

Patent Product Innovation Re-Design Based on Function Analysis

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Abstract: Background: Function is the essential requirement of the user to the product and functional innovation is to optimize, update and restructure the function of the product.



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Objective: In this paper, the first objective is to accomplish function innovation re-design of patent product based on function analysis methods.

Method: This method includes the following steps: function definition, re-design problem identification, problem solving and solution evaluation. Firstly, the total function is identified to build the function model based on patent claim of target patent. Then, judging whether there is a problem with the model and choosing the appropriate method of solving the problem. The method consists of two techniques: (a) using the method of patent around strategies based on TRIZ problem-solving tools to solve the innovation re-design problem; (b) applying the function tree structure and function change to solve function element, and to realize the patent product innovation re-design.

Results: Finally, refining and optimizing the design concept to develop a new product. Results demonstrated that the method of patent innovation re-design based on function analysis is more accurate.

Conclusion: Recent patent product study on the Red Wine Packaging is investigated to illustrate the method.

Keywords: Function analysis, function change, function element, function tree, innovation re-design, patent around strategies, red wine packaging.

1. INTRODUCTION

In the global businesses market, patent product innovation re-design is an effective way for the enterprises' product entering into the market without infringement of the existing patent. Throughout the product design stage, the concept design process of product design is the most active and creative design stage. Product innovation includes four parts: User Innovation (or market innovation), functional innovation, principle innovation and structure innovation. Product innovation is the main method to achieve user innovation [1, 2]. Function is the essential requirement of the user to the product; Product is the actual form of function [3]. Functional innovation is to optimize, update and restructure the function of the product, so that it would be suitable for the needs of a new market and facilitate the process of market competition strategy [4].

Functional analysis is an important method for product innovation design. At present, some researchers have proposed several approaches for the method of functional

analysis. Jiang [5] researched the integrated process in designing around patents through functional analysis, trimming rules and patent infringement judgment, and the spiral bevel gear milling machine was analyzed to illustrate the integrated process. Yuan [6] proposed a new process model of function and principle solution, which is based on TRIZ and Functional Analysis. An innovative design of paint-bottling machine has been achieved with application of the proposed model. Lu [7] introduced Functional analysis, ideal final result and S-Field analysis method. The process of product innovation design based on the theory of TRIZ and functional analysis is proposed. Reciprocating sealing of hydraulic cylinder is given to illustrate the process. However, the above researchers mainly studied the patent around method based on functional analysis, and did not provide a detailed description for solving the innovation problem of a new re-designing after the functional analysis.

This paper proposes the method based on functional analysis for patent product innovation re-design. After searching the target patents, functional analysis method is used to extract the total function and establish the functional model. In order to analyze the functional model, the solution method is selected in solving the re-design problem, and finally achieving the re-design of the patent product. The

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relationship between the function components in the functional model should be analyzed before selecting the solution method. If there is a conflict problem, it can be solved by using the method of patent strategies based on TRIZ problem-solving tools; if not, the patent product innovation re-design is realized by the function tree structure, function change and function element solution. Thus, patent product innovation re-design based on function analysis method has been established, and designers can achieve the re-design of patent product.

2. GENERAL PROCESS OF FUNCTIONAL ANALYSIS

Function is the essence of products and the core of functional innovation. Functional analysis is required to completely and clearly express the functional model of the product at the conceptual design stage [8]. Analyzing function model and combining with innovative design theory, a new method solving the function innovation re-design problem is explored.

As shown in Fig. (1), the general process of patent innovative re-design based on function analysis mainly consists of the following four steps: function definition, re-design problem identification, problem solving, and solution evaluation. Specific steps are as follows:

- Step 1: Searching and analyzing the related patents to identify the target patent and excavate the core technology of the studied product, identifying total function.
- Step 2: All the related Components from Engineering System and Supersystem are identified. By analyzing functional relationship, the function rank can be identified, and functional model is established. Then the conflict problem is a low rank of function in the functional model.
- Step 3: Solving innovation re-design problem by two methods. The method of patent around strategies based on TRIZ can be used to solve the conflict problem. Function tree structure and function change can be selected to fulfill the function element.
- Step 4: Refining and optimizing the design concept to develop a new product. By observing the relationship between the product target parameters and the engineering parameters, add and subtract the score of the product target parameters corresponding to the engineering characteristics.

