DEVELOPMENT OF HIGH STRENGTH STEEL WITHOUT ACCELERATED COOLING PROCESS

2018 SEAISI CONFERENCE
25th – 28th June 2018
Jakarta
Day by day, the traffic jam is getting WORSE...

Solution given by the Indonesia’s government is...

Elevated Toll Road Construction!

An increase trend of elevated toll road project ordered by government
Why using **STEEL** bridge?

**Steel bridge,**

Higher strength, easy to transport, and had short construction period.

Long distance between the piers, so it’s need a longer bridge.

To get longer bridge, we need

**High strength steel** more than **TS 570 Mpa** !!!
High strength steel is usually made by accelerated cooling facilities...

But,
Our company doesn’t have these facilities...

We cannot receive any order!

Can we make high strength steel made without accelerated cooling?
The solution is using **TMR (Thermo Mechanical Rolling)** method as a substitution of heat treat facilities to get the high mechanical properties.

Increasing reheating Temperature + Controlled the Rolling Schedule + Proper Metallurgical Design (Using Nb and Ti as a precipitation hardening and grain refinement)

Grain refinement is a key to obtain the high mechanical properties.

**High Mechanical Properties Material**

The concept is how to achieve the **fine grained austenite to yields the fine grained ferrite**.
This is the **Rolling Schematic and Schedule** that we used and try

- Slab with same heat number produced by PT. Krakatau Posco
- Slab dimensions: 230 x 2300 x 3880mm
- Rolled with 3 schedules

<table>
<thead>
<tr>
<th>Schedule (Thickness)</th>
<th>Cooling time to reach non-recrystallization zone (C-D)</th>
<th>Rolling finish temperature (near/inside the Υ+α zone) (D-E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (20mm)</td>
<td>Short time</td>
<td>Upper finish temperature</td>
</tr>
<tr>
<td>2 (21mm)</td>
<td>Intermediate time</td>
<td>Lower finish temperature</td>
</tr>
<tr>
<td>3 (22mm)</td>
<td>Longer time</td>
<td>Intermediate finish temperature</td>
</tr>
</tbody>
</table>
High reheat temp + plastic deformation process:
Refine the coarse austenite grain through the presence of Nb and Ti precipitate.

Reduction above Ar3 temp (Non-recrystallization zone):
The form of austenite grain was in fine and pancake form. And also appear the deformation band.

Air cooling (entering the $\gamma+\alpha$ zone):
The ferrite grain starts to nucleate on grain boundaries and deformation band.

PT.KP tried to applied
Finally, without accelerated cooling facilities, we can achieve the finer grain through controlling the TMR parameters.

### Mechanical Result

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Thickness (mm)</th>
<th>EL (%)</th>
<th>YP (MPa) (Min 450MPa)</th>
<th>TS (Mpa) (Min 570MPa)</th>
<th>Impact Temp (°C)*</th>
<th>IV 1 (J)</th>
<th>IV 2 (J)</th>
<th>IV 3 (J)</th>
<th>IV average (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>37</td>
<td>512</td>
<td>611</td>
<td>-23</td>
<td>225</td>
<td>223</td>
<td>233</td>
<td>227</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>32</td>
<td>550</td>
<td>638</td>
<td>-23</td>
<td>199</td>
<td>209</td>
<td>199</td>
<td>202</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>38</td>
<td>510</td>
<td>604</td>
<td>-23</td>
<td>232</td>
<td>230</td>
<td>233</td>
<td>232</td>
</tr>
</tbody>
</table>

*Project requirement

### Microstructure Result

Lowering the rolling finish temperature (specimen 2) (near or inside the Y+α region) will get the finer ferrite grain.

Finer ferrite grains are obtained!
PTKP’s Plates
Terima Kasih
Thank You for Your Attention