

METHOD AND ALGORITHM OF RANGING OF RELIABILITY OBJECTS OF THE POWER SUPPLY SYSTEM

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ABSTRACT

Ranging of objects is widely applied at the decision of operational problems. However, it is spent mainly intuitively. There are developed method and algorithm of ranging of objects of a power supply system on independent parameters of reliability and profitability of work with the recommendation of the basic directions of improvement of these parameters.

INTRODUCTION

Ranging of the equipment and devices (objects) of an electro power system on reliability and profitability of work is widely used at the decision of many operational problems, including at the organization of maintenance service and repair. Known, that reliability and profitability of work of objects characterized by a number of parameters (for example, factor of readiness, specific charge of conditional fuel, etc.). To group objects by way of increase of their reliability and profitability on each of these parameters does not represent difficulty. However, often the situation when these parameters contradict each other observed. For example, on size specific the charge of fuel the power unit can exceed average value on power station. At the same time, under the charge of the electric power in system of own needs - to be it is less, than average value. As an example in table 1 some monthly average parameters of eight power units 300 MWt are resulted.

Table 1. Data on work of power units of power station

N	Parameter	Index number of the power unit							
		1	2	3	4	5	6	7	8
1	Operating ratio of the established capacity, %	62,8	27,9	68,6	71,3	80,0	76,8	75,9	78,9
2	Average loading, MW _T	222	211	216	229	276	231	228	237
3	The charge el. energy on own needs, %	4,1	4,4	4,0	3,9	3,5	4,0	3,7	3,5
4	The specific charge of conditional fuel, q/(kW _{T.C})	374,6	371,0	368,4	369,7	336,7	373,9	363,0	374,2

We will use these data in the further for an illustration of methodology of ranging of objects. They concern to a class of discrete multivariate data with a nominal scale of measurement [1] as each of noted above parameters considered as an attribute with a quantitative scale of measurement of continuous sizes. It is necessary to note, that alongside with discrete multivariate data there are also multivariate data of continuous random variables. For example, initial information for calculation of parameters of individual reliability. Features of classification of these data are

considered in [2,3]. Practical realization of algorithm of ranging of objects is preceded with transformation of initial data

Transformation of initial data provides overcoming the difficulties connected with natural distinction of units of measure and a scale of quantitative estimations of parameters, distinction of their orientation of change, with elimination of interrelation of these parameters. For example, the charge of the electric power on own needs differs from the specific charge of conditional fuel both on units of measure, and on scale. The interconnected parameters at ranging initial data result not only in increase in labour input of calculations, but also to erroneous result. Therefore, classification of used parameters on independent groups makes one of the primary goals of transformation of data.

Overcoming of distinction of units and scales of measurement of parameters is reached by normalization (standardization). Normalization in practice spent on one of following formulas:

$$Z_1 = \frac{X}{\bar{X}^*}; Z_2 = \frac{X}{\sigma^*(X)}; Z_3 = \frac{X}{L^*(X)}; Z_4 = \frac{X - \bar{X}^*}{\bar{X}^*}; Z_5 = \frac{X - \bar{X}^*}{\sigma^*(X)}; Z_6 = \frac{X - \bar{X}^*}{L^*(X)}$$

where X and Z -quantitative estimations of parameters before transformation; $\bar{X}^* = m^{-1} \sum_{i=1}^m X_i$;

$$L^*(X) = (X_{\max} - X_{\min}); \sigma^*(X) = \sqrt{\frac{(X - \bar{X}^*)^2}{m-1}}; X_{\max} = \{X_1, X_2, \dots, X_m\}; X_{\min} = \{X_1, X_2, \dots, X_m\}; m-$$

number of objects.

