MECHANICAL MEASUREMENTS

ERRORS IN DETERMINING HARDNESS BY MEANS OF IMPACT-TYPE INSTRUMENTS

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Impact instruments of the Nikolaev, Schwarz, Bauman, Graven, Poldt, and other types are used in industry for determining the hardness of metals. These instruments are mainly used for determining the static HB hardness. They are particularly convenient for testing large parts or metal sheets, since they obviate the necessity of either moving heavy parts to testing racks or of cutting out special test samples.

Below we provide the accuracy test results of the Instruments of the Nikolaev type (the Nikolaev type as improved by us), in which the second blow of the striker on the indentation has been eliminated, and the triggering perfected, and of the Schwarz, Graven and Poldt types.

These Instruments cover practically all the types used commercially for evaluating the static HB hardness.

The Nikolaev and Schwarz Instruments consist of vertical impact machines in which the blow against the holder carrying the ball is made by means of a weight, which falls under the force of gravity in a guiding tube. Graven’s instrument consists of a striker which on release of a tightly compressed spring hits the end-piece of the ball. The Nikolaev, Schwarz and Graven Instruments work with a fixed energy of impact and weight of the striker. Poldt’s instrument operates with an indefinite striker energy (a hand hammer is used as a striker) by means of which the steel ball is indented simultaneously into the material under test and a reference sample.

The evaluation of the HB static hardness is made according to an empirical calibration chart or table established in advance for each type of instrument.

In the practical application of these Instruments it is essential that the line of action of the striking force should be perpendicular to the surface of the tested sample. For the Nikolaev and Schwarz Instruments this condition holds only for horizontal samples, whereas the Graven and Poldt Instruments can be used at any angle to the horizontal.

Table 1 shows the basic parameters of the tested instruments.

The error in determining the static hardness by instruments of the impact type consists of the error of the method, the error of the instrument and of measuring the diameter of the indentation.

The error of the method is determined mainly by two factors:

1. The unequal relative rise of resistance to plastic deformation in various brands of steel when hardness is determined by means of an impact. It is shown [1] that the dynamic coefficient for carbon steels varies between 1.15 and 1.31. This coefficient is understood to be the ratio between the chosen value of the characteristic resistance to plastic deformation in dynamic testing to the corresponding value in static testing; in [1] the dynamic coefficient was determined as the ratio of the impact to static hardness. If the calibration curve from which the static HB hardness is determined from readings of the impact instrument corresponds to a certain mean value of the above-mentioned dynamic coefficients, the possible measuring errors will amount to + 6.5%.

2. The effect of the forces of inertia which arise during testing when the mass of the striker hits that of the tested sample. The error caused by this factor can be neglected as compared with that caused by the first factor providing the tested sample mass referred to the striking line is at least 10 times larger than that of the striker [2].
Fig. 1. Calibration curves for the Nikolaev instrument. 1) According to the author; 2) according to Nikolaev.

Fig. 2. Calibration curves for the Schwarz instrument. 1) According to the author; 2) according to Schwarz.

<table>
<thead>
<tr>
<th>Basic parameters of the instrument</th>
<th>Nikolaev</th>
<th>Improved Nikolaev</th>
<th>Schwarz</th>
<th>Graven</th>
<th>Polid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Striker's weight, kg</td>
<td>2.940</td>
<td>3.040</td>
<td>0.880</td>
<td>1.800</td>
<td>Arbitrary</td>
</tr>
<tr>
<td>Energy stored in the striker, kg·m</td>
<td>1.588</td>
<td>1.520</td>
<td>0.440</td>
<td>0.9–1.0</td>
<td>Arbitrary</td>
</tr>
<tr>
<td>Diameter of the ball, mm</td>
<td>10</td>
<td>10</td>
<td>6.35</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Note. In Graven's instrument the variation of the stored energy is due to the possibility of varying the test position of the instrument's axis which coincides with the line of action of the striking force from the horizontal to the vertical.

The instrument error is determined by the losses of energy in the striker caused by the striker's friction against the sides of the guide; the air resistance; deviations of the instrument axis from the normal to the sample surface; deviations of the striker energy from the nominal value established for each type of instrument and for other reasons.

The error due to inaccuracies in measuring the indentation diameter, is determined by the quality of the measuring microscope employed.

The total error can be established for each type of instrument either by adding the partial errors, or from the deviation of the experimental hardness values from those obtained by testing various metal samples with different known hardnesses.

We determined the total error by both methods.

The absence of published data on the conditions under which the calibration relations between the static HB hardness and the diameter on the indentation were established in instruments of the impact type, led to the necessity of producing these curves for each instrument.