Method for Quantitative Evaluation of Innovation Tasks for Technical Systems, Products and Processes

Pavel Livotov
TriS Europe GmbH, Germany

Abstract

The paper is addressing the main needs of the industrial sector regarding early stages of innovation process, product development and inventive problem solving. The proposed method includes a formalized identification and quantification of system functions and properties as well as of corresponding innovation tasks. For each identified function the level of its current performance, priority and measurable value of its innovation potential are estimated. A new approach is proposed for calculation of the ideality level of technical systems. Method is illustrated by example of its application for innovation concept development of a packaging line for food industry. Opportunity for identification and quantitative evaluation of innovation tasks for processes and for non-technical systems is outlined.

Keywords

Technical System, Innovation Potential, Innovation Strategy, Quantitative Analysis, Ideality Level, TRIZ

1 INTRODUCTION

This paper is addressing the main needs of the industrial sector regarding the early stages of innovation process, product development and inventive problem solving activities.

As well known, the description of initial problem situation with TRIZ includes system analysis with definition of positive and negative functions and properties of significant system components, continued by contradiction analysis [1]. Contradiction analysis results in the identification and prioritising of innovation tasks to be solved. This initial phase of innovation process often faces serious difficulties within working teams, which are often unable to find a consensus in understanding of origins of contradictions and to select a set of innovation tasks, which are crucial for successful innovation. This fact often leads to weak innovation strategies or to a “solving a wrong problem” phenomenon.

The proposed method includes formalized identification and quantification of system functions and corresponding innovation tasks. For each function, its priority, the level of its performance and measurable value of innovation potential are estimated. A new original approach is proposed approach for calculation of the ideality degree of whole technical system. Additionally method allows to identify and to measure following function clusters:

- core functions with insufficient performance,
- core functions with high level of performance,
- over-engineered functions.

Based on this analysis, innovation strategies that lead to a significant measurable innovation and growth of system ideality can be systematically developed. The quantitative method helps also to anticipate market opportunities of innovation concepts in the very early stages of the innovation process - already in the phase where the innovation strategy and tasks are formulated. It structures the innovation activities, focusing them on the tasks that are essential for market success, reducing innovation costs and risk of poor investments.

The paper demonstrates how this method was applied for developing of innovation strategy for a packaging machine in food industry.

The method can also help to identify and evaluate innovation opportunities for processes and as well as for non-technical systems.

2 METHOD

The method is demonstrated step-by-step on example of innovation tasks formulation for a packaging machine.

2.1 Definition of innovation tasks

Description of all essential components of technical system with their useful functions and all undesired or negative properties is the basis for the formulation of complete list of all thinkable innovation tasks. These tasks can be separated in two groups:

- further improvement of positive functions or properties,
- elimination of negative functions or properties.

For example, two following functions/properties (one positive and one negative) of a product packaging line in the food industry deliver two innovation tasks:

function / property		*innovation task*
high number of run product formats (*positive*)	➔	increase number of product formats
high energy consumption (*negative*)	➔	reduce energy consumption

The mentioned list of functions and corresponding tasks can be rather long including 30...80 or more positions.

2.2 Tasks priority and performance level

The priority or importance of formulated innovation tasks has to be defined by expert group quantitatively using following scale from 0% (lowest priority) to 100% (highest priority) with for example interval of 25%.

Furthermore the expert group have to evaluate current performance level of each function using following scale from 0% (no performance) to 100% (ideal performance). Definition of measurable ideal values for each function and corresponding innovation task is of high significance in this step of the process. For example, for tasks mentioned above following ideal values, corresponding to 100% of performance, can be proposed:

innovation task		*ideal value (100%)*
increase number of product formats	➔	unlimited number of run product formats
reduce energy consumption	➔	no energy consumption

Quantitative market surveys and customer interviews can be used additionally for final estimation of tasks priority and performance values:

innovation task		*priority*	*performance*
increase number of product formats	➔	84% (*high*)	45% (*low*)
reduce energy consumption	➔	62% (*medium*)	66% (*medium*)

2.3 Calculating ideality of technical system

Based on captured data we calculate the performance level of the whole technical system, which can be interpreted as measurable definition of the system's ideality. In the fact the proposed formula (1) considers the complete list of positive and negative functions (properties) of technical system as well as estimated weights (i.e. priority) and current performance level of functions.

$$\text{Ideality} = \sum_{i=1,n} \frac{Z_i (X_i + a X_i (X_i - Z_i))}{\sum_{i=1,n} (X_i + a X_i (X_i - Z_i))} \qquad (1)$$

where
X_i - priority of a technical function, 0…100%;
Z_i - performance of a technical function, 0…100%;
n - number of technical functions, e.g. n=30…80;
a - regression coefficient, e.g. a=0,5…2,0.

The performance of technical function can be also interpreted as satisfaction level of corresponding customer need. In this case the ideality (1) can be understood as a total satisfaction value of a system. The ideality value of 100% corresponds to a technical system, in which all known needs are performed absolutely to a highest thinkable ideal level. The proposed formula is based on the mathematical model originally described in [2].

2.4 Innovation potential of tasks

To one of TRIZ postulates belongs a statement that technical systems are developing towards growth of their ideality [3], [4]. The equation (1) delivers information about current ideality value. Accountable evolutionary potential of technical system in terms of presented approach is a difference value between 100% and current ideality (1).

