Increased productivity and quality through conversion of secondary cooling to air-mist system on beam blank, bloom and round combi caster

The 4-strand combi caster at SMS-II of Jindal Steel & Power Ltd commissioned in 2003, was designed to produce two beam blank section sizes, two bloom sizes and four sizes of rounds. As demand increased and the product range extended, caster productivity, casting speeds and product quality did not meet the necessary standards needed. Lechler assessed the secondary cooling system and designed and installed an air-mist system to replace the existing water-only system for the beam blank sizes. Significant gains in productivity and quality have been achieved. The strands will now be converted for use with blooms and rounds.

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Lechler GmbH, Lechler India Pvt. Ltd and Jindal Steel & Power Ltd

Table 1 Max. casting speeds before conversion

<table>
<thead>
<tr>
<th>Beam blank format (w x h x flange t) (mm)</th>
<th>Max. casting speed (m/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>355 x 280 x 90</td>
<td>1.1</td>
</tr>
<tr>
<td>480 x 420 x 120</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Fig 1 Web surface cracks on beam blank

Over time, the product range has widened as a result of the growing market for long products, leading to the need for higher productivity, combined with a greater flexibility and an improved product quality and resulting in the project described below.

CASTING DATA BEFORE CONVERSION
Casting speeds for beam blank grades were limited due to insufficient cooling intensity and quality issues of the final products. The respective maximum average casting speeds for both section sizes are given in Table 1.

Local overcooling as a result of nozzle clogging, poor nozzle alignment and uneven cooling were causing deformations of the flange side. The subsequent flange side concavity was also a major quality issue. In addition, the secondary cooling was suspected as a cause for frequent breakouts which further reduced the productivity of the caster.
for a C18 grade is shown in Figure 2. Also, the critical shell thickness to contain the liquid steel and minimise bulging was calculated and benchmarked using a simplified geometry of both section sizes as shown in Figure 3.

During a plant visit the simulated bloom surface temperatures on all faces were verified with pyrometer measurements. Based on these results an optimised secondary cooling system was designed to maintain good quality at increased speeds and productivity. The water supply was to remain as existing, but for segments 1 and 2 an additional air supply was required.

The nozzle layout was modernised by installing air-mist nozzles of Lechler Mastercooler and Billetcooler type in segments 1 and 2. By using the increased heat transfer and the increased water turn down ratio of the new nozzle type as well as the available maximum water flow rate in each cooling zone, the maximum casting speed was defined. Also the required air flow rates were defined for the air-mist cooling zones at a constant air supply pressure of 2 bar.

The casting speeds could be significantly increased over the previous system while maintaining similar solidification profiles. The recommended casting speeds with the new secondary cooling design are shown in Table 2.

The simulation result of a C18 grade at the new proposed maximum casting speed is shown in Figure 4. Although the cooling intensity could be significantly increased the solidification length of both web side and flange sides are increased as a result of the casting speed increase. Even though the final solidification on both sides takes place shortly after the end of support the shell thickness is sufficient to reduce bulging to an acceptable level.

SECONDARY COOLING CONVERSION

The secondary cooling system of cooling zones 2-4 in segments 1 and 2 was redesigned and converted to air-mist cooling. Therefore the nozzles, piping, instrumentation and control systems were upgraded, matching the new requirements.

A new air valve skid shown in Figure 5 was installed to provide air supply and control of the air-mist cooling zones. The air pressure can be individually controlled for each cooling zone. Also individual strainers have been installed in each air line to provide optimum air quality.

Headers for the new nozzle layout shown in Table 3 were engineered and designed, providing a maintenance-friendly and wear resistant design to meet high quality standards.

The Mastercooler nozzles were especially designed to match the process requirements. Extensive measurements of liquid distribution for all required operating conditions were carried out and new spray plans have been provided which define the water flow rates as a function of the casting speed for all cooling zones. Also, correction factors have been
supplied taking into account variations in tundish superheat and secondary cooling water supply temperature.

The piping and instrumentation diagram has been updated with the additional pipes and instrumentation. A commissioning manual has been created listing all required checks before casting and a process manual supplied summarising the new systems requirements, process data, spray plans and solidification profiles.