Comparative estimation of expediency of these transformations has shown [4]:

1. Transition as a result of the certain transformations to sizes Z_1, Z_2 and Z_3 (unlike Z_4, Z_5 and Z_6) does not solve a problem of distinction of scale of measurement;
2. Sizes $\sigma^*(X)$ and $L^*(X)$ are correlated. The factor of correlation is significant, but the size of scope $L^*(X)$ demands less calculations, than an average quadratic deviation $\sigma^*(X)$. The size $\sigma^*(X)$ provides presence of general population of random variables. Real statistical data concern to statistical data of multivariate type and are small. Data on distribution of realizations of attributes are absent. The information on attributes is concentrated in statistical function of distribution (s.f.d.) realizations of attributes $F_{\Sigma}^*(\Pi_1)$. Advantages of scope $L^*(X)$ cause expediency of its application;
3. Comparison of transformations $Z_5 = \frac{X - \bar{X}^*}{\sigma^*(X)}$ also $Z_6 = \frac{X - \bar{X}^*}{L^*(X)}$ shows, that factor of correlation

between $(X - \bar{X}^*)$ and \bar{X}^* it is essential below, than between $(X - \bar{X}^*)$ and $L^*(X)$;

Thus, the most effective should consider transformation $Z_6 = \frac{X - \bar{X}^*}{L^*(X)}$.

As follows from table 1, the vector of parameters has a various orientation. If operating ratio of the established capacity (K_E) and average loading of one power unit (P_A) similar parameters for other power unit with the minimal risk of the erroneous decision it is possible to conclude, that exceed reliability and profitability of work of the first power unit above. The conclusion will be erroneous for the charge electric power on own needs (E_{ON}) and the specific charge of conditional fuel (S_F). Heuristic character of discussion of this question demands formalization of the decision. For what take advantage of concepts and methods of the correlation analysis.

Results of calculations of factors of correlation (r) between K_E, P_A, E_{ON} and S_F are resulted in table 2. Calculations spent under the formula [5]

$$r = m^{-1} \sum_{\substack{j=1 \\ k=1 \\ j \neq k}}^m [\Pi_{i,j} - M^*(\Pi_i)][\Pi_{k,j} - M^*(\Pi_k)] / [\sigma^*(\Pi_i) \cdot \sigma^*(\Pi_k)],$$

Which, in particular, testifies to independence of factor of correlation of an orientation of change of a parameter

Table 2. Estimations of factors of correlation of parameters

Parameters	K_E	P_A	E_{ON}	S_F
K_E	-	0,59	-0,83	-0,30
P_A	0,59	-	-0,77	-0,84
E_{ON}	-0,83	-0,77	-	0,52
S_F	-0,30	-0,84	0,52	-

Analysis of data of table 2 confirms the distinction of an orientation of vectors of attributes noted above. Orientation K_E and P_A differs from orientation E_{ON} and S_F . Factors of correlation on size are significant and allow assuming interrelation of considered parameters.

Casual character of realizations of parameters causes casual character of observable interrelation. To consider this feature, critical values of factors of correlation $[\bar{r}; \bar{r}]$ pay off with the set significance value α . This problem solved as follows:

1. Two samples of random variables are modeled ξ with uniform distribution in an interval $[0,1]$. Number of elements of the first and the second samples we shall designate through m_v ;
2. Calculate factor of correlation r between realizations samples;
3. Items 1 and 2 repeat N time;
4. On realizations of factor of correlation is under construction s.f.d. $F^*(r)$ critical values \bar{r}_α and $\bar{r}_{(1-\alpha)}$ for of some significance values also are defined α ;
5. Under standard programs are established in view of symmetry $F^*(r)$ dependences $\bar{r} = f(m_v)$. These dependences with the big assurance look like $\bar{r}_{(1-\alpha)} = A m_v^{-B}$. Some results of calculation of factors R^2 , A , B , m_v , X and \bar{r} are resulted in table 3

