

THE ANALYSIS OF THE TECHNICAL SYSTEMS' EVOLUTION

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ABSTRACT

AHP/ANP, which was developed by T.L. Saaty, gives a lot of opportunities for forecasting, that characterize a practical value of any decision-making method. One of such opportunities consists in using dynamic judgments as the elements of pair comparisons matrixes. This approach allows to predict and to tradeoff the consequences of the decisions considered. Other tool is ANP, which enables to obtain the limit priorities of influence for all elements of a complex decision in conditions of mutual dependence and feedback. The present paper describes an application of AHP and marginal judgments to the problem of analysis of technical objects' evolution, which consists in revealing the tendencies of quality parameters' changes for devices with the certain functionality, and also in defining main directions of their further perfection.

The designing and the manufacturing of a competitive technical solutions need the analysis of development prospects for the devices being created. This problem is connected with the handling of large data-bases, where there is an information on devices of the considered class and close to it classes. The application of AHP for the information analysis enhances the creative labor efficiency at initial stages of de-signing. It is known from evolution theory, the information's value is determined by measure of its use. In this connection the software destined for the analysis of design databases enables to improve an information use and also gives an opportunity to discover a new knowledge.

The analysis of technical systems (TS) with the same main function, which were created for a long period, enables to reveal criteria determining TS' evolution and its laws. The TS' evolution is considered as consecutive transformations series represented by an evolutionary chain or an evolutionary tree. Each previous technical solution is the prototype for an improvement at the next evolution stages. The certain stable changes of attributes (or criteria) during many generations of TS are named the laws of TS' development. The trends of functional, technological and economic properties of technical systems, if they are discovered, give to engineers a number of advantages in designing.

During an evolution, the improvements of TS by some quality criteria may be accompanied by significant deteriorations by other criteria. Therefore a multiple criteria analysis of inventions should be included in evolutionary chain. Application of AHP for evolutionary chain's analysis allows to find out the criteria importance trends and the tendencies of TS parameters' changing. Taking into account these tendencies, engineers and inventors can predict the properties of probable alternatives. When new technical systems (inventions) are being creating, there is an uncertainty in evaluating their properties. If some important parameters of TS deteriorate with time, the direction of TS' perfection may be determined. Using marginal judgments, which allows to evaluate what properties should be improved the most, it is possible to find out preferable direction for perfection. After that one can choose the most suitable TS prototype. Thus, marginal analysis promotes to prevent mistakes, when rational variants of TS are being selected at early stage of designing for further design researches.

We have applied Analytic Hierarchy Process (AHP) for multiple-criteria analysis of vibroprotective devices' evolution, researching a number of technical solutions created at different moments of time. We researched the class of pneumatic devices with an adjustable throttle, which ensure vibrations damping by the certain law. The evolutionary chain included six air dampers A_i ($i=1...6$), protected by the USSR

patents. These alternatives were chosen as a result of the preliminary analysis of 102 patents, which were related to class examined.

The main goal was formulated as follows: "To reveal the most perspective vibroprotective devices for perfection ". It was the focus of a hierarchy. The second level contains the following criteria groups: Functional, Layout, Technological, Economic, Innovative. At the third level there are criteria connected with appropriate groups. The experts in the field of vibroprotection have assigned the following set of quality criteria, which are essential for evolution: K_1 – quality of the vibration damping; K_2 – patentability; K_3 – reliability; K_4 – opportunity for the system adaptability to various frequencies spectra; K_5 – constructional, technological and operational complexity of a system; K_6 – the cost of the device; K_7 – operational costs; K_8 – vibroprotection quality at various spatial orientation of the device; K_9 – opportunity for realization of the various damping laws; K_{10} – conformity of the system to the best analogues; K_{11} – compactness of the system; K_{12} – a need in new materials and technologies at the device creating.

Alternative's priorities concerning main goal and criteria groups in described hierarchy allow to find out the following tendencies:

- General perfection of air dampers with time (Focus);
- Improvement of quality of vibration's damping (Functional);
- Refinement of layout parameters;
- Enhancement of innovation properties;
- Deterioration of economic and technological parameters.

The purpose of marginal analysis consists in revealing criteria, which are most desirable for the improvements in the future. When experts were doing pair comparisons, we asked them a question: "Is an improvement by one criterion more preferably than commensurable improvement by another, and how much more preferably?" The priorities obtained allow to estimate an importance of criteria during evolution of devices considered. Improvement of a vibroprotective system's quality over one criterion is usually accompanied by a decreasing of its priorities over another. In this connection it is interesting to determine criteria, whose deterioration is admitted in a certain degree. It was found, that Functional, Layout and Innovative criteria groups are the most important ones for the progress. Some deterioration is admitted for Innovation and Economic criteria.

In result of marginal analysis of criteria it was found out, that loss of vibroprotection quality (K_1), spatial orientation (K_8) and frequencies spectra reorganization (K_4) are unacceptable. The most urgent tasks are: improvement of K_1 , K_8 and adaptability to manufacture (K_{12}), then decreasing of complexity (K_5), operational expenses (K_7), and increasing of reliability of systems (K_3) follow. Criteria the most tolerant to deterioration are: patentability (K_2), cost (K_6), conformity to the best analogues (K_{10}), and complexity (K_5).

The outcomes obtained allow to discover TS properties, the most important for further perfection, and also the criteria groups, which strongly influence the parameters of systems examined. In this research the best prospects for development have air dampers with high values of priorities over Functional and Layout properties. Their perfection is connected with improvement of Economic and Technological parameters.

The evolution tendencies established give additional information promoting decision-making procedures in conceptual designing stage. Besides, these results help to determine directions for devices' perfection and to find out the contradictions between quality parameters.

The results of the marginal analysis of criteria have been completely proved by the analysis of evolution of the technical systems examined. Thus, the marginal analysis of criteria may be used as a tool for forecasting of development of TS from researched class. Such approach gives the opportunities to reduce the expenses of labor and time at the handling of patent information and also to frame hypotheses on devices' perfection in conceptual designing.