2.1. Identify Total Function

The total function of a product is the sum of the total system functions and the basic condition of the product or system [9]. The description of the total function is accurate, concise and reasonable to seize the essence, which can help the designer inclear and open thinking.

The total function reflects the relationship between the input and output of the technical system. The processing object of the technical system is energy, material and signal

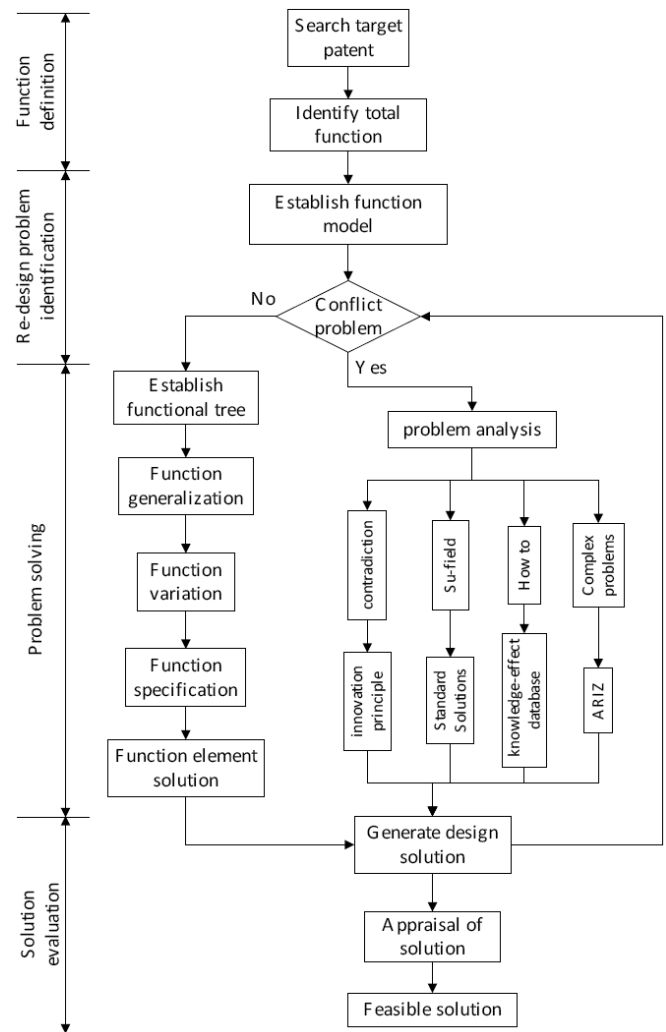


Fig. (1). General Process of patent innovative re-design.

[10]. The technical system function is motivated to convert or change the input energy, material, and signal. The relationship between the technical system and the processing object is represented in Fig. (2).

In this paper, through the analysis and summary of the patent product function, the total function of the product system is abstracted from the technical system model (Fig. (2)). For the technical system, the functional performance of the product system has the characteristics of transforming the material, energy and signal. The total function must be highly abstract to design problem, so as to ensure the process of solving the problem has more search space. Re-design product as the model of the box, analyzes and compares the difference between the system's input and output, eventually defining the total function.

