The problem of improving the quality of semiproduts made of the widely used alloys type EI437BVD is still fairly serious. For instance, in the production of seamless-rolled rings of alloy EI437B there is substantial inequigranularity in different zones of these semiproduts, and that greatly impairs the level and stability of their mechanical properties. The specifics of the expanding of the rings makes its mark on the process of recrystallization of the alloy. We therefore investigated the grain size in different zones of rings with shaped section after heat treatment in different regimes.

We investigated three rings with typical shaped section from industrial melts (Table 1) after heat treatment in different regimes (Table 2).

The quality of the rings after heat treatment was evaluated according to the results of the investigations of the mechanical properties and the analysis of the structure in different zones.

The phase composition and phase distribution in the structure of the alloy were investigated by electron microprobe analysis on an instrument JXA-733 Super-Probe equipped with an analytical system for studying x-ray spectra with dispersion according to energies Link 860-2.

Alloys type EI437BVD are prone to inequigranularity, and a single characteristic, viz., mean grain size, does not suffice for evaluating the structure. In the analysis of the granular structure we therefore did not confine ourselves to the determination of the mean grain size (Dme) but also determined the degree of inequigranularity \( \bar{\sigma} \) by the method of secants by a procedure envisaging the use of elements of mathematical statistics.

The mean grain size was calculated by the formula

\[
D_{me} = \frac{i_1D_{nom 1} + i_2D_{nom 2} + \ldots + i_nD_{nom n}}{i_1 + i_2 + \ldots + i_n},
\]

where \( D_{nom n} = l/b_n \) (l is the length of the secant, mm; n is the number of intersections; b is the magnification of the microscope); i is the number of secants with the same number of intersections.

The rms scatter of grain size or the degree of inequigranularity \( \bar{\sigma} \) was calculated by the formula

\[
\bar{\sigma} = \sqrt{\frac{i_1(D_{nom 1} - D_{me})^2 + i_2(D_{nom 2} - D_{me})^2 + \ldots + i_n(D_{nom n} - D_{me})^2}{i_1 + i_2 + \ldots + i_n}}.
\]

Figure 1 shows the macrostructure of a ring with typical shaped profile and the zones in which the grain size and the degree of inequigranularity were determined.

The change of Dme and \( \bar{\sigma} \) in different zones of the rings (Fig. 1) in dependence on the regime of heat treatment was analyzed.

Below we present the results of the investigation of one of the shaped rings.
TABLE 1

<table>
<thead>
<tr>
<th>Ring</th>
<th>C</th>
<th>Cr</th>
<th>Fe</th>
<th>Ti</th>
<th>Al</th>
<th>Si</th>
<th>Mn</th>
<th>B</th>
<th>C</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.045</td>
<td>20.18</td>
<td>0.59</td>
<td>2.67</td>
<td>0.87</td>
<td>0.29</td>
<td>0.19</td>
<td>0.08</td>
<td>0.01</td>
<td>0.004</td>
<td>0.009</td>
</tr>
<tr>
<td>2</td>
<td>0.06</td>
<td>20.43</td>
<td>0.68</td>
<td>2.69</td>
<td>0.56</td>
<td>0.07</td>
<td>0.18</td>
<td>0.07</td>
<td>0.02</td>
<td>0.003</td>
<td>0.004</td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>21.04</td>
<td>1.0</td>
<td>2.62</td>
<td>0.81</td>
<td>0.15</td>
<td>0.23</td>
<td>0.04</td>
<td>0.01</td>
<td>0.003</td>
<td>0.004</td>
</tr>
</tbody>
</table>

*The remainder is Ni.

Remark. In addition to the listed elements, each melt contained 0.02% Ce and 0.0005% Pb.

TABLE 2

<table>
<thead>
<tr>
<th>Regime of heat treatment</th>
<th>$\sigma_u$</th>
<th>$\sigma_{0.2}$</th>
<th>$\delta$</th>
<th>$\eta$</th>
<th>$\sigma_u$, J/cm²</th>
<th>$\tau$, h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardening from 1040°C (8 h), aging at 750°C (1)</td>
<td>1040--1090</td>
<td>670--710</td>
<td>23--29</td>
<td>21--23</td>
<td>29--34</td>
<td>77--84</td>
</tr>
<tr>
<td>Annealing at 1000°C 3 h, hardening from 1080°C (8 h), aging at 750°C 16 h (2)</td>
<td>1110--1130</td>
<td>760--770</td>
<td>26,0--30,0</td>
<td>31,0--35,0</td>
<td>24,5--25,0</td>
<td>101--112</td>
</tr>
<tr>
<td>Hardening from 1080°C (8 h), aging at 750°C 16 h (3)</td>
<td>1015--1050</td>
<td>680--700</td>
<td>19,0--21,0</td>
<td>22,0--23,5</td>
<td>25,0--29,0</td>
<td>47--72</td>
</tr>
<tr>
<td>According to Technical Conditions</td>
<td>$\geqslant850$</td>
<td>$\geqslant600$</td>
<td>$\geqslant8$</td>
<td>$\geqslant10$</td>
<td>$\geqslant30$</td>
<td>$\geqslant40$</td>
</tr>
</tbody>
</table>

Remarks: 1. In parentheses is the number of the regime; regime 3 is the standard regime.
2. After annealing, hardening, and aging the specimen were cooled in air.
3. The numerator gives the mechanical properties at 20°C, the denominator at 700°C.
4. Creep-limit tests with the determination of $\tau$ were carried out for $\sigma = 460$ N/mm² and $t = 700$°C.

![Fig. 1. Macrostructure and diagram of the zones of cutting out specimens from the seamless-rolled rings with shaped section made of alloy ÉI437BVD.](image-url)