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GENERALIZED PARAMETER OF TECHNICAL OBJECTS OPERATION MODES MONITORING

A new mathematical equation of generalized parameter is offered, that allow to obtain the most effectively estimation of a stock of functional reliability of technical object operation modes.

Keywords: functional reliability, generalized parameter, metric space, central control room

Centralizing of monitoring and control of complex technical objects set operators of central control room (CCC) before the necessity of simultaneous monitoring of a large number of physical parameters of a different nature that characterize the objects operation modes. This is complicated the analysis and estimation of their state and the operations of the operative management [1].

Therefore, for providing of the effective monitoring of the object operation from the CCC operator should not be overloaded much information, and at the same time, he should form a comprehensive picture of the state of the whole object of monitoring. For that it could use the special parameter that fully characterizes all the major part of the working process [2]. However, this parameter is usually difficult found, in this case it is possible to use the principle of a generalized parameter Коп [3].

The idea of generalized parameter consists in the fact, that object operating process characterized by the multidimensionality of description is changed by a one-dimensional function. This function is constructed artificially, usually does not have a specific physical sense, because, all ways of defining of generalized parameter are based on the use of combination of normalized numerical characteristics of the parameters characterizing the object technical state.

There are the requirements to the generalized parameter:

1. The Коп should be able to obtain a generalized estimation of the object technical state.

2. The Коп must be very informative, because it allows to examine the enough large volume of information and sharply to abbreviate the large arrays of information, doing them as complex and evident.

3. At taking of information array in Коп should not lose the individual traits of separate parameters of object.

4. The Коп should reproduce the impact on the object of different nature parameters.

5. Each of the factors directly is connected with a specific chain of transmission, that or other external disturbance. Changing any of the parameters leads to the change of the Коп.

There are many mathematical equations of generalized parameter Коп, but they are all based on the principle of average size, and therefore have the disadvantages that are difficult to compensate, for example, the fluctuation of the parameters for which there is a simultaneous reduction of some parameter and increasing of other one in the same amount of time, as a result a generalized parameter does not change its value, that reduces its information [3].

The purpose of this paper is to obtain a mathematical equation for Коп, reproducing the peculiarities of the investigated objects. To develop the such parameter the property of a metric space is used. To get away from the shortcomings of generalized parameter that is implemented by the principle of average size, the equation for Коп is found, which on the basis of dialectical understanding, has the properties of general and individual categories. As a result, the equation for the definition of a generalized parameter Kop having the following form:

$$K_{ОП} = \frac{(\prod_{i=1}^{n} \hat{x}_i^{\mu_i})n^{\frac{1}{2}}}{\left[\sum_{i=1}^{n} \left(\hat{x}_i^{\mu_i}\right)^2\right]^{\frac{1}{2}}} \quad (1)$$

where: i- number of parameters;

$\hat{x}_i$ - a normalized value of parameter;

μ_i - the weight of each parameter;

n - the number of parameters taken into account.

The physical meaning of Коп consists in that: its numerator is the area or volume in a multidimensional space depending on the number of parameters and varies according to a quadratic (two parameters), cubic (three parameters) or n-dimensional (for n - parameters) dependence, and the denominator is the length of the diagonal of the figure varies according to a linear relationship.

Due to the fact that one or the other operation mode of a technical object is characterized by various physical parameters (pressure, temperature, voltage, frequency, etc.) which have different dimensions, all parameters are reduced to a single numbering system, in which they can be compared. Such a system is the dimensionless (normalized) relative notation.

If for each parameter x_i , $i = 1 \ldots n$, there is an opportunity to select the current value $x_i\ (t)$, the permissible value x^*, at which the object loses efficiency, and optimal (nominal) $x_{опт}$, the dimensionless parameter can be written as [3]

$$\hat{x}_i(t) = \frac{x_i(t) - x^*}{x_{опт} - x^*}\ , \quad \text{где:} \ \ 0 \le x_i(t) \le 1 \quad (2)$$

When $x_i\ (t) = x_{opt}$ - normalized value will be equal to one $\hat{x}_i(t) = 1$; when $x(t) = x^*$ - normalized value will be zero $\hat{x}_i(t) = 0$. With the help of equation (2), parameter $x_i\ (t)$ is normalized, and the dimensionless normalized value changes over time from 1 to 0. From here on the size of parameter $\hat{x}_i$ it is possible to see about the reserve of object operability to this parameter in the mode.