2.2. Re-design Problem Identification and Solution

Based on the process of Patent Claim decomposition, Technical Features are identified in the patent. Then, the Technical Features can be represented as Technical Feature A, B, C, D, etc. [11]. According to the Technical Features of

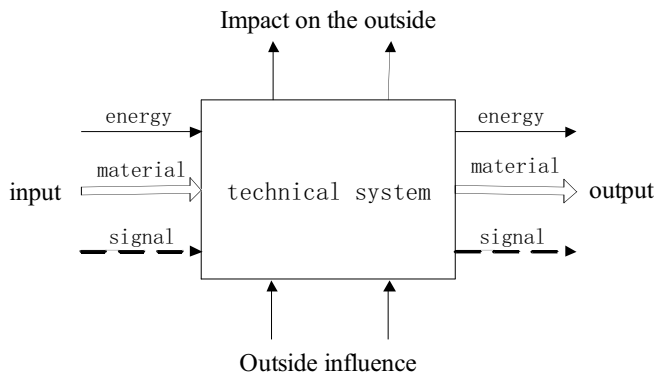


Fig. (2). Relationship diagram of technical system and processing object.

the subordinate relationship, the relationship between all components is determined and identified, and functional model of the patent product is established.

Functional model combines the various functional elements. It can clearly reflect the product's design idea and the logic relationship between the function, and express the relationship among the material, energy, signal and function. After establishing the functional model, whether there exist conflict problems (harmful, insufficient or excessive function) between the function relationships [12]. If there is a conflict problem in the functional model, the product creative re-design is achieved by using patent circumvention design method, and TRIZ problem-solving tools are used to find solution for the patent around innovative problem [13]. If there is no conflict problem, functional transformation method is used to achieve product re-design. The patent product innovation re-design is realized by establishing the function tree structure, applying function change and solving function element.

2.3. Solution Evaluation

Evaluation is an essential and important part of conceptual design. This stage is to evaluate the feasibility of the solution. Through the comprehensive evaluation of the design solutions, the optimal scheme is obtained, which provides the follow-up production with a strong guarantee. If the solution is not feasible, it may need to go through the re-design process again, and generate new feasible solutions.

Evaluation method is to analyze engineering technical parameters. According to the TRIZ theory, the 39 engineering technical parameters are put forward. According to the product life cycle, we give 8 product target parameters [14]: A--reducibleness; B--Save energy; C--Operability; D--information availability; E--security; F--retrievability; G--persistence; H--decomposability.

At first, we found out the parameters which need to be improved from 8 product target parameters, and provided different scores according to the weight of the parameters. Secondly, engineering technical parameters improved and deteriorated were analyzed in the design scheme. Thirdly, the score of the product target parameters corresponding to

the improved engineering characteristic was added to the final scheme. The score of the product target parameters corresponding to the deteriorated engineering characteristics was subtracted from the final scheme. It is generally feasible scheme when the final scores of design scheme are more than 0. In the design process, by observing the relationship between the product target parameters and the engineering parameters, the appropriate engineering parameters corresponding to the product target parameters are found to improve the design efficiency of the product. The comprehensive evaluation of the design solutions provides the follow-up production with a strong guarantee.

3. SOLVING INNOVATION RE-DESIGN PROBLEM

3.1. Patent Around Method Based on TRIZ

Patent design around (also called as “Patent Circumvention”) is used for designing similar solution based on competitive patent but not equivalent to the existing patents [15, 16]. It can be achieved in the following ways: Trimming (Eliminating) one or more technical features, and the function is transferred to the other components in the claims; Substituting one or more technical features of the claims; Evolution trends of technical features are applied to achieve same or better function, which combine one or more technical features or use a number of new features together to achieve the required functions [17]. The above description is summarized in Table 1.

After using the above method, a number of design problems are generated. TRIZ provides tools to solve the different corresponding problems, which can lead to different TRIZ models of problem-solving [13]. For example, corresponding tools to solve Technical Contradictions include Contradictions Matrix and the Inventive Principles. The methods to solve Physical Contradictions are Separation Principles and the Inventive Principles. There are 76 Standard Solution models to solve Su-Field problems. Knowledge-Effect database is used to solve “How to” problems. ARIZ is a wide problem-solving tool that can transform a complex inventive problem into a model of TRIZ problem-solving [11-13].

