The operation of chemical reactors, gas containers, steam boilers, and similar equipment in the
elastic-plastic region can occur with alternating loads. For calculating the service life of such equipment
the important factor is the resistance of the material under conditions of repeated loading (low-cycle fatigue)
[1].

The data in the literature indicate that the resistance of steels to low-cycle fatigue is not characterized
by the results of standard tests of tensile and impact strength [2, 3] or ordinary fatigue tests [4]; also, the
resistance of steel to low-cycle fatigue depends little on aging [5].

The low-cycle fatigue resistance of steel depends on the composition and condition of the material, the
testing conditions [6], the cumulative plastic deformation [2], and also the type and the surface condition
of the sample.

This work was undertaken to determine the low-cycle fatigue characteristics of boiler steels, with
samples of different types subjected to different heat treatments and surface hardening by cold working.

The heat treatments and mechanical properties at room temperature for the steels investigated are
given in Table 1.

Different heats of the same steel differed in composition within the standard commercial limits.
Beads were applied to rolled angles, using UONI 13/45 electrodes.

The tests were made with smooth samples and samples with notches 1 mm deep with a root radius of
0.5 mm; in both cases the diameter of the critical section was 8 mm. The notches were made on a lathe and
corrected by honing.

One group of samples was roller burnished on a lathe with a three-roller (smooth samples) or single-
roller (notched samples) apparatus under the following conditions; P = 100 kg, roller radius 2 mm, one pass,
and P = 150 kg, roller radius 0.45 mm, three passes, respectively.

<table>
<thead>
<tr>
<th>Steel</th>
<th>Heat treatment</th>
<th>$b$</th>
<th>$b0.2$</th>
<th>$\sigma$</th>
<th>$\varphi$</th>
<th>HB</th>
</tr>
</thead>
</table>
| 16GTM   | Normalized 960°C, dou-
| ble tempered                  | 48   | 34     | 29.2      | 62.3      | 170 |
|         | Quenched 950°C, tem-
| pered 650°C                     | 64   | 51     | 27.2      | 63.9      | 212 |
|         | Normalized 950°C, dou-
| ble tempered                  | 61   | 45     | 25.0      | 63.3      | 187 |
| 15GSMF  | Quenched 950°C, tem-
| pered 450°C                     | 49   | 30     | 29.1      | 62.2      | 170 |
| 22K     | Tempered 650°C             | 47   | 35     | 34.4      | 74.5      | 152 |
| Weld metal                                   | 47   | 35     | 34.4      | 74.5      | 152 |

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The depth of the hardened surface layer, determined from measurements of the Vickers hardness, was several tenths of a millimeter. As the result of cold working, the hardness of the smooth samples increased by 30–50 units HV.

The tests were made in the Ya-8 machine modified for low-cycle fatigue tests of vertical samples.

The samples were heated in a muffle furnace in such a way that the maximum temperature occurred in the critical section of the samples. The temperature was measured with a thermocouple placed in a drilled opening in the sample. The low-cycle fatigue strength was tested on 6–8 samples at $N = 5 \times 10^3$.

The results of the tests are given in Table 2.

The low-cycle fatigue limit of steels 16GNM and 22K after normalization and double tempering differed little in tests at 370°C. The effective stress concentration coefficients were relatively low (1.2–1.3).

The low-cycle fatigue limit of steel 15GSMF was higher than that of steels 16GNM and 22K. The weld metal had a low-cycle fatigue strength somewhat lower than that of the parent metal of the steels investigated.

The low-cycle fatigue limits of smooth samples of steels 16GNM and 22K (normalized and double tempered) was somewhat higher at 20°C than at 370°C. Roller burnishing increased the low-cycle fatigue limit.