PECULIARITIES OF ROLLING CONTINUOUS CASTING BLOOMS AND BILLETS FOR HOT ROLLED BULB-FLATS PROFILES

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As a result of research of the manufacturing technology and quality big section symmetric bulb-flats profiles from continuous casting billets is shown, that the level, achieved in Ukraine, in a condition to ensure parameters of service properties of roll according to the requirements of the conducting world registers of shipping. For the first time made in Ukraine a trial and skilled party bulb-flats profiles from continuous casting billet in comparison with traditional technology (casting in ingots + subsequent manufacture of billet) are characterized by the greater uniformity of mechanical properties, high viscosity and plasticity.

Discussing a condition and directions of reconstruction section of manufacture of Ukraine the whole set of the rather inconsistent factors is necessary to take into account, to major of which it is possible to attribute the following three. Firstly, today approximately 75 % of metal production made in Ukraine are exported to near and distant foreign countries, that has made the Ukraine as one of the main exporters metal production in the world [1]. Secondly, tendency of development of the world market of consumption metal production of last years testifies that the coming years of a significant gain in its consumption hardly it is necessary to expect [2, 3]. Thirdly, in a facilities with market economy of the purpose of reconstruction are defined rigidly enough:
- Reception of such quality of rolled products, which completely would meet the requirements of the consumer and promoted replacement of the competitor in the market;
- Decrease of the cost price of production;
- Minimization of terms recoupment.

In a context all above-stated reconstruction of black metallurgy spent in the country as conducting branch of a national economy is proved quite to consider as one of components of the program of consecutive inclusion of the country in the All-European process of integration. The complex realization of this program in turn requires from various subindustries of mechanical engineering also aspiring to an output on the All-European and world markets, significant increase of a level of consumer properties of let out production that it is also impossible without radical improvement of quality section and sheet roll. Thus, the world experience shows that an indispensable condition of successful realization of a worth problem is the application of advanced technologies of melt of steel and receiving of billet by a method of continuous casting.

Continuous casting billets by section from 150x150 mm up to 200x200 mm represent the large interest for manufacture of the whole scale of shaped profiles of responsible purpose on heavy section and medium rolling mills and first of all such as bulb-flats profiles (GOST 21937-76, GOST 9235-76) used in shipbuilding. In a metallurgical complex former of the USSR the Ukraine was actually monopolist in manufacture of the given kind of production having concentrated on 6 rolling mills approximately 90 % all let out range. At the same time, today all volume domestic bulb-flats rolling is made from billet received in the result of re-rolled ingots.

The employees of Donetsk State Technical University E.L. Philipov and Y.I. Yrchenko carried out the first manufacture experiences of bulb-flats rolling from continuous casting steel in middle
80 years at "Donetsk Iron & Steel Works". Steel smelted in open-hearth furnace and casting in slabs by thickness of 120-140 mm on vertical type of CCM which then have cut lengthways on billets. The received billets re-rolling in non-symmetrical bulb-flats profiles № 8 – 10 on mill "400". The output suitable on quality of a surface has increased, the mechanical properties bulb-flats profiles corresponded to the requirements of the standards. However, macrostructure both received billet (fig. 1) and finished bulb-flats profiles (fig. 2) was unsatisfactory. Practically, the axial defects (segregations) on all rolls were observed which were distributed in area of the head (fig. 2.a) or were extended on all width rolls (fig. 2.b). The given condition has not allowed receiving production suitable for operation and works were suspended.

The conditions of operation bulb-flats profiles in designs of the ships put forward the certain requirements to their quality and first of all – bulb-flat profile should have high plasticity and viscosity guaranteeing strength and resistibility to development of defects under action high-cyclic dynamic and thermal loadings. The reception of products with such combination of properties is possible at a correct choice of a material and technology of their manufacture including melt and casting of steel, warping and thermal hardening of finished production.

The researches according to quality of bulb-flats profiles, rolling from continuous casting metal have executed in conditions at mill "620" of JSC "Kramatorsk Iron & Steel Works". The specificity of the mill consists in it range manufacture 10 of 19 profiles-dimensions (i.e. 52,6%) non-symmetrical bulb flats on GOST 21937 - 76 is stipulated and the presence of the correct equipment and complex of thermal processing makes mill practically unique from the point of view of an opportunity of manufacture of all grades of ship steel from A up to Е.

As initial were used two types of billets made in conditions at JSC "Dneprovsky Integrated Iron & Steel Works" on the following variants of technological processes:
1-st variant – moulding on CCM of curvilinear type of blooms by section 335x400 mm with subsequent rerolling last on mill "950/750" in preparation of square section 170x170 mm;

2 variant – moulding on CCM of curvilinear type of directly square billet by section 160x160 mm.

Melting of a trial party of ship steel, grade А32 – D32 (GOST 5521 – 93) in quantity of more than 400 tons appropriate to Rules of the Maritime register of shipping in a part of chemical composition, carried out in the 250-ton converter of combine according to the working technological instructions on melt, finishing and continuous casting.

Macrostructure of section roll depends from macrostructure of initial billet and rolling schedule. An estimation of quality of the received billets made in conformity OST 14-1-235-91 [4].