3.2. Function Transformation Method

3.2.1. Establish Function Tree

Through establishing the function tree, the design idea of complex product can be gradually refined to realize the simple function and make the abstract problem concrete [9]. The function model of the product was established by various function elements to make a combination and connection for function tree. According to the functional model, function tree starts with the function elements of the product. Establishing function tree method is from the function element or basic function part to realize the simple sub function, until the total function is satisfied. As shown in Fig. (3), the function relationship is converted into function tree structure. The process of function tree is to deepen cognition process for the product.

Table 1. Patent around Strategies Method.

Patent around strategies	The expression Of around strategies	Method description	The design requirements
Trimming	$A+B+C+D \rightarrow A+B+C_1$	Eliminating one or more technical features, and the function is transferred to the other components	the all elements rule
Substituting	$A+B+C+D \rightarrow A+B+C_1+D_1$	Replace some components with other components to achieve the same function.	$C \neq C_1$ & $D \neq D_1$ the all elements rule the doctrine of equivalents
Evolution	$A+B+C+D \rightarrow A+B+E$ $A+B+C+D \rightarrow A+B+C+D_1+D_2$	Combine one or more technical features, or use a number of new features work together to achieve the required functions	$E \neq C+D$ & $D \neq D_1+D_2$ the all elements rule the doctrine of equivalents

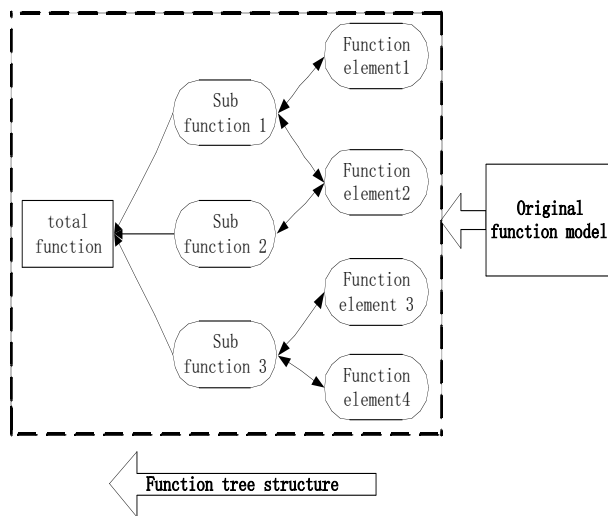


Fig. (3). Diagram of function tree structure.

Function tree structure can be divided into various function levels. The highest level is the total function, and the sub functions can be divided into lower level function. This process ends until the function elements divided. The same function level of the sub functions or function elements should be combined to meet the requirements of the upper level function. Finally, a total function is satisfied. It is easy to find out the working principles of each sub function and function element after establishing the function tree. Through the function tree of the logical connection between sub function and function element, the relationship among the function elements can be determined, and the sub functions can be changed subsequently.

3.2.2. Function Change Method

Variation means the form of function changes after functional analysis and keeps the effect of function granularity unchanged. In a same functional class, variation can be performed by searching functional synonyms or antonyms [18]. First, One or more functions in the original function tree architecture are generalized. Then, function is redefined which depends on the variation during the re-design process. Finally, the changed function is specialized. The flow chart of function variation is proposed in Fig. (4).

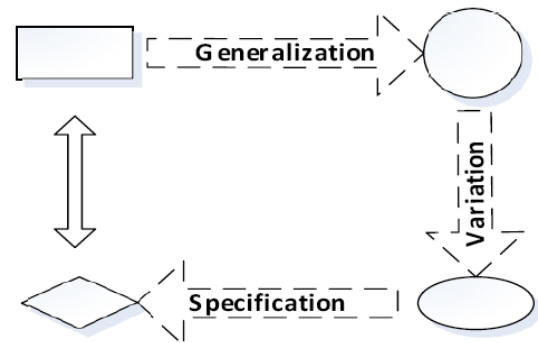


Fig. (4). Flow chart of function variation.