While secondary cooling air control had to be completely engineered, designed and supplied, the water control could be maintained as before with exception of the spray headers.

New control software was supplied and the additional controls for the new instrumentation for air supply was implemented. The software RS Logic-5000 (Ladder logic) by Rockwell Automation has been used for the upgrade. Within the software new air-supply related emergency routines and spray water control factors for varying steel superheat and spray water temperature have been implemented.

**COMMISSIONING**

The commissioning of both beam blank formats was successfully accomplished in February 2014. Engineering teams from Lechler supported JSPL in converting the secondary cooling systems and advised on control software programming.

Before the first cast on the newly converted strand #1 all newly installed systems were successfully cold run.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>355 x 280 x 90</td>
<td>1.5</td>
</tr>
<tr>
<td>480 x 420 x 120</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 2: Proposed maximum casting speeds after conversion

<table>
<thead>
<tr>
<th>Segment</th>
<th>Zone</th>
<th>Nozzle type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring</td>
<td>1</td>
<td>Water only</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Master cooler</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Billet cooler</td>
</tr>
</tbody>
</table>

Table 3: New nozzle layout for beam blank caster

Lechler offers the widest range of Single Fluid and Air-Mist Nozzles for Continuous Casting and Solidification Modelling.

- Increase of casting speed and production capacity
- Expansion of product mix to more profitable special steel grades
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commissioned, including functionality checks of all old and new instrumentation. The new software was tested to ensure correct flow rate and pressure control of the secondary cooling water and air supply system. Pressure flow checks in all segments ensured correct flow rate supply of the new secondary cooling nozzles. Additional visual checks of the spray performance and nozzle alignment in all segments were conducted.

Figure 6 shows segments 1 and 2 with the new air-mist headers with Mastercooler and Billetcooler nozzles during cold commissioning checks.

After successful cold commissioning and verification of the extended control options of the new air-mist secondary cooling system, the first beam blanks were cast in February 2014. Temperature measurements on all beam blank faces confirmed the simulated temperature profiles of the new system and validated the new aim casting speeds. Figure 7 shows a top view of the straightener during hot commissioning. Strand #1 on the right side of the picture has been converted to air-mist cooling while the other strands were still operating with the old system. Clearly the elevated surface temperature can be seen.

First surface inspection after hot commission indicated an improved quality of the converted strand #1. There were no indications of flange face deformations and the web surface cracking was reduced to a minimum. After successful hot commissioning of 1 strand for small and big beam blanks, all strands have been subsequently converted. The initial observation was verified and confirmed during the first year of operation. The results for longitudinal cracking are shown in Figure 8 for all strands indicate an average cracking reduction from 3.4% before the conversion to 1.2% with the new air-mist cooling system.

The amount of running water on the beam blank fixed web side was also significantly lowered, so reducing overcooling and hence reducing thermal strains of the material.

The problem of breakouts has been virtually eliminated after the conversion with no breakouts occurring which can be attributed to the optimised secondary cooling (see Figure 9). Significantly reduced maintenance costs and the increased productivity of the caster are the other two objectives which have been met.

The now achievable casting speeds are matching the minimum ladle tap-to-tap time, thus maximising the productivity of the caster.

Nozzle clogging issues have been reduced to a minimum with the new air-mist nozzle layout reducing maintenance work and material costs.

**FUTURE PROJECTS**

Based on the very good results of the conversion of the beam blank casters in terms of productivity, product
CONCLUSIONS

1. The secondary cooling system of one strand of a 4-strand combi caster at SMS-II of Jindal Steel & Power Ltd has been converted from water only to air-mist with the aim of improving caster productivity, cast product quality and operating cost.

2. As a result, caster productivity has significantly increased, resulting both from a 15 to 20% increase in casting speed and a reduction in cooling-related breakouts from 16 per year to nil. Spray nozzle clogging has been eliminated.

3. As a result of these improvements, plans are being developed to convert the remaining bloom and round sections and also to convert caster number 3 to a similar secondary cooling system.

DEFINITIONS (FIGURES 2 AND 4)

Max Solidification: Point of final solidification in area between web and flange side
Max Web Solidification: Point of final solidification on web side. MS

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