Table 3. Results of calculations of factors of the equation $\bar{r} = f(m_v)$

(1-2 α)	R^2	A	B	Estimations \bar{r} at m_v equal						
				3	5	8	10	20	30	50
0.8	0.997	1.65	-0.56	0,990	0,690	0,507	0,442	0,397	0,240	0,168
0.9	0.999	1.88	-0.52	0,992	0,811	0,624	0,549	0,379	0,310	0,240
0.95	0.95	2.00	-0.5	0,995	0,880	0,712	0,629	0,444	0,360	0,281
0.975	0.975	2.02	-0.46	0,999	0,927	0,774	0,700	0,499	0,410	0,320

As follows from table 3 at $n \leq 5$ to establish dependence between two parameters it is practically impossible, since even at $\alpha=0,05$ absolute values of factors of correlation independent samples random variables (\bar{r}) \bar{r} not less than 0,81. At $m_v=8$ and $\alpha=0,05$ according to table 2 it is possible to approve presence of dependence between K_E and E_{ON} , P_A and E_{ON} , P_A and S_F (table.2). At the same time dependence between K_E and P_A , K_E and S_F , and also E_{ON} and S_F can be casual. A graphic illustration of dependence $\bar{r} = f(m_v)$ at $\alpha=0,025$ it is resulted in figure 1.

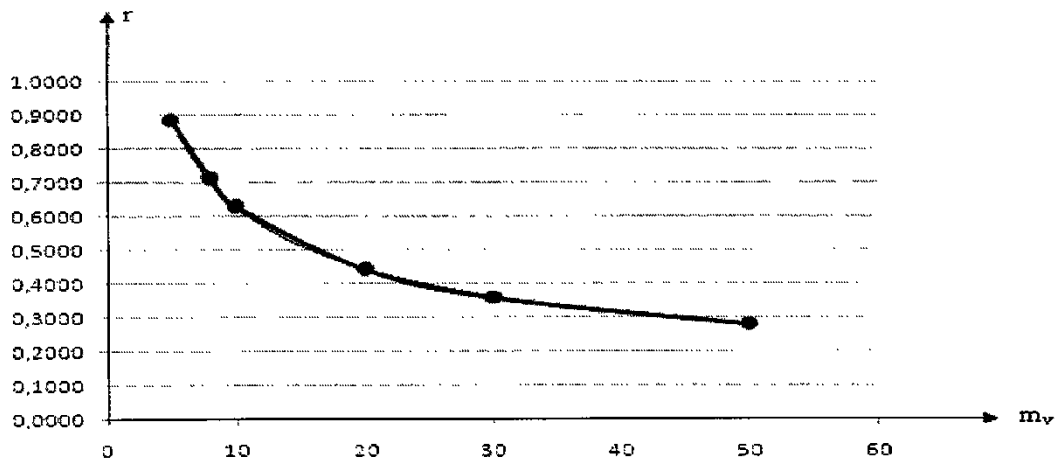


Fig.1. A graphic illustration of change of critical values of factor of correlation independent samples random variables

These curves show, what even at $m_v=50$ absolute size of critical values \underline{r} and \bar{r} with a significance value $\alpha=0,05$ not less than 0,2.

To eliminate distinction in an orientation of vectors of parameters we shall enter into consideration an opposite parameter on sense «factor of underexploitation of the established capacity», calculated as $K_U=1-K_E$, and instead of P_A we shall enter size $\Delta P_A = P_{NOM} - P_A$.

At small number of objects, probably essential influence of casual character of factor of correlation on result of the analysis of interrelation of attributes. Validity of the analysis is provided by comparison of an estimation r with bottom \underline{r}_α and top $\bar{r}_{(1-\alpha)}$ critical values. Absence of interrelation of parameters with probability α takes place either at $r < \underline{r}_\alpha$ or at $r > \bar{r}_{(1-\alpha)}$.

