MATHEMATICAL FOUNDATIONS OF COMPLEX DESIRABILITY FUNCTION FOR EVALUATION OF THE PRODUCT QUALITY IN THE RELATIONSHIP WITH ANTHROPOGENIC IMPACTS ON THE ENVIRONMENT

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Abstract. *The article is devoted to the development of integrated assessment of the industrial enterprise, in collaboration with the impact on the environment. A new method of multicriteria evaluation of the enterprise activities is given. Provides the mathematical foundations of complex function of desirability. The example of calculation for the industrial enterprise, which produces printing paper is given.*

Keywords: complex function of desirability, mathematical model ecology

MATEMATYCZNE PODSTAWY ZESPOLONYCH FUNKCJI CELÓW STOSOWANYCH DO EWALUACJI JAKOŚCI PRODUKTU W ZWIĄZKU Z ANTROPOGENICZNYM WPŁYWEM ŚRODOWISKA

Streszczenie. *Artykuł przedstawia unowocześnienie zintegrowanej oceny przemysłu, względem oddziaływania na środowisko. Została opisana nowa metoda wielokryterialnej oceny działalności przedsiębiorstw w oparciu o aparat matematyczny. Dodatkowo został podany przykład obliczeń dla przedsiębiorstwa produkującego papier.*

Słowa kluczowe: złożona funkcia celu. model matematvczny. ekologia

Introduction

Most common at present time formulation of optimization problems, prescribing to calculate the maximum efficiency under given conditions, should no longer be considered a special case of finding a rational solution. Circumstances to actually turn out to be much more difficult. In the real situation of enterprises rating is based on more than a dozen criteria: performance, at a cost in terms of profitability, on air pollution and water body, etc. We have to live and work in multicriteria a world where goals are often conflicting. For example, productivity and profitability to maximize, and the cost and pollution - to minimize [1, 2].

Developing a method for comprehensive assessment of the company in its interaction with the environment addressed in this article.

1. The basic part

If there is a multicriteria problem of parameters with different dimensions in order to resolve this problem, use their normalization. It is known several methods of normalization:

1) the classic:

$$\frac{f(x|y)-\min\limits_{x\in X}(f(x|y))}{\max\limits_{x\in X}(f(x|y))-\min\limits_{x\in X}(f(x|y))}; \quad (1)$$

2) normalization of comparison:

$$\frac{f(x|y)}{\max\limits_{x\in X}(f(x|y))}; \quad (2)$$

3) normalization of averaging:

$$\frac{f(x|y)}{\sum\limits_{y\in Y} f(x|y)}. \quad (3)$$

It is proposed to function with unilateral constraints to use the logistic normal expression of type-forming:

$$d_{ij} = e^{-e^{(b_0+b_1 Y_{ij})}}. \quad (4)$$

Bilateral criteria should normalize the bell-shaped function:

$$d_{ij} = e^{-(Y_{ij}-Mx_j)^2/2\sigma_j^2}, \quad (5)$$

where d_{ij} – partial desirability function for the *j*-th the criterion *i*-th dimension; Y_{ij} – measured values of the *j*-th criterion;
Mx_j – the best the desired value of the *j*-th criterion; σ_j – the criterion value corresponding to the value 0.33 of private functions desirability.

Application of (4) and (5) makes it possible to compare the results of measurements in one scale (d_{ij} vary in the range from 0 to 1) [1, 2].

Since the *i*-th dimension of *j*-criterion can characterized the situation in terms of only one criterion (although we can not ignore the importance of such information and, knowing that the win and the sacrifice, we can estimate each of the solutions and choose the most acceptable), then to have the opportunity to consider the situation and evaluate comprehensively, taking into account all criteria simultaneously, it is necessary to carry out the convolution of criteria.

The first way - this is the summation, or "economic" way of the connection - the way to when the process is to maximize a criterion such as

$$W = \sum_{i=1}^{p} \alpha W_i, \quad (6)$$

where α – weight of the corresponding criterion.

The positivity of α is not assumed. With such a formation of a generalized criterion does not exclude the situation where you can achieve high performance on some criteria at the expense of other indicators. In this case, the values of some particular criteria may be less than the limit value.

In the second method exit criteria for productivity-usual consistent achievement of individual goals. Accounting for the implementation of follow-up operation begins only when the absolute maximums achieved the performance criteria of previous private transactions. The result of the total transaction amount is assumed to be taken into account progress of operations:

$$W = W_i + \sum_{k=1}^{i} \sup W_k \quad (7)$$

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A third way to fold - a logical grouping of quality objectives.