This innovation potential is non-uniformly distributed between identified innovation tasks. In other words, each task possesses its specific (partial) innovation potential, depending on task's priority and current performance of underlying function. Innovation potential of a task Y_i can be calculated as its maximal contribution to ideality growth, which can be obtained in case of ideal solving of this task with performance of 100%:

$$Y_i = \frac{X_i + a X_i (X_i - Z_i)(1 - Z_i)}{\sum_{i=1,n} (X_i + a X_i (X_i - Z_i))} \qquad (2)$$

where
Y_i - innovation potential of task in %;
X_i - priority of a technical function, 0…100%;
Z_i - performance of a technical function, 0…100%;
n - total number of technical functions and tasks;
a - regression coefficient, e.g. a=0,5…2,0.

If the performance of technical function is interpreted as satisfaction level of corresponding customer need, the innovation potential demonstrates the role of each innovation task in total growth of satisfaction with whole system.

Some calculation results for innovation strategy and concept formulation of a packaging line for food industry are summarized as a case study in Table 1 below. Innovation tasks, sorted in accordance to their potential, help to bundle innovation activities, focusing them on the most essential aspects. The top three innovation tasks in this example have a total innovation potential of 10,5%.

Solving of these tasks will increase calculated ideality value (1) of packaging line from 67% to 77,5%. These tasks define the innovation strategy and their solutions will shape promising innovation concept of packaging line with higher ideality level and innovation success.

innovation task	*priority*	*perfor-mance*	*innov. potential*
increase number of run product formats	84%	45%	3,8%
tolerate higher size deviation of product	75%	50%	3,5%
avoid contamination of primary packaging	75%	58%	3,2%
tolerate density deviation of product	79%	80%	1,6%
increase line productivity	78%	82%	1,5%
reduce compressed air consumption	70%	74%	1,2%
...	...	...	...
reduce energy consumption	65%	76%	0,6%
reduce noise and vibration level	62%	76%	0,5%

Table 1: Choice of innovation tasks for a packaging line.

2.5 Typical clusters of innovation potential

One and the same technical system, e.g. packaging line, can be utilized under different conditions (e.g. in different plants, for different product types or packaging materials). In each application of the system the priority and performance values of innovation tasks can be different. One can classify various application cases into four typical clusters in accordance to corresponding combinations of priority and performance values for each innovation task:

cluster 1: high priority functions with high performance,
cluster 2: high priority functions with low performance,
cluster 3: low priority functions with high performance,
cluster 4: low priority functions with low performance.

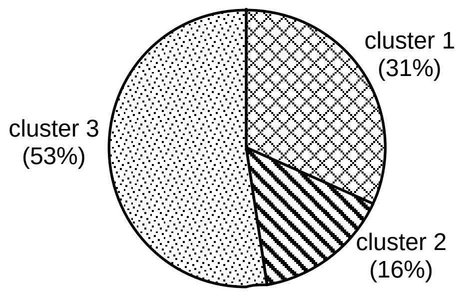

Figure 1: Example of clusters for innovation task.

Clustering example of 25 different application cases of packaging line for innovation task "Reduce consumption of compressed air" is illustrated in Figure 1.

Task “Reduce consumption of compressed air” shows for 16% of applications high priority combined with low performance (cluster 2): innovation efforts here are highly recommended.

For 31% of applications (cluster 1) the already achieved high level of performance has to be kept. And finally for the majority of applications (cluster 3, 53%) reduction of compressed air consumption is of low priority by already high level of performance: no innovation activities are recommended here.

The size of the clusters mentioned above has an effect on innovation potential values (2). The corrected values of innovation potential Y^*_i for each task can be calculated with help of following empirical formula:

$$Y^*_i = Y_i (1 + C_{1i} + 2C_{2i} - C_{3i}) \quad (3)$$

where

Y_i - innovation potential of task in %, calculated with (2);
C_{1i} - standardized value of cluster 1, $C_{1i} = 0…1$;
C_{2i} - standardized value of cluster 2, $C_{2i} = 0…1$;
C_{3i} - standardized value of cluster 3, $C_{3i} = 0…1$.

Such correction of innovation potential helps to increase calculation accuracy if capturing of priority and performance values for innovation tasks was performed by interviewing of users or customers.

3 SUMMARY

This paper presents a new quantitative method for calculation of ideality degree of technical systems and for selection of most promising innovation tasks for directed system evolution. We understand the innovation strategy for technical system, product or process as bundle of innovation tasks with the highest innovation potential. Depending on degree of their ideality, innovation tasks may require disruptive or sustainable solutions. Based on this analysis, innovative concepts that lead to a significant measurable growth in customer value and satisfaction can be systematically developed.

4 REFERENCES

[1] Livotov P., Petrov V., “Innovationstechnologie TRIZ. Produktentwicklung und Problemlösung“, Handbuch. TriSolver Consulting, 2002, Hannover, 302 S., ISBN 3-935927-02-9.

[2] Livotov P., “Differentiating the role of TRIZ in sustainable and disruptive innovation process,” in Proceedings of the TRIZ Future 3rd World Conference, ETRIA, Aachen, 12.-14.11.2003.

[3] Altshuller G.S., Creativity as an Exact Science. The Theory of the Solution of Inventive Problems, Gordon & Breach Science Publishers, 1984. ISSN 0275-5807.

[4] Petrov V., “The Laws of System Evolution”, Proceedings of the TRIZ Future 1th World Conference, Bath, 7-9 November 2001, p. 109-128, ISBN 90-77071-01-6.

5 CONTACT

Pavel Livotov, Dr.-Ing.

TriS Europe GmbH,

D-30175, Hannover, Germany

E-mail: p.livotov@tris-europe.com

Phone: +49 (511) 811 200 40

FAX: +49 (511) 811 200 45