20 years of CSP®

The success story of an outstanding technology

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SMS Siemag AG, Germany
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Situation of the steel industry in the mid-eighties

World steel production
1950 – 2009

- Worldwide stagnation of steel consumption, reduction of production capacities in Europe and America
- No investment in new hot flat rolling facilities
- Mini-mill concept using electric steel making already established for long products

1989
NUCOR: First industrial CSP® plant

Driven by Asia + China

Post-war boom → Stagnation → New boom
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Definition of 'minimill'

**Minimill**
Steelmaking – Casting – Rolling  
(inline concept)

- Compact design
- Small plant footprint
- Economics of local sourcing of scrap
- Local product supply
- Strong in regional markets

<table>
<thead>
<tr>
<th>Compact strip production</th>
<th>Long products plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 – 3.0 m. tpy</td>
<td>0.5 – 1.5 m. tpy</td>
</tr>
</tbody>
</table>

Near-net shape technology

0.2 – 0.6 m. tpy
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Introduction of CSP®: Market demands meet technology

- Tailor made and economical production plants
- Minimized investment and operation costs

Heart of the CSP® technology
Patented funnel-shaped mold
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The success story of Nucor Steel, USA

**Nucor**: minimill pioneers in long and flat products

- **1966**: Entering the steelmaking business
- **1969**: First minimill for long products (Darlington works)
- **1989**: First minimill for flat products (Crawfordsville works) by commissioning the world first thin slab CSP plant
- **Today**: Largest steelmaker and most profitable steelmaker in the United States (20.4 m. tons in 2008)

Source: http://www.nucor.com

A World First

Nucor ushers in a new era of steelmaking as thin-slab technology goes on-line at the new mini mill in Crawfordsville, Indiana. It is the first mini mill in the world to make quality flat rolled steel using the technology.
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**CSP® plant concept**

- **Thin slab thickness:** 50 - 90 mm
- **Strip thickness:** 0.8 - ca. 16 mm
- **Strip width:** 800 - 1,880 mm

- **1-strand:** up to 1.5 m. tpy
- **2-strand:** up to 3.0 m. tpy
- **3-strand:** up to 4.0 m. tpy
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Advantages of CSP®

- Reduced conversion costs
- Constant process conditions
- Excellent mechanical properties
- Excellent metallurgical properties
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Flexibility of CSP® process

Casting concepts
- Vertical bending caster
- Bow type caster

Connecting concepts of casting and rolling
- Tunnel furnace
- Coilbox
- Heat panels
- Inductive heating

Rolling mill concepts
- FM
- RM
- Steckel Mill
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Realized concepts

Compact CSP® plant

References: 26
Nucor, TKS, Jisco, SeverCorr, Tata, …

CSP® concept with 1 roughing stand

Reference: 1
Handan

CSP® concept with 2 roughing stands

Reference: 1
Saldanha
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References since 1989

1. Nucor Crawfordsville, USA
2. Nucor Hickman, USA
3. AST/TKAST ¹, Italy
4. Ternium Hylsa (Hylsa), Mexico
5. Hyundai (Hanbo), Korea
6. Gallatin, USA
7. SDI, USA
8. ISPAT Industries, India
9. AM Sestao (ACB), Spain
10. AM Riverdale (ACME), USA
11. Nucor Berkeley, USA
12. GJS (NSM), Thailand
13. Megasteel, Malaysia
14. Saldanha, South Africa
15. Zhujiang, China
16. Handan, China
17. Baotou, China
18. TKS, Germany
19. EZDK (ANSDK), Egypt
20. Corus ², Netherlands
21. MaSteel, China
22. LYSteel, China
23. JISCO, China
24. Bushan, India
25. SeverStal, USA
26. WISCO, China
27. Essar, India
28. Tata Steel, India

Remark:
1) Plant converted into Thick Slab Plant
2) Thin slab caster SMS, Rolling Mill MHI

28 Plants in total
26 Plants in operation
169 Mill stands
54 Mio TPY rated capacity

2 Plants still to start up
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Changing market and adjusted customer demands on CSP® since 1989

- Minimized overall investment cost and appropriate capacity
- Most economic process for hot strip production
- Increase of production with 2nd strand
- Thin-gauge rolling
- Ferritic rolling
- Production of advanced steel grades
- Maximized utilization of rolling plants of a steel corporation
- 3rd strand
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Customer demands on CSP® since 1989

CSP® plant Nucor Crawfordsville 1989

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Casters</td>
<td>1</td>
</tr>
<tr>
<td>Finishing stands</td>
<td>4</td>
</tr>
<tr>
<td>Downcoilers</td>
<td>1</td>
</tr>
<tr>
<td>Strip thickness</td>
<td>2.5 - 12.7 mm</td>
</tr>
<tr>
<td>Production</td>
<td>990,000 tn sh/year</td>
</tr>
</tbody>
</table>
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Severstal North America – Minimill close to customer market

- Steelmaking plant 2.7 m. tpy
- Thin slab plant 2.7 m. tpy
- Tandem cold mill 1.8 m. tpy
- Galvanizing line 0.8 m. tpy

- Greenfield-supply from a single source
- Complete electrics and automation system
- Two phases
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Severstal North America – Ramp-up curve

