TRIAL – PRODUCTION OF HRB400 HOT ROLLED RIBBED BAR Ø6.0 mm

Kong Junqi, Zhao Baomin, Wang Zhiyi, Zheng Yongrui, Zhang Shaobo, Zhao Guangxing

(Technical Center, Xingtai Iron & Steel Co. Ltd., Xingtai 054027, Hebei, China)

Abstract: To meet the needs of building constructions for rebar of high strength and plasticity, processes adopting technologies such as V micro-alloying, converting, ladle bottom—blown argon stirring, continuous casting to 150 mm x 150 mm billet are applied and then to produce Ø6.0 mm hot rolled ribbed bar with high speed wire rod mill. The products are in accordance totally with the standard of GB1499 – 1998.

Key Words: HRB400; hot rolling; ribbed bar; micro—alloying

1 Preface

Grade III hot rolled ribbed bar is produced with micro-alloying process. Comparing with the grade II ribbed bar, it demonstrates advantages both higher strength and high rate of strength versus price, safe reliability, significant economic benefits, excellent performances both in process and mechanics, fine weldability and high asismatic capacity. When it is used in construction, more than 15% bars can be saved. Now, the 400 MPa and 500 MPa – grade ribbed bar are widely used in construction in many developed countries of Europe and America. But in our country still 235 MPa and 335 MPa bar are mainly used, these bars of low strength, low comprehensive capability cannot meet the requirement of the rapid development of the country’s construction industry, especially the building of skyscraper.

In order to meet the requirement for Ø6.0 mm ribbed bar, in our company, 789.975 tons have been manufactured in trial—production, and the performances are all up to grade.

2 Trial Process and Main Parameter

There are many ways to heighten the strength of 400 MPa grade hot rolled ribbed bar. At present micro—alloying is a mature method, in this way element Nb or V or Ti is used. In the process of heating up the billet or rolling, the micro—alloying element can prevent grain growing by precipitating carbon—nitrogen; restraining austenitic recrystallization during rolling; depressing austenitic transformation temperature, refining microstructure, enhancing steel strength and plasticity. Add micro—alloying element, such as Nb, V, Ti, all can lead to the same intention. Due to resource reason, our company adopt V as the micro—alloying element.

2.1 Smelting

2.1.1 Smelt process

(1) It’s required: molten iron S ≤ 0.05%, iron lump S ≤ 0.05%; when S content in iron lump can not meet the requirement, proper quantity of steel scraps are needed to add into converter;

(2) Using SiMn, SiFe, SiC, FeV to deoxy-
(3) To assure V absorptions, it’s prescribed the addition of VFe shall start after that all other alloy addition finished and the molten steel would have been entirely deoxygenated, and shall end at 3/4 tappings.

(4) To assure molten steel uniformity, the time for ladle bottom – blown argon stirring should not be less than 5 minutes.

2.1.2 Smelting result

Inspection results shows that billet compositions are all accordant with the standard, V content is about 0.08%. Chemical analysis shows in table 1. Inspections are also done in macro – structure and surface quality for the cast billet, all items checked are as required.

Table 1 20MnSiV chemical composition

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>V</th>
<th>V absorptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>0.20 - 0.22</td>
<td>0.49 - 0.51</td>
<td>1.37 - 1.42</td>
<td>0.016 - 0.022</td>
<td>0.017 - 0.023</td>
<td>0.068 - 0.097</td>
<td>70.5 - 98.3</td>
</tr>
<tr>
<td>Average</td>
<td>0.21</td>
<td>0.50</td>
<td>1.39</td>
<td>0.018</td>
<td>0.020</td>
<td>0.086</td>
<td>90</td>
</tr>
</tbody>
</table>

2.2 Rolling

2.2.1 Rolling process

Rebar rolling process goes through a high speed wire rod mill, total 28 passes, single line without twist, rolling speed 80m/s. In order to entirely exert V strengthening – toughness, controlled rolling and cooling is necessary. Main parameters are as follows:

To assure carbide and nitride of micro – alloy V completely dissolved, the heating temperature is controlled between 1130 - 1180 °C.

Low finish rolling temperature can contribute to refine grain and make the V(C, N) entirely precipitate. Considering bar temperature rises severely in finishing mill, pre – cooling and intermediate cooling in finish mill should be sufficiently utilized to ensure a temperature at entry of finish mill is 880 - 920 °C, and the exit temperature is 850 - 900 °C.

Cooling after rolling: roller table speed 0.6 m/s, fan 1# - 5# /80 %, all temperature covers open.

Through several trial rollings, process parameters are optimized, details are listed in table 2.

<table>
<thead>
<tr>
<th>Heating/ °C</th>
<th>Entry temperature at finishing mill/ °C</th>
<th>Exit temperature/ °C</th>
<th>Roller table speed/ m/s⁻¹</th>
<th>(1 - 5) Fans/ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1130 - 1180</td>
<td>880 - 920</td>
<td>960 - 1000</td>
<td>0.5 - 0.6</td>
<td>80</td>
</tr>
</tbody>
</table>

2.2.2 Rolling process

In rolling process following aspects are solved: well controlled sizes of semi finished products at various stands and passes; ensuring longitudinal and transverse ribs forming in finish mill; reducing water cooling intensity after finishing rolling to ensure laying steady; applying wind distributions well along rebar length to ensure an even performance all through the bar.

3 Results and analysis

3.1 Dimensional inspection

Measured results show that the sizes of rebar are all qualified, the tolerance is retained about -0.1 mm, details in table 3.

3.2 Weight tolerance

Length of measured rod: 103.14m, weight: 22.1 kg, nominal sectional area: 28.27mm², actual
weight: 22.1/103.14 = 0.2143 (kg/m), (GB)
ominal weight: 0.222 kg/m. Weight tolerance:
(1 - 0.2143 / 0.222) × 100% = 3.47% ≤ 7%

The result is in accordance with the stan-
dard.

Table 3 Dimensions of rebar

<table>
<thead>
<tr>
<th>Rating diameter</th>
<th>Inner diameter</th>
<th>Transverse rib</th>
<th>Longitudinal rib</th>
<th>Width of transverse rib</th>
<th>Width of longitudinal rib</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5.6 - 5.75</td>
<td>0.6 - 0.75</td>
<td>0.6 - 0.9</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Trim size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3 Performances
Inspection of mechanics and cold bend test results are detailed in table 4.

Based on table 3, we know the strength of rebar meeting the requirement of GB1499 - 1998, furthermore the strength and elongation are fairly sufficient, see figure 1.

3.4 Application
After trial – production, we have already yield HRB400 06.0 mm rebar, accumulative total 4 000 tons. And the feedbacks of consumer are satisfying.

Table 4 Tensile test and bend test

<table>
<thead>
<tr>
<th>σu/MPa</th>
<th>σb/MPa</th>
<th>δs/%</th>
<th>bend(d = 4a, 180)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>464 - 265</td>
<td>647.5</td>
<td>28.35</td>
</tr>
<tr>
<td>GB1499 - 1998</td>
<td>≥ 400</td>
<td>≥ 570</td>
<td>14</td>
</tr>
</tbody>
</table>

Figure 1. Yeild and tensile strengths

4. Conclusions
(1) HRB400 06.0 mm rebar can be produced successfully with processes of top – blown oxygen converter smelting, ladle bottom – blown argon stirring, V micro – alloying, continuous casting 150 mm × 150 mm billet, rolling by high speed wire rod mill.
(2) With appropriate processes, qualified hot screwed rebar in accordance with GB1499 - 1998 can be produced.
(3) Rebar shows stable mechanic performances, and strength and plasticity are more than enough.