Managing the Ideality Concept and the Evaluation of The Innovation Level

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Abstract:
Lately, there is the great stimulus for research of modelling the innovation process for products, especially for SME companies. This paper present some researches regarding usage of ideality as a basic concept derived from Theory of Inventive Problem Solving (TRIZ) methodology. TRIZ is a structured approach to managing innovation that puts a scientific process behind problem solving so individuals can generate more solutions of a higher quality, in less time. The ideal final result (IFR) is one of the tools used during the “problem definition” phase of TRIZ. IFR is a description of the best possible solution for the problem situation (or contradiction), regardless of the resources or constraints of the original problem. The IFR has the following characteristics: eliminates the deficiencies of the original system preserves the advantages of the original system; does not make the system more complicated (uses free or available resources); does not introduce new disadvantages. The Ideal Final Result encourages the use of breakthrough thinking by allowing you to visualize an ideal solution that leverages advantages of the current system while disregarding any deficiencies. The process of using this approach starts by defining/formulating the Ideal Final Result; this helps to: encourage breakthrough thinking, inhibit moves to less ideal solutions (reject compromises), lead to the discussions that will clearly establish the boundaries of the project. On this basis, the authors suggest methodologies which uses the ideality concept in product development, first of all for establish the level of innovation of a product. The IFR uses the technical tools of TRIZ effectively in solving the right problem and this is done by controlling the level of negative characteristics of the or undesired costs.

Keywords: Ideality, Ideal Final System, ideality degree indicators, evaluation indicators, costs

1 Introduction
Nowadays, one of the most important factors that determine the industrial competitiveness of the marketable products is the innovation degree, with special emphasis on the innovative activities in small and medium sized enterprises. A more frequently used tool in the managing the process of fostering inventiveness of the products is the TRIZ methodology associated to other adjacent methods. This methodology is based on the philosophy of the evolution towards ideality.

2 Problem Formulation
One of the important problems that concern the designers is measuring the ideality degree and how the ideality could be used in product’s development. Ideality is one of the basic concepts of the Theory of Inventive Problem Solving – TRIZ method. It is used during the „problem definition” phase and describes a solution to a problem free of any mechanisms or constraints from the original problem or issue. Three primary activities for problem analysis and definition are: formulating the Ideal Final Result, functional analysis and trimming, finding the zones of the problem. The Ideal Final Result (IFR) is a implementation-free description of the situation after the problem has been solved. It focuses on customer needs or functions needed, not the current process or equipment. The goal of formulating the IFR is to eliminate rework by addressing the root cause of the problem or customer need. The IFR is a psychological tool that orients you to the use of the technical tools. Formulating the IFR helps for looking at the constraints of the problem, and consider which constraints are required by the laws of nature,
and which are self-imposed. A basic principle of TRIZ is that systems evolve towards increased ideality, where ideality is summarized by the equation:

$$\text{ideality} = \frac{\sum \text{benefits}}{\sum (\text{costs} + \text{harms})}$$

The key to IFR evolution is increasing benefits while decreasing costs and harm associated with the new design. The extreme result of this evolution is the Ideal Final Result: It has all the benefits, none of the harm, and none of the costs of the original problem.

The application of the ideality within the products development requires the knowledge and usage of some basic concepts such as: the Ideal System, the Ideal Final Result, the Ideal Product, the Ideal Process and the Ideal Substance.

○ The **ideality of a system** is defined as the “ratio between the useful effects and the sum of the costs and harmful effects” [4]. This general definition of the ideality opens new paths in designing and production of products with profitable effects as well as cost minimizing or functionality increase.

○ The **Ideal System**. Theoretically one considers the Ideal System as a non-existing structure, however a structure that accomplishes the desired function. The Ideal System is the system in which obtaining the designed function and neutralising the unwanted effects is done with a minimum of possible changes of the system and its environment, namely by using only the resources available within the system and its environment.

