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DECISION MAKING IN COMPLEX SYSTEMS

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This article describes methods of decision-making in complex systems - fuzzy mathematical programming methods, implemented in the man - machine decision-making procedures with the use of the decisions support systems (DSS)

Index terms: decisions support systems, fuzzy mathematical programming

Optimization problems considered in the design and operation of complex technical systems are solved by methods of mathematical programming.

Energy system can be viewed as a large complex cybernetic system type.

In power searches solving problems, realizing not only the mathematical model, an algorithm which does not provide hard the program, but also a model ergatic problem. An algorithm for solving the problem provides ergatic during the study directly involved human - operator. In ergatic model deviation from the intended situation, the algorithm is adjusted person – operator [2].

In the energy sector in the study of complex electric power systems while optimizing the regulation applies cybernetic modeling method. The basis of this method, put one of the fundamental principles of cybernetics, which is as follows: the study of the system is based on the study of its behavior, that is, the observation of the state of the system output when given the external environment influences on the inputs.

Thus, cybernetic modeling reveals the functional dependence of the system from the effects of the environment. Thus analyzed primarily open systems that are exposed to the external environment and to respond to this action. With this type of modeling the processes occurring within the system, is not considered to influence the system response to the external environment is not taken into account.

Cybernetic model provides a hierarchical structure of the studied system. Cybernetic model of the electric power system is also hierarchical model type. At the highest level of the hierarchy is reproduced the process of interaction between the subsystems on the basis of modeling subsystem functions. At the lower levels the functional characteristics of subsystems are determined and the processes occurring in them analyze, if necessary.

The solution of the optimization problem of decision-making in complex systems requires the solution of the following subtasks:

1) definition of optimality criterion;

2) Adequate representation of the formalized process of electricity;

3) selection of a method for implementing a mathematical model.

The optimization problem of electricity as the equations - the limit is the balance of power. Active power imbalance leads to disruption of the quality of electrical energy.

For each installation has a nominal frequency and voltage, their optimal value, which corresponds to the minimum cost of the consumer, as well as the technical limits of deviations from the nominal value. The greater tolerance of quality indicators from the optimal values, the lower the cost of the power system, but the greater the damage to consumers.

In the simulation of steady electric power system operation mode subsystem, non-linearization, can be described by the equation [2]:

$$Y=|k|X+Y_0,$$

where |к| the square matrix of the generalized system parameters;

X - vector boundary currents;

Y - vector of the boundary voltages;

Y0 - the vector components of the boundary variables due to the influence of domestic sources of energy subsystems.

Optimization is the final stage of solving the problem of decision making in complex systems. Most practical solutions to optimization problems are problems of constrained optimization. Methods for solving these problems are based on models of unconstrained optimization.

Optimization problems of electric power are finite-dimensional optimization problems.

An optimization problem is solved to minimize the design of power supply system for a minimum financial outlay. As a result, the task of determining the optimum power compensation devices that meet a minimum total cost. Currently gradient methods are offered for solving this problem.

At higher hierarchical levels of the power system it is advisable to search for the best solutions to simulate using heuristic schemes gradient descent, which is a heuristic modifications gradient methods [3].

Convergence of numerical methods to search for the extremum of functions of several variables because of their heuristic is not enough studied, however, these methods are useful for solving unconstrained optimization. It is noted that they possess a high computational efficiency in comparison with conventional gradient methods.

Mathematical model of the transportation problem is realized for solving optimization problems of electric power, which optimizes the cost of implementing the mains circuit. The transportation problem of electric power under the product means the electric power transmitted from the power supply to the consumers of electric power lines. Power sources are power plants or substations, consumers - industrial, urban, agricultural electricity consumers. A valid solution to the transport problems of electric power can be obtained in accordance with the method of potentials. Realization of the algorithm for solving the transport problem is the optimal scheme of the electrical network.

An optimization problem of distribution of total active power grid consumers between the electrical stations is a nonlinear programming problem which is solved by Lagrange [5, 6].

Search for optimal solutions in conditions of uncertainty with regard to the optimization problems of electric power is carried out using a computing apparatus of game theory. Uncertainty of information is a promising growth capacity in developing the power system to which you want to determine the optimum amount of input power generating facilities.

When optimizing the power grid mode by the presence of degrees of freedom of the mode parameters are selected such values, which provide a minimum active power losses in the network.

From an ergonomic point of view, information preparation of decision-making in complex systems composed of external and internal information provision. The task external information guarantee is the selection of the necessary information and the selection of methods of its optimal performance. The internal information provision is the procedure of classification and generalization of the information on the current situation, the construction of the operational models of activity. Thus, the external information support is carried out by preparing a priori decision, internal - to solve specific operational tasks. According to the research, decision-making information training in the operation of automated control systems for various purposes is 30 - 60% of the time [1].

A feature of the decision-making is uncertainty manifested in the absence of a priori information on the feasibility of the system states. The basis for the search of effective solutions in the face of uncertainty is a compromise between efficiency and sustainability solutions.

Compromise selection algorithm may be represented by [3]:

$$x^0 = \arg\max_{x \in X} \sum_{i=1}^{2} a_i k_i(x);$$

$$\sum_{i=1}^{2} a_i = 1,$$

where x^0 – the reference solution;
X - feasible set of solutions;
k1 (x), k2 (x) - the criteria that characterize the effect and sustainability solutions, respectively.

The choice of weighting coefficients a_i in the form of interval and fuzzy sets of values determines the type of decision-making criteria [3-4].

To find the optimal solution to the problem of decision-making under conditions of uncertainty it is advisable to employ methods of fuzzy mathematical programming (FMP) and heuristic programming [3, 5-6].

The task of mathematical programming is formulated as follows [5-6]:

$$f(x) \to \max$$

with constraints

$$g_i(x) \le 0, i = \overline{1,m},$$

where $f(x)$ – the objective function.

In mathematical modeling under uncertainty decision-making tasks vagueness is expressed in the form of a fuzzy description of the objective function, constraints and parameters on which they depend.

Fuzzy option FMP problem [6]:

$$\max\ f(x), g_i(x) \le 0, x \in X$$

It can be realized by:

1) mitigating restrictions;

2) $f(x) \underset{\sim}{\ge} z_0,\ g_i \underset{\sim}{\le} 0,\ x \in X,$

where the sign $\sim$ is fuzzy execution limitations.

That is, instead maximization objective function should strive to achieve a given value z_0 of this function.

Adaptive mathematical model of decision making under uncertainty is a multi-criteria algorithm of nonlinear programming (MCNP) with fuzzy parameters.

In [8], the theoretical and practical results of adaptive algorithms for determining the place of power lines damaged are considered.

In general, the problem is the MCNP vector optimization problem that can be represented as [6]:

minimize

$$f(x) = [f_1(x), f_2(x), \mathbf{K}, f_k(x)]$$

with constraints

$$x \in X = \{x \in R^n, g_j(x) \le 0, j = \overline{1,m}\},$$

where X - n- dimensional vector of decision variables;

$[f_1(x), f_2(x), \mathbf{K}, f_k(x)]$ – k the different objective functions;

$[g_1(x), g_2(x), \mathbf{K}, g_m(x) \le 0]$ – the set of feasible solutions.

Uncertainty information on the distribution law in electric load for the individual nodes in networks with voltage 3 - 10 kV the industrial enterprises in the problem of determining the electric power losses allows to consider a way of representing the electrical loads in the form of fuzzy intervals [10].

The process of finding a solution to the problem of covering the peak demand for electricity in the solution of electric power supply problems requires a complex approach [9].

Decision support is to help the decision-maker in the decision-making process, which includes [1]:

- help decision-makers in the analysis of situations and limitations caused by the actions of the environment;
- priority ranking in decision-making;
- the generation of possible solutions;
- the choice of the optimal variant.