During the function transformation, we should pay attention to the change from the function tree. The changed function must meet the requirements of the upper function level. The function element is solved by using the following method of the next part, and ultimately a new product based on the function model is generated in a modified version of the original one.

3.2.3. Solution Function Element

How to achieve the new function tree? This is the solution function element, which is to seek for the function carrier of the technique. Solving methods are shown in the following:

- (1). Intuition: Intuition is to solve a function element by virtue of designers' wisdom, experience and creativity.
- (2). Investigation and analysis: Designers should understand the current situation of development of domestic and foreign technology, consult a large amount of literature (professional books, patent information, academic reports, research papers, etc.), and master the latest research results of a variety of professional categories.
- (3). Design catalogue: Design catalogue is an effective tool and the design knowledge is based on the design work. Solutions can be classified, arranged and stored in the form of a clear table, which is convenient for the designers to search [19].

- (4). Function-Oriented Search (FOS): FOS provides more concrete and feasibility solutions based on the same or similar functions analogy that adopts an already existing technology from remote technology area to the initial problem area [20].

4. CASE STUDY

In recent years, a symbol of people enjoyment is the consumption of red wine, because people’s requirements of life quality are gradually improving. Therefore, the packaging of red wine has become a necessary market product. Now, we will use the above mentioned method to design a red wine packaging.

4.1. Defining the Re-design Target

At present, the following problems exist in the traditional wine packaging on the market. Existing wine packaging [21, 22] is mainly used in fixed carton and wooden boxes, the transport buffer effect is poor to cause damage to the bottle, and packaging is too simple to cause visual effect difference. At the same time, in the sale of red wine is usually placed on a special display or direct damage to the outer box to achieve the purpose of display, but this caused a waste of packaging materials [22-24]. Therefore, the problems in the presence of red wine packaging need to be improved. Through the patent of a red wine packaging box, this paper describes how to use the above method to complete the innovative re-design process.

Based on the keyword search, Patent No. CN103318496 [25] is identified as design around target patent. After reading and analyzing content of the patent, there are two key systems, which are 1-inner buffer packing and 3-outer seal packing. As shown in Fig. (5), the structure of the inner buffer packing is the fence type with 2-show slot, and the outer seal packing consists of 4-holding tank, 5-insert and 6-folded plate.

According to the relationship of technical system and processing object, the main function of the Red Wine Packaging is protecting fragile bottle in the process of hauling and transportation and exhibiting the red wine when showing to customers. Analyzing the relationships between all system components and super system components in this patent, the function model of this Red Wine Packaging is established, which is shown in Fig. (6).

4.2. Analyzing and Solving Problems

4.2.1. Patent Around Method

After the analysis of the above model, two problems of the target patent are found: a. the wine bottle is easy to be broken because protection of the inner buffer packing is insufficient; b. the folded plate lack of support for the inner buffer packing.

A designing scheme is generated when we chose patent around method based on TRIZ. Firstly, according to the Table 1, we choose substitution method to find out another structure that can substitute the Inner Buffer Packing to protect wine bottle. This problem is solved to use the Knowledge-Effect

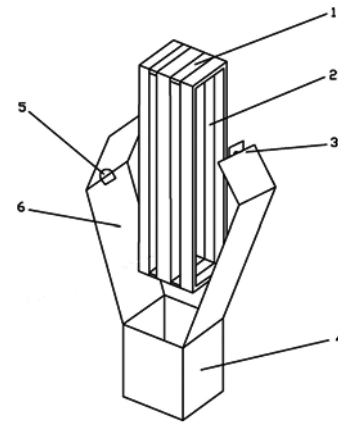


Fig. (5). Model of the red wine packaging.

