# Research on Configuration Method of Product Module And Service Module Based on TRIZ

## Zhang Jianmin, Zhou Jun

*(College of Mechanical Engineering, Shanghai University of Engineering Science, Shanghai 201620,China,*

**ABSTRACT:** In order to solve the problem of product and service configuration in product service system, this paper proposes a method of product service configuration based on TRIZ(Theory of Inventive Problem Solving). The first product service system problem analysis and construction analysis of root causes, using 40 inventive problems in TRIZ theory to solve the problem and find out the theory, configuration of products and services, to solve problems with the help of 39 engineering parameters, so that the configuration principle of product module and service module.
**Keywords:** TRIZ; product service system; root cause analysis diagram; product service configuration principle

## I.    INTRODUCTION

With the support of the PSS concept, more and more users started not directly buy a product, but the choice of the way of rental use of the product, which saves cost, but also reduce the waste of resources, at the same time, along with the more and more use of leasing products, its problems are increasingly frequent, such as mechanical and electrical fault, scrap parts etc.. It is very important for this kind of product service configuration, not only need manual service (non functional service module), also need to provide the physical components of integrated automatic service (functional service module).

Although the goal of the product and service is similar, but the characteristic of the two completely different products, is the physical parts of a standardized service, which is a non standardized and diversified, therefore the combination of the two will cause a lot of problems [1]. So this paper puts forward the principle of product configuration module and service module based on the TRIZ theory, mainly through root cause analysis of 39 standard engineering drawings and the parameters in the TRIZ theory and 40 inventive principle to solve the product and service allocation, so as to construct the product module and service module configuration service principle, laid an important foundation the design and implementation of integrated products and services.

### 1.Product service system

The United Nations Environment Programme put forward the concept of product service system in the last century (90s Product Service System, PSS)[2], then many scholars have made relatively thorough research on it, such as Robin[3], Mont[4], Manzini and Vezzoli[5] respectively from their respective angle put forward the concept of product service system, comprehensive the nature of a product service system is the product of the development of modern manufacturing industry, its purpose is to make the "objects" are less harmful to the environment, a sustainable design so as to carry out the activities.

### 1.1 Service compositions of product oriented

The organic combination of products and services in the form of product service system, product service system for use in products and services that are complementary to each other, in order to make the products and service function and value to maximize, rational use and integration of various types of service function is very key, because some services must be with the other the service function together to make services play a greater effect, and for different products, the appropriate fusion service function is also very important.

In summary, the definition of the relationship between service functions, including complementary and synergistic, respectively, with the symbol "+" and "•" to express [6].

The relationship between the combination of complementary services mainly refers to between two and above the service function through some combination of excellent performance, not only keep the original function, also won the service function better, because of the combination of the characteristics of the purpose is to improve the service function itself, is the inherent attribute of the service portfolio, and not with the product structure change. Maintenance services such as maintenance services.

The relationship between the cooperative service function mainly refers to the single service function can better meet user needs on the use of the product, in order to improve the utilization efficiency of products, reduce product loss rate, increase the new service function, and cooperate together to complete service products, the combination is to improve product performance for the purpose, and it will change because of changes in the structure of products. Such as (technical transformation services + recycling remanufacturing services) • (online monitoring services + fault diagnosis services). As shown in figure 1.
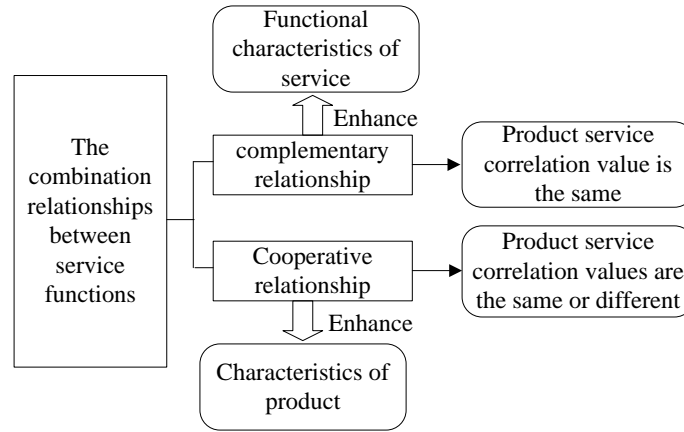
**Fig.1** Composition relationships between service function

## II. TRIZ

Theory of Inventive Problem Solving(TRIZ) was developed in the end of the Second World War in 1946. The research scholars represented by Archie Schuler began to study the concept of TRIZ. The goal is to study the scientific principles and principles of human beings in the process of invention and creation, to solve the technical problems, and extract the knowledge content and basic principles of TRIZ theory [7,8].