Algorithm ranking objects. Ranking of objects of a power supply system spent in following sequence:

1. Realizations of each of the parameters describing reliability and profitability of object, we shall consider as population of random variables $\{\Pi_i\}_{m_\Sigma}$;
2. Let's calculate a number of their statistical parameters. Namely, average arithmetic value $M_\Sigma^*(\Pi_i)$, the minimal $\Pi_{i,min}$ and maximal values $\Pi_{i,max}$, scope $L_\Sigma^*(\Pi_i)$ under formulas:

$$M_\Sigma^*(\Pi_i) = m_\Sigma^{-1} \sum_{j=1}^{m_\Sigma-1} \Pi_{i,j}$$

$$\Pi_{i,min} = \min\{\Pi_i\}_{m_\Sigma}$$

$$\Pi_{i,max} = \max\{\Pi_i\}_{m_\Sigma}$$

$$L_\Sigma^*(\Pi_i) = [\Pi_{i,max} - \Pi_{i,min}]$$

where $i=1, n_\Sigma$; n_Σ - number of parameters

List of parameters is caused by necessity of representation of each population two samples as versions of i - th attribute (parameter) with $i=1, n_\Sigma$;

3. Realizations for which $\Pi_i > M_\Sigma^*(\Pi_i)$, we carry to the first sample (to the first version i -th an attribute). Realizations, for which $\Pi_i < M_\Sigma^*(\Pi_i)$ -(to the second the second version i -th an attribute). Such classification is widely used in practice, physically proved;

4. For both samples (v) each data population average arithmetic values $M_{v,1}^*(\Pi_i)$ and $M_{v,2}^*(\Pi_i)$ with $i=1, n_\Sigma$ are calculated. Thus, the minimal value of realizations i- th a parameter of the first sample– $\Pi_{i,1,\min}$, and the maximal value in the second sample– $\Pi_{i,2,\max}$. Notice, that essential distinction $M_{v,1}^*(\Pi_i)$ and $M_{v,2}^*(\Pi_i)$ are caused by distinction of number of realizations samples $\{m_v, 1 \neq m_{v,2}\}$;

5. Under formulas

$$\delta M_{v,1}^*(\Pi_i) = [M_\Sigma^*(\Pi_i) - M_{v,1}^*(\Pi_i)] / L_\Sigma^*(\Pi_i)$$

$$\delta M_{v,2}^*(\Pi_i) = [M_\Sigma^*(\Pi_i) - M_{v,2}^*(\Pi_i)] / L_\Sigma^*(\Pi_i)$$

are calculated normalization values of absolute size of average value of a relative deviation;

6. The greatest absolute size of average value of a relative deviation under the formula is defined

$$\delta M_{v,\max}^*(\Pi_i) = \max\{\delta M_{v,j}^*(\Pi_i)\}_{j=1,2, i=1, n_\Sigma}$$

That defines sample, which to the greatest degree differs from corresponding set. It is necessary to note, that as $\Pi_{i,2,\max} < M_\Sigma^*(\Pi_i) < \Pi_{i,1,\min}$ both considered samples are unpreventable (not representative). In other words, the group of objects that versions to the greatest degree differ from other objects on j-oh i- th an attribute allocated;

7. Further from this group of objects, the subgroup for which distinction on i- th to an attribute from the value average on set is even more allocated. This subgroup can be allocated under condition of a finding of the second significant attribute. Recognition of a subgroup is spent as follows:

7.1. For the allocated group of objects the matrix of realizations j-oh versions κ - th an attribute, where $k=1, n_{v,j,i}$ and $k \neq i; n_{v,j,i}$ – number of realizations of sample on j-oh versions i- th an attribute;

7.2. Each realization κ - th an attribute with $k=1, n_{v,j,i}$ and $k \neq i$ in a matrix it is replaced with realization corresponding everyone object i- th an attribute;

7.3. According to the transformed matrix average arithmetic values of realizations κ -го an attribute with $k=1, n_{v,j,i}$ and $k \neq i$ are calculated;

7.4. The greatest size among these average values defined;

7.5. This greatest value is normalized and compared with $\delta M_{v,\max}$. If at $j=1$ it is more, and at $j=2$ it is less, than $\delta M_{v,\max}$ classification of data on i- th to an attribute is expedient. Otherwise – it is inexpedient;