○ Based on the TRIZ method, one considers that the application and formulation of the **Ideal Final Result – IFR**, offers a special motivation in solving the design problems and product production on a high level of inventiveness. Therefore, the Ideal Final Result represents for the designer a target and a guideline to be followed, in the same time. Application of the concept of Ideal Final Result does not allow the designer to divert from the path of obtaining the best solution and to accept off-grade solutions based on trade-offs or suboptimal solutions.

In solving a problem it is very important for the Ideal Final Result to be kept in mind during the process of problem solving. A correct **Ideal Final Result** allows action upon one of the conflict elements of the system, ousting the useless or harmful effects, while keeping the useful functions without letting other elements being inserted in the system.

The concept of **Ideal Final Result** is linked to the concepts of Ideal Product, Ideal Process and Ideal Substance.

○ The **Ideal Product** is a non-existing product that accomplishes all the desired effects. Sometimes the Ideal Product is obtained through its functions accomplished by other product or by another part of the system or together with another product or with another part of the system.

○ The **Ideal Process** is the self-adjustable process that doesn’t consume any energy or time while obtaining the desired effects.

○ The **Ideal Substance** is the substance that practically does not exist but still accomplishes its functions.

### 3 Problem Solution

The main indicators that give an overview upon the ideality degree of a system can be classified into two classes: **one-way evolution** indicators and **bidirectional** evolution indicators. These indicators show also the evolution paths of the technical systems towards the so-called Ideal Final System- IFS.

#### 3.1. One-way evolution indicators

The one-way evolution of a technical system can be measured with indicators such as: the dimensionality degree of a system and its parts, the aggregation stage or phase of the system or components, the type, nature and frequency of the actions applied on the system or its parts, the “porosity” degree of the system or its parts, the dynamic capability degree – the adaptability, flexibility of the system or its parts and the human involving degree.

Next it will be presented the essential elements associated with the definition and characterisation of these indicators, based on meaningful examples.

1. **Dimensionality degree of the system**. One very important indicator of the ideality degree of a technical system, product or process is the dimensionality of the system or its parts. According to this indicator, the change of the dimensionality of the technical system leads to improvements of its functions and to evolution towards the Ideal System (fig. 1).

![Figure 1. System’s evolution in the direction of dimensionality degree increase](image)

For the increase of the ideality of the system, one must change the number of dimensions of the system from zero dimension (Point) to one dimension 1D (Line), to 2 dimensions 2D (Plane) and in the end to 3 dimensions 3D (Volume).

**Aggregation phase of the system**. Generally, according to this indicator the technical system evolves towards ideality respectively towards the Final Ideal System, as the elements or the components of the system become more mobile. One of the ways of accomplishing these modifications is changing the aggregation stage or phase of the system (Figure 2).
In this way the gaseous elements are considered to be more “flexible” then the solid ones. **The type, nature and frequency of actions applied on the system.** All technical systems include one or more actions. One action can be found as an interaction between two parts of a system or between a part and one exterior element of the system.

**The “porosity” degree of the system.** The evolution of a technical system towards the Final Ideal System can be measured through the degree of “porosity” of the system or its components. According to this indicator along with the increase of the porosity degree of a system, this one evolves towards the Ideal Final System (fig. 4). From this point of view the less evolved system is a mono system, the system evolves by turning into a bi-system and this one also evolves into a multi-system. Depending on the type, nature and dimensionality of the functions and features of the system, the system evolves by turning into a bi-system and this one also evolves into a multi-system.

**Dynamic capability degree of the system.** The system evolution model based on the dynamic capability refers to the capacity of a technical system to become more “dynamic” or more flexible in certain conditions (Figure 5).

Based on this indicator it is considered that the flexibility increase of a system determines the increase of the ideality degree and its evolution towards the Ideal Final System (Fig.5). From this point of view, the system’s flexibility and the possibility of the functions to change are the most important characteristics that a system should own.

**Human involving degree** One of the most important indicators of measuring the degree of ideality is the degree of human involving in the system’s functionality (Fig. 6).

Depending on the human factor involvement (Figure 6) together with the decrease of human implication a given system can be: a human operated system, a human controlled system, a human interfaced system, an autonomous system, a self reproductive system and finally the Ideal Final System.

