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«Application of Phase Transitions for Inventive Problem Solving»

TRIZ Master thesis abstract

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General Description of Research

This paper deals with methods of inventive problems solutions by the standards applying. Objective is to create a complete methodology, which facilitates the effective application of phase transitions for inventive problems solutions. The methodology involves:

- Text of the five standards (including 15 substandards)
- Detailed examples of the use of standards (98 examples)
- Application Condition Table, which is used to select the standards from Subgroups 5.3 and 5.4. It allows to move from the results of Functional Analysis to the use of a particular standard / substandard (list of Functional Clues)

The methodology can be used both independently and as a part of a complete system of 76 standards instead of Subgroup 5.3 and 5.4.

Relevance and Importance of the Subject

Phase transitions can be attributed to the most significant (in practical terms) physical effects. The reasons are:

- Phase transitions are often used in patents and practical solutions
- They are most similar to the idea of ideality, because of: a) using the resources of the system is maximum (the desired change in the system is often achieved without the introduction of new substances), b) provide a dramatic properties change due to changes in the micro level, and c) they are simple one-parameter effects (only one control parameter is used)
- Phase transitions are studied in detail both in theory and by experiments

It should be noted that over the past 10-15 years the concept of phase transition has a significant expansion into the following areas:

- The phase transitions in polymer and composite materials. The emergence of the "smart material" concept is mainly associated with the implementation of previously unknown (or practically unknown) phase transitions in polymers and composites. Role of the "smart materials" in modern technology is significant.
- Structural phase transitions in nanoscale systems are actively studied and used. The importance of nano-materials for modern technology is grown rapidly, it is "fueled by" a powerful research funding.
- The analogues of phase transitions in open dissipative systems are discovered. This makes it possible to understand the behavior of a wide range of physical, technical and social systems and effectively manage them. This includes the processes of turbulence formation (the quasi-periodic structures), chaotic noise-like processes (phenomena such as the kinematic phase transition), ecosystem processes (an abrupt change in population size), economy and social structure (the concept of the phase crisis and its analogs), etc. This theme goes far beyond the scope of this work, but its development could enable to apply the TRIZ-tools in non - technical areas.

The first methodological tool for use of physical effects and phase transitions is the "Index of the physical effects". It was established by Yury Gorin in 1973. Then this index was complemented by chemical, geometrical and biological effects. The first versions of the indices provided the information fund for solving tools, but there was no any algorithm for effect selection.

Functional input for index was a step forward (for example, index in "Invention Machine" and "Gold Fire" software). However, we still could not:

- Identify situations in which the phase transitions using is most appropriate
- Choose a specific phase transition from the recommended list
- Identify a best way to use the phase transition

Potentially, the standards have higher instrumentality than indices. The System of 76 Standards has two subgroups for the use of physical effects and phase transitions (subgroups 5.3 and 5.4). However, these subgroups were developed last of all and are described very briefly. For example, the Standard 5.3.1 contains only two lines of text and one line of illustrating example. Brief description of these standards makes them practically unusable. Moreover, these standards are the last part of the System of 76 Standards. Often teachers give these standards for self-study. In this case, the brevity of the description is fatal for the understanding and practical application of these standards. It is necessary to develop detailed standards and Case Studies, suitable for individual study.

G.S. Altshuller pointed out the importance of regularly standards examining: "Description must contain an indication of the validity of the standard. Standard's solutions are the best one only for a current level of technology. Still, periodic updating of standards is absolutely necessary". There is a large number of publications devoted to the standards development. However, analysis of standards for relevance (i.e., at the appropriate level of technology) is absent.

And finally, the last problem. Historically, Vepol Analysis is the first and most widely used tool for the standards selection. However, at present the Functional Analysis became widespread and significantly expand Vepol Analysis. Currently there are no methodological tools for the transition from the Functional Analysis results to the standards.

Above problems make the improvement of standards extremely important. This work focuses on the improving of Subgroup 5.3 and 5.4. At glance, this choice of research object may seems too narrow. But these standards aren't only the most applicable in the innovation practice. They are a tool for resolving of physical contradictions in ARIZ-85C (Step 5.3, in which 5 of the 11 methods of resolving of physical contradictions address to the application of phase transitions). In addition, improved methods of application of phase transitions are the most promising way for all other indices improving.