7.6. If the lead classification has appeared inexpedient:

7.6.1. In a basis data on previous stage of classification undertake;

7.6.2. From the general list of objects the objects having essential features (by results of expedient classification) withdrawn;

7.6.3. We pass to classification of the remained list of objects with constant sequence of the analysis.

Control criterion representativity of samples. Above at the analysis representative samples we started with unconditional position conformity with which sample it is considered not representative if at $M_\Sigma^*(\Pi_i) < M_v^*(\Pi_i)$ size $\Pi_{i,\min}$ as would exceed $M_\Sigma^*(\Pi_i)$, and at $M_\Sigma^*(\Pi_i) > M_v^*(\Pi_i)$ size $\Pi_{i,\max}$ would be less $M_\Sigma^*(\Pi_i)$ with $i=1, n_\Sigma$. It has made meaning to not distract from algorithm of classification of data. Actually the criterion of the control representative samples is more strict, since a place of conditions $\Pi_{i,\min} > M_\Sigma^*(\Pi_i)$ and $\Pi_{i,\max} < M_\Sigma^*(\Pi_i)$ parities $\overline{M_{v,\beta}^{**}(\Pi_i)} > M_\Sigma^*(\Pi_i)$ and $\overline{M_{v,(1-\beta)}^{**}(\Pi_i)} < M_\Sigma^*(\Pi_i)$, where $\overline{M_{v,\beta}^{**}(\Pi_i)} > \Pi_{i,\min}$ are checked, and $\overline{M_{v,(1-\beta)}^{**}(\Pi_i)} < \Pi_{i,\max}$;

$\overline{M_{v,\beta}^{**}}(\Pi_i)$ and $\overline{M_{v,(1-\beta)}^{**}}(\Pi_i)$ - cvantil distributions $F^*\{M_v^{**}(\Pi_i)\}$ for $F^*\{M_v^{**}(\Pi_i)\} = \beta = 0,05$ and $F^*\{M_v^{**}(\Pi_i)\} = 1 - \beta = 0,95$; $M_v^{**}(\Pi_i)$ - modeled on $F_v^*(\Pi_i)$ estimations of average arithmetic values n_v realizations Π_i ; n_v – number of realizations of sample.

CONCLUSIONS

1. The method and algorithm of ranking of objects by way of increase of reliability and profitability of their work is developed;
2. In real conditions when the number of the factors influencing reliability and profitability of work of objects is great, classification of objects at an intuitive level leads to essential risk of the erroneous decision;
3. The automated ranking of objects allows:

3.1. To classify objects on two groups. Provided that with increase in quantitative value of parameters of reliability and profitability of work of objects their reliability and profitability increases

- The first group includes "bad" objects for which the quantitative estimation of the most significant parameters exceeds their average value on all objects;
- The second group includes "good" objects, for which quantitative estimation of the most significant parameters less their average value on all objects;

3.2. To define the basic ways of increase of reliability and profitability of work

REFERENCES

1. Lbov G.S., Method's foreheads of processing of polytypic experimental data. Novosibirsk. A science, 1981, 160c
2. Farhadzadeh E.M., Farzaliyev Y.Z., Muradaliyev A.Z. Method and algorithm of the choice optimum number attributes describing reliability of the equipment of electro installations. Journal: «Reliability: Theory&applications». R&RATA (Vol.9 No.2 (33) 2014, June, USA, p.21-26
3. Farhadzadeh E.M., Farzaliyev Y.Z., Muradaliyev A.Z. Some feature of calculation of parameters of individual reliability of the equipment and devices of electro installations. Kiev, Electronic modeling, №2 2015
4. Farzaliyev Y.Z., Comparison of normalization ways at classification initial data. Journal: «Reliability: Theory&applications». R&RATA (Vol.9 No.2 (34) 2014, September, USA, p. 50-56
5. Lukomskiy Y.I., Theory of correlation and its application to the analysis of manufacture. State comity issue, 1961