### 2.1 The process of TRIZ to solve the problems

The general steps to solve the problem using TRIZ theory are shown in figure 2. The first step, analysis of system problems and determine the types of problems, according to the TRIZ theory, the specific problem types can be divided into technical analysis, analysis of physical conflict analysis and conflict - field problems; the second step, according to the different types of problems, using different TRIZ tools to solve the problem; the third step, the corresponding TRIZ query tool the solution of the problem; the fourth step, the TRIZ solutions are combined with the examples, the ultimate solution for solving the problem.
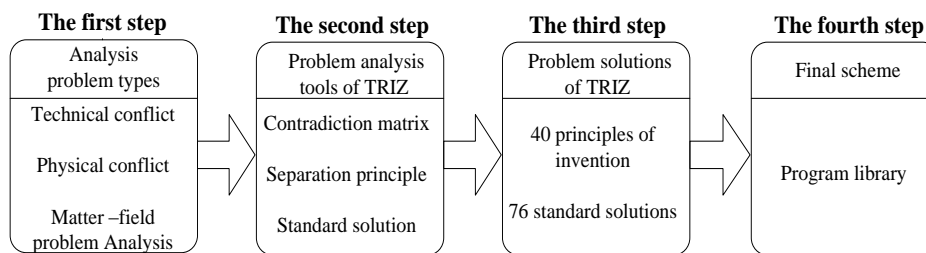
**Fig.2** The common process of solving problem in TRIZ

### 2.2 Major innovative design tools of TRIZ

TRIZ theory divides the tools of problem solving into two kinds of analysis tools and knowledge base tools. The analysis tools include the principle of material field analysis, function analysis tools and product evolution tools. In this paper, we mainly introduce the innovative design tools related to the research: conflict matrix and conflict resolution.

➢ **The contradiction matrix**

In solving technical problems, when a certain characteristic of the system is improved, it often leads to the deterioration of the system, so there is a contradiction in the system. For example, for the car rental payment

system, when payment systems to improve the car rental, will help provide driving a single billing service to the car when using a single, can provide a reasonable fee for the user, so as to avoid the one-time charges too high, causing users dissatisfied; on the contrary, improve the payment system of automobile rental car, will increase the complexity of information system, increase the design cost and difficulty of the system, then you need a reasonable method to guarantee payment system to improve the car rental, car rental provider makes single drive single billing service for users, but also to ensure the simplicity of the information system.
As shown in Figure 3 for the specific configuration principles of the establishment process.
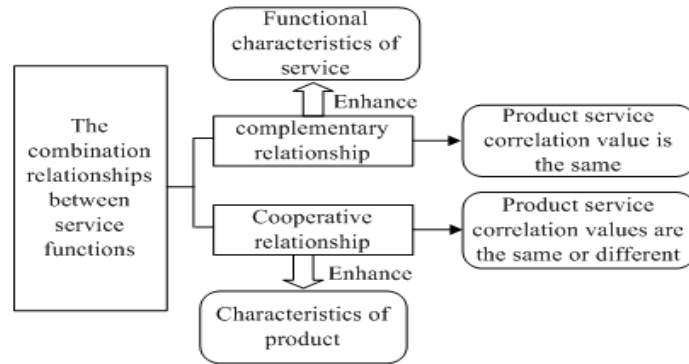


**Fig.3** The establishment process of configuration principle between product and service module

**1. System analysis and root cause analysis**

Due to the structure of large mechanical and electrical products is relatively complex, involving the service is also very messy, the service period is longer, resulting in the service process, prone to two problems: first, service reliability is low; second, the high cost of service. According to the two main problems, the root cause analysis chart is constructed to find out the root cause of the problem.