3.2. The indicators of the bidirectional evolution

The indicators of the bidirectional evolution can be classified into three categories: the system multiplicity degree, the nature, the type and dimensionality of the functions and features of the system and the convolution degree of the system.

**The multiplicity degree of the system** According to the degree of multiplicity of the system (Figure 7) it can be concluded that if the technical system or a subsystem of the system is a mono system, the system evolves by turning into a bi-system and this one also evolves into a multi-system.

**The nature, type and dimensionality of the functions and features of a system.** The most lowered level of ideality for a system, bi-system or multi-system is to have a single specific function, respectively, a mono-function.
accomplishment. The number of elements involved in the function’s ration between the number of functions and the total elements of the system – substances and fields” or “the ration between the number of fields and the total number of system’s functions. Based on the above presented indicators there can be made an evaluation of the degree of ideality of a system. The convolution degree of a system, One of the laws of the technical systems evolution shows that the systems evolve first in the direction of the number of fields increase further, through convolution, the fields join transforming into a new mono-field. The degree of convolution is expressed through the convolution coefficient. The convolution coefficient \( C_c \) is defined as the “ration between the number of fields and the total number of elements of the system – substances and fields” or “the ration between the number of functions and the total number of elements involved in the function’s accomplishment” [1].

For example for a substance-field, elementary Su-Field model (Fig. 9a), a model made out of two substances and one field, the convolution coefficient is \( C_c = 1/3 \), for a Su-Field chain, a model that contains at least three substances and two fields (Fig 9b), the convolution coefficient is \( C_c = 2/5 \), and for the double Su-Field model made out of two substances and two fields (Fig 9b) the convolution coefficient is \( C_c = 1/2 \).

9. Su-Field Models: a – Elementary model; b - C model; c – Double model

Based on the above presented indicators there can be made an evaluation of the degree of ideality of a system.

3.3. Methodology

The evaluation of the innovation level of the products faces some difficulties due to the lack of scientific instruments to facilitate this step. This is why nowadays there exists a high degree of subjectivity regarding the general definition of the concept of new product; this situation is met also in the assessment of the novelty of some material products as well as in the assessment of some specific products such as scientific paperwork from different fields. Regarding all the above, the proposed methodology has as objective the assessment of the innovation level of the products. This can be easily particularized to the assessment of the level of innovation of the scientific papers especially the applications regarding the financing of researching grants within European and national programs.

Establishing the global indicator of the innovating level

The methodology of assessing the innovating level of products is based on the development of a global indicator build up through the weighting addition of three indicators proposed by the authors: the client satisfaction indicator \( I_{SC} \), in accordance to the delightful characteristics from the Kano model [1, 5], the inventiveness indicator, \( I_{IN} \), associated with the Altshuler 5 levels of inventiveness [1, 5] and the Ideality Indicator \( I_{ID} \), that reflects the ideality degree of a product [4]. In order to evaluate the level of innovation of a product, the authors propose a global indicator of the innovation level \( I_{NI} \) that can be expressed as follows:

\[
I_{NI} = I_{SC} \cdot p_{SC} + I_{IN} \cdot p_{IN} + I_{ID} \cdot p_{ID} =
\]

\[
= I_{SD} \cdot p_{SC} + I_{IN} \cdot p_{IN} + \left( \sum_{k=1}^{9} i_k \cdot q_k \right) \cdot p_{ID}, \tag{1}
\]

where:

\( p_{SC}, p_{IN} \neq p_{ID} \) are the weights of the three indicators, \( i_1, i_2, ..., i_9 \) are the indicators of the ideality degree \( q_1, q_2, ..., q_9 \) are the weights of the ideality degree indicators. The sum of the weights from every category equals 1, respectively: \( p_{SC} + p_{IN} + p_{ID} = 1 \) \( q_1 + q_2 + ... + q_9 = 1 \).

Depending on the field where the methodology is applied, some weights might be zero.

Establishing the client’s satisfaction indicator

The characteristics of a product can be classified in accordance to the client’s satisfaction presented in the model developed by Noriaki Kano, in three main groups: dissatisfactory characteristics, satisfactory characteristics and delightful characteristics [1, 2].

