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**ALGORITHM FOR AUTOMATED BUILDING OF CAUSE-
EFFECT CHAINS OF DISADVANTAGES**

Abstract of TRIZ Master Degree Thesis

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General characteristic of research

Based on the idea/hypothesis that disadvantages-causes usually stemming from the same components as disadvantages-consequences (or from components, which directly interact with the former), the author has developed schemes of possible types of disadvantages-causes and disadvantages-consequences. To verify this idea/hypothesis, the author used statistical approach involving analysis of actual cause-effect chains (CEC) built in the course of work on consulting projects carried out by Algorithm/GEN3 Partners. In the course of analysis schemes of specific disadvantages-causes and disadvantages-consequences were identified, and the frequency of their occurrence was counted. As a result of this work with CEC from 50 actual projects, the author has determined frequency of occurrence of specific schemes of disadvantages-causes and disadvantages-consequences (around 2 500 pairs of disadvantages-cause and disadvantages-consequence).

Based on conducted studies, the author has developed methodological recommendations for the algorithm of CEC construction taking the statistical trends of occurrence of “disadvantage-cause and disadvantage-consequence” schemes. The flow chart of improved algorithm for CEC construction could be used as a basis for developing a special software program. The author also analyzed possible scenarios of dialog between a user and software program and possibilities of automated data exchange between software modules. And finally, the author proposed to develop a software program for constructing CEC in interactive mode.

Importance of the subject matter of research

The cause-effect analysis (CEA) is an efficient tool for identifying causes of target disadvantages of an engineering system (ES) with the aim to identify its key disadvantages. The CEA methodology was initially developed by S.Litvin and B.Axelrod. Subsequently this methodology was refined and improved by A.Kislov, A.Pinyaev, A.Kashkarov, E.Kudryashov, I.Petiy, V.Pavlov and a number of other TRIZ experts.

The CEA philosophy consists in elimination of all target disadvantages in ES via solving problems on elimination of a small number of key disadvantages generating all other ES disadvantages interrelated with one another in cause-effect manner.

The cause-effect analysis (CEA) is widely and efficiently used in the course of project execution at Algorithm/GEN3 Partners (the number of projects, in which CEA was used, exceeds several hundred projects). Besides, CEA method is widely used by researchers employed in domestic and foreign companies, who were specially trained, when working on internal projects aimed to improve company products.

However, it makes sense to point out here that CEA (to be more exact, the stage of CEC construction) is one of the most labor-consuming procedures in the course analytical stage of any consulting project. This is quite understandable if one takes into account that, when executing this procedure, researcher need to keep in their minds and handle a huge body of information. It includes data about a system as a whole, data about ES components and their structure, about deep-laying levels of

hierarchy, data about their functions (useful, harmful, and about level of function performance), data about physical (chemical, electric, and so forth) processes taking place both in individual components and in the system as a whole.

Thus, the importance of this research is determined by the necessity of refining CEA method with the aim to upgrade the level of detail of the existing CEC construction algorithm to save efforts and time expenditures of the analysts. Besides, the importance of the present research is explained by insufficient degree of existing CEC construction algorithm from the standpoint of its application in special software for supporting TRIZ analytical procedure execution and by trends of innovation research studies – namely, on-going reduction in the duration of research work.

The thesis follows the traditions of Saint Petersburg TRIZ school, which is characterized by practice-oriented targeting of research, wide-scale application of functional approach and production of methodological recommendation that are algorithmic to the maximum extent possible.

Goals of the research

The main goal of the research consists in optimization of the existing methodology for constructing cause-effect chains to the level of detailed algorithm enabling to minimize the efforts of analysts and reduce the terms of cause-effect chain analysis performance.

An additional goal of the research consists in preparation of obtained data, working on possible options of relationships between software modules and dialog scenarios for users and software for the purpose of subsequent development of software products for cause-effect chain construction.

