Conceptual Design Based on Substance-Field Model in Theory of Inventive Problem Solving

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***Abstrac*—The paper shows the innovative conceptual design for the Inventive Standards based on Su-Field notations which can indicate characteristics of TRIZ problems and solutions instantly. The substance-field model and 76 Inventive Standard were conceptualized by Genrich Altshuller who has built classical TRIZ. The conceptual design provides the intuitive understanding of the TRIZ problem characteristics. The TRIZ characteristics based on this notation method in the paper also indicate the candidate solutions only with minor knowledge of the Inventive Standards.**

***Index Terms*—TRIZ, TIPS, innovation, standard solution, substance-field model.**

I. Introduction

Systematic innovation [1] is a set of continuous evolving tools that will improve ability to solve the problems. TRIZ (Teoriya Resheniya Izobretatelskikh Zadatch) that is also called TIPS (Theory of Inventive Problem Solving) is a methodology that is the practical innovation tool and the model-based technique for generating innovative ideas by Genrich Altshuller [2-4]. TRIZ is the most powerful methods for systematic innovation methodologies. It is the model-based technology for generating innovative ideas and solutions for problem solving [5] and has been developed by Genrich Saulovich Altshuller who has believed that can learning how to invent is new things [1-5]. After his first approach, TRIZ has been evolved as the science of innovation and many companies are adopting TRIZ to solve complex technical problems.

In addition, Genrich Altshuller and his colleagues identified 76 standard solutions [6-7] to fixing problematic Su-Field models based on their intensive research of a huge number of patents [2-4, 8]. Substance-Field (Su-Field) model is for analyze the problems related existing technological systems [9-11]. Su-Field model analysis is applied for making innovative problems to the form of analysis model related to the current technical system. It means that Su-Field model is the tool for identifying problems in a technical system and finding innovative solutions to these identified problems [10].

Even though, 76 Inventive Standards do not provide graphic models for every standard and the standards are not new to the TRIZ community, they can help the TRIZ specialist find solutions concepts for many kinds of problems as a collection of methods to identify [7]. The Standard Solutions are grouped by constraints, so they can help the specialists find appropriate solution concepts. They are more accessible to TRIZ newcomers than ARIZ, since the user is liberated from the ARIZ [8] dictum of mastering every step before using any step. The 76 Inventive Standard Solutions are among the fundamental techniques that provide the foundation for most of commercial major TRIZ softwares but they are not currently being used widely [6-7].

There are several reasons why the Inventive Standards are not applied widely and two main reasons need be addressed. First, people learning TRIZ still must do a lot of case studies that illustrate the principles of TRIZ using terms and technologies before using Inventive Standard correctly. Second, the standards are categorized by physical interactions. The Inventive Standards (76 Standard Solutions) are well defined and organized [6]. But it is still difficult to learn and complicated even for TRIZ specialists. More importantly, the 76 Inventive Standards are not intuitive [10].

Currently, TRIZ tools are applied not only in physical engineering but also in software, even in business. Most of physical interactions are not have direct matches with the actions in software [12-13] or business and others [7]. TRIZ specialists must *abstract* the solutions to fit their area for solving their problems. The standards must be reformulated more intuitive way.

The special notations so called *Su-Field notations* (aka. *Amang's notations*) are introduced in the paper. The notations give intuitive explanations both problems and solutions based on the Inventive Standards. The core for Su-Field model notation is adopted by the queuing model notations also kwon as Kendall-Lee notations. Basically, Kendall-Lee notations can explain all kind of queuing model and users who know the rules of the notations understand the characteristics of the queuing model almost instantly when they see the notation [14]. Su-Field notations cover all of the Inventive Standards except for Group 5 which is guidelines for other four groups. Someone who does not even have the full knowledge of the 76 Inventive Standard solutions can understand the problems and candidate solutions intuitively based on Su-Field notations.

II. Innovative Su-Field Model Solutions

Before starting Su-Field notations (Amang's notations), Theory of Queuing system and its notations (Kendall-Lee notations) are introduced first. Queuing theory is the mathematical study of waiting lines, or queues. It is generally considered a branch of operations research because the

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results are often used when making business decisions about the resources needed to provide service.

There are many kinds of queues with various conditions but all of queues can be categorized by the certain notation schemes. Classification of the queuing models has been suggested by D. G. Kendall in 1953 as a three-factor notation of queuing system and it has since been extended to include up to six different factors by A. M. Lee in 1966. This queuing notation has been known as Kendall-Lee notation and it exhibits the summarized main characteristics of a queuing system.

$$a / b / c \ : \ d / e / f \qquad (1)$$

where the symbols *a*, *b*, *c*, *d*, *e* and *f* stand for basic elements of the model as follows:

a = arrivals distribution,
b = service time distribution,
c = number of servers (*c*=1, 2, 3, …)
d = service properties (i.e., FCFS, LCFS, SIRO)
e = capacity of the system
(a waiting room and servers)
f = population of input resources.

For instace, *M/G/1{/FCFS/∞/∞}* is the open queuing system (i.e., population of input resources is unlimited) with Poison input, general service properties and unlimited waiting capability. *M/G/1* queuing system is one of most typical queuing systems.

The similar but innovative notation scheme to cover the 76 Inventive Standards is defined by adopting the classical queueing notations. This notation method is clarifying the Inventive Standards simpler ways and users can be guided to the candidate solutions from the problems based on Su-Field model with the minimal knowledge of 76 Inventive Standard solutions. The new notation for Su-Field model (Su-Field notation) is provided (aka. *Amang's notation* that is alias of author). The Su-Field model for Inventive standard solution can exhibits the summarized main characteristics of a Su-Field model.

$$\left(x / s / f \right) : \left(/ \, a \right) \qquad (2)$$

where the symbols *x*, *s*, *f* and *a* stand for basic elements of the model as follows:

x = solution (or problem) types (*x* = 1, 2 or 4)
s = substance attributes,
f = field attributes,
a = strength of actions (*a*=0; *Normal* or *a*=1; *Stronger*)

The attributes of the substance *s* are as follow:

S^* = general terms of the substance that can solve the problems

S^+ = +1 substance from basic structure to solve the problems

S' = modify the substance (tool) to solve the problems without changing the number of components from basic structure

S^- = -1 substance from basic structure (i.e., tool is missed)

S^∞ = substance (tool) is divided infinitely (Technical System Evolution)

S" or S^2 = adding the clone of the substance (+1)

The attributes of the field *f* are similar with substance attributes:

F^* = general terms of the field that can solve the problems

F^+ = +1 field from basic structure to solve the problems

F' = modify the field to solve the problems without changing the number of components from basic structure

F^- = -1 field from basic structure

F^∞ = field is divided infinitely (Technical System Evolution)

F" = adding the clone of the field (+1)

$\overleftarrow{F}$ = reverse direction of the field

The basic structure of Su-Field model for the Inventive Standard consist one object (S_1), one tool (S_2) and one field (*F*) The basic structure can be notified as:

$$x / s / f \, \{/ \, 0\}, \ x = 1,2,4 \qquad (3)$$

where *x* is the types of problems or solutions (see Figure 1)

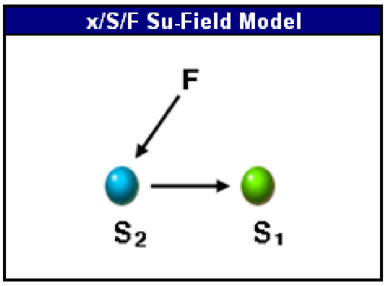


Fig. 1. Basic structure of Su-field model.

Overall of 76 Inventive Standards except for Group 5, the problems can be categorized as three types. Type 1 is the problem that contains the weak useful action (or function) and the candidate solution of Type 1 is enhancing the strong useful action. Type 2 is the problem that contains the harmful action and the candidate solution of Type 2 is removing the harmful action. Type 4 contains mainly measurment problems. It is a separate group of 76 Inventive Standard solutions. Group 4 in the Inventive Standard are exact matched with Type 4.

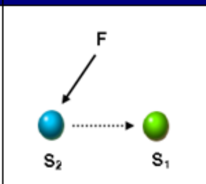
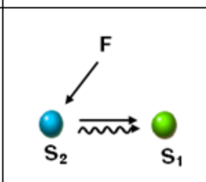
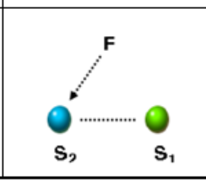
Problem Type	Su-Field Diagram	Solution Guideline
1 (1/S/F)		Enhancing the useful action
2 (2/S/F)		Removing the hamful action
4 (4/S/F)		Mesurement (Same as Group 4 in 76 inventive standards)

Fig. 2. Types of the problems.

For instant, *2/S/F* is the problem (see Figure 2) contains the harmful action and the candidate solution is $2/S^+/F$ that means removing the harmful action by additional substance S_3 (remarked as S^+ in Su-Field notation). As seen above, Problem Types also represent Solution Types (i.e., same type number). So, it is same type in Su-Field notation regardless of problems or solutions.

There are 3 solution types based on the problem types. Compare to the group of 76 Inventive Standard, Group 1, 2 and 3 are integrated to Type 1 and 2. Group 4 in the Inventive Standard is integrated to Type 4 that is much simplified and remained as Conceptual Solution. Problem Type 1 contains two sub types based on the problem conditions. Type 1-1 is the problem because of missing the substance (tool) or the field (action). Type 1-2 is the problem of weakness and $1/S\infty/F\infty$ that means the unlimited modifications of the substance and the field based on Technical System Evolution can be the candidate solution of Problem Type 1-2. The solution for Problem Type 1 can be concluded as follow:

$$1/S^{\{-1\}}/F^{\{-1\}} \rightarrow \begin{cases} 1/S/F, & \because Type\!-\!1 \\ 1/S^*/F, & \{S^* | S', S^+, S^2, S^\infty, S^n\} \\ 1/S/F^*, & \{F^* | F', F'', F^+, F^\infty\} \\ 1/S^*/F^*, & \end{cases} \tag{3}$$

where $S*$ and $F*$ are the optimal attributes of the substances and the fields to solve the problem. Problem Type-2 is the problem that contains the harmful action and the candidate solution is basically removing the harmful function and the candidate solution of Problem Type 2 can be determined as follow:

$$2/S/F\{/0\} \rightarrow \begin{cases} 2/S^*/F, & S^* = S^+ \; or \; S' \\ 2/S/F,^+ & \\ 2/S/F/a, & 0 < a < 1 \end{cases} \tag{4}$$

Problem Type-4 is the measurement of the system. Even though Group 4 in 76 Inventive Standards can be applied Type-4 problems, Amang notation can be applied for the measurement problems. In case of Type-4, the notation for the action attributes is mandatory factor because the strength of the measurement signals:

$$4/S/F \rightarrow 4/S^{\{*\}}/F^{\{*\}} \tag{5}$$

One of the practical solution for the Type-4 Problem is *4/S-/F-* that means removing the components requiring the measurement (i.e., Inventive Standard 4-1-1).

From (3), (4) and (5), the inventive standard solutions based on Su-Field notations can be summarized as follow:

$$x/S^{\{y\}}/F^{\{z\}} \rightarrow \begin{cases} 1/S^{\{*\}}/F^{\{*\}}, & x = 1, \\ 2/S^{\{*\}}/F^{\{*\}}, & x = 2, \\ 4/S^{\{*\}}/F^{\{*\}}, & x = 4 \end{cases} \tag{6}$$

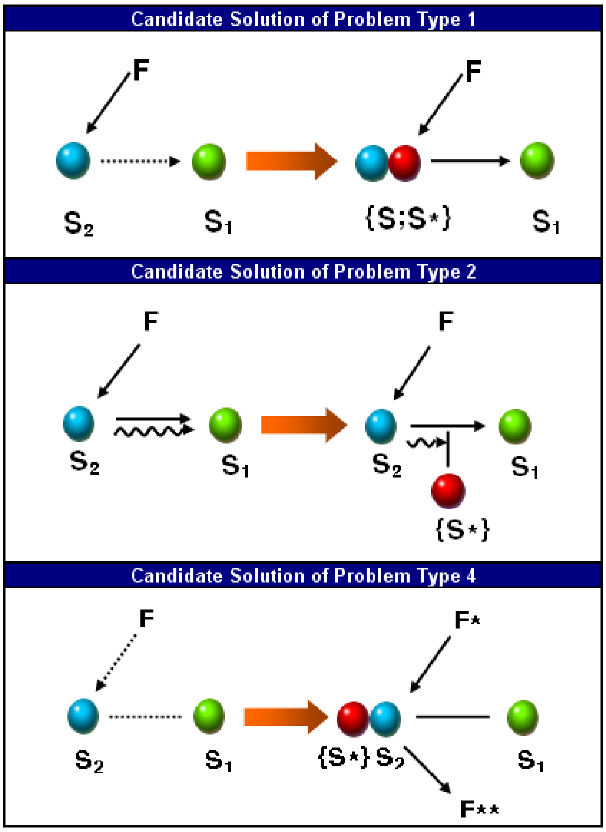


Fig. 3. Diagram based on Su-Field notations.

Formula (6) is the most abstracted version of the conceptual solution from (3)-(5) and it very the simple explanation but practically covers all of the Inventive Solutions (Group 1-4). The conceptual solution can applied not in the classical TRIZ problems but also in the problems of software and business more flexible.

For instant, Su-Field notation can be applied one of the previous TRIZ applications in mobile industry by author [12-13]. The problem for enhancement of user experience has been solved by using the Standard Solution 1-2-2 [12]. This is problems typical Type-2 problem in Su-Field notations because it have solved by removing the harmful function [13]. Su-Field model *2/S+/F* is the solution of this problem by using Su-Field notation. In other words, the Standard Solution 1-2-2 can be notated as *2/S+/F* in Su-Field notations.

III. Conclusion

Su-Field notation (*Amang's notation*) is the generalization of the classic 76 Inventive Standard solutions and the reformulating of them on Su-Field model and Queuing notations have adopted to give intuitive explanations not only the characteristics of the problems but also suggest the candidate solutions. The problem solvers can adopting the candidate solutions based on Su-Field notations without the full knowledge of 76 Inventive Standard solutions because the notations provides the concept solution that can be applied to the various areas. The examples will give you how Su-Field notions to apply the real-world problems.

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