Continuous casters for every purpose – made by SMS group

- 8 Horizontal slab casters
- 1 BCT® caster
- 29 CSP® / 1 CEM casters
  51 strands
- 74 Stainless slab casters
  89 strands

1962 – 2017

516 casters for flat products

- 326 Curved slab casters
  507 strands
- 8 Vertical slab casters
  14 strands
- 302 Thick/ultra-thick slab casters / 488 strands

770 strands

989 casters ◆ 2616 strands

1958 – 2017

- 42 Bloom casters
- 32 Beam blank casters
- 399 Billet casters

473 casters for long products

- 274 1-4 strand machines
- 178 5-6 strand machines
- 21 >6 strand machines

1846 strands
OVERSIZED BLOOMS EXPERIENCE AND MARKET POTENTIAL IN ASIA

SEAISI 2017
## SMS Concast Technological Milestones

Providing the market with inventions since 1956  
A brief view on inventions and achieved records

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Commissioning of the world largest round caster on continuous industrial operation at Taewoong – South Korea 1,000 mm round</td>
</tr>
<tr>
<td>2014</td>
<td>Commissioning of the world largest vertical caster a Timken – USA: 610 x 460 mm</td>
</tr>
<tr>
<td>2012</td>
<td>Order for world largest round bloom cast on CCM in Korea: ø 1,000 mm</td>
</tr>
<tr>
<td>2008</td>
<td>World largest bloom CCM 8 strands 400 x 500 mm at Posco Pohang – South Korea</td>
</tr>
<tr>
<td>2008</td>
<td>World widest beam blank section 1,150 mm at Peiner - Germany and first DMSR plant for blooms at JYXC - China</td>
</tr>
<tr>
<td>1995</td>
<td>High speed casting for billets (CONVEX technology®)</td>
</tr>
<tr>
<td>1966</td>
<td>1\textsuperscript{st} beam-blank caster at Algoma, Canada</td>
</tr>
<tr>
<td>1963</td>
<td>1\textsuperscript{st} curved mould CCM (at von Moos, Switzerland)</td>
</tr>
<tr>
<td>1956</td>
<td>1\textsuperscript{st} straight mould CCM</td>
</tr>
</tbody>
</table>
CCM DESIGN TRENDS
<table>
<thead>
<tr>
<th>Customer</th>
<th>Country</th>
<th>Scope</th>
<th>Main Data</th>
<th>Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP Youlchon</td>
<td>South Korea</td>
<td>New CCM</td>
<td>600x450, 390x250, 192x250, Ø800, Ø600 R16.5m, 2 Strand</td>
<td>2012</td>
</tr>
<tr>
<td>Henan Jiyuan</td>
<td>China</td>
<td>New CCM</td>
<td>500x400, 370x300, Ø600 R16.5m, 3 Strand</td>
<td>2012</td>
</tr>
<tr>
<td>Timken</td>
<td>USA</td>
<td>New CCM</td>
<td>250x380, 460x610</td>
<td>2014</td>
</tr>
<tr>
<td>TISCO (*)</td>
<td>PRC</td>
<td>New CCM</td>
<td>Ø390, Ø550, Ø690, Ø800 R16.5m, 3 Strand</td>
<td>2015</td>
</tr>
<tr>
<td>Taewoong</td>
<td>South Korea</td>
<td>New CCM</td>
<td>310 rd. 410 rd. 600 rd. 700 rd. 800 rd. 1000 rd. 18.0 m, 3 Strand</td>
<td>2016</td>
</tr>
<tr>
<td>Asil Celik Sanayi ve Ticaret AS</td>
<td>Turkey</td>
<td>New CCM</td>
<td>310 rd. 406 rd. 500 rd. 600 rd. R14.0 m, 5 Strand</td>
<td>2016</td>
</tr>
</tbody>
</table>
IS IT A TREND?

