Operative Benchmarking Same Type Technical Objects

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Abstract

Objects, with the same identical varieties of attributes belong to the same-type. One of the main tasks of benchmarking is objective comparison and ranging of work efficiency. In modern representation, work efficiency is the integrated property consisting of profitability, reliability and safety. In general, the work efficiency is characterized by tens technical and economic indicators. For new objects reliability and safety of work guaranteed at relevant rules and guidelines. And the work efficiency is characterized by one of economic parameters. For example, on thermal power stations this is the specific consumption of equivalent fuel. If the of service life of the main equipment exceeds of normative value, the guaranteed term of compliance of the reliability and safety with the requirements is completed. Comparison and ranging of the same technical objects in these conditions without change of methodology leads to increase in risk of erroneous decisions and occurrence of system failures with inadmissible consequences. Decrease in risk of the erroneous decision reached by transition to calculation of an integrated parameter of work efficiency. At the same time, it turns out to be necessary to overcome the numerous difficulties caused by distinction of dimensions and scale of individual parameters, presence of interrelation and differences in the direction of change, multidimensionality and small number of realizations, bulkiness and laboriousness. An indispensable condition is the development of the automated systems of information and methodical support of the personnel and the Management of objects.

Keywords. Benchmarking, same type of technical object, work efficiency, integral parameter, profitability, reliability, safety.

I. Introduction

The opportunity of objective ranging of the same technical objects for their work efficiency defines one of the most important problems of the organization of operation, maintenance service and repair [1]. For example, the ranking of power units of thermal power stations (TPS) allows you to reduce the risk of the erroneous decisions when distributing the load, planning of diagnostics of a technical condition, conducting routine and major overhauls and requires the ability to compare objects, i.e. conduct their benchmarking [2].

Today, as many years ago, comparison of the same type objects spent mainly on one of technical and economic indicators (TEI). For example, on TPS - this is a specific consumption of equivalent fuel. But, the specific consumption of equivalent fuel partially characterizes only one of components of work efficiency - economic efficiency. Accepted, that two others components - reliability of work and safety of service guaranteed when the relevant Rules and guidelines are execute. And this guarantee operates, as always, only during normative service life. The consequences from "neglect" to reliability and safety, when exceeding the service life of objects of normative value, shown in system failures, accompanied by the death and injury the personnel, infringement of ecology, greater material inputs [3].

There are two ways of maintenance of work efficiency of technical objects, which service life exceeds calculated are possible. The first and simplest - to replace object on modern and effective. But input of modern objects of the big capacity demands scale concentration of financial and other resources, otherwise it is beyond the strength even to many economically developed countries. The second way is modernization. Though modernization demands in (3-4) times of less cost, than replacement, the absolute value of these costs is still extremely great.

It is supposed to "legitimize" the third method, which provides for partial modernization of objects (replacement of auxiliary equipment and devices) and rapid assessment not only profitability of object, but also its reliability and safety. It also requires the comprehension that process of ageing (technical and moral) cannot stopped. The most important task in this is development of computer technology for operational (average monthly) estimation of integrated parameters of work efficiency and methodical support of a Management by way of increase of work efficiency of object [4].

Multidimensional character of the numerous indicators characterizing work efficiency of technical objects, determines multidimensionality of difficulties of objective comparison and ranging of work efficiency of objects (difficulty in benchmarking a technical object). Some of these difficulties overcome, the some people are overcome, and up to the some people still «do not reached the hands». The method of calculation integral indicator of operative work efficiency among of overcome difficulties. Recommendations by calculation of an integral indicator is based on summation TEI and calculation of their average arithmetic value [5, 6] in view of distinction of their units of measure, scale, the importance, directivity and other factors.

At the same time, it known, that as TEI can significantly differ from each other, their arithmetic mean value not always objectively reflects character of distribution composed [7]. Consequently, the risk of the erroneous decision when comparing and ranking such integral indicators of operative work efficiency is unacceptable. In these conditions, recommended to use not the arithmetic mean, but the geometric mean of the normalized TEI values. This recommendation has found the greatest reflection in a method of curves of Harrington's desirability [8]. The method has found wide application in psychology, ecologies, economy, and medicine and in other fields. The estimation of character of a divergence of integrated indicators concerns to number of difficulties (calculated as average geometrical mean) at classification of statistical data on versions of attributes.

II. Estimation integrated indicators of operative work efficiency.

Suppose, that in a considered interval of time tj (possible intervals: shift, day, month, etc.) operative work efficiency *n* the same type objects is characterized *m* TEI. According, on these data the integrated indicators [$Ip(t_j)$] operative work efficiency as an mean geometrical [$G^*(t_j)$] *m·n* relative deviations TEI from normative (factory) value $\delta P_{i,k}(t_j)$ can be calculated by the formula

$$Ip^*(t_j) = G^*(t_j) = \sqrt[m]{\prod_{i=1}^{n}\prod_{k=1}^{m}[1-\delta P_{i,k}(t_j)]} \tag{1}$$