○ The dissatisfactory characteristics in the sense of “not happy” are these product’s characteristics that determine the insatisfaction of the client where they are not found in the product or when they are less represented within the product and they influence the client satisfaction in a very low level when they are highly represented in the product. The unsatisfactory characteristics represent the so-called “expected quality”.

○ The satisfactory characteristics are these characteristics that the clients know, they want them in the product and they ask about them when buying the products. When the clients do not find them in the product they are not satisfied and when they are well represented in the product they characteristics produce satisfaction. These characteristics express the so-called “desired quality” because they are features of the product with high importance to the client.

○ The delightful characteristics are these characteristics that the clients do not ask about them because they are aware of them, therefore their missing is not inducing insatisfaction but they produce a high level of satisfaction and delight when the...
customers encounter them in the product. The delightful characteristics are surprising or attractive or enthusiastic characteristics and they express the “enthusiastic quality” or the “unexpected quality”.

Following this methodology, the authors consider as “quality” or the “unexpected quality” characteristics and they express the “enthusiastic characteristics are surprising or attractive or enthusiastic customers encounter them in the product. The delightful product.

For a level four product and mark 10 for a level 5 product.

Establishing the inventiveness indicator

Level one products – are products that do not involve any invention and the new products are produced by slightly improving the existing products through well known methods within the field and the inspiration source comes from the personal knowledge.

Level tow products - are new products produced through minor improvements brought to existing products when the inspiration source comes from the scientific field where the designers are working.

Level three products – are new products produced with fundamental improvements brought to existing products through known methods where the solutions should be searched in adjacent fields or in other fields;

Level four products - are new products or products from the new generation where new principals are used; the solutions come from clarifying phenomena coming from different fields, fields that are less understood till that moment.

Level five products – are products based on rare scientific discoveries (breakthroughs), they are new products with solutions discovered by pushing the existing limits of the science.

To make allowance for this classification, the product’s evaluation and especially the scientific paperwork’s evaluation, the Inventiveness Indicator \( I_{IDN} \) should be expressed as mark 2 for a level one product, mark 4 for a level two product, mark 6 for a level three product, mark 8 for a level four product and mark 10 for a level 5 product.

Establishing the ideality indicator

The ideality indicator \( I_{IDN} \), takes into account the product’s ideality as the authors emphasize in the paperwork [4]. The measurement of the ideality level of a product and especially of a scientific paperwork it is made based on nine ideality measurement indicators. [4] It is proposed for the indicators to take values from 1 to 10 depending on the accomplishment level. Every indicator has a weight \( q_i \) with a value depending on the product’s specific (features). These indicators and their marks assigned to the accomplishment levels are presented bellow:

1). The system’s dimensionality degree \( i_1 \): zero dimensions - 0D - Point – mark 2, one dimension - 1D – Line – mark 4, two dimensions – 2D - Plan – mark 6, three dimensions – 3D – Volume – mark 8, and for more then three dimensions – complex structures – mark 10.

2). Aggregation phase indicator \( i_2 \): for the solid stage the indicator is expressed through value 1, the liquid phase is expressed through value 3, the gaseous phase is expressed through value 5, the plasma phase – value 7, the field phase – value 9, vacuum phase – value 10.

3). The indicator of the type, nature and frequency of actions applied on the system \( i_3 \): continuous actions - mark 3, vibrating actions - mark 6, vibrating actions with high resonance frequency - mark 9, and for stationary waves - mark 10.

4). The “porosity” degree indicator, \( i_4 \): takes the value 1 for the mono solid, value 3 for the homogeneous solid (body), value 5 for the solid (body) with large dimension gaps, value 7 for the solid (body) with capillary gaps, value 9 for the porous material and value 10 for disperse fine solid particles.

5). The system’s dynamic capability of the indicator, \( i_5 \) for the rigid system - value 1, for the system with 1 – 3 joints - value 3, for the multi-joined system - value 5, for the elastic system - value 7, for the system with high flexibility – value 9, for the system based on the flexible field – value 10.

