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## **Method of evaluating the characteristics of measurement accuracy of moment of inertia of electric motors**

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**Abstract.** Proposed a method for evaluating the characteristics of accuracy allows the transformation equations based on analytical expressions for the additive and multiplicative errors and explore their characteristics change depending on the different values of the measurement range and influencing parameters.

**Keywords:** accuracy of measurement, method of estimation accuracy, moment of inertia, electric motor.

**Statement of the problem.** In tests electric motor on regulatory compliance a key parameter is the rotational moment of inertia. Based on the moments of inertia are calculated many other rotational parameters of an electric motor (EM). The most important of these are dynamic moment, the moment of resistance, and so on [1].

The development of measurement and study of their metrological characteristics is an actual scientific problem for every exact measurement (test), especially during the tests, the EM and the study of their quality. In this regard, there is a need to develop a qualitatively new means of measurement (MM), the moment of inertia, which correspond to the modern development of science and technology, as well as studies of their basic metrological parameters for the synthesis of this type of MM from normalized metrological characteristics.

**Analysis of research and publications.** Given the well-known analytical expression for finding the moment of inertia, which is given in references [1, 2], we write the transformation of MM inertia as

$$N_J = \frac{2 \ln \left( \frac{M_k^2 \xi^2}{e r^4 C \Delta \delta} \right)}{P T_0} J, \quad (1)$$

where  $N_J$  – number of pulses at the input timer-counter MM moment of inertia for a time interval of free oscillations of the rotor EM (initial value);

$M_k$  – torque at slip  $S = 1$ , which is described by Kloss [1];  $l$  – length of the measuring arm;  $\xi$  – modulus of elasticity of the membrane sensor efforts (SE);  $h$  – thickness of the membrane SE;  $e = 0.17$ ;  $r$  – the radius of the membrane SE;  $C$  – stiffness SE;  $\Delta \delta$  – Normalized value absolute error

transducer (in particular, the accuracy SE);  $J$  – moment of inertia is measured (input value);  $\alpha$  – coefficient of damping;  $T_0$  – period model pulses, which is filled with time measurement of the moment of inertia after the completion of the transition process (with and without power and electric motor torque reduction of the value of  $M_k$  to zero).

The aim is to create models of basic metrological static characteristics of MM inertia and research on the basis of their metrological characteristics that will identify the reasons for the increased errors, correct them by taking into account deviations investigated and synthesized MM inertia with normalized metrological characteristics.

**Findings.** In operating conditions pollutants inertia carries functional transformation informative parameter  $J$  (moment of inertia) to the number of pulses, which are calculated over a time interval meter free vibration rotor EM  $N_J$ . In addition to an informative signal on him are influencing variables which include all the other parameters that have a direct connection with the original value and attract emergence uninformative component transformation. From equation of (1) that the process of converting information parameter  $J$  in output affects a large number of influencing factors. But due to the fact that almost all the values are the same, and shall be measured at the EM deenergized when the value of the torque value changes from  $M_k$  to zero, then it is reasonable to study the torque is affected as the influence quantity on the measured moment of inertia (information parameter).

To obtain metrological models of basic static characteristics of MM inertia expand transformation equation (1) in a Taylor series, which will take the form

$$N_J = N_{J_0} + \left[ \frac{\partial N_J}{\partial J} \right]_t J + \frac{1}{2!} \left[ \frac{\partial^2 N_J}{\partial J^2} \right]_t J^2 + \frac{1}{3!} \left[ \frac{\partial^3 N_J}{\partial J^3} \right]_t J^3 + \dots + \left[ \frac{\partial N_J}{\partial M_k} \right]_t J \Delta M_k + \left[ \frac{\partial N_J}{\partial M_k} \right]_t \Delta M_k + \frac{1}{2!} \left[ \frac{\partial^2 N_J}{\partial M_k^2} \right]_t \Delta M_k^2 + \dots, \quad (2)$$

where  $N_{J_0}$  - free term of the expansion of space equal to the output signal

at zero input value ( $N_{J_0} = 0$  for  $J = 0$ );  $\left[ \frac{\partial N_J}{\partial J} \right]_t$  -

Sensitivity MM inertia ( $S_J$ );  $\left[ \frac{\partial^2 N_J}{\partial J^2} \right]_t$  - Changing the MM of inertia ( $S_J'$ );  $\left[ \frac{\partial N_J}{\partial M_k} \right]_t$  -

The rate of change of sensitivity MM moment of inertia ( $S_J''$ );  $\left[ \frac{\partial N_J}{\partial M_k} \right]_t$  - The combined effect of the influence quantity the rated sensitivity ( $\alpha_{M_k}$ );  $\Delta M_k$  -

Change (deviation) of the normalized influence quantity (graded) torque  $N_J$ ;  $\frac{\partial N_J}{\partial M_k}$  - influence factor affecting the value to the output ( $\beta_J$ );  $\frac{\partial N_J}{\partial M_k^2}$  - The rate of change of the coefficient of influence affecting the value on the output signal ( $\beta_J'$ ).