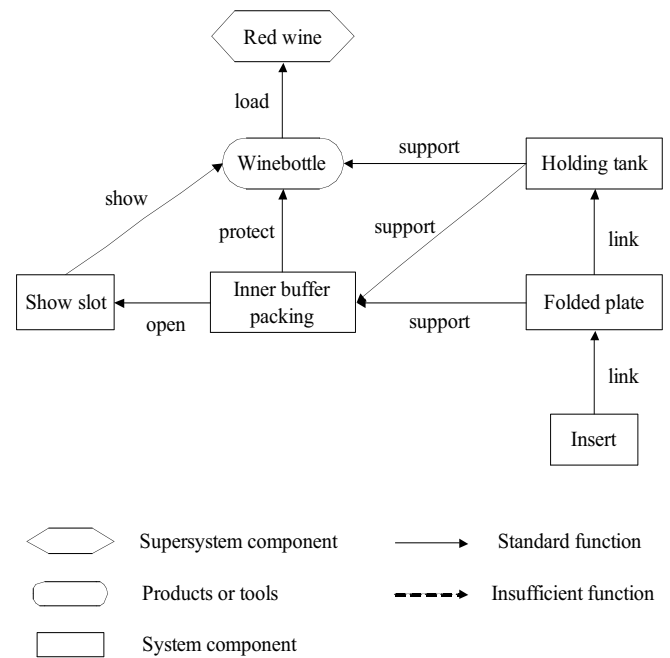


Fig. (6). Function model of the red wine packaging.

database. By searching the database, we can find out a spiral structure of rubber that can protect the bottle by its good toughness. Then, choosing trimming method, the Folded Plate can be trimmed, so the Insert should also be trimmed. We use physical contradictions to solve this problem. Inventive Principle 5(Merging) and Principle 17(Another Dimension) are used to generate ideas. We improve the Holding Tank into a bucket structure. Finally, a new design is produced by utilizing the patent around method and TRIZ problem-solving tools to improve system performance of the red wine packaging. New function mold is established in Fig. (7).

4.2.2. Function Transformation Method

After establishing new function model of the red wine packaging, the relationship between the function components needs to be analyzed whether there is a conflict problem. The

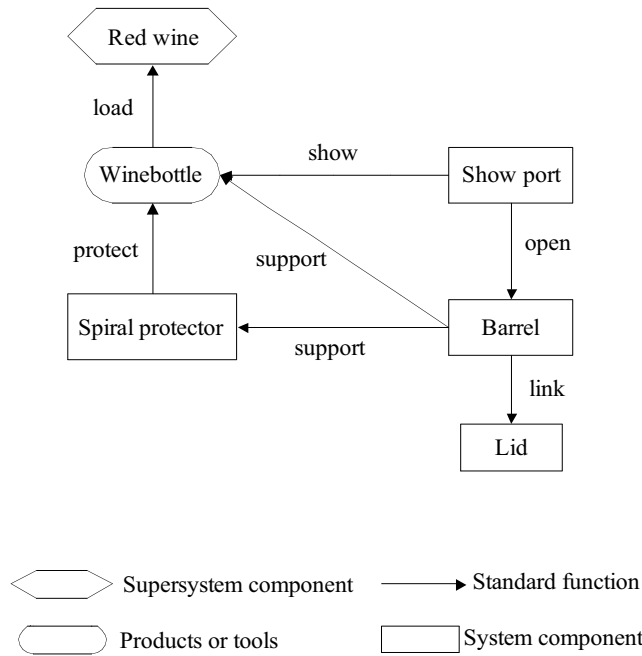


Fig. (7). New function model of the red wine packaging.

