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Two Aspects of Function for Technical Systems

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Abstract

Function is very important to understand to understand technical systems. It is defined as 'specification of an action performed by a material object (Function Carrier) that results in a change or preservation of a value of an attribute of another material object (Object of the Function)'. (International Association of TRIZ (MATRIZ) definition). This 'Subject-Action-Object' function model, which is widely used in innovation process, is 'action' oriented definition. Sometimes, however, understanding the function from an outcome perspective and solving problems produce better results. In this paper author proposes two aspects of function definition (action oriented function and outcome oriented function) to understand technical systems and find creative solutions.

Keywords: Function carrier, object of the function, action oriented function, result (outcome) oriented function, core problem.

1. Introduction

The meaning of existence of technical systems is the main reason why people make technical systems. That's why function analysis is so important to understand a technical system. We use the 'ideality' to qualitatively evaluate the development level of technical systems and define it as the sum of the useful functions which a system performs divided by cost and harmful functions. A technical system is evaluated as the sum of its functions.

There are several important TRIZ tools associated with the function such as FOS (Function-Oriented Search), function analysis and trimming. Function-Oriented Search is a method or a tool for problem solving based upon identifying existing technologies in other areas of technology from a function perspective. Function analysis is an analytical method to model technical systems and their supersystems in terms of functional carriers, objects of the functions and their actions. Function carrier is a material object that performs (delivers) a function. It can be either a substance and a field, or a combination of both. Function modeling helps us to better understand, visualize, and categorize functional relationships between the elements in the system, and identify problems. Trimming is a method for improvement of a technical system by removing (trimming) certain components and redistributing their useful functions among the remaining system or supersystem components while preserving quality and performance of the system. We can also define the contradiction as the case when a component performs a useful function and a harmful function simultaneously.

MATRIZ defines the function as 'specification of an action performed by a material object (function carrier) that results in a change or preservation of a value of an attribute of another material object (object of the function)' (Souchkov, 2018a). Function analysis slices the technical system into small simple unites which are delivered function created by substance-action-object, S-a-O model (Gadd, 2011). It's very reasonable approach and this action oriented definition of function helps us to analyze a technical system and solve the problems effectively (Song et al. 2017). This is the "Mini-Problem" solving technique, which TRIZ suggests to solve with priority. In TRIZ society, Mini-Problem means a type of inventive problem definition which is obtained by imposing the following constraints on a given inventive situation: everything remains as is (without any changes) or becomes even simpler but the required positive effect is provided or the harmful effect disappears. Definition of Mini-Problem targets at obtaining a solution required with as minimal changes in the existing technical system as possible (Souchkov, 2018b). But sometimes solving a Mini-Problem doesn't satisfy us and we need a new approach-to solve a Maxi-

Problem, which does not impose constraints on future inventive solutions. To define the Maxi-Problem we need another aspect of function definition, the result/outcome-oriented function.

2. Two Aspects of Function for Technical Systems

MTRIZ definition of function for a technical system is focused on 'action' of components (action-oriented function; AF), but what we really want from the technical system is not an action itself, but the "result/outcome" of action in function (result-oriented function; RF). For example from the action point of view, the function of glasses is to refract light. But what we really want is to see clearly, the result of action between lens and light. Therefore function analysis should be done in two respects; Action and Result/Outcome aspects.

2.1 Action-Oriented Function

The functional definition of the technical system in terms of action is the traditional technique in TRIZ society and very good method to understand the system and highlight problem places for any system or situation. This method will be briefly described as a general approach in TRIZ society.

The steps of action-oriented function analysis are:

(1) Components analysis

- List the components of the system of interest (sub-system components)
- List the super-system components of the system, which have interactions with the system components.

(2) Interaction analysis

- Identify interactions between components (sub-system and super-system components)
- It can be performed by creating a matrix

(3) Function Modeling (Subject-action-Object (S-a-O) Model)

- Subject is the active tool of an action, action provider
- Object is the passive receiver of an action. It is changed in some way by this action from the subject
- Action is provided by some kind of field between Subject and Object components. And the action is portrayed as transitive verbs

The action-oriented function analysis is used not only to understand a technical system, but also to analyze and solve problems. All system problems can be shown by S-a-Os (harms, insufficiencies, contradictions). S-a-O model reveals the problem areas in which two or more components are harmfully, insufficiently interacted to each other. Any problems are identified with the concrete elements and the interactions between them. If we understand the nature of the problem through functional analysis, we can derive a variety of solutions with TRIZ tools.

2.2 Result/Outcome-Oriented Function

What people/customers want to get from a technical system is not the "action" itself, but the result of the action it does. Therefore, it is necessary to define the function and solve the problem from the viewpoint of the result. The "Result/Outcome-oriented Function (RF)" helps to get a new approach to the problem. (Maxi-Problem approach). The action-oriented function and result/outcome-oriented function are closely related to each other and can be expressed as follows:

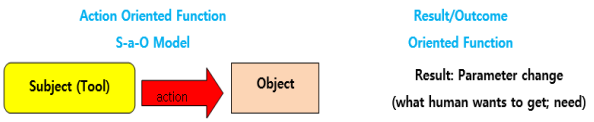

Fig. 1 Two aspects of function for technical systems, AF and RF

RF can be expressed as 'human need' or 'what the human wants to get'. The result/outcome can be obtained by changing the parameters of the object by the action. For example, RF of a military helmet is to protect the head, while its AF is to block the bullet. RF of a fan is to cool the person, but AF is to move the air (make the wind). When solving the problems of a fan, we should

focus how to effectively move the air (AF). However, in some cases it may be necessary to come up with a solution that will satisfy the resulting function, "how to cool the person effectively" (see Fig.1). This concept was proposed in 1989 by Royzen as a TOP (Tool-Object-Product) model (www.trizconsulting.com). In this paper, the author combines two different aspects of function to understand the whole concept of function to solve problems effectively.

