The Secrets and Solutions of Vertical and Horizontal Casting technologies

Dr.-Ing. Jens Kempken
Executive Vice President

SMS Group AG, Germany
Agenda:
- Introduction in Vertical Casting Technology for flat and long products
- Challenges and technical solutions
- References
- Horizontal Belt Casting Technology
- Conclusion
Introduction in Vertical Casting Technology for flat and long products

Why vertical casting?

- Crack sensitive Steel grades doesn’t allow any stress in the solidified shell (bending, unbending)
- Thick Casting thickness (>= 400 mm) require a casting radius of more than 14m
- Replacement of ingot casting

Benefits:

- Symmetrical solidification
- Improved cleanliness by flotation of non-metallic inclusions
- No inclusion band)
- No entrapment of Argon bubbles in the solidifying shell
- Improved surface quality, minimized crack formation due to stress limitation while bending and unbending, temperature control
- Maximised Casting thickness of more than 400 mm (slab, blooms)
- For CSP: ease of operation, highest utilisation, restanding with hydraulic dummy bar
Where is vertical casting applied today?

**flat sector:**
- CSP – thin slab casting up to 100 mm thickness
  (productivity per strand 1,5 mio. t, metallurgical length 14m)
- Thick slab up to 550 mm thickness, maximum slab weight 120 t

**long sector:**
- big blooms
- stainless steel billets
### Vertical Casting Solutions for the flat steel sector

<table>
<thead>
<tr>
<th>Type</th>
<th>Year</th>
<th>Customer</th>
<th>Country</th>
<th>Strands</th>
<th>Dimension (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLB</td>
<td>2014</td>
<td>Siderar</td>
<td>Argentina</td>
<td>1 x 2</td>
<td>250 x 1,900</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>Fuxin</td>
<td>China</td>
<td>1 x 1</td>
<td>220 x 1,600</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>MMK</td>
<td>Russia</td>
<td>1 x 1</td>
<td>300 x 2,700</td>
</tr>
<tr>
<td>VB/VSB</td>
<td>2015</td>
<td>Dillinger Hüttenwerke</td>
<td>Germany</td>
<td>1 x 2</td>
<td>500 x 2,200</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>Wuhan Iron and Steel</td>
<td>China</td>
<td>2 x 1</td>
<td>50 x 1,600</td>
</tr>
<tr>
<td></td>
<td>1996</td>
<td>Nippon Steel Co.</td>
<td>Japan</td>
<td>1 x 1</td>
<td>400 x 2,360</td>
</tr>
</tbody>
</table>

Transformation and Revamp of Casters from bow type casting,
implementation of vertical section (mould and 1st segment (2 – 2.5m)
due to quality reasons (pencil pipe defect with IF-ULC grades)
Challenge in Vertical Casting Technology for flat and long

Special solutions for unique requirements:

Although main operation activities like steel supply via ladle in turret, tundish and SEN are already commonly established, unique solutions needs to be developed for Vertical Casting Technology:

- Control of weight of strand, decelleration torque of pinch rolls
- Torch cutting (synchronisation of speed)
- Controlled movement/fixing of released slab/bloom
- Transport of slab/bloom out of the basement
- Temperature control in basement while slab/bloom surface radiates energy
Product Focus

Tailor made heavy plate products (examples) which requires product thicknesses of 150 mm and more (min deformation ratio)

- Heavy plate for shipbuilding
- LNG tankers – low temperature steel for extreme demands on strength
- Application in the construction of offshore platforms, high-rise buildings, bridges or construction machinery
Technical concepts of vertical caster design at Dillingen

DILLINGER
HÜTTE focusses on vertical casting solutions for their superior product portfolio.

They adopt two design concepts:
- vertical solid bending
- straight vertical
1 x 2-strand, purely vertical type caster for heavy plate products

Main technical data

- **Slab width**: 2,200 mm
- **Slab thickness**: 300-**500 (600)** mm
- **Metallurgical length**: 17.4 m
- **Production capacity**: 1,200,000 t/year
- **Max. casting speed**: 0.6 m/min

<table>
<thead>
<tr>
<th>Slab Thickness (mm)</th>
<th>Max. Casting Speed (m/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>0.60</td>
</tr>
<tr>
<td>400</td>
<td>0.34</td>
</tr>
<tr>
<td>500</td>
<td>0.22</td>
</tr>
</tbody>
</table>
# Technical data and technical features

## Main technical data
- **No. of strands**: 1 x 2
- **Machine type**: vertical (pure)
- **Ladle capacity**: 185 t
- **Tundish capacity**: 50 t
- **Slab thickness**: 300 – 500 (600)* mm
- **Slab width**: 2,200 mm
- **Slab length**: 6.7 – 11 m
- **Height of casting floor**: +15 m
- **Height of foundation**: - 39 m
- **Machine length**: 17.4 m
- **Max. $v_c$**: 0.60 m/min (300 mm)
  - 0.22 m/min (500 mm)
- **Production**: 1,200,000 tpy

## Technological highlights
- Resonance mold oscillation
- Mold 700 mm
- Segment 1 mech. clamped
- Segment 2-9 hydr. position controlled
- Secondary cooling: Water, edge control system
- Dynamic soft reduction

*) Design made for
<table>
<thead>
<tr>
<th>Machine Equipment</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Unit</td>
<td>3 driven roller pairs, Ø 900 mm, hydraulically adjustable</td>
</tr>
<tr>
<td>Dummy bar system</td>
<td>bottom feeding, dummy bar car below drive unit</td>
</tr>
<tr>
<td>Hot Strand Drive Unit</td>
<td>2 driven roller pairs, Ø 600 mm, hydraulically adjustable</td>
</tr>
<tr>
<td>Torch cutting machine</td>
<td>horizontal cutting machine with clamping unit arranged on a car</td>
</tr>
<tr>
<td>Slab turning unit</td>
<td>independent turnable basket and lifting unit</td>
</tr>
</tbody>
</table>

© Photo by Dillinger
### Highlights

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavation works</td>
<td>220,000m³</td>
</tr>
<tr>
<td>Depth of pit</td>
<td>-46m</td>
</tr>
<tr>
<td>Concrete for foundations</td>
<td>33,000m³</td>
</tr>
</tbody>
</table>
## Driving unit

### Highlights

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>580 t</td>
</tr>
<tr>
<td>Roller</td>
<td>6, all driven</td>
</tr>
<tr>
<td>Roller dia</td>
<td>900 mm</td>
</tr>
<tr>
<td>Adjusting cylinder</td>
<td>12</td>
</tr>
<tr>
<td>Secondary cooling</td>
<td>without</td>
</tr>
</tbody>
</table>

Reference: Dillinger Hüttenwerke – CC No. 6
### Hot strand driving unit

#### Highlights

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>280 t</td>
</tr>
<tr>
<td>Moveable</td>
<td>Interchangeable with dummy bar car unit</td>
</tr>
<tr>
<td>Roller</td>
<td>4, all driven</td>
</tr>
<tr>
<td>Roller dia</td>
<td>600 mm</td>
</tr>
<tr>
<td>Adjusting cylinder</td>
<td>8</td>
</tr>
<tr>
<td>Secondary cooling</td>
<td>Without</td>
</tr>
</tbody>
</table>

Reference: Dillinger Hüttenwerke – CC No. 6
**Dummy bar car unit**

<table>
<thead>
<tr>
<th>Highlights</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>150 t</td>
</tr>
<tr>
<td>Moveable</td>
<td>In changing use with hot strand drive unit</td>
</tr>
<tr>
<td>Roller</td>
<td>4, all driven</td>
</tr>
<tr>
<td>Roller dia</td>
<td>500 mm</td>
</tr>
<tr>
<td>Adjusting cylinder</td>
<td>4</td>
</tr>
<tr>
<td>Secondary cooling</td>
<td>without</td>
</tr>
</tbody>
</table>

Reference: Dillinger Hüttenwerke – CC No. 6
Steel structure

<table>
<thead>
<tr>
<th>Highlights</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological steel structure (machine scaffold – machined with exact tolerances)</td>
<td>2,700 t</td>
</tr>
<tr>
<td>Building steel structure (Casting platform, platform structure, walking)</td>
<td>2,500 t</td>
</tr>
</tbody>
</table>

Middle section

Technological steel structure

Building steel structure
Vertical Caster to substitute ingot casting
Steel grades for automotive & aerospace applications

3(4) Strands, heat weight of 165t
460x610mm, \( v_{\text{cmax}} = 0.40\text{m/min} = 858\text{kg/min} \)
280x430mm, \( v_{\text{cmax}} = 0.85\text{m/min} = 782\text{kg/min} \)

280x430
944kg/m

460x610
2201kg/m
Continuous Vertical Casting Machine, Construction Sites

- Ground level: -24m
- Building height 54m
Metallurgical results – superior quality – 110% customer satisfaction

Figure 19: As cast (460x610) metal cast in 1026 steel grade. The vertical line on the metal was made during sample production.

Figure 22: Rolled (Ø14") sample - 1026 grade.
Conclusion on Vertical Casting Technology:

- Vertical Casting Technology is established for special application of products in the flat and long sector
- Especially products for biggest dimensions (geometry, thickness, weight) and requirements for highest metallurgical cleanliness are vertically casted, ingot casting is substituted
- Equipped with state of the art technological packages (Hydraulic mould oscillator, dynamic soft reduction, EMS, etc), the casters guarantee highest quality levels
- As the construction cost (especially for civil and building due to vertical dimensions) is magnificently higher compared to curved/bow type design, only specialized and focused nice players are adopting this technology.
New micro-mill concepts with Belt Casting Technology (BCT®)

Jens Kempken
Jochen Wans, Christian Geerkens, Dirk Austermann, Hermann Cremers
Driver: Making the material steel more competitive / Customers needs

“With our process, we absolutely break new ground. As a consequence, with our HSD® steel we can offer something new to our customers that they cannot get anywhere else in that kind.”

Prof. Dr.-Ing. Heinz Jörg Fuhrmann, CEO of Salzgitter AG

New steel grades to explore new markets: casting technology is at the ready
Features of Belt casting technology

- **Stress-free strip solidification in horizontal direction**
  No bending and straightening

- **Casting without powder**
  Utilization of steels with high aluminum/silicon content possible, no reaction with mould powder

- **Traveling mold, no oscillation**
  Plane strip surface without oscillation marks

- **Inert atmosphere and exclusively indirectly cooling**
  No scale formation during casting process

- **Rapid solidification**
  Excellent inner microstructure, no segregation

- **Sufficient degree of deformation at a strip gauge of 14-20mm**
  Production of high-quality hot strip
Layout of belt casting plant at Peiner Träger, Salzgitter AG

- **Strip:** 15 mm x 1000 mm
- **Casting speed:** 10-30 m/min
- **Plate:** length: 9 m
- **Output:** up to 70 plates per cast

One step ahead
Benefit of BCT®

- Tailor-made and compact plant design, to be implemented in all common process routes
- Modern casting process as part of a trendsetting plant concept for thin strip
- Wide product mix for new high-performance and conventional critical steel grades
- Technology for steel concepts of the future
- No breakouts
- Reduced maintenance compared to conventional continuous casters (e.g. mold and segment shop)
- No water consumption (closed circuit)
Milestones of commissioning the Belt casting plant

2012

- **Erection** by SMS group;
  Acceptance after cold commissioning
- **1st cast 12/2012** (carbon steel);
  Hot commissioning and test operation in cooperation of SMS and SZFG

2013 / 14 / 15

- Since then **continuous improvement** of equipment and process performance
- **1st FeMn-cast** 10/2013 (trial alloy composition)
- **1st HSD®-cast** 02/2014

2016

- HSD®-cast to be on the increase
- Regular Production and processing of HSD
- Development of **inline-concepts**

**Successful corporation**
Pilot plant in casting operation – Weekly Production Campaigns

Successful corporation
Summary and outlook Belt Casting Technology

- Capability and reliability of BCT process assured within more than 140 casts
- Start of hot and cold strip processing
- Optimization for process and product running
- Active market response for BCT process and new steel grades
- Concept for first inline plant

SMS is looking for a partner to realize the first industrial BCT inline production plant