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Technical System Expansion

Abstract

of a thesis for the highest level TRIZ certification (TRIZ Master)

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1 Research issue relevance

As shown in the works by Salamatov, the evolution of the main useful function of technical systems is the result of interaction between two contrary processes: producing of ideal substances and expansion (the running wave of idealization) which are a response to the "environmental claims". Technical system trimming is considered as a process of formation and evolution of an ideal substance.

Producing of ideal substances is realized through such mechanisms as trimming and combining of alternative systems. These mechanisms are supported by detailed methods which have been repeatedly tested by solving practical problems and which are widely used for technical system improvement.

The technical system expansion mechanisms, on the contrary, are underresearched. The existing approaches lack detailing; therefore, their application results do not fully satisfy the repeatability criterion[1].

Meanwhile, due to the high functional load of technical systems, their market promotion success is in many ways determined not only by the efficiency of the main function performance but also by the presence and effective performance of secondary functions. And customers are often interested in the presence and performance quality of secondary functions implying that the high quality and reliability of the main function performance are provided by default.

In this connection, creation of function-determining methods for technical systems which are expected to be needed by customers are becoming the issue of the day.

2 Research goals

The basic research goals are:

- analyzing of technical system «external» functionality;
- revealing of regularities of occurrence of new external functions in technical systems;
- developing of methods for formulating new functions in technical systems.

3 Review of current approaches to the problem

The main current strands of work relating to the technical system expansion[2] are:

The law of transition to a supersystem (expansion according to the "mono-bi-poly" pattern).

Inhomogeneous bi- and polysystems with shifted characteristics as well as multifunctional bi- and polysystems perform more functions and increase the technical system universality.

The running wave of idealization

The action of environmental claims shows itself in that the technical system evolution is the result of simultaneous trimming and expansion of technical systems. The "mono- bi-poly" mechanism is regarded as an expansion mechanism.

[1] The results of applying the method to one technical object by different users should be close

[2] A detailed review of reference literature is given in the work itself

The law of system completeness (the law of expelling an operator from a system)

The formulation of this law points to an extremely important source of origin of new functions in technical systems – the performance by a technical system of those functions, which were previously performed by an operator himself.

The law of satisfaction of human needs

Different classifications of human needs are known. There also exist the laws of the formation of human needs. Accordingly, technical systems should satisfy these needs.

Human-computer interface, ergonomics and usability

Consideration is given to the work comfort of a technical system user from the viewpoint of technical system usability and ease of control. Considerable attention is dedicated to the comprehensibility of device control and information perception processes. Employed are approaches intersecting with the law of expelling a man from a technical system.

Generally, analyzing the works dedicated to technical system expansion proved that this topic is given much attention in research. However, the specification level is insufficient for elaborating technical system expansion methods. This fact probably explains the absence of detailed methods.

The analyzed materials afford ground for the opinion that the problem of filling technical systems with functions needs a more detailed analysis, which is required for elaborating constructive methods.

4 Research results

4.1 Classes of functions in expanding a technical system

The analysis resulted in formulating the following types of external functions, which appear with technical system expansion.

1. Functions that are targeting on the product:
    a. increasing the number of actions performed on a product
    b. increasing the number of treated products.
2. Functions designed to expel a man from a technical system.
3. Functions providing improved interaction with a supersystem.
4. Functions of fighting with harmful functions.

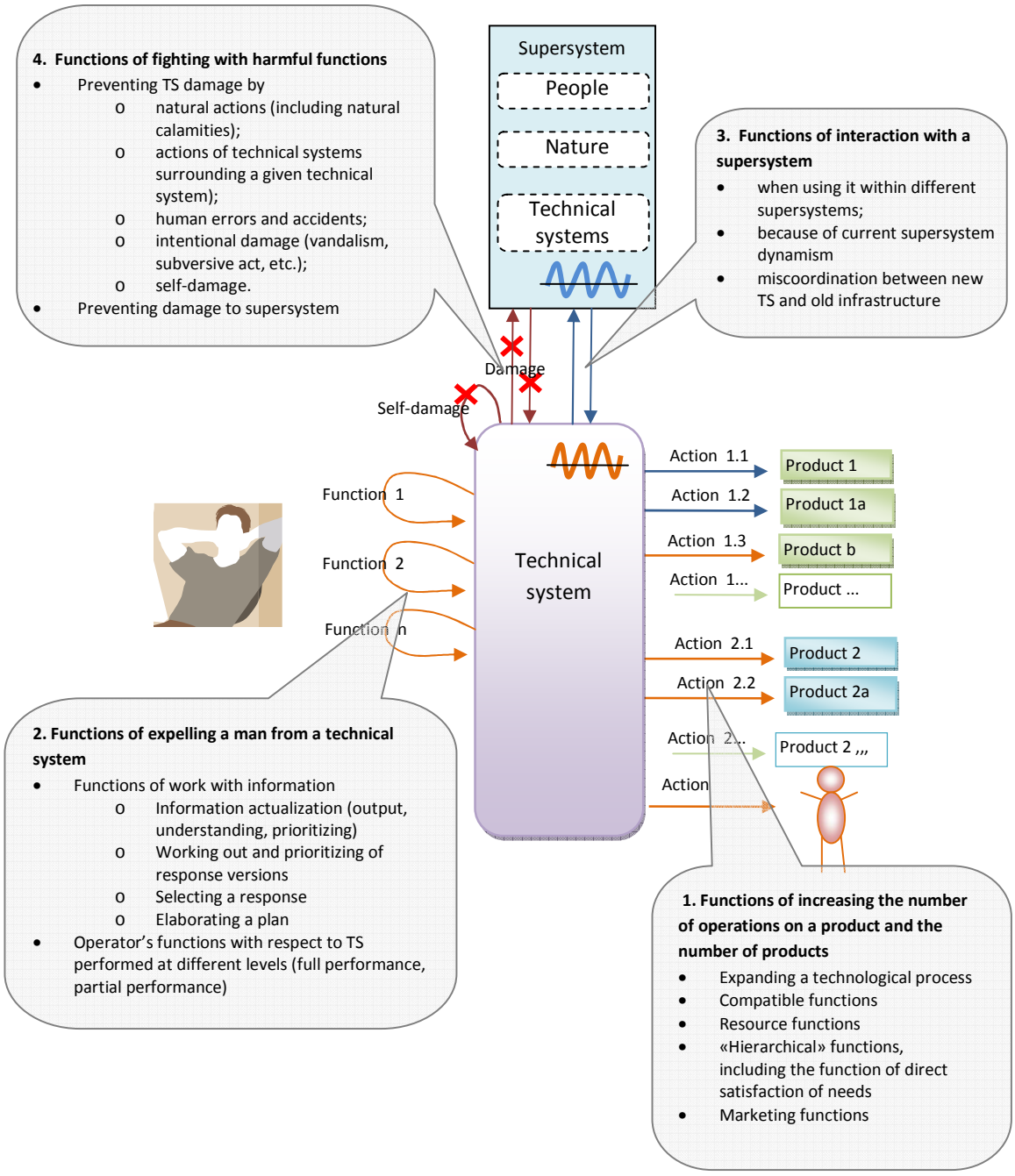

Fig. 1. Technical system expansion scheme.

Each type of functions, in effect, determines the technical system expansion regularity.

4.2 Functions of increasing the number of operations performed on a product and the number of products.

The regularity consists in increasing the number of actions performed by a technical system with respect to a product and increasing the number of products.

The need for such functions is caused by the fact that a customer must perform these functions in any case in order to manufacture a product. And having the opportunity to perform such functions by means of one technical system is convenient for a customer as it partially reduces his expenses and increases the ease of handling.

The need for functions aimed at satisfying human demands originates from the essence of these functions because their direct result is relevant for customers.

An additional benefit of introducing this class of functions is the fact that they are often performed at the stages of the technical system life cycle at which useful functions have not been performed before. This reduces the share of time and expanses of auxiliary stages of the technical system life cycle.

Below are given groups of functions belonging to this class.

4.2.1 Expanding a technological process

A technical system performs one or several functions with respect to a product. This is, however, only part of "operations" of a full technological process of product treatment.

A technical system often “assumes” the functions of those operations of a product treatment process which it has not performed before.

4.2.2 Compatible functions

A technical system is intended to perform its functions with respect to a product within the framework of a certain supersystem. Frequently enough, a system user also performs other functions within the framework of the same supersystem (manually or by means of other technical systems). The object of these functions may be either the technical system product or other articles.

Such functions are called “compatible” and a technical system can also take over these functions.

4.2.3 Resource functions

Technical system possesses the set of the substance and energy resources. If so then these resources can be used for performing of new functions of technical system at the stages of the technical system life cycle at which useful functions have not been performed before. In this case, the performed functions can turn out to be far enough from the functions for which the given TS was initially designed and sometimes they can also be used in supersystems different from the initial one.

The need for functions aimed at decreasing of customer’s expenses and reducing the share of time and expanses of auxiliary stages of the technical system life cycle.

4.2.4 “Hierarchical" functions and human needs

Performing a function gives a certain set of results aimed at product parameters changes. These set of results is used for achieving another set of results of a next hierarchical level.

The highest hierarchical level is satisfaction of a certain human need.

A technical system often “assumes” the functions of achieving results from the different hierarchy levels of results including satisfaction of a certain human needs.

4.2.5 Marketing functions

If people who can be affected in a certain way by a technical system become the object of the technical system action, this peculiarity is used frequently enough to attract people’s attention to this technical system (product). Such functions may be called marketing.

Functions of this type are close in some measure to the previous group because they also concern human needs. The peculiar feature of these functions consists in providing a kind of action on customers (these functions are mostly information) which can arouse their interest in a given technical system.

4.3 Function of expelling an operator from a technical system

The regularity consists in that a technical system performs an increasingly large number of functions, which were previously performed by an operator.

The need for this class of functions is determined by reducing (sometime to zero) the user’s expenses on performing these functions.

4.3.1 Function performance level

The following function performance by engineering system level can be obtained:

A. Full performance of a function previously performed by an operator (maximally possible variant)
B. Partial performance a function previously performed by an operator

4.3.2 Information-handling operations

If customer performs the functions directed at the technical system then he/she has to always perform a great number of functions the object of which is information.

The user receives information about the condition of a technical system, product and supersystem.

Then the operator should “process” this information, namely:

- understand it;
- prioritize it, that is, single out the most important information, which affects his action, from the entire body of obtained information and identify its most significant part;
- invent possible ways of action (such ways may be several);
- prioritize them;
- select the best way;
- elaborate a plan of actions.

Only with this done can an operator perform a function with respect to a product or correct the performance of this function.

When expanding, technical systems take over full or partial performance of these information functions.

Accordingly, the technical system acquires an information infrastructure, which provides the performance of information functions:

- sensors for receiving information;
- converters for converting information into a convenient form for transmission and analysis;
- processors for analyzing information and working out a solution;
- transducers which transform this solution into a signal;

- transmitters, receivers and information conductive elements that provide exchange of information between all elements mentioned above;
- executing mechanisms for executing the obtained solution.

4.3.2.1 Second level information functions

The 2nd level information systems provide:

- Monitoring the execution of functions which are fully or partially performed by a system
- Information about the system control methods

4.4 Functions of interaction with a supersystem

The regularity consists in that a technical system performs functions of enhancing the effectiveness of its interaction with a supersystem.