➢ Aiming at the problem of low reliability in service, there are two main reasons: 1, the product structure is complex; 2, service efficiency is not obvious. It is decided by the characteristics of the product itself for the complexity of product structure, product function, the complexity of its structure are; we can change the service function, figure root cause by layer by layer analysis and the system problems, as shown in figure 4.
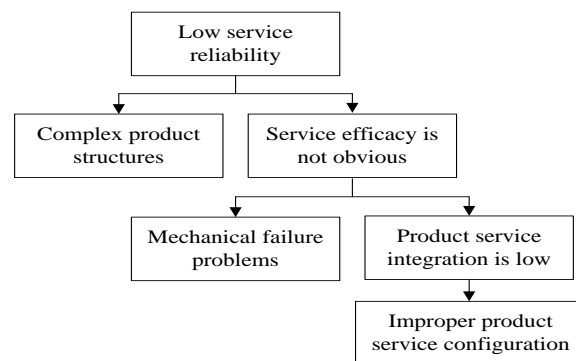


**Fig.4** The root cause analysis of low service reliability

➢ The cost for service of high prices, there are two main reasons: 1, long service period; 2, the service is too redundant. For PSS products and services throughout the life cycle of products is necessary, that is to say from the product development until the product scrap and recycling, enterprises have to be responsible for product management and service, so the products produced for the long service period of expenditure is necessary, not easy to change; we can change redundant service, map root cause layer by layer analysis and the system problems, as shown in figure 5.
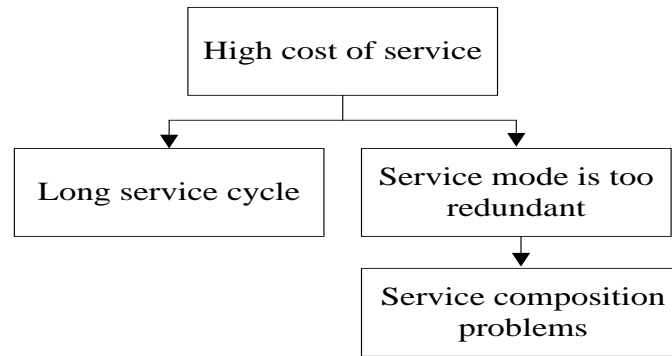
**Fig.5** The root cause analysis of high cost of service

## 2. Problem solutions of TRIZ

For the low reliability, the root cause analysis that belongs to the product service improper allocation problem, the traditional service configuration, will often take service as combination and arrangement of an invisible module and any products, but did not take into account the service actually can be integrated to design as a physical module and the product module, due to the complex structure of large degree of mechanical and electrical products, only consider the non functional service module configuration, is clearly not enough, and will only bring lower reliability.

Into the TRIZ problem, engineering parameters need to improve the degree of automation; 38: due to the improvement of the degree of automation of the service, the corresponding technical system itself will increase the difficulty of manufacturing, the deterioration of the 32 engineering parameters: manufacturability.

➢ The cost for service price, cost price analysis service from the root causes of the high, the main reason is because the service is too redundant, but due to the structure of large mechanical and electrical products are complex, diversified service mode is necessary, so the reasonable combination of some similar functions or can enhance the service module function itself which is necessary.

Into the TRIZ problem, the need to improve the engineering parameters: 22 energy loss; because the service module rationalization together, then compared to before, to reduce the energy loss, but the total number of service modules will be reduced accordingly, the deterioration of the engineering parameters: 26: the amount of substance.

The conflict matrix engineering parameter into TRIZ theory the above two problems in the two groups of the invention of the original understanding, as shown in Table 1, and according to the principle of innovation are to find the corresponding solutions, innovative principle solutions are shown in table 2.