Analytical expression for the sensitivity characteristics of MM research inertia is given by

$$S_J = \frac{\partial N_J}{\partial J} = \frac{2 \ln \left( \frac{M_k \theta^2}{E r^4 C \Delta \delta} \right)}{P T_0} \quad (3)$$

Metrological additive model error in the changing influence quantity  $M_k$  by value (value)  $\Delta M_k$  is the sum of the last two terms of the Taylor series, presented in equation (2) and is described by the following analytical expression

$$\Delta N_{add} = \beta_J \Delta M_k + \frac{1}{2} \beta_J' \Delta M_k^2 = \frac{2J}{M_k P T_0} \Delta M_k - \frac{J}{M_k^2 P T_0} \Delta M_k^2 \quad (4)$$

Metrological model multiplicative uncertainty in the changing influence quantity  $M_k$  to the value (value)  $\Delta M_k$  is the fifth term of the Taylor series, which is represented in equation (2) and is described by the product of the combined effect of to reject the influence quantity  $\Delta M_k$  the normalized value and the input value (moment of inertia J)

$$\Delta N_{mult} = \alpha_{mult} \Delta M_k J = \frac{2J}{M_k P T_0} \Delta M_k \quad (5)$$

On the basis of metrological models can investigate their properties by changing the nominal values impact the variables at different measurement ranges, as well as rejected options impact the values of the nominal values. Characteristics of additive and multiplicative changes of errors since the measuring device and are shown in Figures 1 - 2.

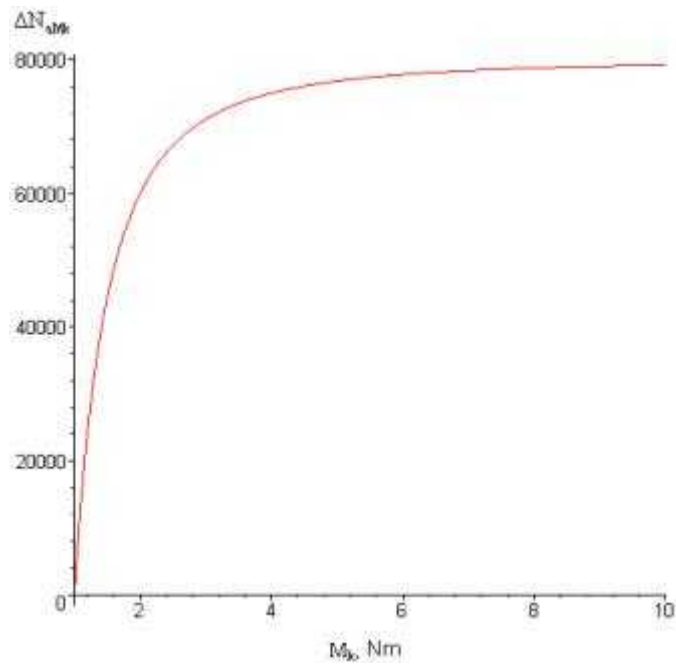


Figure 1 - Characteristic changes of the additive error

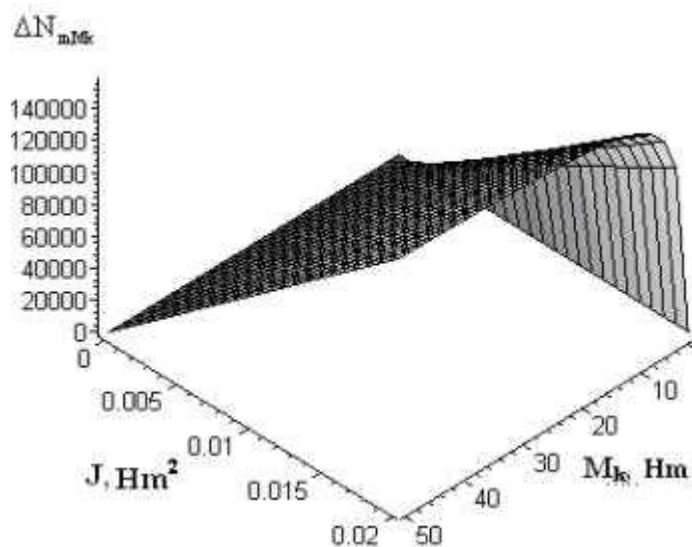


Figure 2 - Surface changes multiplicative error MM moment of inertia in changing influence quantity  $k$ :  $\Delta N_{mMk}$  - the number of pulses, the latter corresponding to the multiplicative error;  $J$  - moment of inertia;  $k$  - torque

**Conclusions.** Proposed a method for evaluating the characteristics of measurement accuracy, which allows on the basis of the Taylor series expansion transformation equations to obtain metrological chuvstvitelnosti models, additive and multiplicative errors. On the basis of these models can be synthesized by means of measurements with valuations metrological characteristics.

## Literature

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