The necessity of coordination manifests itself in the following cases:

- when a technical system is expected to be used within different supersystems;
- when the supersystem which incorporates a given technical system is itself dynamic, that is, changes its composition and/or characteristics with time.
- miscoordination between new TS and old infrastructure

The need for this kind of functions is explained by the increase of the technical system capabilities and reduction of expenses on coordinating it, manually or by means of separate special devices, with a supersystem, owing to the technical system "ingrowth" within the supersystem.

4.5 Functions of fighting with harmful functions

The regularity consists in that a technical system performs an increasingly large number of functions, which provide neutralization of the harmful functions aimed to the technical system and outside technical system.

In so doing, the mechanisms of realization of these functions are analogous to the mechanisms, which are used to expel an operator from TS: an analogous information system appears.

4.6 Methodology

Methods of function formulation are developed for each function type. The common feature of these methods is the following. At the beginning function that can be transferred to a technical system are formulated on the base of the developed classification of the functions and analysis of interactions between the engineering system and product, customer and supersystem. In this case, engineering system components (existing or new) shall perform these new functions.

After that, procedure of trimming of these components is applied.

5 Novelty and candidate's personal contribution

1. Developing the classification of functions, which provide technical system expansion (Fig. 1).

2. Suggesting the classification of functions aimed at increasing the number of operations performed on a product:

- expanding a technological process,
- compatible functions,
- resource functions,
- "hierarchical" functions including functions of direct satisfaction of needs,
- marketing functions.

A hierarchical approach to describing the results of performing by a technical system of a function with respect to a product is used. It is demonstrated that a man becomes an object of technical system's functions even if the system's main functions act not on a man.

3. Specifying the mechanisms of "expelling" a man from a technical system:
    - Due to different levels at which a technical system performs operator's functions
    - Due to assuming by a technical system of operator's information-handling functions
        - information actualization (output, understanding, prioritizing),
        - elaborating and prioritizing response versions,
        - selecting a response,
        - elaborating a plan of actions.

Showing the regularity of expanding an infrastructure for information-handling support in technical systems.

4. Specifying the mechanism of appearance of functions designed for interaction with a supersystem. Showing the effect of various supersystems on the functional filling of technical systems.

5. Specifying the mechanism of appearance of functions aimed at providing safety both to a technical system and to a supersystem.

6. Giving reasons, for which a given class of functions is potentially needed by customers.

7. Developing a formulation method for each class of functions, which provides, to a high degree of probability, the repeatability of the method application results.

8. The main theses of the work have been developed by the candidate and presented in 5 publications.

6 Conclusions and application recommendations

There has been elaborated a classification of technical system expansion functions (functions of increasing the number of operations performed on a product and the number of products, functions of expelling a man from a technical system, functions of interaction with a supersystem, functions providing TS and supersystem safety) which are potentially needed by customers.

There have been developed methods for formulating each class of functions.

These methods may be used as a constituent part of the method of short-range and medium range forecasts of technical system evolution.

The methods can be easily adapted to use in different specific conditions such as software functionality development, analysis of human/technical system interaction interface, etc.

7 Application practice

The author carried out the first full-scale test of the method in 1991 within the framework of the work performed for the Digital Television Institute of Minsk Plant "Horizont", which set as one of its goals the identification of possible functions of TV-sets.

Further, the method was used by IMCorp specialists for executing consultation projects and developing functionality of «TechOptimizer» and «Goldfire Innovator» software.

8 List of published works dedicated to the dissertation theme.

1. Девойно И.Г. Усложнение технических систем. - Журнал ТРИЗ т.2, № 1, 1991.
2. Devoino I. Forecasting additional functions in engineering systems. Proceeding of ICED-93. The Hague, 17-19 August Vol.1, 1993, pp 274-277.
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4. Девойно И.Г. Функциональное наполнение ТС. – Журнал ТРИЗ. - Обнинск: Протва-Прин, 1996, 1 (№11)
5. Девойно И.Г. Прогнозирование дополнительных функций в технических системах/ / Тезисы докладов 3-го научного семинара по проекту «Изобретающая машина» (Минск, 15-17 сентября 1992), с.10-13.