**Table 1** System problems and principle solutions

| problems | Problem description engineering parameters | Innovative principle solutions |
|---|---|---|
| Improper product service configurations | Improvement of engineering parameters：38 Deterioration of engineering parameters：32 | 01，26 13 |
| Service composition problems | Improvement of engineering parameters：22 Deterioration of engineering parameters：26 | 07，18 25 |

**Table 2** Original understanding of innovation

| Innovative principle solutions | Application methods of innovative principle solution |
|---|---|
| principle 01：Segmentation principle | 1) Divide an object into independent parts.<br>2) An object is divided into easy assembly and disassembly.<br>3) Strengthen the system to achieve divisibility, technical transformation system. |
| principle 26：Replication principle | 1) Replace a difficult, complex, expensive, inconvenient, or breakable object with a low-cost copy.<br>2) Replace the object with an optical copy and zoom in or out in a certain proportion.<br>3) If you have used a copy of the visible light, infrared or ultraviolet. |
| principle 13：Inverse principle | 1) Replace the action specified in the definition of the problem with the opposite action.<br>2) Turn the body upside down or inside out.<br>3) To allow an object or an environment to move, a stationary part, a stationary part. |
| principle 07：Suit principle | 1) Insert an object into another object, and then put the two objects into the third objects, and so on.<br>2) To allow an object to pass through a cavity in another. |
| principle 18：Principle of mechanical vibration | 1) To cause an object to vibrate.<br>2) If the object is in a state of vibration, increasing the frequency of the vibration.<br>3) Using resonance phenomena.<br>4) Replacing mechanical vibration with piezoelectric vibration.<br>5) Ultrasonic vibration and electromagnetic coupling. |
| principle 25：Self service principle | 1) Object to perform auxiliary or maintenance functions for their own services.<br>2) Using waste energy and matter. |

## 3. Establishing the principles of product module and service module

➢ According to the analysis of system problems, innovative principles 26 and 13 are not suitable for the problem, the principle of 01: the principle of segmentation for low reliability problems. First we can have large mechanical and electrical products is divided into several modules, a module which will be divided into several sub modules, and according to the characteristics of each sub module (such as material recyclability, sub module disassembly etc.) for the corresponding service module configuration, simple and non core product module then, do not need to configure the automatic service (non functional service module), the product core module need to configure automatic service (functional service module), for easy recycling and removable product modules, you can configure the artificial service (non functional service module), such as recycling and remanufacturing service and installation service. In order to express the relationship between the product module and the service module, we can use the correlation matrix of product service.

According to the configuration of the product and service module, it is necessary to configure the appropriate service according to the characteristics of the product, so as to realize the transformation of the system and improve the reliability of the service.

➢ According to the system analysis, the innovation principle of 18 and 25 are not suitable for the problem, the 07 principle: set principle for service cost problem of high prices. The service module is a functional element acts on the product module, in the realization of service module and product module configuration, can enhance

the service function and the properties of the product as the premise, the various service modules for the corresponding combination, not only reduces the single way of service function, and integration and improve the overall function of the service module, thus it reduces the cost of the service price.

## III. CONCLUSION

In this paper, the key technology in TRIZ theory, to solve the conflict problem of product and service product service system configuration, so as to obtain the configuration principle of corresponding products and services, has laid an important foundation for the integrated design of PSS products based on service.

## REFERENCES

[1]. Hou Shijiang, Yuan Xumei, Chen Guoqiang. Research on conceptual innovation of product service system based on TRIZ theory [J]. mechanical design,2016,33(3):109-114.
[2]. He Zhe, Sun Xin, Zhu Chunyan. The concept, problems and Prospect of service manufacturing [J]. science research,2010,28(1):53-60.
[3]. Huang Weiqiang, Wang Hui. How manufacturing companies "to service industry" [J]. China Industry Review,2015,(11):32-38.
[4]. Geng Xiuli. Research on Modeling and decision making of product service system design driven by customer value [D]. Shanghai Jiao Tong University,2012.1-144.
[5]. Zhang Minghui, Zhao Quanxi, Wang Yan. Study on the relationship between automobile consumption and air pollution based on linear regression model [J]. Journal of Communication University of China Natural Science Edition,2015,22(4):16-20.
[6]. Zhang Yu Fang, Yu Wei, Liu Yuan. Research and development of product service system design [J]. Journal of Hebei University Of Science and Technology,2013,34(5):381-385.
[7]. Liu Xuntao, Cao he. TRIZ theory and application [M]. Peking University press,2011.
[8]. Shen Shide. Concise tutorial of TRIZ [M]. Mechanical Industry Press,2010.