Improvement of the method of relative measurements using a lever micrometer when setting up the end measures block

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Abstract. The foundations of the modern approach to quality management at enterprises also include elements of metrological support, which gives a certain effect from control. Universal measuring instruments for linear quantities are widely used in single and small-scale production, as well as in the repair of machines, it is with them that engineers first get acquainted when conducting laboratory measurements. Versatile measuring instruments also include a lever micrometer that can be used for absolute and relative measurements. The article discusses the issues of improving the method of relative measurements of deviations using a lever micrometer with deviations outside the measurement range of the reader, and provided that the tolerance does not go beyond the measurement. Using the technique of relative measurements with a lever micrometer will allow you to quickly perform a large number of measurements in a short time with the required accuracy.

1. Introduction

Metrological support of production is one of the urgent tasks of improving the quality of machine-building products [1, 2]. At present, new approaches to the repair and metrological support of production are being developed [3], measurement methods are being improved [4], and the calculation of losses at the tolerance of control products [5]. In addition, the accuracy normalization standards are improved.

Improving calculations in the field of accuracy standards, tolerances and landings of critical joints with gaps [6,7], with interference [8,9], as well as the use of new high-precision technological equipment leads to tougher tolerances, and in some cases - to the need to use incomplete methods interchangeability [10-12]. Consequently, the requirements for the accuracy of measuring instruments are also increasing [13]. In the repair industry, where universal measuring instruments are mainly used, for example, to control the crankshaft journal [14], the use of a conventional micrometer is already unacceptable, it already requires the use of a lever micrometer, the error of which is less. It is also recommended to use it for flaw detection of worn parts surfaces [15]. And when using the adjustment according to the end measurements, the error from the microscrew is eliminated, which can further increase the measurement accuracy, which will reduce the losses during control [16, 17].
2. Method of relative measurements with a lever micrometer

The lever micrometer is one of the unique measuring instruments that can be used for both absolute and relative measurements. To determine the actual deviation from the nominal size, use the lever micrometer for parts whose tolerance value does not exceed the reading range of the reader.

The device can be configured to detect the actual deviation from the nominal size in two ways:

- by the block of end measures;
- by micro screw.

Let us consider the technique of adjusting a lever micrometer using gage blocks. When adjusting the micrometer with finite measures, it is not necessary to calibrate and zero the micrometer.

Select the size of the final measure block according to the following recommendations. If the maximum absolute value of the limit deviation does not exceed half of the reference range of the reference device, it is recommended that the device be adjusted to the size of the end measure block \( L_{bl} \) equal to the nominal size \( d_n \):

\[
L_{bl} = d_n. \tag{1}
\]

If the size tolerance is less than the reading range of the reader, and one of the maximum deviations exceeds half of the reading range, then the block of finite measures is selected equal to the average size:

\[
L_{bl} \approx d_a = \frac{d_{max} + d_{min}}{2}. \tag{2}
\]

The limit values of the deviations of the part from the dimensions of the end measuring unit are determined and the deviation indicators are set in accordance with them:

\[
es' = d_{max} - L_{bl}, \tag{3}
\]
\[
ei' = d_{min} - L_{bl}. \tag{4}
\]

Determine the deviation of the block of end dimensions from the nominal:

\[
e_{el} = L_{bl} - d_n. \tag{5}
\]

By rotating the micro screw, the measuring surfaces of the heels are raised to a position where the end measures can freely fit between them.

Between the measuring surfaces of the heels, a block of end measures is inserted and, by rotating the drum, the scale arrow is set to zero. Fix the micro screw with a locking ring (stopper). When the stop is pressed, the block of measuring blocks is removed, and the measured part is inserted instead.

The actual deviation of the part size is calculated as the algebraic sum of the deviation of the block size of the end measures from the nominal size \( e_{el} \) and the reading of the reader arrow when measuring \(- X\):

\[
e_x = e_{el} + X. \tag{6}
\]

The part is considered suitable if the actual deviation is within the tolerance. With this approach, the time for monitoring is significantly reduced, since you do not need to turn the micro-screw and read the readings on it. And when you use the adjustable arrows on the scale of the device, the control process will be even faster.