Quantitative parameters changes are not equivalent on the degree of impact on the object operation mode change, so they are differentiated in importance. The degree of influence of each parameter on the operating mode of the object is estimated by the introduction of positive weighting coefficients of controllable parameters which can be determined, for example, by the method of expert evaluations.

For object parameters $x_1, x_2, ..., x_n$ is corresponding the weights coefficients џ$_1$, џ$_2$ …, џ$_n$, which satisfy some given criteria, where 0 <џ$_i$ <1. The weighting coefficients џ$_i$, having the largest value within the parameters that have the greatest impact on the continuity of the object, and therefore on the coefficient of generalized parameter.

Let us assume that the system is controlled by two parameters x_1 and x_2 for which you want to define a generalized parameter (Fig. 1).

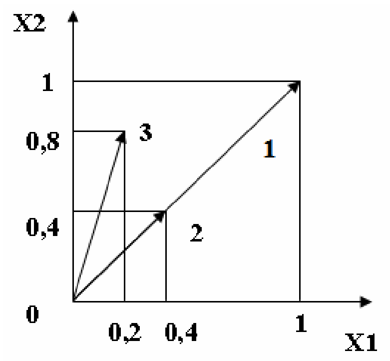

Fig. 1 - Graphic representation of the generalized parameters:
1- nominal mode 2, both parameters have the same values,
3- one parameter increased and another one decreased 2 times as much

It is obvious, that a change of the object mode will change the value of the generalized parameter Коп. The increase of the generalized parameter indicates an increase in the stock of functional reliability of the operating mode of the object and its reduction is vice versa. Therefore, knowing the boundary change within the Коп parameters (they are regulated by the normative documents), it is possible to quantify the supply of functional reliability of the object operation mode.

Any change of the parameter x_i change a vector of coordinates, and hence the diagonal shape, so the same area (volume) will be different diagonals, and hence the values of their relationships (Коп). This property allows to get rid of such negative properties as fluctuations. In the proposed equation for Коп fluctuations do not affect on the parameter value at the expense inherent in it the principle of changing the ratio between variations in area (volume) of the figure and its diagonal, which allows to detect the parameters

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changes in that or either side of the mean one and the same amount for the ratio of the area (volume) of the figure. Due to the existing law, at a linear increasing of the diagonal, the area (volume) changes according to the quadratic (cubic or n - dimensional dependence) dependence.

To confirm the above mentioned it will compare two cases. In the first case assume that $x_1 = x_2 = 0{,}4$. The length of the hypotenuse in this case is 0.52, and the area is equal to 0.16. Assume that in the second case the parameter x_1 halved $x_1 = 0{,}2$, and the parameter x_2 doubled $x_2 = 0{,}8$. The length of the hypotenuse in this case increases, and equals 0.82, and area remain unchanged 0.16. As can be seen from the above example, when areas equal in the first and second case, a significant deviation from the parameters resulted in a significant deviation of the hypotenuse, and hence a change in the Коп. If any parameter in the equation for Коп overrunning the setting limits $\hat{x}_i(t) = 0$, then Коп = 0. Based on the physical sense when reaching zero by any of the normalized parameters $\hat{x}_i$ object loses reliability margin. From equation (2) for the generalized parameter implies that the component $n^{1/2}$ allows to take Коп = 1 in normal mode, that corresponds to the physical sense.

From the analysis of mathematical equation for Коп is evidently, that than the nearer generalized parameter to unit, then the supply of functional reliability (stability) of the object operation mode is higher, and than nearer Коп to the zero, then this supply is smaller. Thus: at all $\hat{x}_i$ =1, the generalized parameter will be equal to unit: Коп=1 (normal mode), at any $\hat{x}_i = 0$ the generalized parameter will be equal to zero: Коп = 0 (pre-alarm mode).

Movement of Коп locus vector in the state space describes a certain trajectory, which allows to investigate the behavior of the object in the past, present and future, that is the generalized parameter allows to specify not only the stock performance of multi-parameter object in the investigated mode, but also to trace the variation of its performance over time.

In conclusion it is possible to draw a conclusion about the high information content of this equation for a generalized parameter, the application of which will get an idea about the complex object operation and will estimate the stock of its functional reliability in various modes.

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