6). The human implication indicator, \( i_6 \): value 3 for the human-operated systems, value 6 for the human controlled systems, mark 9 for the human interface systems, mark 10 for the autonomous, self-reproductive systems.

7). The multiplicity degree indicator, \( i_7 \): value 2 for mono-system, mark 6 for bi-system and mark 10 for multi-system [4].

8). The indicator of the nature, type, function’s dimensionality, and system’s features, \( i_8 \): value 2 for the mono-function, value 6 for the multi-function and mark 10 for the multi-function system with opposite functions.

9). The convolution degree indicator, \( i_9 \): value 0 for \( C_c = 0 \), value 1 for \( (0;0,15) \)

\[
C_c = \begin{cases} \in (0;0,15), & \text{value 2 for } C_c \in [0,15;0,25), \text{ value } 3 \text{ for } C_c \in [0,25;0,35) \ldots \text{ value 9 for } C_c \in [0,85;0,95) \text{ and value } 10 \text{ for } C_c \in [0,95;1]. \\
\end{cases}
\]

By analogy with the estimation methodology of the global indicator of the product’s quality level, there have been analysed two ways of determining the ideality indicator \( I_{IDN} \): the weighted addition of the 9 indicators and the weighted multiplication of the same.
The drawn conclusion was that in order to determine the indicator there shall be considered the weighted addition because in the case of the weighted multiplication the ideality indicator can be zero, in this situation the indicator does not reflect the reality. Therefore, the ideality indicator can be expressed as:

\[ I_{ID} = \sum_{k=1}^{9} i_k \cdot q_k \quad (2) \]

where:

- \( i_k \) represents the nine indicators of the ideality degree;
- \( q_k \) – its weights, \( \sum_{k=1}^{9} q_k = 1 \).

The indicator’s weights will be established according to the assessed product and they will be valid for all the products or scientific paperwork that takes part in the same category.

**Defining the ideality within the Su-Field Analysis**

The Su-Field analysis is applied in next steps as follows:

- **Step 1 - Problem Description**- in this step the system is evaluated and there are emphasized the system’s functions and the problems that should be solved.
- **Step 2 – Building up the Su-Field Model** – in this step a scheme of the model shall be drawn emphasizing for example: Substance S2 – the active substance, Substance S1- the substance ought to be operated upon, the field that induces the undesired action and the unwanted action expressed through corrugated arrow (figure 10).
- **Step 3- Reconsidering the Su-Field Model**. In this step it is reconsidered and redrawn the Su-Field Model trying to eliminate the unwanted action by transforming it into a useful or neutral action.
- **Step 4- Declaring the ideality.** In the Su-Field Analysis, the ideality is defined as “there is a element X which can transform the unwanted action into a useful one”.
- **Step 5 – Looking for the X element – solution among the internal resources** – one tries to identify the X element within the internal resources, among the system’s elements. This can be done by reformulating the ideality definition inserting one by one instead of the X element, each component of the system trying to solve the problem first using only the internal resources without modifying the system.

Figure 10. Basic model of Su – Field analysis

**Step 6 Looking for the X element- solution among the external sources.** When the solution cannot be found in step 5, the Su-Field analysis proceeds further with the last phase where the solving of the problem shall be considered by inserting a third substance S3 inside the system.

### 4 Conclusion

It is obvious that even SME could use the IFR approach for improving the inventiveness and innovation degree – it is convenient to use, it is less expensive and, more, resource saving and brings much benefit when is properly followed. Based on all above presented there could be drawn the following conclusion:

1. The paperwork presents the ideality and Ideal Final Result concepts as well as the indicators that can evaluate the ideality degree of a product.
2. It is proposed a methodology of evaluating the level of innovation of the products and of the scientific paperwork by taking in consideration the Kano Model, the five levels of inventiveness proposed by Alshuller and the degree of ideality of the products.
3. Through the application of the presented methodology there has been eliminated the subjectivity within the evaluation of the inventiveness level of the products.
4. In this paper, there has been emphasized the modality through which the ideality should be declared, defined and targeted with the help of different methods associated to the TRIZ methodology, as well as its importance in finding inventive solutions to product’s development.

### References: