

AUTOMATION OF THE QUALIMETRIC METHOD OF SELECTING LAYOUT SOLUTION OF THE PUMPING EQUIPMENT FOR NPPS

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Abstract. *Discusses qualitative methods of evaluation the layout of pumping equipment implemented in the software. There are various methods of processing expert assessments, analysis has shown that the evaluation of pumping equipment design results for nuclear facilities the best in terms of accuracy, the complexity and time-consuming method is the weighted average expert assessments. On the basis of this method, the technique of choosing the optimal layout decision of several options in the design of new equipment. Implementation of the developed algorithm in a dedicated software allows to automate and optimize the process of selecting the layout in the technical design stage of pumping equipment.*

Key words: AUTOMATION, QUALITY, LAYOUT SOLUTION, SYSTEM OF SUPPORT OF DECISION-MAKING

1. Introduction

The share of electricity generated by nuclear power plants (NPPs) grows annually, contracts are signed for the construction of nuclear power units both in Russia and abroad. The State Atomic Energy Corporation ROSATOM has developed road maps, the strategic goals of which are the construction of 16 power units in Russia until 2020 and 38 power units in other countries until 2030. High competition in the world market in design and construction of NPP units defines strict requirements for the quality of the product. In order to increase the competitiveness of Russian products, in this case the project of NPP unit, the developers are trying to reduce the commissioning time of each new NPP unit, but with the shortening of the NPP unit commissioning time, the quality, reliability and safety of Russian NPP projects should be at the required level.

Modern technologies allow to design of new generation nuclear power plants with WWER-1000 and WWER-1200 reactors. One of the most important elements of the NPP reactor facility is the pumping equipment of the primary circuit - the main circulation pump (MCP). This equipment has the same high requirements for safety and reliability, as well as for the reactor plant. The MCP is a complex technical system. Proceeding from the definition of the technical system [1] it follows that in order to perform the given functions, it must have a certain structure and relative arrangement of units, that is, the technical system must have the appropriate layout solution.

2. Description of the qualimetric method of selecting layout solution

Layout solution of pumping equipment is a set of design works to justify the relative location of nodes, systems and shape of pump. It is during the definition of the layout solution the entire structure of the future pump is created. When choosing a layout solution, it is determined not only the appropriate location of its devices and assemblies, but also determines the optimal sizes and shapes of the surfaces of parts, the choice of materials that meet the technical and economic requirements specified in the technical specification (TS). The volume of the pump depends on its weight, the space occupied by it in the engine room, and transport costs. The general design trend is the desire to reduce the dimensions of the structure with the optimal layout.

When designing the equipment an important issue is the problem of ensuring the quality indicators specified in the technical specification (TS), taking into account resource limitations. The choice of characteristics of the future design is a task that can be classified not only as relating to reliability engineering and engineering technology [2], but also to decision theory [3, 4].

At the initial stage of the design of pumping equipment, especially in the design of new structures, where there is no

sufficient statistical data to evaluation the quality of layout decision and approving it for further development decision, the decision-maker evaluates the layout solution under conditions of non-stochastic uncertainty. To solve this problem, the author proposes to apply the developed qualimetric method [5, 6], implemented in special software. The software is developed in Visual Studio 2015 in C++ [7].

The essence of the methodology is the application of the method of expert assessments and taking into account risks by the Savage criterion. The software belongs to the class of decision support systems (DSS) [8, 9, 10], and implements the algorithm of work, shown in Fig 1.

3. Description of software operation

The window application of the program allows the user to enter the initial value of the parameters provided by the technical specification and normative documents, Fig. 2.

The First stage based on the data entered, as well as the results of calculations that depend on these data, the parameters of the technical system being designed, the program selects the layouts appropriating to the requirements set by the user from the relational database used in the program. Further, with any result of this sample, the program allows to determine the optimal layout for the technical system being designed, Fig. 3.

If in the course of the selection the program finds several, appropriating to the requirements, layouts, then according to the developed algorithm of the qualimetric method, the user is invited to enter the data of the experts' questionnaires and their estimates for the layouts selected by the program at the first stage.

If only one layout solution satisfy the requirements of the technical specification, then the program offers it for approval, as an optimal one, without expert analysis.

If there are no layouts in the database that satisfy the requirements of the technical specification, the means of the program provides for the compilation of new layout solutions from the replenishable device databases for the designed technical system

The second stage, expert analysis is implemented in the program as follows. The user defines a set of quality indicators, by selecting the number of these indicators from one to twelve.

The user selects the set of quality indicators from the most relevant indicators for a designing technical system or by entering their own.

Also, the user can save the selected sets of quality indicators in the program database.

For each set of quality indicators, there is a database of experts with rank rankings included in this set of quality indicators, which the user can complement with new experts and their rankings of quality indicators. From among these experts an expert commission is drawn up, which may include from three to ten experts. When adding each expert to the commission, the

concordance coefficient is calculated. On the basis of significance of the concordance coefficient, at the level of significance selected by the user, the consistency of the opinions of experts selected to the commission is determined.

When the program determines the inconsistency of the opinions of experts, the program will not allow expert analysis until the commission is re-elected, Fig. 4.

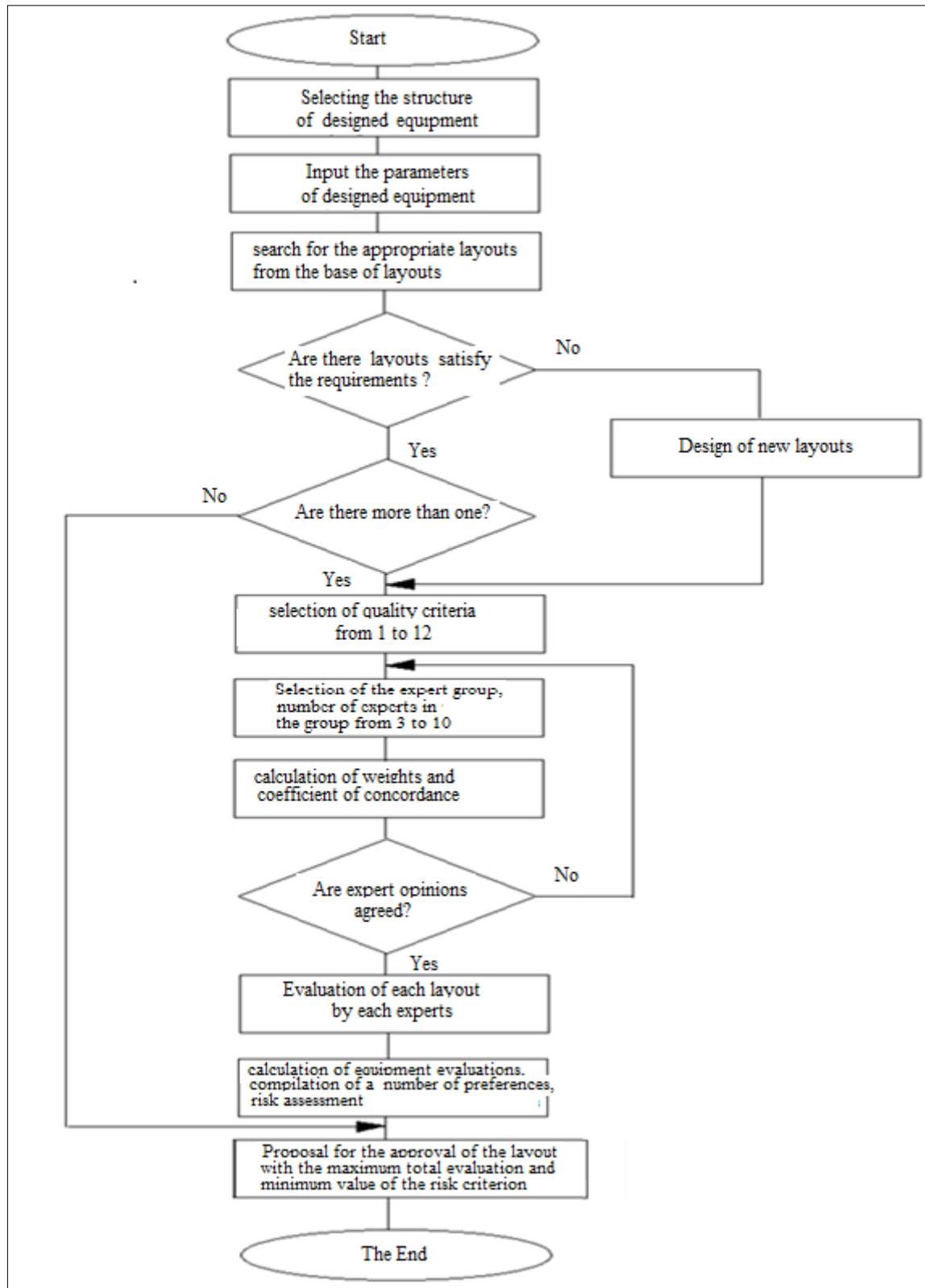


Fig.1. Algorithm of software operation

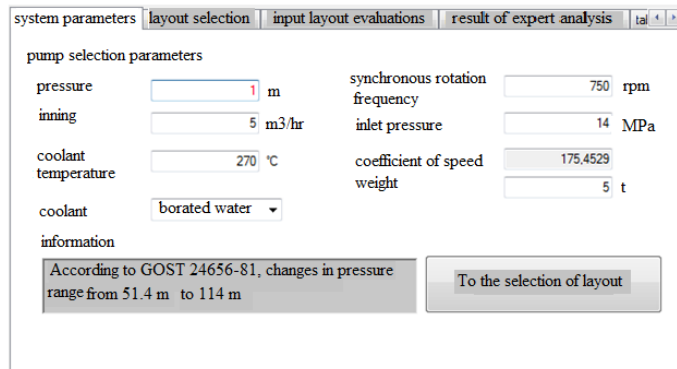


Fig.2. The input window for the parameters of the technical specification.

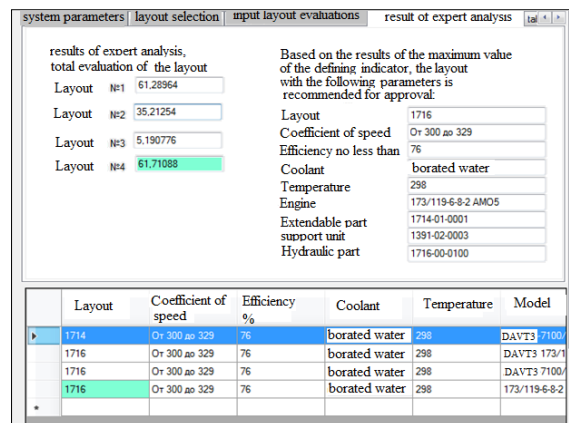


Fig.3.Result of selecting the optimal layout solution

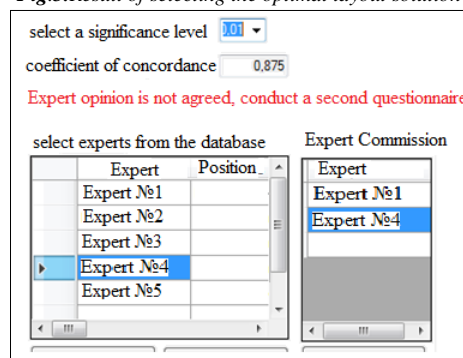


Fig.4. Assessment of expert opinions concordance

4. Conclusions

The implementation of the developed qualimetric method in specialized software allows to automate and optimize the selection process of the layout solution at the stage of technical design of pumping equipment for nuclear power plants. The use of special software ensures verification of the project, reduces the risk of approving a suboptimal layout, reduces design costs, allows to ensure the required quality of pumping equipment, which in turn increases the competitiveness of the Russian project of NPP unit.

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