Scientific novelty of the research

- The author has developed methodological recommendations on construction of cause-effect chains. The existing method for CEC construction is supplemented with rules for CEC disadvantage formulation, standard schemes of disadvantages, rules for step-by-step construction of CEC and identification of relationships between disadvantages with the use of statistical regularities.
- The author has developed an approach employing theory of probability methods and conducted analysis of CECs from the projects executed at Algorithm/GEN3 Partners on the basis of this approach. Statistical regularities of disadvantage occurrence obtained by the author as a result of such analysis were then used for developing methodological recommendations for CEC construction.
- The author has developed a flow chart for enhanced algorithm for CEC construction, which could be used as a basis for creating special software program. He has also formulated practical recommendations for the creation of such software program.

Practical significance of research

- Statistical regularities regarding probability of disadvantage occurrence identified in the course of research were then used for developing recommendations for cause-effect chain construction. They enabled to supplement the existing methods for preparation of initial data and identification of relationships between disadvantages, which would allow reducing the number of trial-and-error search of relationships between disadvantages, and, ultimately, reducing the time period for the execution of cause-effect analysis.
- Developed recommendations on cause-effect chain construction are oriented, first of all, on practical use during execution of consulting projects not only by professional users of innovation methods, but also by researchers, who are beginners.
- The thoroughly worked out algorithm for cause-effect chain construction may serve as a basis for the creation of special software program. The author has analyzed possible scenarios for working out a dialog between users and program, plus possibilities of data exchange between program modules. All this is intended to save efforts of analysts and reduce time period required for cause-effect analysis.

Main provisions of the present thesis

- Methodological recommendations on cause-effect chain construction supplement the existing methods with the following rules:
 - Formulation of disadvantages in compliance with developed standard schemes of disadvantages;
 - Step-by-step construction of CEC starting from target disadvantage;
 - Use of statistical regularities of disadvantage occurrence in the course of CEC construction.
- Hypothesis on CEC structure on the whole and structure of specific disadvantage in particular, plus method for verification of these hypotheses.
- Statistical regularities identified after analyzing CECs from data base of projects executed at Algorithm/GEN3 Partners.
 - Probability of occurrence of specific scheme of disadvantage-consequence;
 - Dependence of occurrence of groups of disadvantages-causes from a scheme of disadvantage-consequence;
 - Probability of occurrence of disadvantages-causes within these groups.
- Recommendations on creation of special software program based on the flow chart of enhanced algorithm for CEC construction.

Personal contribution of the applicant

Problem statement for the research, development of the methodology and research proper, analysis of results and development of methodological recommendations on

cause-effect chain construction based on the said results, development of detailed algorithm for CEC construction and preliminary study of possible schemes of relationship organization within special software program and dialog between users and software program represent personal contribution of the applicant.

Testing of the work

The algorithm for CEC construction without using statistical regularities proposed in the thesis (a structure consisting of continuous chain of pairs “disadvantage-cause and disadvantage-consequence”, rules for formulating disadvantages and approach for the search for disadvantages-causes) was used by the author in the course of execution of over 10 consulting projects at the Algorithm/GEN3 Partners.

Structure and volume of research

The work consists of introduction, six sections, conclusion (in total 41 pages). It includes 11 Figures, 6 Tables, and list of reference sources consisting of 30 titles.

Publications of the author on the topic of research

1. A.V. Medvedev, A.L. Lyubomirskiy. Approach to Enhancement of Algorithm for Constructing Cause-Effect Chains of Disadvantages. St.-Petersburg, 2013
2. A.V. Medvedev, A.L. Lyubomirskiy. Enhancement of Algorithm for Constructing Cause-Effect Chains of Disadvantages on the Basis of Statistical Regularities. St.-Petersburg, 2013
3. A.V. Medvedev, A.L. Lyubomirskiy. Application of Special Software Program for Constructing Cause-Effect Chains of Disadvantages. St.-Petersburg, 2013