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MEASUREMENT METHODS FOR ERROR ANALYSIS

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Abstract: *It is necessary to reduce the individual measurement error as much as possible. For this purpose, it is necessary to know the description of the measurement error and at least a list of the main factors that affect the amount of error in the measurement result.*

Measuring a quantity is the process of comparing it with another quantity that is accepted as a unit of measurement that is homogeneous with it. For example, when measuring wear, an operation is performed to find out how many times the decrease or increase in diameter, thickness, or other linear dimension (including the length of a circle) is greater or smaller than the accepted unit of measurement of millimeters or micrometers. Since the measurement result cannot be absolutely accurate, it is necessary to know the description, classification, and main factors affecting the measurement result of experimental errors.

Keywords.

Size, types of sizes, measurement errors, measuring instrument, error, absolute error, relative error, calibration, random errors, accuracy index,

Login.

As a result of a measurement, a value is usually found that differs from the true value of the quantity being measured. Often, the true value of a physical quantity is unknown, and instead of this value, its experimentally determined values are used. This value is so close to the true value of the quantity that it can be used for the intended purpose. The value of the quantity found by the measurement method is called the measurement result.

The difference between the measurement result and the true value of the quantity being measured is called measurement error. The error of the measurement method is understood as an error that arises due to the imperfection of the method. They often appear when using new methods, when equations are used that approximate the true relationship between values. The error of the measurement method must be taken into account when assessing the errors of the measuring instrument, in particular the measuring device, and sometimes the measurement result.

Error size The set of factors in a measurement depends on the measurement conditions, which are determined by the probability of their constancy.

The set of factors includes: the person performing the measurement; the object of observation; the instrument used in the measurement; and the external environment.

Since the quantity being measured and the unit of measurement are almost always of unequal magnitude, it is necessary to determine some fraction of the unit of measurement. Even when measurements are made with great care and precision using the most sophisticated instruments, errors are bound to occur.

Measurement errors are the differences between the values obtained during the

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measurement process and the true values. The following methods are widely used to calculate errors :

1. Absolute error is the difference between the measurement result and the true value. Formula:

$$\Delta = \boldsymbol{X_{o'lchangan}} - \boldsymbol{X_{haqiqiy}}$$

Here:

X – measured value

X – actual value

2. Relative error is an indicator of the absolute error in percentage terms relative to the true value. Formula:

$$\boldsymbol{E_{nisbiy}} = \frac{\Delta}{\boldsymbol{X_{haqiqiy}}} \times \mathbf{100}\ \%$$

3. The average error determines the average value of the absolute errors between several measurements. The formula:

$$\Delta = \frac{\sum_{i=1}^{n} X_{o'lchangan,i} - X_{haqiqiy}}{n}$$

Here:

n – number of measurements

4. Standard deviation. If there is a dispersion in the measurement results, the standard deviation is determined. Formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(X_{o'lchangan,i} - X)^2}{n-1}}$$

Here:

X – average measured value

Example:

Actual value X $_{actual}$ = 50

Measurement results: 48, 51, 49, 52

1. Absolute errors:

|48 - 50| = 2, |51 - 50| = 1, |49 - 50| = 1, |52 - 50| = 2

2. Average error:

$$\Delta = \frac{2+1+1+2}{4} 1.5$$

3. Relative error (average):

$$E_{nisbiy} = \frac{\Delta}{50} \times 100\% = 3\%$$

4. Standard deviation:

$$X = \frac{48+51+49+52}{4} = 50$$

Let's solve a detailed example of measurement errors.

the true value X $_{true}$ =100, and the measurement results be 95, 98, 102, 101, 99. We calculate the following errors:

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1. Absolute errors
2. Relative errors
3. Average error
4. Standard deviation

1. Absolute errors

Absolute error is the difference from the true value for each measurement. Formula:

$$\Delta_i = |X_{o'lchangan,i} - X_{haqiqiy}|$$

For each measurement we calculate:

$$\Delta_1 = |95 - 100| = 5$$

$$\Delta_2 = |98 - 100| = 2$$

$$\Delta_3 = |102 - 100| = 2$$

$$\Delta_4 = |101 - 100| = 1$$

$$\Delta_5 = |99 - 100| = 1$$

Absolute errors: 5,2,2,1,1.

2. Relative errors

We calculate the relative error for each measurement using the following formula:

$$E_{nisbiy,i} = \frac{\Delta}{X_{haqiqiy}} \times 100\%$$

For each measurement we calculate:

$$E_{nisbiy,1} = \frac{5}{100} \times 100\% = 5\%$$

$$E_{nisbiy,2} = \frac{2}{100} \times 100\% = 2\%$$

$$E_{nisbiy,3} = \frac{2}{100} \times 100\% = 2\%$$

$$E_{nisbiy,4} = \frac{1}{100} \times 100\% = 1\%$$

$$E_{nisbiy,5} = \frac{1}{100} \times 100\% = 1\%$$

Relative errors: 5

3. Average error

We calculate the mean absolute error as follows:

$$\Delta = \frac{\sum_{i=1}^{n} \Delta_i}{n}$$

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Here n = 5, the sum of the errors is:

$$\sum_{i=1}^{5} \Delta_i = 5 + 2 + 2 + 1 + 1 = 11$$

Average error:

$$\Delta = \frac{11}{5} = 2.2$$

4. Standard deviation

The standard deviation indicates the degree of dispersion.

Formula:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(X_{o'lchangan,i} - X)^2}{n-1}}$$

The first step is to find the average value:

$$X = \frac{\sum_{i=1}^{n} X_{o'lchangan,i}}{n}$$

$$X = \frac{95 + 98 + 102 + 101 + 99}{5} = 99$$

Now we find the squared difference of each value from the mean:

$(95\text{-}99)^2 = (-4)^2 = 16$

$(98\text{-}99)^2 = (-1)^2 = 1$

$(102\text{-}99)^2 = (3)^2 = 9$

$(101\text{-}99)^2 = (2)^2 = 4$

$(99\text{-}99)^2 = (0)^2 = 0$

Sum of squared differences:

16 + 1 + 9 + 4 + 0 = 30

Standard deviation:

$$\sigma = \sqrt{\frac{30}{5-1}} = \sqrt{\frac{30}{4}} = \sqrt{7.5} \approx 2.74$$

Results:

1. Absolute errors: 5,2,2,1,1
2. Relative errors: 5
3. Average error: 2.2
4. Standard deviation: 2.74

Overall result:

The measurements given are close to the true value and the error rate is small. This indicates that the accuracy of the measurement process is high. By identifying and evaluating errors, the quality of the measurement can be improved or the accuracy can be analyzed.

Conclusion:

1. Absolute error – refers to the difference between each measurement and the true value. In the example, the largest absolute error is 5, and the smallest is 1. This indicates that the accuracy of the measurements is good.

2. Relative error – the absolute error expressed as a percentage of the true value. The largest

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relative error in the measurements was 5, and the smallest was 1. This means that the measurement results are very close to the true value.

3. Average error – the average of all errors 2.2. This reflects the level of overall measurement error and confirms that the values are close to the true result.

4. The standard deviation is 2.74, which indicates the degree of dispersion of the measurement results. This dispersion is not large, which means that the measurements are close to each other and reliable.

Measurement errors are inevitable in any measurement process, and their identification and analysis make the results more reliable. To reduce errors, it is necessary to correctly select technical means and improve measurement methods.

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