According, on the same data as a result of their classification on *n* to objects, we calculate the integrated indicators of an operative work efficiency of everyone i-th object $[Ip^*_{o,i}]$ and the integrated indicators characterizing the operative importance of everyone TEI of objects $Ip_{n,m}(t_j)$ by the formula:

$$Ip^*_{o,i}(t_j) = G^*_{o,i}(t_j) = \sqrt[m]{\prod_{k=1}^{m}[1-\delta P_{i,k}(t_j)]} \tag{2}$$

$$Ip^*_{п,к}(t_j) = G^*_{п,к}(t_j) = \sqrt[n]{\prod_{i=1}^{n}[1-\delta P_{i,k}(t_j)]} \tag{3}$$

The relative deviations of the TEI are calculated by the formulas:

$$\left.\begin{aligned} \delta P_{i,k}(t_j) &= \frac{\overline{P_k^f} - P_{i,k}}{\overline{P_k^f} - \underline{P_k^f}} \qquad \text{at } A=0 \\ \delta P_{i,k}(t_j) &= \frac{P_{i,k} - \underline{P_k^f}}{\overline{P_k^f} - \underline{P_k^f}} \qquad \text{at } A=1 \end{aligned}\right\} \tag{4}$$

where: $\overline{P_k^f}$ and $\underline{P_k^f}$ - accordingly the upper and lower boundary values of the fiducial (f) interval of possible values of realizations of the k-th TEI ($P_{i,k}$); A - the indicator of the direction of change of work efficiency.

It is necessary to note, that factors $[1-\delta P_{i,k}(t_j)]$ with i=1,n and k=1,m characterize value of a residual resource. The values $G^*(t_j)$ and $G^*_{o,i}(t_j)$ - are the geometric mean of the residual resource of the average and concrete object. $G^*_{P,k}(t_j)$ - the importance concrete TEI. They have a visual physical sense.

Since the realizations TEI in an interval t_j are a result of influence of some attributes and their varieties (serial numbers of objects and them TEI, loading, a season, service life, etc. attributes), they considered as random variables. Consequently, casual character of change accompanies also to integrated parameters $Ip^*(t_j)$, $Ip^*_{o,i}(t_j)$, $Ip^*_{P,k}(t_j)$. In these conditions observable between objects of a divergence, also as well as the divergence in estimations of importance TEI may be insignificant and classification by a given type of sign is inexpedient.

III. Results of calculating of boundary values the fiducial interval of integral indicators

The method and algorithm for calculation the fiducial distributions of the indicators, characterizing the dispersion *r* of random variables with uniform distribution in an interval [0, 1] given in [9]. The method and algorithm of calculation the fiducial distribution of the geometric mean of these random variables $G^*_r(\xi)$ is practically similar, c that difference, that the parameter $G^*_r(\xi)$ is calculated under by the formula $G^*_r(\xi)=\sqrt[r]{\prod_{i=1}^{r}\xi_i}$. The method is reduced to multiple modelling of possible realizations $G^*_r(\xi)$, ranging of these realizations in ascending order and estimations of probability of occurrence of everyone *(i)* realizations under by the formula $F^*_i[G^*_r(\xi)]=i/N$, where N - number of modeled realizations $G^*_r(\xi)$.

The analysis of results of modelling allows to conclude:

3.1. As one would expect, with increase *r* the spread of realizations $G^*_r(\xi)$ decreases, in other words, the sizes of the fiducial interval decrease. The following relation pays attention: if $r_1 < r_2$, then $\underline{G^f_{r1}(\xi_{\alpha 2})} < \underline{G^f_{r2}(\xi_{\alpha 2})}$, and $\overline{G^f_{r1}(\xi_{\alpha 2})} > \overline{G^f_{r2}(\xi_{\alpha 2})}$, where $\alpha_1+\alpha_2=\alpha$; α - a significance level of the fiducial interval; $\overline{G^f}$ and $\underline{G^f}$ - respectively, the upper and lower boundary values of the fiducial interval (f). Let us remind that *fiducial intervals* are intervals of change of concrete possible realizations of multivariate random variables, which law of distribution not known. And *confidential intervals* are intervals of theoretical random variables, which law of distribution is known;

3.2. Distributions $F^*[G_r^*(\xi)]$ are asymmetric, which confirmed by the histograms of the distributions. Thus, asymmetry of the geometric mean value exceeds asymmetry of the arithmetic mean value;

3.3. Laws of change of boundary values of the fiducial interval $[\underline{G_r^*(\xi)};\overline{G_r^*(\xi)}]_\alpha$ with the significance level α are "nonlinear";

3.4. Considering, that tabulated values r far not always correspond to actual number of versions of attributes, the curves of changes in the boundary values of the fiducial interval of realizations - $G_r^*(\xi)$ are approximated as a function of the number of realizations t;

Conclusion

1. The estimation of an integral indicator of an operative work efficiency of technical objects, of course, is the significant result, allowing comparing and ranging objects. Thus casual character of these indicators and an opportunity of their casual distinction not considered;
2. Carried out researches allowed us to obtain receive statistical functions of distribution of average geometrical mean of random variables. These distributions called fiducial;
3. On these functions of distribution boundary values of the fiducial interval with a given significance level established;
4. Approximation of laws of change of critical values of an integral indicator in function of number of realizations allowed implement "express method" of calculation for any number of realizations.

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