- Minimills today: Proven concepts and technology by complete mechatronical solutions and overall project responsibility
- Quick entry into the market and cash flow generation
- Reliability for minimill operators
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Thin-gauge rolling: Substitution of cold rolled strip with thin hot strip

**Batch rolling**

- Utilization of capability of CSP® mill by using new automation system
  - Hylsa: min. thickness 0.91 mm (1996)
  - ANSDK: 1.0 mm six months after start-up (2000)

**Semi-endless rolling:**

- Extension of mill area by flying shear and modification of downcoiler
  - Masteel: min. thickness: 0.9 mm (2004)
  - Lysteel: min. thickness 0.78 mm (2004)
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Production of advanced steel grades

Development towards sophisticated applications

- mechanical properties
- surface sensitive requirements
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Production of advanced steel grades (Si-grades, Dual- and Multiphase steel)

➔ Use of all process advantages of CSP®
➔ Maximization of production of rolling plants of a steel corporation (combination of conventional HSM and CSP®)

References: ArcelorMittal, ThyssenKrupp Steel, Wisco, Tata Steel

Product mix TKS CSP® plant, 2005/2006

Source: TKS
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Example: Wisco, China (Start-up 2009 / 2.5 m. tpa)

Technical main data

<table>
<thead>
<tr>
<th></th>
<th>Heat size / TTT time</th>
<th>Slab thickness</th>
<th>Slab width</th>
<th>Containment length</th>
<th>RHF length</th>
<th>Final thickness</th>
<th>Rolling speed</th>
<th>Main drive power mill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150 tons / 36 min BOF</td>
<td>52 – 90 mm</td>
<td>900 – 1,600 mm</td>
<td>10.3 m</td>
<td>261 m</td>
<td>0.8 – 12.7 mm</td>
<td>23 m/s</td>
<td>64.2 MW</td>
</tr>
</tbody>
</table>
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Example: Wisco, China – Product mix (scheduled)

<table>
<thead>
<tr>
<th>No.</th>
<th>Group</th>
<th>Grade</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Silicon grades</td>
<td>50W310 – 50W1300</td>
<td>37%</td>
</tr>
<tr>
<td>2</td>
<td>High quality carbon steel</td>
<td>08, 08 Al, 10 – 45</td>
<td>23%</td>
</tr>
<tr>
<td>3</td>
<td>Carbon &amp; structural</td>
<td>Q195, Q215, Q235</td>
<td>14%</td>
</tr>
<tr>
<td>4</td>
<td>Container steel</td>
<td>SPAH, 09 Cu P Ti Re</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td>Automotive body</td>
<td>DP, Trip</td>
<td>5%</td>
</tr>
<tr>
<td>6</td>
<td>HSLA</td>
<td>Q345 – Q460</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>Pipe steel</td>
<td>API X42 – API X70</td>
<td>2%</td>
</tr>
<tr>
<td>8</td>
<td>Low &amp; ultra low carbon</td>
<td>LC, ELC, ULC</td>
<td>2%</td>
</tr>
</tbody>
</table>
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Example: Wisco, China – Final strip thickness 0.80 mm (08. September 2009)
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Customer demands on CSP® since 1989

3-strand CSP® plant

- First 3-strand CSP® plant: Essar Steel, India
- Capacity: up to approx. 3.5 million tpy
- Commissioning: 2nd quarter 2011 (strand 1 and 2), end 2011 (strand 3)
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Alternative concepts – CSP® line connected with parallel thick slab line

- Extension of thin/medium slab line with second strand for thick slabs
- Flexible use of thick and thin/medium slabs
- Extension of product spectrum (e.g. heavy gauge pipe grades, stainless steel)
- Reference: G Steel, Thailand
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Alternative concepts – CSP® endless

Characteristics
- Slab thickness: 80 – 100 mm
- Casting speed: up to 6 m/min
- Inline stand for a high reduction to reduce the load in the finishing mill

Benefits
- Reliable production of thin and ultra-thin strip
- Homogeneity of metallurgical and mechanical properties
- Batch operation mode possible
- Compact layout with economic equipment
- Low investment and operation costs
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Summary

- 1989: First CSP® plant built at NUCOR, showing the expected advantages
- During the last 20 years, CSP concept in its basic configuration met changing demands of the market
- CSP has the right answers for the future of the steel industry
  - High economic efficiency
  - Saving of resources
  - High flexibility with respect to product spectrum
  - Possibility for a quick reaction to the market

Outlook

- Further optimization of CSP® technology
  - Improvement of strip surface
  - Increasing of productivity (higher casting speed, 3-strand solutions)
  - Extension of product spectrum
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Outlook: New casting technology for production of highly-alloyed steel grades

- Strip thickness: 8 - 20 mm
- Width: 900 - 1,600 mm
- Casting speed: 10 - 30 m/min

Technical benefits
- Fast solidification
- No mould powder required
- No bending and straightening of cast strip
- Suitable ratio of thickness reduction by rolling

Economical benefits
- Compact plant layout, low investment costs
- High flexibility in production rate and amount
- Easy to integrate in the different steel making routes
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Outlook: A new micro-mill concept?

- Near net-shape casting technology: 10%
- Thin slab casting and rolling plant: 30%
- Conventional casting and hot rolling mill: 60%

...2050