The basic defect macrostructure of casting billets are axial physical and chemical heterogeneity, segregation bands and crack, dot heterogeneity. Any them of these defects are not eliminated during hot deformation, at any degree reduction these defects are kept in finished roll.

For reception of section roll with satisfactory macrostructure it is necessary that in macrostructure of initial casting billet dot heterogeneity and segregation bands had the characteristics (in numbers), practically not exceeding requirements GOST to macrostructure of finished roll.
The research of peculiarities of structure of a trial party of square billets by section 170x170 mm received on the first variant of technological process has shown that quality of their surface very good without seen defects of a metallurgical origin, characteristic for billet received in result re-rolling of ingots. The billets are characterized by uniform chemical structure, smaller (in comparison with an ingot) quantity shrinkage and segregation defects, homogeneous and dense macrostructure (fig. 3a), except for a narrow axial zone. In this zone the rests initial dendrite structure on continuous cast bloom, and also axial segregation (axial chemical heterogeneity) 0 – 1 number are visible. Dispersibility of dendrite and granular structure more than in 3 times exceeds initial in bloom became reduced approximately in 4 times pollution of metal by not metal inclusions in comparison with metal of serial manufacture of JSC "Enakievo Iron & Steel Works" (melting in the oxygen converter - casting in ingots – rolling of billet).

For macrostructure of billet received on the given variant of technological process, the presence dense light etched edging by thickness of 5-8 mm on a contour of section inherited from rim zone bloom and poorly expressed thermal center is characteristic also.

In a counterbalance to structure of billets section 170x170 mm, macrostructure of continuous casting billets of an experimental batch received on the second variant of technological process (fig. 3b), testify to them more poor quality expressing in lowered dispersibility dendrite and granular structures, lowered presence axial segregation 0 – 2 numbers with the precisely outlined thermal center. At the same time, the pollution of metal by not metal inclusions is the same as well as in billets received on the first technological scheme.

From the point of view of resistibility of finished products to development of defects under action of high-cyclic and thermal loadings, the greatest danger is represented segregation bands and crack (anguishes) which are settling down on inter-axis to spaces dendrite structure and also crack of a pressure crossing axes dendrites in dendrite to structure and extending on section of the template as broken lines.

The similar influence is rendered also by regional dot pollution representing not metal inclusions endogenous and exogenous origins, which are settling down as isolated, groups and as lines on cross section of the template. The made estimation of quality of the received preparation from the point of view of presence of defects of the given kind has shown, that in researched metal segregation bands are absent and regional dot pollution is present only in rolls section 160x160 mm and does not exceed 1 number.

The presence in continuous casting billets of an axial zone of poor quality has raised the question about an all-round estimation of quality finished bulb-flats profiles. For an estimation of quality macrostructure have accepted for a basis a method of the control regulated by OST 14-1-235-91. However, whereas bulb-flats profiles from continuous casting metal were received for the first time in the Ukraine and countries of CIS and the literary data on the similar works given in the industrially advanced countries of the world are absent, for a basis of methodology of researches according to quality the approach applied by the author of work was accepted [5] to an estimation of quality of rails from continuous casting billet. The legitimacy of such approach is proved on the one hand similar conditions of operation of rolling products (cyclic dynamic and thermal loadings) and, on the other hand by increased requirements to characteristics of the viscosity guaranteeing durability and resistibility to development of defects under action of external influences.
Estimation of a level of the service characteristics of trial parties non-symmetrical bulb-flats profiles №24A, 22A, 20A, 20B on GOST 21973-76 (initial section of billet of 170x170 mm) and experimental batches: №22A, 20A, 18A on GOST 21973-76, 18A, B, C, E on DIN EN 10067 (initial section of billet of 160x160 mm) made according to the requirements of the working standards.

Quality surveillance of a surface both initial preparations and finished bulb-flats profiles carried out during 100% of visual survey of each bar on racks of survey and control. Repartition on defects of a surface (captivity-unrolled bubbles, flaws, crack etc.) billets and finished bulb-flats profiles from continuous casting metal was not to a kind of their absence. The densities of defects of a surface of a rolling origin did not exceed average sizes characteristic for a sold technological levels and condition of the equipment of the mill.

The analysis results of delivery test of metal from each party of rolled products during the current control and also at realization of delivery tests at the presence of the representative of the Sea Register has shown complete conformity of the made production to the requirements of GOST 21937-76 (table 1). The researches of distribution of mechanical properties in a cloth bulb-flats profiles (place of selection of tests) have shown that the properties are distributed practically in regular intervals in roll different profile-dimensions inside one melting. The decrease of the characteristics of strength on 20 – 30 N/mm² because of zone segregation of carbon is on occasion marked and sulfur (samples are cut out from a zone of the thermal center). The average level of critical characteristics of mechanical properties bulb-flats profiles corresponds to the requirements of the standard and exceeds a level stipulated for the given kind of hire from preparation of the current manufacture of JSC "Enakievo Iron & Steel Works" on relative lengthening and shock viscosity on longitudinal samples. The given circumstance has allowed in a first approximation to make a conclusion about the greater uniformity of metal bulb-flats profiles from continuous casting billet.

