UDC 62-95

COMPARISON OF DIFFERENT AUTOMATED POWER PROCESSES USING THE UNIVERSAL HARRINGTON DESIRE FUNCTION

PhD, Associate Professor Nerubatskyi V. P., Postgraduate Hordiienko D. A.
Ukrainian State University of Railway Transport, Kharkiv
NVP9@i.ua, D.Hordiienko@i.ua
Scientific adviser: PhD, Associate Professor Nerubatskyi V. P.

When solving multicriteria problems for automated energy processes, various methods of constructing a generalized indicator are used. One of the most convenient ways is Harrington's generalized desirability function [1]. It arose as a result of observing real decisions of experimenters and has such useful properties as continuity, monotony and smoothness.

The proposed method for comparing various automated energy processes based on estimates of their technical characteristics by the generalized Harrington desirability function provides some ways of universalizing a general approach to the problem of assessing the effectiveness of existing and newly developed automated tools for various purposes, and also explores the possibility of optimizing both the comparison methods themselves and process of developing new energy processes [2]. Instead of a simple comparison, the system parameters are converted to numerical values and then processed to obtain the overall system factor [3].

According to these coefficients, various systems are compared objectively, which makes it possible to assess the capabilities of equipment of different types, and also facilitates the comparison process, making it clearer.

The mathematical apparatus for converting specific parameters into abstract numerical values is extremely simple. It is based on one of Harrington's logistic functions – the so-called "desirability curve". It is determined by the formula:

$$d = \exp\left[-\exp(-y')\right], \tag{1}$$

where d is the desirability; y' is the special rate.

The formula defines a function with two saturation sections (in $d \to 0$ and $d \to 1$) and a linear section (from d = 0.2 to d = 0.63). The coordinate y' axis is called the scale of particular indicators, the d axis is the scale of desirability. The desirability scale is divided in the range from 0 to 1 into five sub-ranges (table 1).

Table 1

Function of Desirability of Harrington

Desirability	Quantitative mark on the scale of desirability
Very good	0.8 … 1
Good	0.63 … 0.8
Satisfactorily	0.37 … 0.63
Bad	0.2 … 0.37
Very bad	0 … 0.2

The characteristic of the generalized Harrington desirability function is shown in Fig. 1.

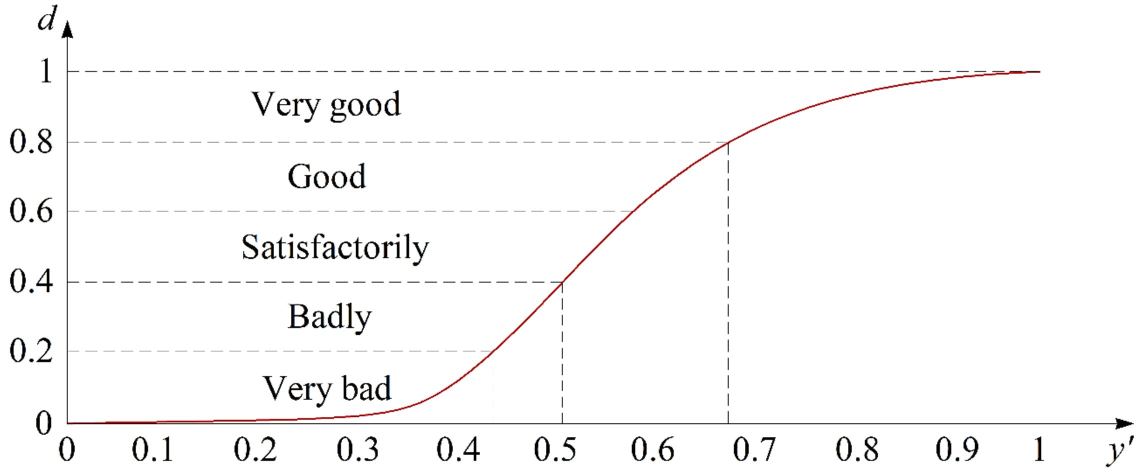

Figure 1 – Harrington's generalized desirability function

The specific parameters of the compared processes are distributed on a scale corresponding to the requirements imposed on them, over the range of effective values of the scale of private indicators. Then the corresponding indicators are recalculated into marks on the desirability scale. The resulting value d_i for the ith parameter is recalculated together with others into the generalized desirability coefficient – *D*. It is calculated by the formula:

$$D = \sqrt[q]{d_1 \cdot d_2 \cdot \ldots \cdot d_q}\ , \qquad (2)$$

where d_1, d_2, … d_q are the particular function of desirability; *q* – the number of comparison parameter metrics used for this process. Moreover, the number of these indicators may be different for different systems. This makes it possible to compare generalized coefficients even when some of the comparison parameters for different processes or data on them are missing. The root of the *q* degree "smoothes out" the deviations that arise, and the result obtained makes it possible to evaluate the processes mathematically with a certain degree of accuracy.

The use of real values of parameters for calibration within the effective range makes it possible to more objectively assess the capabilities of compared energy processes, taking into account the achieved characteristics. In this case, the mutual influence of the comparison parameters should be taken into account. For example, increasing the measurement accuracy inevitably leads to an increase in conversion time. In any case, only the values that are actually achievable should be used. Otherwise, the analysis will lose all objectivity.

Partial coefficients, recalculated into generalized coefficients of systems, make it possible with almost "mathematical" accuracy to judge their advantages and disadvantages. You can also assess the prospects for modernization and further development of certain energy processes.

For example, if the coefficient of desirability of the system is in the lower curvilinear section of the Harrington function, then its modernization is, in principle, possible. Although, in order to achieve satisfactory results, it will be necessary to "pull up" almost all parameters to an acceptable level (which is associated with a large expenditure of effort and time, which must be correctly estimated). The prospects for the long-term development of such systems are highly questionable. It makes sense to consider replacing it.

If the coefficient of the system is located on a linear section from $D = 0.2$ to $D = 0.8$, then even a relatively small modernization (improvement of one or two parameters) can significantly increase its “desirability”, and the possibilities for further development are very great.

When the system has a generalized coefficient of desirability of 0.8...0.9, in addition to being very good, we can say that the automated energy process is close to the limit of its development. Improving its characteristics by "pulling" all parameters to the maximum will require excessively large expenditures, and it is necessary to look for qualitatively new ways of its future development. Thus, by analyzing the partial coefficients of the desirability of specific parameters, it is possible to assess the possibilities and ways of modernizing the process.

The practical result of the application of this technique in assessing the effectiveness of those used and designed in automated energy processes shows the possibility of its successful application in this area with some clarification of the conditions of this application.

Abstract numerical values are easily confirmed by specific technical parameters. Generalized coefficients make it possible to compare processes of the same type with high accuracy. Comparison of processes should be carried out according to their area of application.

The last given result determines the general conclusion that for the qualitative application of this technique in the analysis and design of automated energy processes, it is necessary:

– to classify all analyzed objects by fields of application, defining the most specific parameters for them;

– compile the most complete set of generalized comparison parameters;

– justify the quantity and quality of these parameters;

– introduce and justify the weighting coefficients of each of the parameters;

– to determine the methodology for making changes in the classification of objects of analysis, a set of comparison parameters and their weight coefficients.

References:

1. Terskaya L., Slesarchuk I. Harrington Desirability Function for Multi-Attribute Outdoor Space Quality Assessment. IOP Conference Series: Materials Science and Engineering. 2020. Vol. 753. P. 20–30.

2. Nerubatskyi V. P., Hordiienko D. A. Intellectual system of traction power supply of electric rolling stock. Applied Scientific and Technical Research: Proceedings of the IV International Scientific and Practical Conference, April 1–3, 2020, Ivano-Frankivsk Academy of Technical Sciences of Ukraine. Ivano-Frankivsk: Vasyl Stefanyk Precarpathian National University. 2020. Vol. 2. P. 111–113.

3. Trautmann H., Weihs C. On the distribution of the desirability index using Harrington’s desirability function. Metrika. 2006. Vol. 63. P. 207–213.