CASE STUDY

In the 1990s, a combo system was developed that could read both CDs and DVDs and installed in computers. Optical diodes that read CDs and DVDs were different, and two LD light sources were installed, which made the system complex (see Fig.2). CD lasers were typically AlGaAs semiconductor material with a wave length of 780nm and the DVD diode emitted the light of the wave length of 650nm. Combo systems equipped with CD laser diodes and DVD diodes of different wavelengths were complicated to read data and arrive at a single detector to transmit information.

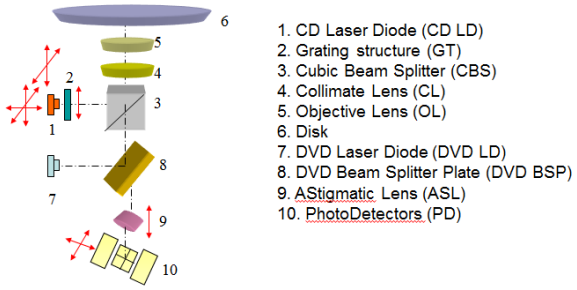

Fig. 2 CD-DVD Combo system.

This technology was developed by a foreign company and patented at home and abroad. A key element of the technology is to use different lenses to guide light of different wavelengths to a detector. A Korean company tried to develop a combo system by avoiding this patent. Researchers had developed various optical systems to collect light of different wavelengths in a detector while avoiding existing patents (Kim, 2009) (see Fig.3). They tried to change the position of laser diodes and the arrangement of optical lenses. (Fig.3 (a), (b) and (d)) Researchers had also developed combo systems of using a beam splitter (Fig.3 (f)) and hologram element (Fig.3 (e)).

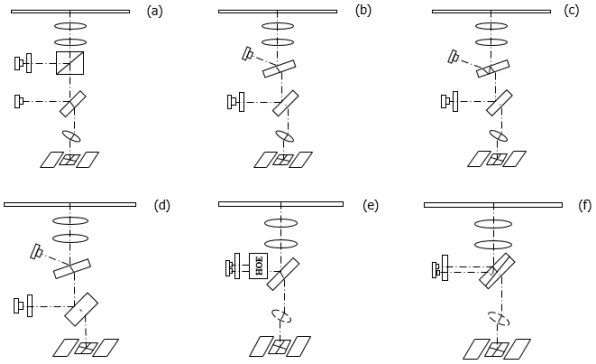

Fig. 3 Various CD-DVD Combo optical systems, developed by a Korea company.

However, the developed optical system was difficult to avoid foreign patents. When the company researchers developed new technology, they focused mainly on the action-oriented function, 'how to guide two lights emitted from different location into a detector' and tried to implement AF diverse and effectively. After many mistakes, engineers had defined the problem in terms of the RF, "what do we want to get from the combo system?" What people want to get from this system is to read information from CDs and DVDs. Therefore, they switched the core-problem from "how to guide (refract) different lights to a single detector" to "how to read CD and DVD data while avoiding patents". The researchers were able to get a solution easily by considering how to realize the RF. Instead of using a complex optical system that refracts two lights emitted from different places into one place, two detectors were installed at the points where the two lights reach. It was a very simple but creative idea! (see Fig.4)

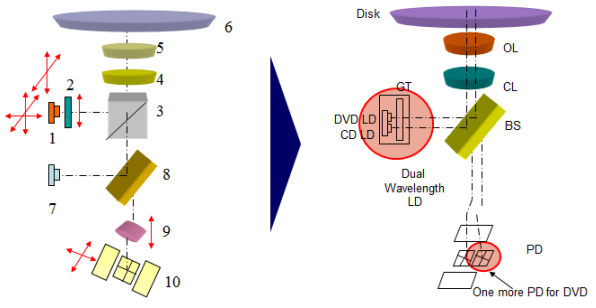

Fig. 4 The idea that had been solved in terms of RF – two detectors were installed.

The combo system with two detectors was able to reduce the cost by 40% compared with the existing system, because the number of optical lenses had been reduced from six to four, the number of joint points had been reduced from 38 to 26, and the number of adjusting joints had been reduced from 13 to 8. In addition, it increased the reliability by 33% and improved the productivity by 38%. The company reported that it earned $ 100 million over three years through this solution.

3. Conclusions

In TRIZ society, a function is analyzed by action. This function analysis helps to solve problems by approaching system problems with "Mini-Problem" perspective. However, defining a problem with a "Maxi-Problem" perspective and solving problems in a technical system, it is necessary to think about the AF and RF at the same time, to define the problem in two aspects and to draw out the solution.

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