6 ‘monster’ casters in 5 years it’s a trend
Taewong, South Korea:
The biggest round bloom caster in the world: 1000mm diameter!
## CCM MAIN FEATURES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of strands</td>
<td>3</td>
</tr>
<tr>
<td>Design Limit</td>
<td>Strand 1, 3:Ø 300 – 1000 mm; Strand 2: Ø 300 – 600 mm</td>
</tr>
<tr>
<td>Sections Sizes Supplied</td>
<td>Ø310, Ø410, Ø600, Ø800, Ø1000 mm</td>
</tr>
<tr>
<td></td>
<td>The CCM can cast different section sizes simultaneously</td>
</tr>
<tr>
<td>Casting speed</td>
<td>0.1 m/min to 1.2 m/min</td>
</tr>
<tr>
<td>Length from meniscus to TCM</td>
<td>Approximately 47 m</td>
</tr>
<tr>
<td>Ladle support</td>
<td>Butterfly ladle turret with lifting/lowering and weighing facilities</td>
</tr>
<tr>
<td>Tundish transport</td>
<td>Overhead tundish car with lifting/lowering and weighing facilities</td>
</tr>
<tr>
<td>Flow control</td>
<td>Electromechanical stopper mechanism with actuation feedback</td>
</tr>
<tr>
<td>Mould level control</td>
<td>Eddy current system for large blooms, Co60 radiometric system for small blooms</td>
</tr>
<tr>
<td>Electromagnetic stirrers</td>
<td>M-EMS + F-EMS</td>
</tr>
<tr>
<td>Mould oscillation</td>
<td>Hydraulic tandem resonance oscillation, frequency and stroke remote adjustable</td>
</tr>
</tbody>
</table>
# CCM MAIN FEATURES

<table>
<thead>
<tr>
<th>ITEM</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary cooling</td>
<td>Air-Mist cooling for very low cooling intensities</td>
</tr>
<tr>
<td>Surface heating system</td>
<td>Flameless surface heater</td>
</tr>
<tr>
<td>Withdrawal straightening (WSU)</td>
<td>6 double WSU modules for Dynamic Mechanical Soft Reduction</td>
</tr>
<tr>
<td>Dummy bar system</td>
<td>Chain dummy bar for top feeding</td>
</tr>
<tr>
<td>Bloom cutting</td>
<td>Automatic torch cutting machines</td>
</tr>
<tr>
<td>Tertiary cooling</td>
<td>Slow cooling pits</td>
</tr>
<tr>
<td>Automation</td>
<td>Level 1, Level 2</td>
</tr>
</tbody>
</table>
...FROM 3D VIEWS
...FROM 3D VIEWS
...TO REALITY
MOULD AND OSCILLATION FOR LARGE ROUNDS

Convex® Mould Tube:
“Leaf” shape meniscus area for compensating shrinkage and improving heat transfer
Slotted external design for improved heat transfer and mould life

Superior Features
Effective guiding with improved shell to mould contact
Uniform heat transfer around perimeter
Improved quality
Improved process stability
Among the strands the design of the tandem hydraulic oscillator is identical.
For the larger sections a controlled increase of the surface temperature before straightening to avoid surface and sub-surface defects.
Heating devices are positioned on the upper part of the bloom before the first straightening module and between the first modules.

The heaters are composed of ceramic flameless gas burners, installed on top of the insulation and equalization tunnels.
Steel that is “heat treated“ with a flameless heater develops a fine grained acicular ferrite that resists crack propagation.

The coarse grained as-cast microstructure of a micro alloyed steel grade is modified by the surface heater like in a heat treatment.

Microstructure w/o bloom heater:
- Ferrite + Perlite

Formation of acicular ferrite that resists crack propagation
The unbending strain is defined by the steel grade whose composition defines the “low ductility range” and some typical values are shown below:

<table>
<thead>
<tr>
<th>Steel Grades</th>
<th>TSur,crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low alloy grades, Bearing Steel</td>
<td>&lt; ~800°C</td>
</tr>
<tr>
<td>Micro-alloy grades with V, B, Nb, high N</td>
<td>850 – 950°C</td>
</tr>
<tr>
<td>High S, Cr+Ni+Mo &gt; 1.5%</td>
<td>950°C</td>
</tr>
</tbody>
</table>

The unfavorable oversized bloom caster conditions, the wide range of steel grades including stainless steels, require special attention to assure crack-free unbending especially on the larger blooms cast at very low speed.
To keep the surface strain under control a very big caster radius has been chosen.

The total strain is distributed over the continuous straightening zone to smoothen the straightening process since the strand surface temperature drops well into the low ductility range.

\[ R = 18 \text{ m} \]
STRAIGHTENING UNITS

The straightening and unbending unit consists of 6 double modules, each with 2 pairs of rolls.

