PRODUCT DESIGN IMPROVEMENT OF WATER DISPENSER TAP USING TRIZ METHOD

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ABSTRACT: To produce the best solution for improving any product design that should be able to satisfy the design requirements (i.e., faster, better and cheaper), there were several stages typically involves the root cause analysis and idea generation activities. In this paper, product design improvement of a water dispenser is demonstrated using Theory of Inventive Problem Solving (TRIZ) method. The objective of this study was to find out the design solution which was able to solve the problem of water spill out that occurred after dispensing water from the dispenser tap. TRIZ Function Model and Engineering Contradiction method were used to model the problem, followed by TRIZ Contradiction Matrix and 40 Inventive Principles to generate potential solutions. The design improvement process based on the TRIZ method generated new concept design of water dispenser tap component which was able to eliminate the water spill out problem, while maintaining the existing dispensing function. In addition, the new dispenser tap conceptual design also required less component to operate compared with the existing design, hence, lowering the product cost.

KEYWORDS: *Product design, water dispenser tap, TRIZ, engineering contradiction, 40 inventive principles.*

1.0 INTRODUCTION

Design improvement of any product design typically involves several stages in the root cause analysis and idea generation, specifically to get the best solution (i.e. faster, better and cheaper) in the design development towards existing products. In modern application, product design improvement process are performed using various systematic problem root cause identification and idea generation methodologies such as the Ishikawa diagram (or fishbone diagram) [1], failure mode and effect analysis (FMEA) [2], morphology chart [3] and brainstorming[4].

Another alternative to the aforementioned methods for similar product design improvement purpose is through the Theory of Inventive Problem Solving (TRIZ) method, developed by a Russian patent engineer named Genrich S. Altshuller in the 1940s. The TRIZ method is a systematic innovation process comprising many problem modeling and problem solution tools with the aim of solving problem with contradictions (where a solution to one problem creates another undesirable consequence) [5]. Thus far, various activities on the application of TRIZ for product development process have been reported, such as for green roof design [6], machine tool cover shape design [7] and mechatronic automotive suspension design [8].

In this study, the improvement was made on a drinking water dispenser which is a common household product utilized by users in daily activity. The product comprises several main components such as the tank, tap and base. The tap serves as the main component which delivers the function of dispensing water from the tank to drinking cup of users. The most common type of tap design operates using lever actuated mechanism. In general, the current tap design assembly encompasses five sub-components which are the level, bonnet, spring, seat cusp and body.

The common lever type tap assembly is used to pour water in the cup with a little effort to pull/push the lever, with the help of the spring actuated mechanism. Despite ease of operation by the existing tap design, it also causes water spill on the table or floor after the lever has been released to its rest condition. Thus, a new solution to address the problem is needed through a modification of the tap design.

In this paper, potential product design solution to the water spill out problem for the water dispenser at a conceptual design stage is formulated using the TRIZ method. Four TRIZ tools were selected in the problem solving process, whereby the Function Model and Engineering Contradiction method were used to model the problem. Finally the solution development was conducted using TRIZ Contradiction Matrix and 40 Inventive Principles to generate new design for the water dispenser tap product.

2.0 RESEARCH METHODOLOGY

The overall research methodology applied to the water dispenser tap design improvement process is shown in Figure 1. There were four main activities involved which started from identifying the root cause of the problem using TRIZ Function Model method, followed by modeling the problem using TRIZ Engineering Contradiction method, identifying potential solution using TRIZ 40 Inventive Principles and finally applying the identified inventive principles to create the new conceptual design of the product. Details of the method applied are described in the following sections.

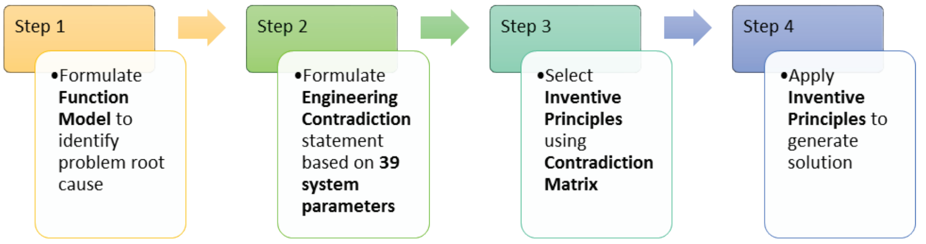


Figure 1: Overall research methodology using TRIZ

2.1 Root Cause Identification using Function Model

Identifying root cause of the problem was essential in developing the right solution. As for the water spill out problem, the root cause of the problem was identified and analyzed using Function Model method. The function model is a tool in TRIZ to illustrate (in graphical manner) the interaction of functions between the engineering system and its sub-system and supersystem [9]. The engineering system is referred to the product in hand, while the sub-system and supersystem are the sub-components which make up the product and the environmental elements that interacted with the product, respectively. The water dispenser was considered as the engineering system, and consisted of five sub-components (sub-system). The supersystem components related to the engineering system in this scenario were the user itself, water, table (where the whole water dispenser product is placed upon) and the floor.

Based on TRIZ method, the function model was generated by determining the function interaction between the engineering system, sub-system and supersystem based on two main categories, which were useful function and harmful function. The useful function could be further divided into three types; normal, insufficient and excessive. Figure 2 shows the graphical form presenting each of the function, while Figure 3 shows the function model diagram created for the water dispenser tap assembly.

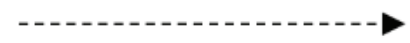
Function type	Line style
Useful (normal)	
Useful (insufficient)	
Useful (excessive)	
Harmful	

Figure 2: Different line styles representing type of function

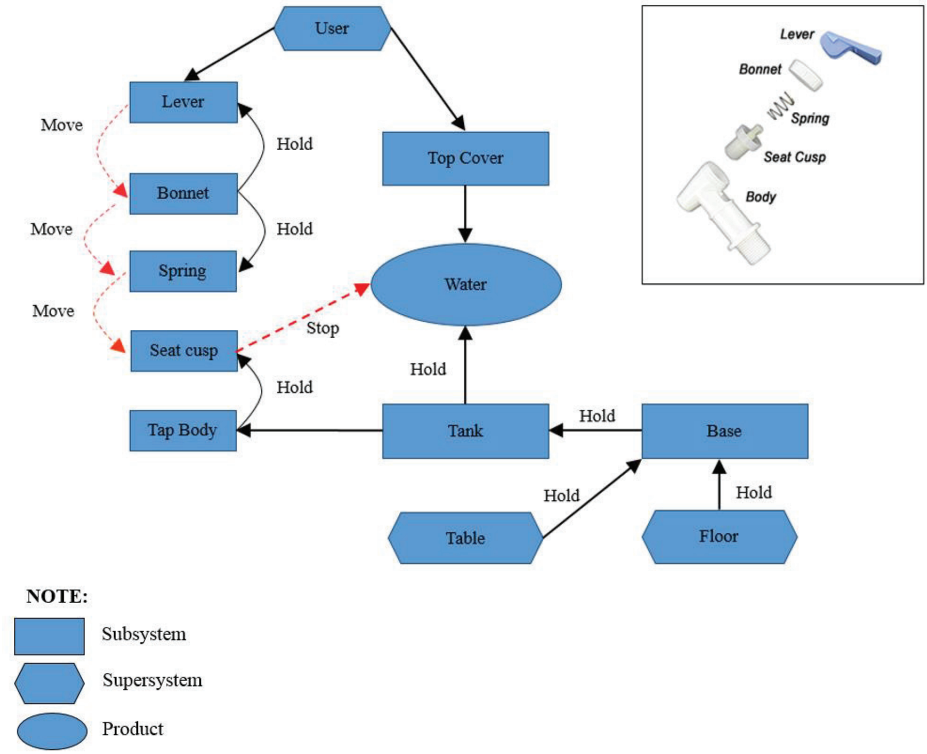


Figure 3: Function model diagram for water dispenser tap assembly

As observed in Figure 3, the water problem faced on the water dispenser tap component can occur due to insufficient interaction between several sub-components in the engineering system. It is identified that there are insufficient function performance between the lever, bonnet, spring and the seat cusp. All the insufficient functions might affect the performance of the seat cup to fully stop the water from flowing through the tap body after the water has been dispensed. The insufficient functions can be used as a reference in identifying the solution for the problem.

2.2 Modeling the Problem using Engineering Contradiction

In order to solve the water spill out problem (caused by the ineffectiveness of the current sub-components to stop water from leaking out), one of the solutions is to have the tap body nozzle to act as the stopper itself. This means that the nozzle direction should be pointing upwards to prevent the excess water leaking out from the seat cusp. However, in current situation, the nozzle is designed to point downwards for user to easily pour the drinking water into the cup, and also easy for the drinking water to gravitationally flow out from the tank. Thus, a contradicting problem can be formulated based on the current situation whereby to stop water spill, the nozzle should be pointing upwards but the solution will reduce user convenience and harder water flow performance.

Using TRIZ method, the problem was modeled into an engineering contradiction as follows:-

If the nozzle pointing upwards, then it will prevent water spill but reduce user convenience (ease of use to the user) as well as reducing water flow process.