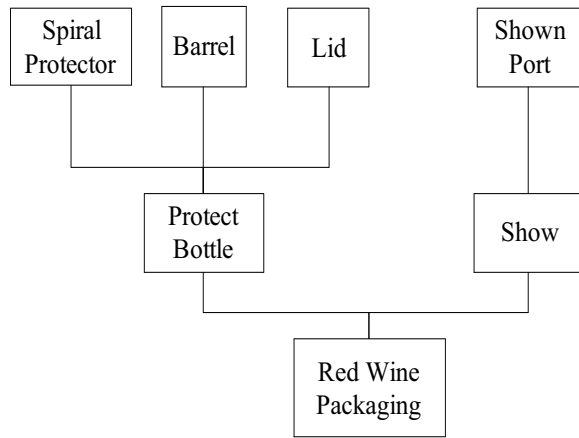


Fig. (8). Function tree of the red wine packaging.

patent product innovation re-design is realized by establishing function tree structure, function change and solution function element.

Firstly, function tree is from the function element (function components) to the simple sub function, finally the total function is realized. As shown in Fig. (8), the function tree structure is expressed by analyzing the above function model.

Secondly, the original function “show” steps back to a more abstracted level “see” by generalization, which can extend the solution scope of the same requirements of the upper level function. After investigating similar functional concepts by using synonyms, “see” is selected to replace “find”. Finally reaching the varied version “appear” performed by specification and the function variation process is shown in Fig. (9).

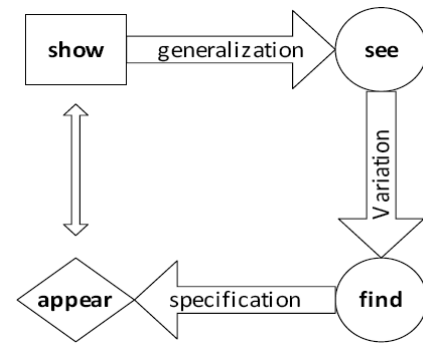


Fig. (9). Function variation process.

Then, a new re-creation function “appear” is specified. According to the actual situation of the red wine packaging, the function “appear” is realized which must satisfy the “exhibit” and “arise” function. The show port is used to implement the “exhibit” function. By searching the Knowledge base, we can find out an out device structure with a spring and plate that can arise the bottle and realize the “arise” function. The new function tree of the Red Wine Packaging is shown in Fig. (10).

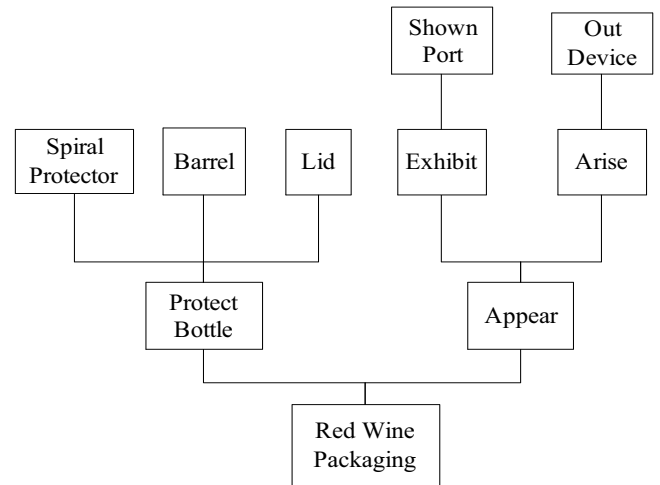


Fig. (10). New function tree of the red wine packaging.

4.3. Generating the Plan

A refined function model for the red wine packaging is constructed in Fig. (11).

Through the above innovation re-design, there is a final product of wooden straight-tube structures of the red wine packaging with a shown port. It consists of six components which are a barrel, lid, show slot, spring and plate and spiral protector. The linear spiral protector made of rubber has a stable protective effect by snapping the outer wall of bottle. The wooden barrel with a shown slot on the side wall plays the role of supporting the linear spiral protector. The lid installed on the barrel is the entrance to put in and take out the bottle. The role of spring and plate is to hold up the red wine bottle. As shown in Fig. (12), there are six key components, which are 1-lid, 2-barrel, 3-plate, 4-spring, 5-plate protector, and 6-shoe port.