If the overall objective of the operation is to perform all the goals at the same time (conjunction), then

$$W = \prod_{i=1}^{p} W_i(x) \cdot \tag{8}$$

If the overall goal is achieved when reached at least one private purpose (disjunction), then

$$W = 1 - \prod_{i=1}^{p} [1 - W_i(x)]. \tag{9}$$

For the convolution of criteria and calculation of the generalized supercriterion we propose a modified expression for the geometric mean:

$$D_i = \left(\prod_{j=1}^{p} d_{ij}^{\delta_j} \right)^{\frac{1}{\sum_{j=1}^{p} \delta_j}}, \tag{10}$$

where d_{ij} – partial desirability function, obtained from (4) and (5); δ_j – statistical weight (importance) of j-th criterion.

The definition of statistical weights of values - the problem is difficult to formalize, so the most reasonable in this situation should consider the involvement of experts.

There are lots of methods for expert evaluation. In some methods, with each expert works individually, it does not even know who else is an expert, but because his opinion regardless of the authority. In others - experts are bring together and the they are discussing the issue with each other, learn from each other, and false opinions are rejected. In some methods, the number of experts is fixed and is such that the statistical methods for checking the consistency of views and then averaging them can make informed decisions. In the other - the number of experts increases during the examination. No less a processing methods and response experts, including highly saturated in mathematics and computer.

Expert evaluations - is a separate issue, in this, without going into the details, we simply denote the procedure for appointing δ_j depending on the relative importance of criteria. Such selection factors, we recommend to carry out yet, according to Table 1.

Table 1. The scale of the relative importance of criteria

The value of weighting factor δ	The definition
0	Equal importance comparable requirements
0,25	Moderate (slight) superiority of one over the other
0,50	Strong (significant) superiority
0,75	The obvious advantage
0,95	Absolute (the great) advantage
1	Full advantage

Fig. 1 shows a general view of the interface for the integrated assessment of functioning production facility in conjunction with the environment.

In the lower left window lists the criteria that will be a comprehensive assessment. At the same time choose the type of normalizing functions: with one-or two-sided constraints. The quality index is represented by the strength of printing paper. This criterion should maximize. Should also maximize the criterion of performance (speed of paper machine). Other criteria to minimize production costs (the amount of energy technology costs) and environmental pollution in the form of the mass of substances discharged into the lake and released into the atmosphere pv.

The window in the upper left corner contains information about the conditions of production. These samples were obtained at the paper two different values of mode parameters - rate of hardening of the polymer additives and freeness pulp suspension, as well as random values registered of electrolytes in the river water.

The right window can be represented as a one-term of three tabs:

- for the valuation criteria;
- for measurements of quality of the output, economic performance and environmental pollution;
- the results of calculations for private functions and as-desirable to the generalized criterion.

The procedure for setting up criteria (partial desirability functions) is reduced to the appointment of the coordinates on the axes of the natural values of the criteria for respective two-point desirability functions: 0.33 (limit marriage or MPC contaminant of matter) and 0.95 (ideal or achievable property value).

The right window of Fig. 1 is for input of the results of measurement values of selected criteria in different contexts. Detailed analysis and commentary on the contents of the window in this article are not required.

Of greatest interest is the analysis of data presented in Fig. 2. Rows can rank the industrial, environmental and consumer levels of each sample. The most eloquent in Fig. 2 - the last column. It gathers comprehensive assessment of the value of all samples. It is easy to distinguish the best results (max D_i), which accompany the receipt of the sixth sample (D_6 = 0,8131). It is also easy to verify that the conditions of preparation and properties of the fifth and ninth samples absolutely not acceptable, and the end result is only fifth of the sample compromises the cost, and the assessment of the company under the terms of the ninth sample is extremely low in four of the five criteria.

