RESEARCH REGARDING THE QUALITY IMPROVEMENT OF THE CONTINUOUS CASTED ROUND SEMI-FABRICATED AND THE REDUCTION OF METAL CONSUMPTION IN PIPE PRODUCTION

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Abstract
This paper describes the technological steps taken towards enhancing the quality of the 270mm continuous casted slabs (G52M steel) used in the fabrication of laminated pipes. Also, it describes the effects regarding metal consumption and the quality of the laminated pipes (acceptance of around 90% after ultra-sound control) using data collected during 1 year of production.

1. OVERVIEW
Research has been carried due to the observation of a high metal consumption (brittle tons/pipe tons) in seamless pipe manufacturing.

In agreement with our industrial partners it has been decided to study the pipe format \( \Phi 270 \) mm, made from G52 type steel, peritectic, with the following chemical composition (table 1):

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>S</th>
<th>P</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu</th>
<th>Mo</th>
<th>Al</th>
<th>V</th>
<th>V+Al+Ti+Cu+Sn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>1.15</td>
<td>0.15</td>
<td>max.</td>
<td>max.</td>
<td>max.</td>
<td>max.</td>
<td>max.</td>
<td>0.020</td>
<td>0.08</td>
<td>max. 0.15</td>
<td>max. 0.30</td>
</tr>
<tr>
<td>-0.14</td>
<td>-1.30</td>
<td>-0.35</td>
<td>0.010</td>
<td>0.020</td>
<td>0.10</td>
<td>0.20</td>
<td>0.05</td>
<td>0.050</td>
<td>0.13</td>
<td>max. 0.15</td>
<td>max. 0.30</td>
</tr>
</tbody>
</table>

Experiments have been made on a manufacturing flow with a EBT(100t) oven – LF furnace ladle – continuous casting machine \( \Phi 270 \) mm - 16” mill.

2. EVALUATION OF THE INITIAL TECHNOLOGICAL STAGE

The first stage was to evaluate the manufacturing quality at the beginning of the activity, afterwards, using the evaluation results to establish and to apply the technological measures necessary for improvement. Every technological stage on the flux was monitored, from both the round billet and the pipe manufacturer.

The evaluation results highlight the following aspects:

2.1 Elaboration – treatment LF sector

Synthetic, the evaluation results for a number of 28 batches are presented in table 2.

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>S</th>
<th>P</th>
<th>Al_{total}</th>
<th>Al_{sol}</th>
<th>Ca</th>
<th>O</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>min.</td>
<td>0.12</td>
<td>1.16</td>
<td>0.31</td>
<td>0.003</td>
<td>0.027</td>
<td>0.025</td>
<td>0.010</td>
<td>0.0030</td>
<td>0.0074</td>
</tr>
<tr>
<td>max.</td>
<td>0.14</td>
<td>1.24</td>
<td>0.33</td>
<td>0.007</td>
<td>0.017</td>
<td>0.051</td>
<td>0.050</td>
<td>0.0030</td>
<td>0.0034</td>
</tr>
</tbody>
</table>
The presented data reveal narrow limits for the alloying elements, and also that they are suitable in their technologically imposed limits.

Regarding the gas content, it is situated in technologically accepted limits, noting that the oxygen level is quite high and can affect the efficiency of using Ca in order to modify the Al₂O₃ inclusions.

2.2 Continuous casting sector

First evaluation results are presented, synthetic in table 3.

Table 3

<table>
<thead>
<tr>
<th>Overheating ∆T, °C</th>
<th>Vt m/min</th>
<th>Primary Cooling l/min</th>
<th>Secundary cooling l/min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>min.</td>
<td>21</td>
<td>0,70</td>
<td>1810</td>
</tr>
<tr>
<td>max.</td>
<td>38</td>
<td>1,0</td>
<td>1850</td>
</tr>
</tbody>
</table>

Quality reception performed on the continuous casted round surfaces has highlighted a series of specific defects – longitudinal and transversal cracks, prints, depressions, deep and wide oscillation marks.

Internal quality reception highlights: primary crust insufficiently developed, patchy (irregular), with big and very big columnar crystals (in many cases starting from the brittles surface), a faint central area with echiax crystals (10-20% of the surface), internal fissure with an intercrystalline character.

Based on observations made in the monitoring stage, we proceeded to carry out technological measurements with the man objective being the improvement of casted round quality:

- Modifying the chemical composition towards exiting the peritectic area, providing mechanical characteristics on the produce;
- Reducing the overheating degree;
- Increasing the specific water consumption on secondary cooling with about 0,8 l/kg casted steel;
- Modifying the secondary cooling water distribution on areas: 40% 1st area, 40% 2nd area, 20% 3rd area.

This scheduled (programmed) measures and the obtained results are synthetically presented in table 4.

Table 4

<table>
<thead>
<tr>
<th>Chemical Composition, %</th>
<th>Overheating ∆T, °C</th>
<th>Secondary cooling, l/min</th>
<th>Sraitening billet temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Mn</td>
<td>Area 1</td>
<td>Area 2</td>
</tr>
<tr>
<td>Scheduled programmed</td>
<td>0,17 ± 0,02</td>
<td>1,15 ± 0,05</td>
<td>25 - 32</td>
</tr>
<tr>
<td>Realised</td>
<td>0,15 - 0,17</td>
<td>1,14 - 1,16</td>
<td>25 - 33</td>
</tr>
</tbody>
</table>

These billets have been laminated in pipes with dimensions 324 x 12.7 mm, respectively 324 x 10,3 mm. The obtained results after quality investigations on laminated pipe, in the technological intervention stage reveal an important growth of the metal usage efficiency – date are presented in table 5.

Table 5

<table>
<thead>
<tr>
<th>Stage</th>
<th>Number of laminated pipes</th>
<th>% of pipes accepted on flux</th>
<th>Finally accepted pipes (even after reshuffle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>437</td>
<td>22,65</td>
<td>44,62</td>
</tr>
<tr>
<td>II</td>
<td>226</td>
<td>57,14</td>
<td>76,33</td>
</tr>
</tbody>
</table>
Monitoring the pipe manufacturing quality was made over the years 2006 (stage III), and 2010 (stage IV), with respect to the set technological parameters in the experimental stage II.

Relative, the evolution of metal efficiency in seamless pipe production, is presented in table 6.

<table>
<thead>
<tr>
<th>Stage</th>
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<th>% finally accepted pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>22.65</td>
<td>44.62</td>
</tr>
<tr>
<td>II</td>
<td>57.14</td>
<td>76.33</td>
</tr>
<tr>
<td>III (2009)</td>
<td>79.6</td>
<td>96.8</td>
</tr>
<tr>
<td>IV (2010)</td>
<td>67.68</td>
<td>93.38</td>
</tr>
</tbody>
</table>

CONCLUSIONS:

1. Obtained results reveal the fairness of the adopted technological measures:
   - bath overheating 25-30 ° C;
   - water repartition on secondary cooling areas, % - 40/40/20;
   - casting speed 1 – 1.3 m/min;
   - semi-finished temperature during entry in the straitening rollers > 950°C;

2. Metal efficiency variations, are in direct relationship with the degree of compliance of the promoted technologies.