Independently from the oversize blooms, the design of the modules is strong enough to perform mechanical soft-reduction.
D800 – 304L

Vc=0.19 m/min
SH=44K
S-EMS = 400A, 4Hz, ASM10-10s
No MSR

Vc=0.19 m/min
SH=44K
S-EMS = 400A, 4Hz, ASM10-10s
MSR (total 49 mm reduction)
A top feeding dummy bar solution has been chosen to reduce non-productive time.

![Graph showing restranding time comparison between top and bottom feeding for different sections.](image-url)
TERTIARY COOLING

Controlled Tertiary Cooling aims at:
- Eliminating tensile cracks due to fast cooling on large blooms
- Decreasing the risk of hydrogen flake formation
- Avoiding the formation of martensite

<table>
<thead>
<tr>
<th>Δ°C/h</th>
<th>1 h</th>
<th>5h</th>
<th>12h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td><img src="image" alt="12°C/h 1h" /></td>
<td><img src="image" alt="12°C/h 5h" /></td>
<td><img src="image" alt="12°C/h 12h" /></td>
<td><img src="image" alt="12°C/h 24h" /></td>
</tr>
<tr>
<td>24</td>
<td><img src="image" alt="24°C/h 1h" /></td>
<td><img src="image" alt="24°C/h 5h" /></td>
<td><img src="image" alt="24°C/h 12h" /></td>
<td><img src="image" alt="24°C/h 24h" /></td>
</tr>
</tbody>
</table>

Low cooling rate reduces the circumferential tensile stress.
Ø800mm, grade 316L macro and surface quality
BLOOM QUALITY ON THE ‘MONSTER BLOOM’

As-cast blooms are cracks free and show a large equiaxed zone together with minimal center porosity or piping.

Ø1,000 mm, grade 1016 macro sample and detail

Ø1,000 mm, grade 4140 macro sample and detail at center
THE VERSCON CONCEPT

Ingot producers face increasing requests to deliver ingots with CCM quality, but cannot afford low flexibility of CCMs with high opex at 1-heat sequences hence the VERSCON is the solution

The semi-continuous casting process has a capacity that ranges from 50,000 to 180,000 tpy
COMPARISON VSCCM Vs. Ingot Route

SURFACE QUALITY
VSCCM superior to Ingot Route:
- Reduced scarfing,
- Reduced conditioning prior to rolling
- Reduced material losses

INTERNAL QUALITY
VSCCM superior to Ingot Route
- Homogeneous along the bloom length

YIELD
VSCCM superior to Ingot Route
- Increased yield due to increased bloom length
POSSIBLE VSCCM CONFIGURATION

Strands 5 Ø800-1200

Strands 1 - 4 Ø410-700
Simulation of VERSCON process

Casting started

Casting finished

Solidification ongoing

Solidification finished

9 min, 31 s

82 min

2h, 38 min

3h, 37 min, 57 s

Solidification Simulation for VERSCON process: Ø 850mm, 0.15m/min casting speed
Tail crop is the main influencing factor for the yield of a VSCCM. To minimize tail crop state-of-the-art technologies of ingot casting and continuous casting are combined with novel approaches.
INFLUENCING THE FINAL SOLIDIFICATION
ASEAN OUTLOOK
OVERALL INGOT CASTING OUTLOOK

14% of existing ingot production are expected to be attractive for replacement by oversized bloom CCM with an upside due to special steel demand growth – The outlook in Asia appears also attractive.

Recent analysis show that 2.3 million tpy of ingots are cast in the ASEAN.

There is an effective market potential for replacing the low yield ingots plants with more efficient casting machines being CCM or VSCCM.

**SOURCE:** WSA, SMS Concast analysis
CONCLUSION

We experienced a movement away from the near-net-shape idea towards casting of large blooms in order to cope with higher reduction ratios during hot deformation (up to 1,000 mm diameter)

The higher yield and the more homogeneous product that the continuous casting can deliver compared to the traditional ingot casting are found to be the reasons behind this development
CONCLUSION

These cast sections require a high standard of know how and training, reliable equipment and a the highest degree of automation.

With great effort and advanced technology (know how & know why) a zero-defect quality like the bloom caster installed at Taewoong can be assured achieving:

improved quality
higher yield
more economic process
more homogeneous product
Contact

The information provided in this presentation contains a general description of the performance characteristics of the products concerned. The actual products may not always have these characteristics as described and, in particular, these may change as a result of further developments of the products. The provision of this information is not intended to have and will not have legal effect.