Based on the above statement, there were two parameters involved: categorized as the improving (or desirable) parameters for the system and the worsening (or undesirable) parameter. The improving parameter for the system was preventing water spill, however the worsening parameter was reducing user convenience to use the system as well as slowing the water dispensing process. In the problem modeling process, both engineering parameters were matched with TRIZ system parameters.

The TRIZ system parameters are a list of 39 keywords created to represent the current engineering parameters in a more general manner. The idea is that many idea-thinking processes are often limited by the use of high-order technical terminology or jargons involved, thus, by simplifying the jargons into lower-order terminology, users can break the creative barrier ,hence, enabling the user to think more creatively to achieve more diverse and better idea to solve the problem [10].

The current engineering parameters are matched with TRIZ system parameters as shown in Figure 4 as follows:-

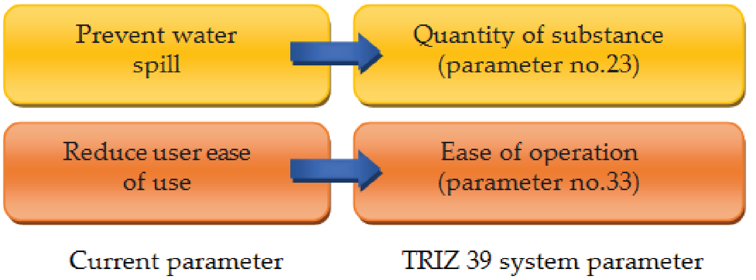


Figure 4: Matching current parameter with TRIZ 39 system parameter

2.3 Identify General Solution using Contradiction Matrix and 40 Inventive Principles

The next step to the problem solving process using TRIZ was to identify general solution using the contradiction matrix. During patent analysis conducted by Altshuller [11], he observed that many of the patents report the use of similar solution principles for the invention, and the solution principles are repeated across many different applications. After analyzing nearly 40,000 patents which have contradicting scenario, he successfully classified all the solution principles used in those patents into a list called the TRIZ 40 inventive principles [11]. Among the 40 inventive solutions identified are segmentation, taking out, merging and copying. Moreover, through the patent analysis, he was also successfully able to link the interaction of the inventive principles with the contradicting (improving-worsening) scenario. As a result, a new matrix called TRIZ contradiction matrix is developed which maps all the 39 system parameters with the most occurring inventive principles [12, 13].

Using the TRIZ contradiction matrix, the inventive principles to solve the contradiction problem of the current drinking water dispenser design are identified. The results showed that there are 4 inventive principles which can be used to solve the contradiction. Among them is by using the solution principle of colour changes, whereby it indicated that the problem can be solved either by changing the colour of the object (can also include changing the object external environment), or changing the transparency of the object (can also include the transparency of the object external environment). The recommended inventive principles served as a quick guide to user to find new ideas or explore other possible idea to solve the problem. Table 1 summarizes the inventive principles recommended using the contradiction matrix.

Table 1: Summary of the inventive principles recommended using the contradiction matrix [14]

Parameter to improve	Worsen parameter	Recommended TRIZ 40 inventive principles and descriptions
No. 23: Quantity of substance	No. 33: Ease of operation	**No.32: Colour changes** a) change the colour of an object or its external environment. b) change the transparency of an object or its external environment.
		No.28: Mechanics substitution a) replace a mechanical means with a sensory (optical, acoustic, taste or smell) means. b) use electric, magnetic and electromagnetic fields to interact with the object. c) change from static to movable field-activated (e.g ferromagnetic) particles.
		No.2: Taking out a) separate the interfering part or property from an object, or single out the only necessary part (or property) of an object
		No.24: Intermediary a) use an intermediary carrier article or intermediary process. b) merge one object temporarily with another (which can be easily removed).

3.0 PRODUCT DESIGN IMPROVEMENT OF WATER DISPENSER TAP

Based on the recommended inventive principles obtained from the contradiction matrix (Table 1), the final step of the problem solving process was to convert the general solution into workable specific solutions. Interpreting the inventive principles is among the challenging task for users, and it is best done by group brainstorming method so that many ideas can be generated. Group with diverse knowledge and experience can provide higher advantage to the solution development process to explore as many solutions as possible based on a single inventive principle.

As for the water dispenser tap contradiction problem, the brainstorming process created several workable solutions based on the inventive principles. One of the simple solutions identified based on the inventive principle of colour changes was by changing the water dispenser tap solid colour to transparent colour. The transparency property will help user to see whether all the drinking water are fully dispensed into the cup or there are still remaining water trapped inside the nozzle. If there are still water left, then the user can hold the cup a bit longer until all the water inside the nozzle is dispended.