3. Results of relative measurements using the lever micrometer when setting up the end measures block

Let's consider the measurement method using the example of controlling the dimensions of parts with different deviations (table 1) with a lever micrometer MP-50.
Table 1. Controlled dimensions with deviations.

| Symbolic size designation (mm) | Designation of dimensions with deviations (mm) | Maximum allowed size (mm) | Minimum allowable size (mm) | Size tolerance (μm) | Permissible measurement error (μm) |
|--------------------------------|----------------------------------------------|---------------------------|-----------------------------|---------------------|----------------------------------|
| 1 30 f 7                        | 30−0.010 0.014                               | 29.980                    | 29.959                      | 21                  | 6                                |
| 2 30 g 7                        | 30−0.007 0.028                               | 29.993                    | 29.972                      | 21                  | 6                                |
| 3 30 j 7                        | 30+0.013 0.008                               | 30.013                    | 29.992                      | 21                  | 6                                |
| 4 30 c 7                        | 30−0.010 0.013                               | 29.890                    | 29.869                      | 21                  | 6                                |
| 5 30 d 7                        | 30−0.008 0.026                               | 29.935                    | 29.914                      | 21                  | 6                                |
| 6 30 e 7                        | 30−0.004 0.001                               | 29.960                    | 29.936                      | 21                  | 6                                |
| 7 30 h 7                        | 30−0.021                                     | 30.000                    | 29.979                      | 21                  | 6                                |
| 8 30 p 7                        | 30+0.043 0.022                               | 30.043                    | 30.022                      | 21                  | 6                                |
| 9 30 k 7                        | 30+0.023 0.002                               | 30.023                    | 30.002                      | 21                  | 6                                |
| 10 30 m 7                       | 30+0.029 0.008                               | 30.029                    | 30.008                      | 21                  | 6                                |

Adjust the lever micrometer for relative measurement. Measure the size and deviation. Record the measurement results in table 2.

Table 2. The results of the measurements.

| End measure block size (mm) | Deviation of the end size block from the nominal dimensions (mm) | Readings of the arrow of the reader during measurement | The actual deviation when setting the device according to the end measures (mm) | Actual size (mm) | Measurement error (μm) | Conclusion of suitability |
|-----------------------------|------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------------|-----------------|------------------------|--------------------------|
| 1                           | 29.97                                                            | +0.004                                               | −0.026                                                                      | 29.974          | 4.5                    | suitable item            |
| 2                           | 30                                                               | −0.030                                               | −0.030                                                                      | 29.970          | 4.5                    | unsuitable item          |
| 3                           | 30                                                               | +0.002                                               | +0.002                                                                      | 30.002          | 4.5                    | suitable item            |
| 4                           | 29.88                                                            | +0.007                                               | −0.113                                                                      | 29.887          | 4.5                    | suitable item            |
| 5                           | 29.92                                                            | +0.007                                               | −0.073                                                                      | 29.927          | 4.5                    | suitable item            |
| 6                           | 29.95                                                            | −0.014                                               | −0.064                                                                      | 29.936          | 4.5                    | unsuitable item          |
| 7                           | 30                                                               | −0.013                                               | −0.013                                                                      | 29.987          | 4.5                    | suitable item            |
| 8                           | 30.03                                                            | −0.009                                               | +0.021                                                                      | 30.021          | 4.5                    | unsuitable item          |
| 9                           | 30                                                               | +0.017                                               | +0.017                                                                      | 30.017          | 4.5                    | suitable item            |
| 10                          | 30                                                               | +0.015                                               | +0.015                                                                      | 30.015          | 4.5                    | suitable item            |

In figure 1 shows a diagram for measuring size; the circuit for taking other measurements will look similar.
Relative measurements with a lever micrometer, provided that the tolerance does not exceed the measurement limits, can be carried out fairly quickly. To do this, it is necessary to adjust the device according to the block of measuring blocks to the nominal or average size, after which it will be possible to carry out a large number of measurements and process the results. As a result, we will save time and material resources, which is especially important at the present time.

4. Conclusion
Thus, the method of adjusting the lever micrometer is determined in case of deviations outside the measurement range of the reader, and provided that the tolerance does not exceed the measurement limits.

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Figure 1. Dimension measurement implementation diagram $30 f^{730^\circ} 0.020$. $-$ 0.041 $-$ 0.020.
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