For macrostructure bulb-flats profiles from continuous casting metal received on both schemes of technological process is also characteristic dense light etched edging by thickness 1 – 1,5 mm (fig. 4) on a contour of section. Thus, on finished roll made from billet 160x160 mm it has more brightly expressed display.

Defects of macrostructure of roll from continuous casting steel [5] carry out basically to the three types: 1 – axial chemical heterogeneity; 2 – regional dot pollution; 3 – segregation bands.

Thus, as the carried out researches testify the degree of axial chemical heterogeneity can serve one of the main criteria of an estimation macrostructure bulb-flats profiles, rolled from continuous casting billet. In roll the given defect is shown first of all in streakiness macro- and microstructure (fig. 5), that is connected with typical of an axial zone continuous casting billet segregation of sulfur, carbon and phosphorus. The carried out quality surveillance macrostructure of finished roll various profile-dimensions (12 sulfuric prints) to the given attribute has shown that in bulb-flats profiles it is present only on the certain site inside a shelf (fig. 5). Outputs on a surface, in the head and also zone to it adjacent was not observed. As a place of its concentration the area removed on distance (0,65-0,70) b from edges of a shelf (b – width bulb-flat profile) can be considered.
The carried out researches according to the quality and level of service properties bulb-flat profiles of trial and skilled parties allow to assert that the made roll to the full answers the highest requirements showed to given kind of production, given a kind of world shipping registers. Besides, the additional given analysis, concerning regulation of percentage of elements in steel in light of chemical composition trial melts made in Oxygen Converter Shop at JSC "Dneprovsky Integrated Iron & Steel Works" (heat № P924213: C - 0,15%; Mn - 1,30%; Si - 0,30%; S - 0,023%; P - 0,028%; heat № 914488: C - 0,12%; Mn - 1,30%; Si - 0,33%; S - 0,020%; P - 0,012%) allows to make a conclusion that the achieved technological level of melt, operational development and continuous having poured of steel at the conducting metallurgical enterprises of the Ukraine in a condition to ensure production (billet for rerolling) world level.

Thus, researches of the technology process and the qualities heavy section symmetric bulb-flats profiles from continuous casting billets have shown that the level, achieved in the Ukraine in a condition to ensure parameters of service properties of roll according to requirements of the conducting world registers of shipping. For the first time made in the Ukraine a trial and skilled party bulb-flats profiles from continuous casting billet in comparison with traditional technology (casting in ingots + subsequent manufacture of billet) are characterized by the greater uniformity of mechanical properties, high viscosity and plasticity. It allows correcting the perspective program of reconstruction and modernization section manufacture of the country in perspective of possible use high-quality continuous casting billet for manufacture heavy and medium profiles.

Literature:
Figure 1 – Macrostructure (sulfuric print) cross template of billet received by cross cutting continuous casting slab, $\times 0.7$.

a – from edge of slab;  
b – from middle of slab.
Figure 2 – Macrostructure (sulfuric print) cross template bulb-flats profile № 10, × 1.

a – billet from edge of slab;
b – billet from middle of slab.
Figure 3 – Macrostructure (sulfuric print) cross template of billets, × 0.6

a – 160×160 mm;
b – 170×170 mm.
Figure 4 – Macrostructure cross template bulb-flats profiles from continuous casting steel, × 0,7
a) bulb-flats №20A, initial section of billet 170×170 mm, heat № P914488
b) bulb-flats №22A, initial billet 160×160 mm, heat № 2P914488

Figure 5 – Macrostructure cross template bulb-flats profile from continuous casting steel experimental party with axial chemical heterogeneity, × 0,7
- bulb-flats №20A, initial billet 160×160 mm, heat № 2P914488
Table 1 – Mechanical properties of metal of symmetrical bulb-flats profiles from continuous casting billet

<table>
<thead>
<tr>
<th>Number of profile</th>
<th>Type of billet, mm</th>
<th>Characteristic of mechanical properties **</th>
<th>Bend in cold condition</th>
<th>Impact work, Joule*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \sigma_b ) N/mm²</td>
<td>( \sigma_t ) N/mm²</td>
<td>( \delta_5 ) %</td>
<td>( 0^\circ C )</td>
</tr>
<tr>
<td><strong>Experimental-industrial party</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 A, B GOST 21937-76</td>
<td>170×170</td>
<td>481 – 525</td>
<td>334 – 363</td>
<td>29,0 – 33,0</td>
</tr>
<tr>
<td>22 A, B GOST 21937-76</td>
<td>170×170</td>
<td>490 – 540</td>
<td>324 – 363</td>
<td>26,0 – 32,0</td>
</tr>
<tr>
<td>24 A, B ***</td>
<td>170×170</td>
<td>491</td>
<td>334</td>
<td>32,3</td>
</tr>
<tr>
<td><strong>Experimental party</strong></td>
<td></td>
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</tr>
</tbody>
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* - longitudinal specimens;
** - in numerator – minimum and maximum values, in denominator – average values;
*** - small volume of under consideration party.