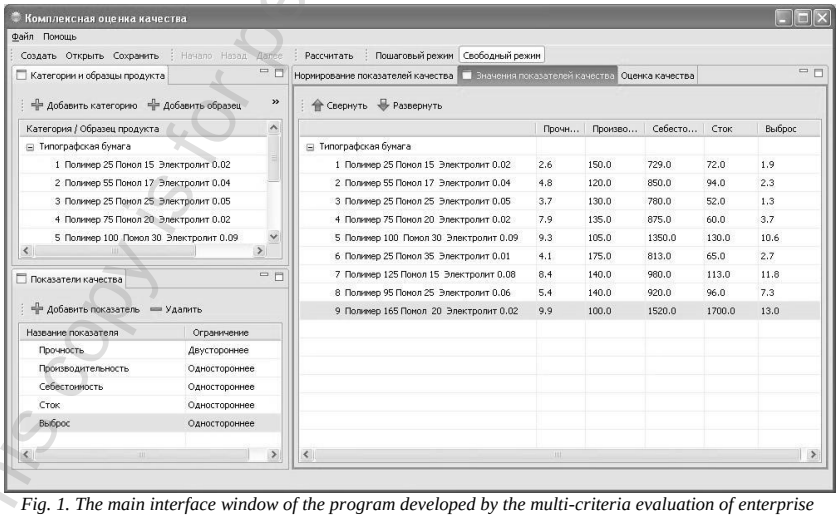

Fig. 1. The main interface window of the program developed by the multi-criteria evaluation of enterprise

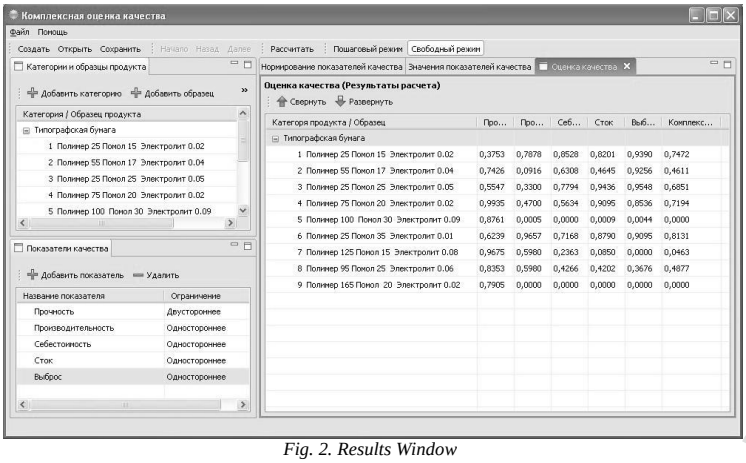

Fig. 2. Results Window

With the results in the form in which they are grouped in Fig. 2, it suffices simply to present the whole picture of well-being and anxiety in the enterprise to identify and eliminate the causes of problem situations, identify objects, the volume and sequence of investments.

It is clear that the high cost of strengthening additives of polymers does not lead to the desired effect. Quality control is a rational way of mechanical reinforcement. There is no doubt the presence of harmful electrolytes in the river water.

2. Conclusions

In this paper a new method of multicriteria evaluation of the enterprise for production, economic, environmental and consumer indicators, where the synthesis evaluation criterion performs a complex function of desirability. The example of calculation for the company, which produces printing paper, is given.

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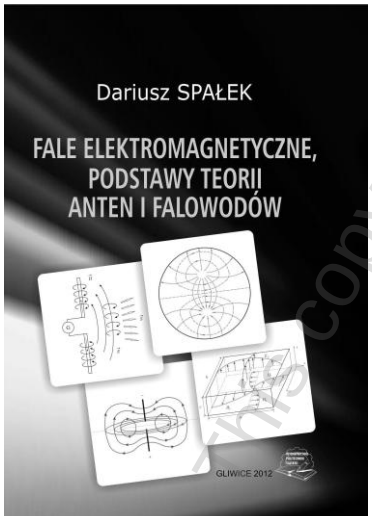

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FALE ELEKTROMAGNETYCZNE

PODSTAWY TEORII ANTEN I FALOWODÓW

Wydawnictwo Politechniki Śląskiej, Gliwice 2012

Podręcznik omawia zagadnienia z zakresu teorii fal elektromagnetycznych, podstaw teorii anten, falowodów i mikrofal. W szczególności prezentuje właściwości fal elektromagnetycznych płaskich i sferycznych. Omawia zachowanie fal na granicach środowisk dielektrycznych i przewodzących. Systematyzuje definicje stref promieniowania bliskiej, dalekiej oraz pośredniej. Przedstawia podstawowe parametry anten i ich charakterystyk promieniowania. Jeden z rozdziałów poświecony jest omówieniu właściwości falowodów prostokątnych i cylindrycznych – jak również – warunkom powstawania fal typu TE oraz TM. Podręcznik uzupełnia program symulacyjny napisany w językach C++ i C# dostępny na stronie autora http://www.elektr.polsl.pl/dspalek/.