NEW PORTABLE HARDNESS TESTERS

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This article examines portable hardness testers for real-time determination of the hardness of large parts of complex form in different directions in space, in hard-to-reach places, and on flat and curved surfaces.

In recent years, the market for instruments designed to measure the hardness of metals has been expanded by the development of new domestic designs of portable hardness testers that make it possible to perform the measurements directly on products, under laboratory or factory conditions, and in different areas of machine-building, metallurgy, power generation, and other sectors.

Portable hardness testers are distinguished by their low weight, high accuracy and productivity in performing the measurements, and a convenience and ease of operation that makes special operator training unnecessary.

The main specifications of portable hardness testers are shown in Table 1.

Let us more closely examine the hardness testers listed in the table.

All portable hardness testers can be placed in one of two groups according to the method used to introduce the indenter into the specimen surface: quasistatic indentation; dynamic (impact) indentation.

The first group includes contact-impedance hardness tester KIT-M-01-1, which is designed to measure the hardness of products made of metals and alloys with an elastic modulus in the range from 70 to 350 GPa.

The principle of operation of the tester is based on measurement of the frequencies of free vibration of an acoustic resonator with a diamond Vickers pyramid subjected to a constant force of 9.8 N.

In contrast to "impact" methods, quasistatic introduction of the indenter makes it possible to measure the hardness of relatively small, thin-walled products, as well as large products of complex form under either shop or field conditions.

The tester contains a transducer and a measurement block connected by cable, an independent block (with a set of batteries) rigidly connected to the measurement block, and a network power supply.

The transducer consists of the acoustic resonator with diamond pyramid, a resonator exciting circuit, a contact element that applies a clamping force to the indenter, and a light-diode contact. Acoustic vibrations are excited and transmitted via piezoelectric elements built into the resonator. Attainment of the calibrated clamping force causes the light diode to be illuminated, and the transducer sends the data to the measurement block. The frequency of the acoustic vibrations is proportional to the hardness of the part being measured.

The measurement block of the hardness tester is a specialized microcontroller that analyzes data coming from the transducer and displays the measurement results on a four-bit display with 12-mm high numerals. The operation of the microcontroller is directed by means of a keyboard on the front panel of the instrument.

The controller allows for operation of the tester in the following regimes:
- measurement of hardness on Rockwell scale C in the range 20-70 HRC;
- measurement of hardness on the Brinell scale in the range 150-450 HB;
- tolerance-setting, with establishment of the upper and lower boundaries of the hardness values within the ranges of the HRC and HB scales;
- averaging of the results of from 2 to 16 measurements;
- automatic correction of temperature-related changes in the natural frequency of the acoustic resonator.

 Provision was also made for an indication of discharge of the batteries.

### TABLE 1

<table>
<thead>
<tr>
<th>Hardness tester</th>
<th>Measurement range</th>
<th>Measurement error</th>
<th>Time of one measurement, sec</th>
<th>Roughness of specimen surface $R_a$</th>
<th>Power supply</th>
<th>Dimensions, mm</th>
<th>Remarks</th>
<th>Capabilities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>iKIT-M-01-1</td>
<td>20—70 HRC 150—450 HB</td>
<td>2.5% for all ranges</td>
<td>8</td>
<td>1.25</td>
<td>Storage batteries or 220-V network</td>
<td>Electronic block $30 \times 75$; $180$; $22$; $154$</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>TEMP-2</td>
<td>22—68 HRC 100—450 HB 23—99 HSD 200—950 HV</td>
<td>2.5 HRC 15 HB 3.0 HSD 15 HV</td>
<td>5</td>
<td>2.5</td>
<td>Three power supply elements (4.5-V)</td>
<td>Electronic block $35 \times 95$; $125$; first transducer $22 \times 107$; second transducer $22 \times 87$</td>
<td>0.4</td>
<td>Determination of ultimate strength $R_m$, viewing and highlighting of measurement results</td>
</tr>
<tr>
<td>TPTs-4M</td>
<td>20—68 HRC 90—450 HB</td>
<td>2.0 HRC 15 HB</td>
<td>5</td>
<td>1.6</td>
<td>&quot;Nika&quot; batteries (9-V)</td>
<td>$125 \times 85 \times 45$</td>
<td>0.4</td>
<td>Measurement of hardness only in the vertical direction</td>
</tr>
</tbody>
</table>

The hardness-tester unit includes a kitbag, set of batteries, battery charger, set of hardness measures, and auxiliary gear: a support and a set of props and chocks to allow measurement of the hardness of parts of any configuration.

Testers TEMP-1, TEMP-2, and TPTs-4 are in the larger, second group of hardness testers, the operation of which is based on the rebound of a striker from the specimen surface.

Small portable electronic testers TEMP-1 and TEMP-2 are designed for quick measurement of the hardness of steels and alloys on the Brinell (HB), Rockwell (HRC), Shore (HSD), and Vickers (HV) scales. The range of application of these testers can also be expanded to other materials (such as cast irons and nonferrous metals).

Hardness testers TEMP-1 and TEMP-2 make it possible to measure hardness in any position in space and on flat, cylindrical, and concave surfaces with a radius of curvature of at least 15 mm. The impressions must be at least 3 mm apart. Hardness is determined on the basis of the ratio of the impact and rebound velocities of the striker.

Hardness testers TEMP-1 and TEMP-2 consist of a transducer with a striker and an electronic block. The striker includes a spherical hard-alloy indenter and a permanent magnet.

During the measurement, the striker impacts the surface of the specimen and rebounds from it. The permanent magnet included in the striker induces an emf in an induction coil that is proportional to the impact and rebound velocities. The emf is transmitted along a shielded cable to the electronic block.

The TEMP-1 and TEMP-2 models differ in the constructions of their electronic blocks.

In the TEMP-1, the signal from the striker is converted by the block into conditional three-digit units of hardness on a digital display. These units are then converted into the desired hardness number HB, HRC, HSD, or HV by conversion tables incorporated into the tester.

Hardness tester TEMP-2 is a more modern version of model TEMP-1.

Hardness tester TEMP-2 is equipped with two transducers of different sizes and an electronic block with a liquid-crystal display (LCD) that automatically converts the conditional hardness unit HL into the required units HB, HRC, HSD, and HV or ultimate strength $R_m$ (MPa). The HL scale shows the ratio of incident (impact) velocity to rebound velocity multiplied by 1000.

The display makes it possible to select the needed scale of hardness or ultimate strength and the position of the transducer relative to the specimen (from top to bottom, horizontal, from bottom to top) and to average the measurement results. The maximum and minimum values are ignored when the results are averaged.

The auxiliary equipment of the TEMP-2 tester includes a kitbag with a strap for convenient transport, a cable that connects the output of the tester with the input of the computer, and a diskette with a testing program that can read out the information stored in the tester.