DSS – is a dialog system, assisting decision-makers that use databases and mathematical models for solving problems of the poorly structured subject areas. Poorly structured or mixed problems in contrast to the well-structured contain both qualitative and quantitative elements and uncertain and quality problems tend to dominate. The theory of fuzzy sets formulated algorithms for solving problems in which subjective assessments play a significant role in the evaluation of uncertainty.

The essence of computer decision support system is a formalized description of the source data processing and the development of solutions and algorithmization these processes.

Selecting the decision-maker solution includes forming a working hypothesis, the analysis of the conceptual models of the current situation; assess hypotheses and comparing the results achieved the optimum solutions and algorithm solutions in accordance with the selected hypothesis.

The distributed DSS get widespread. They are used in automated air traffic control systems, robotics, in moveable object management tasks, decision support systems in emergency situations. Distributed systems facilitate the exchange of information and decision-making by expert systems, managing complex technical objects.

The optimization problem of choosing a distributed DSS structure, minimizing the cost of the system, taking into account the cost of information exchange between tasks solved at different hierarchical levels and operating cost is a non-linear problems of mathematical programming. To solve this problem it applies aggregation - decomposition approach, comprising the steps of:

- decomposition problem on a number of specific problems;
- aggregation of partial results [1].

Structure of distributed DSS must comply with the organizational structure of complex technical objects control systems.

The problem of the distribution of functions between the local DSS can be represented as integer linear programming problem, the search for optimal solutions which carried out heuristic algorithms [1].

The uncertainty requirements for technical means of distributed DSS requires the use of appropriate methods of decision-making based on expert evaluation and processing of the results of fuzzy optimization methods [1, 7].

Conclusions

1. To find the optimal solution to the problem of decision-making under conditions of uncertainty it is advisable to employ methods of fuzzy mathematical programming and heuristic programming.

2. It is recommended to apply the distributed DSS in the control systems of complex technical objects.

3. Selection of distributed DSS structure is based on the synthesis of the structure of complex systems with the use of aggregation - decomposition approach.

Reference

1. B.M Gerasimov, M.M Divizinyuk, I.Y Subachev. Decision support systems: design, application and effect evaluation. - Monograph. Sevastopol, 2004. - 318 p. (in Russian).

2. Venikov V.A. Similarity Theory and Modeling. M:. Vyssh.shkola, 1976.-320 p. (in Russian).

3. E.G Petrov, M.V Novozhilov, I.Z. Grebennik. Methods and tools for decision making in socio – economic systems. Teach. guide/ Ed .. For E.G Petrov.- K .; "Tehnika" - 2004, 256 p. (in Russian).

4. Coffman A.V.Introduction to the theory of fuzzy sets. –M.:Radio and Communications ,1982.- 432p. (in Russian).

5. Taha R. Introduction to Operations Research: In 2 vols. - World, 1985. . (in Russian).

6. J.P Zaichenko. Operations Research.Textbook. – 4 ed.,revised and reported. - K., 2000, 688 p. (in Ukraininan)

7. J.P Zaichenko. Operations Research: fuzzy optimization .- Vishcha School, 1991. - 120 p. (in Russian).

8. M.D Obalin, A.L Kulikov. The use of adaptive procedures in the algorithms determine the location of damage power lines. / Industrial power, number 12, 2013, p. 35 - 39. (in Russian).

9. S.A. Nekrasov, S.A. Tsyruk, M.S. Zharmagambetov. About a systematic approach to the problem of energy storage. / Industrial Energy, number 3, 2013, p. 2-6. (in Russian).

10. A.V. Malafeev, A.A. Antonenko. The mathematical representation of the electrical loads of industrial enterprises in the problem of determining the power loss by using fuzzy sets. / Industrial Energy, №1, 2013, p. 9-13. (in Russian).

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