Big River Steel’s flat steel complex on its way to become a learning steel mill

Big River Steel has built the world’s first Flex Mill™. Started up in late 2016, the facilities incorporate the full production chain including steelmaking and refining, advanced CSP® thin slab production, hot rolling and also downstream operations with cold rolling, annealing and strip galvanizing plants. This article highlights the cutting edge of technology in the different areas and the company’s general approach of taking steel production to the next level.

The new US$ 1.3 billion steel mill in Arkansas at the east banks of the Mississippi River has been in the news for some time now. Also MPT International reported about the project and its progress [1, 2]. This year the company started with an incredibly fast ramp-up. MPT International was invited by SMS group to visit the new flat steel complex at the end of the summer with the opportunity to have an interview with Mark Bula, chief commercial officer at Big River Steel. In the following, the main technical facts of the production facilities are summarized with special emphasis on pioneering details.

**General facts**

The whole flat steel complex has been designed as the world’s first Flex Mill™ in terms of a wide range of steel products. The production facilities have been configured with the ambition to combine the best technologies of integrated mills and EAF based mini-mills in terms of product quality, energy efficiency and flexibility. In more detail the requirements specification included parameters as following:

- EAF meltshop and CSP® thin slab plant,
- widest and thickest materials ever produced by EAF/CSP®,
- widest and lightest materials ever produced by EAF/CSP®,
- liquid steel refining to achieve low carbon and nitrogen levels,
- ability to produce more demanding steel grades previously only available via integrated mills.

**Melt shop and secondary metallurgy**

Big River Steel is the only steel mill in North America that combines an EAF meltshop with an RH vacuum treatment plant. The melt shop contains a DC EAF with a capacity of 150 t (165 short tons). It has a maximum power rating of 160 kA and 1100 V, equal to 176 MW of electricity. The EAF has a top feed conveyor system which provides the ability to direct charge up to 100% scrap substitute material (HBI, DRI etc.). This allows to
produce grades that have higher internal steel cleanliness demands and also is key for achieving very low residual levels. The EAF is operated with a tap-to-tap time of less than 38 minutes.

The vacuum treatment of the heat is a process of utmost importance for the production of demanding steel grades with good cleanliness, low gas contents and close alloying tolerances. Big River Steel is the only North American mill to connect an EAF meltshop with an RH type vacuum circulation plant, where others usually operate ladle degassing processes that are easier to perform.

The RH vacuum treatment plant uses snorkels along with an argon lift to recirculate the molten metal. This creates a more homogenous heat as the metal turns over every 1.1 minutes. The forced decarburization system produces world-class low residual levels of carbon, nitrogen and hydrogen. This enables Big River Steel to produce product categories only previously produced by integrated mills.

A ladle treatment station (LTS) can further achieve final chemistries as the last stage for those grades demanding even tighter chemistries before going to the caster.

**CSP® plant**

Big River Steel operates one of the widest thin slab plants. It combines high productivity in terms of product dimensions and tonnage with high energy efficiency of the thin slab technology. The state-of-the-art casting and rolling equipment enables for the production of demanding steel products.

The thin slab production route using a CSP® plant plays a vital role in the abilities of the Flex Mill™. Slab thicknesses ranging from 55 mm to 85 mm allow the plant to shift between heavy and light gauges and meet the reduction ratios required to produce the most demanding steel grades.

Two mold types are used: the narrow mold for slab widths 900 mm – 1,600 mm (35.5” – 63") requirements and the wide mold for slab widths 1,230 mm – 1,930 mm (48.5” – 76"). The wide mold is a benchmark for the widest thin slabs produced to date on a CSP® plant. The caster runs a speed upwards of 5 meters per minute (200” per minute). It is equipped with liquid core reduction, break-out detection, ram drives, electromagnetic brake, strand alignment etc.

The CSP® plant includes a very long and most powerful tunnel furnace featuring 19 control zones which allow for more uniform slab temperatures, thus improving final product mechanical properties. This also allows to realize energy savings due to a more efficient reheating process. Later phases will include the introduction of induction heating to further enhance the thermal and metallurgical control.

The CSP® rolling mill features a 6-stand, 4-high finishing train with the newest continuous variable crown technology available providing shape, gauge and profile control (CVC® plus). The rolling mill is equipped with an advanced surface inspection system and an extensive laminar cooling control system, that allows Big River Steel to target specific cooling rates to achieve more accurate, consistent and repeatable mechanical properties throughout the strip. This is important to meet increasingly stringent customer requirements, especially critical in higher-strength applications.

**Strip processing facilities**

Downstream processing capabilities add value to the hot rolled strip and...
widen the range of product offerings. Big River Steel’s strip finishing operations comprise

- a continuous pickle line tandem cold rolling mill,
- a continuous galvanizing line,
- a batch annealing plant and
- an off-line skin pass mill.