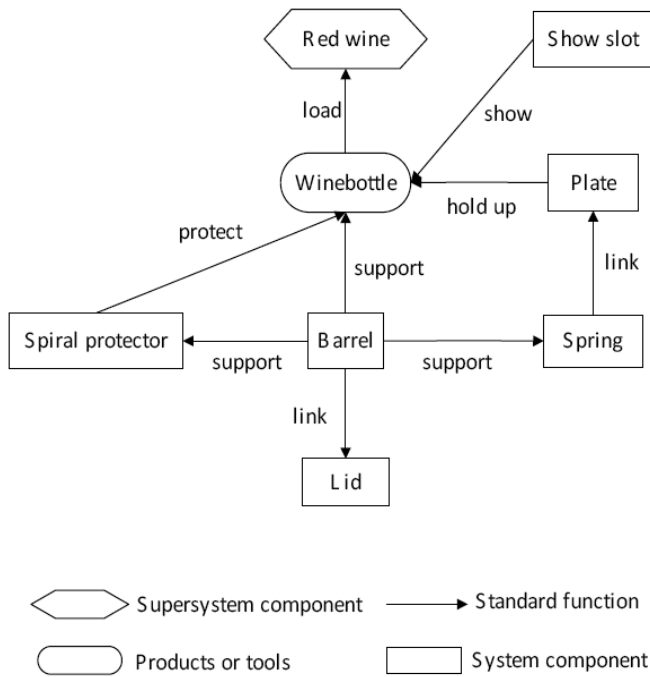


Fig. (11). Final function model of the red wine packaging.

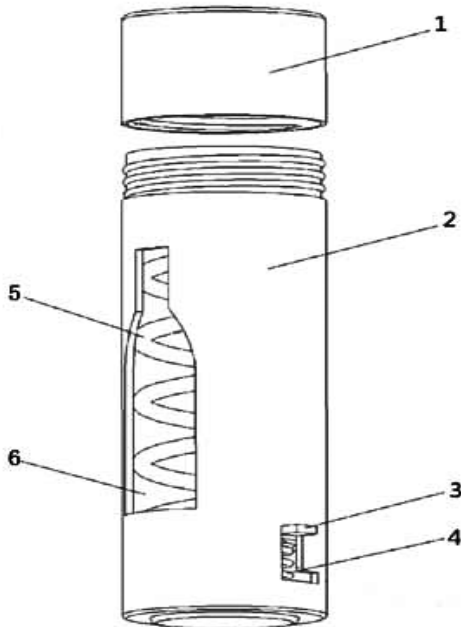


Fig. (12). Final product of design around.

4.4. Solution Evaluation

After design around, the environmental parameters and engineering parameters of the new red wine packaging are security, persistence, save energy and reliability, strength, weight and manufacturability. According to the product cycle, parameters comparison of the final scheme is shown in Table 2. So this is a qualified and feasible new product.

The above packaging box differs from the traditional mode of the red wine packaging design. And the new design of Red Wine Packaging had been granted for patent No. CN201520284639.7 [26].

Table 2. Parameters Comparison of the Final Scheme.

product target parameters	engineering technical parameters	scores
Security	Reliability	+(50%)
Persistence	Strength	+(20%)
Save energy	Weight, Manufacturability	-(30%)

5. CURRENT & FUTURE DEVELOPMENTS

In order to realize patent product innovation re-design, function model of target patent is based on functional analysis. Then function transformation method or patent around method based on the TRIZ problem-solving tools can be selected to create a new product, and is successfully applied by a case of red wine packaging. To the existing outstanding patents as the background, the design method is to circumvent the existing patent rights, and form own valuable patent products. Moreover, this paper describes the solution method of Innovation problem in detail, which could provide guidance for designers to help effectively achieve inheritance and development of patent.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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