Goals and Tasks of Research

The goal of this study is to increase the instrumentality of standards which use the phase transitions. Following problems should be solved to achieve the goal:

- In-depth development of standards which use the phase transitions, including the substandards identification (substandard is typical situation of the standard using/application)
- Synthesis of the algorithm for transition from the Functional Analysis results to the standards, which use the phase transitions
- Development Case Studies for the proposed instruments

In fact, because of the standards description brevity author had to rewrite texts of standards and select up-to-date examples

Research Method

In this paper the traditional research approach is used. Namely, an analysis of scientific and technical information to identify and classyfy high-level technical solutions and methods of their generation. Typically, analysis primarily focuses on patents. This approach has well-known advantages. However, there are also some disadvantages:

- A patent information contains a large number of not implemented (and, sometimes, unrealizable at all) technical solutions
- Patent information is dropped behind the scientific publications (up to 2-3 years, and in some cases - up to 4 years)
- Globalization of the world's patent laws often restrict the usage of patented ideas in other areas. This often occurs in practical use of physical effects and phase transitions

Therefore, significant additions to the traditional approach were done. In addition to patent databases, two types of sources were carefully analyzed:

- Scientific publications describing new phase transitions or new applications of already known phase transitions. Analysis of such publications makes it possible to identify "forward-looking" physical effects and phase transitions before their claiming
- Technical solutions which are the base of the best systems on the market. In this case a single successful application of a physical effect or a phase transition (at the level of the principle of operation) can be considered as a candidate for inclusion into the standard.

The second important feature of this work is the widespread using of the substandard concept. Substandard is more narrow, typically, most frequently occured situation of the standard using. However, scope of any standard isn't limited by the selected substandards and aren't the sum of them. This approach has similarity to the "microstandards concept" proposed by L. Pevsner. However, he proposed "bottom-to-top" construction of the system of standards, i.e. accumulation of microctandard data base and their subsequent classification. The present work offers to build the system of standards through "top-to-down" manner. A similar (in terms of methodology) approach is used in the works of N.Feygenson (identification of microtrends for the 3-rd stage of TC evolution) and A. Lyubomirskiy (identification of subtrends - typical situations of the TESE trends implementation).

It should be noted that this approach leaves the possibility to flexible use of the proposed recommendations. We can use old standards or short version of new standards for simple problems. If the problem is complex, we could apply the recommendations of this dissertation. They are more complex, but at the same time, more powerful.

Structure and Size of the Thesis

This work consists of three parts. The Part 1 is the actual thesis. It contains the relevance and purpose of the study, shows the used method and the main results. It also includes an analysis of standards and explanation of standards modifications. The Part 2 is a short version of a new standards. It is designed for everyday work. It includes the texts of the standards and additional materials. Part 3 is the complete texts of the new standards (70 pages) that includes a description of standards and detailed examples of their application use (i.e. Case Studies). This document could be used for primary acquaintance with the new standards.

Problem statement, the thesis subject relevance, goals and tasks of the study, a review of known approaches and detailed problem statement are shown in Sections 1-5.

Section 6 describes methods of the problem solving. Application of the expanded information database allows to identify patterns of development and improvement of technical systems. Methodological features of the "substandard concept" and their interaction with other TRIZ-tools are shown.

Section 7 contains a detailed analysis of existing standards texts and the justification of changes and additions. Use of the term "phase" was clarified. The feasibility and mechanism of transition from five to three standards for Subgroup 5.3 are shown. The following important changes in the text of the standards were done:

- Examples of phase state change of the tool, transmission, energy source and products were analyzed separately
- The features of standards implementation at the different system levels are shown
- Three-step mini-algorithm for the two-phase element development is formulated
- The concepts “reversibility of the function” and “reversibility of the parameter” is proposed for standard 5.4.1

The final part of the section is the table of Application Conditions. It allows to pass from the Functional Analysis results to the particular Standard/Substandard and to use them as a Functional Clue

Section 8 contains the results of the study analysis and a summary table of the standards text changes.

Sections 9 and 10 describe the results of the practical implementation of the developed standards and personal contribution of the applicant.

Section 11 contains results, conclusions and recommendations.

Scientific Novelty of the Research

Scientific novelty of the research is the development of the new analytical and synthetical (solving) tools, as well as a manner of combining these tools into the system. Specifically, the author considers the following developments novel:

- Proposed text of the standards
- All substandard formulas which describe the typical cases of standards in detail
- Three-step mini-algorithm for the two-phase element development
- Functional Clue formulas
- Table of the Application Conditions. It allows to pass from the Functional Analysis results to the particular Standard/Substandard and to use them as a Functional Clue
- The concepts “reversibility of the function” and “reversibility of the parameter”
- Additional entry points from Part 4 of ARIZ-85C into the system of standards

Practical Significance of Research

The practical significance of the research is the increasing of standards instrumentality, because of:

- Effective instrument for the transition from the Functional Analysis results into the new standards is created
- Detailed Case Studies set is created
- Proposed method is well coordinated with the existing TRIZ-tools (System of 76 Standards, ARIZ-85C (Step 5.3) and TESE)

The proposed tools are "open system". They could be expanded and improved by the inclusion of a new phase transitions and substandards

Main Provisions Presented for Defense

- Text of Standard 5.3.1 “Changing of the phase state”, including 4 substandards and 24 examples
- Text of Standard 5.3.2 “Transition to the two-phase element”, including 3 substandards, 30 examples and three-step mini-algorithm for two-phase element development
- Text of Standard 5.3.3 “The use of phenomena accompanying the phase transition”, including 3 substandards and 12 examples
- Text of Standard 5.4.1 “The use of reversible physical and chemical transformations”, including 2 substandards and 12 examples
- Text of Standard 5.4.2 “Output field amplification”, including 3 substandards and 20 examples
- Table of the Application Conditions and Functional Clues for new standards

Personal Contribution of the Applicant

All proposals described in the section "Scientific novelty of the research" are the personal contribution of the applicant.

Implementation of Main Results

The results were successfully reported at the following international conferences:

- The Conference TRIZFest -2009 (Russia, SPb, 27-28.07.2009)
- The 1st International Conference on Systematic Innovation ICSI 2010 (Taiwan, Hsinchu, 22-25.01.2010)
- The 2nd International Conference KOREATRIZCON 2010 (Korea, Seoul, 11-13.03.2010)

New tools were used by the author in daily practical work. Also, they were tested for training and practical problems solving at SRC “Algorithm”.

Results and Conclusions

Methodological results are:

- Enhanced information base (as against the patent database) should be used to identify patterns of development and improvement of technical systems. Because it provides: a) more efficient disclosure of scientific and technical information, b) identification of breakthrough technical ideas not “umbrella patented”
- Method to identify substandards by empirical data systematization was developed. This method uses the classification formed on the basis of the Functional Analysis and TESE terms
- Links between standards and other TRIZ-tools were constituted: a) additional entry points from Part 4 of ARIZ-85C into a system of standards were determined, b) table of the Application Conditions and Functional Clues was developed, c) level of coordination of the TS’s element (Supersystem – Technical System - Subsystem) was recommended for some standards

- The effectiveness of concepts "reversibility of the function" and "reversibility of the parameter" was shown

Practical results are:

- Instrumentality of standards which use the phase transitions were significantly enhanced
- Case Studies were developed

The results can be used for further development of methodological TRIZ-tools by:

- Usage of the methodological approach to the complete System of 76 Standards
- Development of the “Table of Application Conditions and Functional Clues” for the complete System of 76 Standards.

There are two promising areas for the further work. The first area relates to the physics of clusters. This branch recently has made significant progress. Now we can successfully use the concept of "emptiness" for the phase transitions description. Accordingly, we can logically merge the standards, which describe the use of "emptiness" and the standards, which describe the use of phase transitions. The second area relates to the non-technical systems. We can introduce the definition of phase transitions into standards, which are used to describe the non-technical (social, economic and other) systems. It will allow us to use the standards in non-technical areas

Publications

1. S.A.Logvinov, P.A.Egoyants “Razreschenie protivorechiy s ispolzovaniem fazovykh perekhodov cherez sverkhkriticheskoe sostoyanie”, TRIZ-Fest - 2009, pp.174-180, In Russian. http://www.triz-summit.ru/ru/section.php?docId=4338.
2. Sergey Logvinov, Petr Egoyants «Resolution of physical contradictions with use of second-order phase transitions» The 1st International Conference on Systematic Innovation ICSI 2010, conference proceedings, p.53.
3. Sergey Logvinov «Development of the "5.3 subgroup" of Standard for solving inventive problems» KOREATRIZCON 2010, Conference proceedings, p.50.
4. Sergey Logvinov «Development of the "5.4 subgroup" of Standard for solving inventive problems» International Journal of Systematic Innovation (IJoSI), article in press.
5. S.A.Logvinov, N.B.Feygenson “O vozmozhnosti sovmestnogo ispolzovaniya linii uvelicheniya pustotnosti i fazovykh perekhodov”, In Russian, www.metodolog.ru