The continuous pickle line tandem cold mill produces cold rolled steels ranging in thickness down to 0.3 mm. A five-stand tandem cold mill with continuous variable crown (CVC® plus) control on every mill stand provides for best-in-class gauge and shape control. It is equipped with an in-line inspection station to verify process standards that are yielding the demanding quality requirements necessary.

The continuous galvanizing line includes the ability for dual process, allowing for easy conversion from hot dip galvanizing to continuous annealing. The furnace section is equipped with an ultra-rapid cooling section, achieving best-in-class cooling rates of 82 K/second – 94 K/second, vital to producing multi-phase and other advanced high-strength steels. The in-line roll coater affords the capability to apply multiple post treatments that will enhance the corrosion performance and formability of the galvanized product while complying with Restriction of Hazardous Substances (RoHS) standards. Ultra high-quality, closed loop air knife wiping systems at the coating pot area allow operators to achieve coating weights from G30 – G235. The galvanizing line also accommodates a wider range of thicknesses and width offerings for both cold rolled and hot rolled products.

Big River’s batch anneal plant consists of 24 hi-flo hydrogen stations, each able to handle a maximum coil weight of 38 t (42 st) and a total stack weight of

<table>
<thead>
<tr>
<th>Area foot print</th>
<th>5.25 km² (1,300 acres)</th>
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</thead>
<tbody>
<tr>
<td>Production capacity per year</td>
<td>1.45 million t (1.6 million short tons)</td>
</tr>
<tr>
<td>Planned capacity expansion (phases 2 &amp; 3)</td>
<td>3.65 million t/year (4 million short tons)</td>
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</tbody>
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**General data of Big River Steel**

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot rolled, black</td>
<td>1.4 mm – 25.4 mm</td>
</tr>
<tr>
<td>Hot rolled, pickled and oiled</td>
<td>1.4 mm – 4.0 mm</td>
</tr>
<tr>
<td>Cold rolled (ML/NGOSP)</td>
<td>0.3 mm – 3.2 mm</td>
</tr>
<tr>
<td>Galvanized</td>
<td>0.3 mm – 3.2 mm</td>
</tr>
</tbody>
</table>

**Product dimensions**
129 t (142 st). These stations also process hot rolled pickled (HRP) material. The next set of annealers will allow for higher temperature annealing needed for higher-end electrical steels.

The off-line, 4-high skin pass mill has powerful 18,000 kN of roll force as well as entry and exit bridle rolls with the ability to achieve elongations of up to 10%, required for many niche products including electrical steels.

**Digitization takes plant and order management to a new level**

Electrics and automation supplies for all plants – Level 1, Level 2, Level 3 – were provided from one source: SMS group, who also supplied the mechanical plant equipment. Big River decided to have only one single provider for all the plant equipment and the electric and automation systems to overcome the problems of configuring interfaces and lack of performance when systems from different providers do not communicate properly. The homogeneous automation system is the basis for creating the “learning steel mill” that exploits the enormous potential offered by digitization to manage plants, processes, orders and customer relations.

At Big River Steel the entire process chain is digitally mapped as a precondition for extensive use of all new options offered by digital technologies. The digital map of the complex process chain provides the basis for computer assistant decision making based on in-depth analysis of complex correlations. The advanced digital technologies create an enormous potential. The availability of vast data volumes (“big data”), data linking, and plant networking as well as the ability to process and analyze all types of information offer new potentials that will transform the production of high-quality steel products.

What is more, Big River Steel is going to create a “learning steel mill” powered by artificial intelligence (AI). Noodle.ai, a San Francisco-based company, has been contracted to implement Enterprise AI to optimize operations. Noodle.ai’s predictive AI engines, configured on its industrial operations platform, The BEAST, will help optimize a vast array of functions throughout the steel mill. The plants possess a rich trove of sensor data for the AI platform to leverage. The AI platform can help unlock breakthrough improvements in areas such as maintenance planning, production line scheduling, logistics operations, and environmental protection. The AI algorithms will allow the mill to react to production challenges automatically.

**Conclusion**

Big River Steel is the world’s first smart steel production facility. The facility is designed to be both environmentally resourceful and technologically advanced. The mill is configured for the manufacture of a range of added value products, that previously has been dominated by the integrated iron and steel works.

The flat steel complex has been equipped with high-end technologies that never before were combined to such a unique, innovative configuration. It enables Big River to competitively produce the most challenging steels, from lightweight advanced high-strength steels to the complex electrical steels, energy pipe grades and coiled plate dimensions that today’s and tomorrow’s steel markets demand.

**References**

[1] North America’s latest steel complex inaugurated at Big River Steel. MPT International, 2/2017 (April), 32-34


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