1, 6.2, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>inspection Result</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>center segregation</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>center porosity</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>center cracks</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>triangular crack</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>transverse zone</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ALOs inclusion</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>cell shape hole</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>surface granularity</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>column crystal zone</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Declaration: 1. report is subject to sample. 2. It is unlawful without signature of licensee. 3. It is subject to change. 4. It is forbidden to copy the report without his approval. 5. Any changes made on this report must be put forward within 15 days from issued date.

Date: 01/01/01
Signature: "Signature"
OMK plant (Russia)

The first thin slab casting and rolling plant in the world specifically conceived for the production of top quality pipe grades (including arctic applications)
More than 20 steel grades for pipe steel are already in production

<table>
<thead>
<tr>
<th>Steel group</th>
<th>Steel grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSLA MC</td>
<td>13G1SU, 17G1SU, 20KSX, 22GU, 22GU-1, 22GU-2, 22GU-E, 22GF</td>
</tr>
<tr>
<td>MC</td>
<td>ST20, St3sp, S235JR-3, A36, S235JR-1</td>
</tr>
<tr>
<td>HSLA LC</td>
<td>K52, K56, K60</td>
</tr>
<tr>
<td>PERITECTIC</td>
<td>09G2S, 09GSF</td>
</tr>
<tr>
<td>LC</td>
<td>St08ps, S235JR-2, SAE1006, St1SP</td>
</tr>
</tbody>
</table>
The energetic efficiency embodied in the thin slab casting and rolling process reduces the overall energy consumption and related carbon dioxide footprint to less than 35% compared to conventional process.
“Investment oriented” key design factors:

• Definition of slab thickness
• Definition of mill layout and process
• Modular solutions for future upgrades
Danieli developed a comprehensive portfolio of layouts and technological solutions to get the best transformation cost fitting with:

- Production level according to market request
- Product mix (steel grades and coil dimensions)
- Possible future expansion
- Danieli Vertical Curved caster design vs. vertical design
- Danieli High Speed High Quality (H2) Long funnel Mould vs. conventional funnel mould
- Danieli Dynamic Soft Reduction with mathematical model vs. static soft reduction
- Danieli Air Mist secondary cooling vs. water only secondary cooling
- Danieli Independent Machine Cooling vs. no dedicated machine cooling
TSR technological layout

- Tunnel Furnace
- Laminar Cooling
- Rolling Stands
- Downcoilers
<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab thickness</td>
<td>50/70/80 mm</td>
</tr>
<tr>
<td>Slab min max width</td>
<td>800-1600 mm</td>
</tr>
<tr>
<td>Max slab length</td>
<td>38-150 m</td>
</tr>
<tr>
<td>Max slab weight</td>
<td>30 t</td>
</tr>
<tr>
<td>Strip min max thickness</td>
<td>(0.8) 1.0 - 20 mm</td>
</tr>
<tr>
<td>Strip min max width</td>
<td>800-1600 mm</td>
</tr>
<tr>
<td>Max coil sp. weight</td>
<td>20 kg/mm</td>
</tr>
<tr>
<td>Coil nominal ID-OD</td>
<td>762-2000 mm</td>
</tr>
<tr>
<td>Max coil weight</td>
<td>30 t</td>
</tr>
</tbody>
</table>

**TSR for 1.6/2.0 Mtpy of Hot Rolled Coils with 1 strand caster**

![Diagram showing the TSR technological layout](image-url)
TSR technological layout

- Tunnel Furnace
- Vertical Edger
- Laminar Cooling
- Downcoilers
- High Speed Shear
- Water Descaler
- Rolling Stands
fTSR for 1.6/2.0 Mtpy of Hot Rolled Coils with 1 strand caster

Slab thickness: 50/70/80 mm
Slab min max width: 800-1600 mm
Max slab length: 48 m
Max slab weight: 30 t

Strip min max thickness: (0.8) 1.0 - 20 mm
Strip min max width: 800-1600 mm
Max coil sp. Weight: 20 kg/mm
Oil nominal ID-OD: 762-2000 mm
Max coil weight: 30 t
QSP 90 for 1.8/2.2 Mtpy of Hot Rolled Coils with 1 strand caster

- **Slab thickness**: 90 mm
- **Slab min max width**: 800-1600 mm
- **Max slab length**: 30 m
- **Max slab weight**: 30 t

- **Strip min max thickness**: 1.0 - 20 mm
- **Strip min max width**: 800-1600 mm
- **Max coil sp. Weight**: 20 kg/mm
- **Coil nominal ID-OD**: 762-2000 mm
- **Max coil weight**: 30 t
OMK plant (Russia)
QSP 70 for 1.6/2.0 Mtpy of Hot Rolled Coils with 1 strand caster

- **Slab thickness**: 70 mm
- **Slab min max width**: 800-1600 mm
- **Max slab length**: 38 m
- **Max slab weight**: 30 t

- **Strip min max thickness**: 1.0 - 20 mm
- **Strip min max width**: 800-1600 mm
- **Max coil sp. weight**: 20 kg/mm
- **Coil nominal ID-OD**: 762-2000 mm
- **Max coil weight**: 30 t
ETR for 2,2/2,6 Mtpy of Hot Rolled Coils with 1 strand caster

- **Slab thickness**: 80 mm
- **Slab min max width**: 800-1600 mm
- **Max slab length**: NA
- **Max slab weight**: 30 t

- **Strip min max thickness**: (0.8) 1.0 - 20 mm
- **Strip min max width**: 800-1600 mm
- **Max coil sp. weight**: 20 kg/mm
- **Coil nominal ID-OD**: 762-2000 mm
- **Max coil weight**: 30 t
• The fastest caster in the world: over 7 m/min in steady state operation

• The most productive minimill in the world: 1.8 Mtpy with one casting strand only and 1.3 m max coil width
Productivity
Quality
Modular process and layout solutions, market oriented
The **Danieli minimill** recent experiences concerning UHS (Ultra High Speed) casting and the full integration between casting and rolling process opens the possibility for:

- Installation of compact plants to serve local markets with competitive transformation costs
- Installation of large scale plants with global player strategy in direct competition with conventional casting and rolling plants.
- Target the ultimate production niches, such as automotive exposed applications.