Another solution identified from the inventive principle of taking out is to remove the interfering part from the existing object. In this case, from the function model diagram it is observed that the seat cusp subcomponent is one of the causes of the water spill problem, whereby water leaks from the side of the seat cusp even after closing the tap. Removing the seat cusp will eliminate the problem, but require a new dimension of thinking on how to stop the water. Similar 'taking out' inventive principle also points out that it can be done by single out the only necessary part of the object.

The phrase can be interpreted as to remove unnecessary subcomponents, leaving only the important subcomponents to enable the task of stopping and dispensing water to be performed. In this case, water is dispensed from the tank, flow through the body, exits the body's nozzle and finally into the user's cup. The useful sub-component is the body, to enable the dispensing process.

The next process is to create a dual-function body subcomponent which can also operate to stop the water. Again, using brainstorming process, the water stopping function was successfully solved using simple solution idea inspired by the existing talcum powder bottle cap design. The body was divided into two segments; the body with the pipe and the body with the nozzle, and both segments can move relative to each other as shown in Figures 5 and 6 respectively.

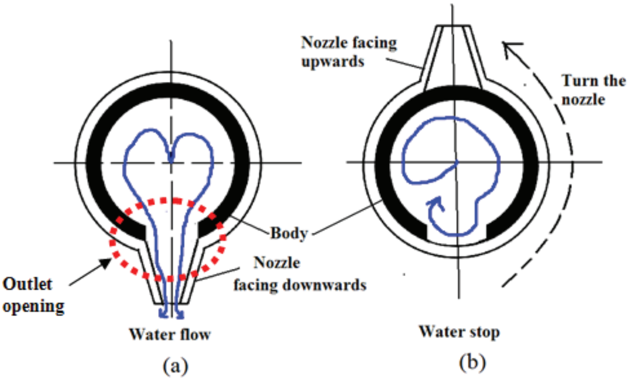


Figure 5: The mechanism of the new water dispenser taps (a) both body and nozzle opening are aligned to permit water flow, (b) the nozzle is turned upwards to stop water flow

On both segments, outlet openings were created. When both openings were aligned with each other, then water could pass through; and when both opening were not aligned, then water stopped from flowing. Using the idea, the body subcomponent was now converted into a water dispensing-stopping mechanism by itself, without requiring additional stopping mechanism within it. The movable body-nozzle segment could also provide better water spill prevention action, as when the nozzle was pointing upwards; it was harder for the excess water to flow out gravitationally.

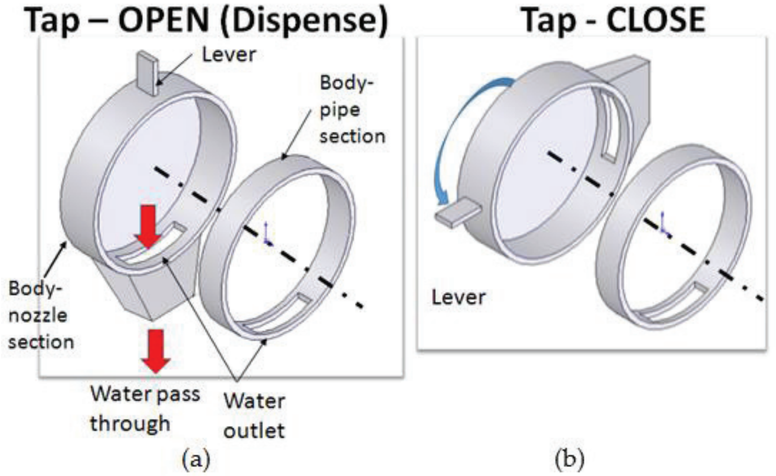


Figure 6: CAD model of the new water dispenser tap design (a) both body and nozzle opening are aligned to permit water flow, (b) the nozzle is turned using the lever to stop water flow

In addition to the multi-functional capability, the new water dispenser tap design also featured quick and simple open-close mechanism to users. Adding a small lever design on the body-nozzle section may also help users to open and close the tap easier. Furthermore, the new design also reduced 60% (from initially 5 subcomponents to only 2 subcomponents) of the existing number of child parts in the whole assembly, which further simplified the current design and potentially lowered the overall cost (based on the number of child parts reduction) of the product.

4.0 CONCLUSIONS

In conclusion, new product design for water dispenser tap has been developed using the TRIZ method. The improvement is made to eliminate the water spill problem faced by the existing product. Through the application of TRIZ, innovative solutions have been identified to be implemented for the new water dispenser tap design. One of the design solutions is also able to add multi functionality performance to the proposed design (the body component able to act both as tap body and water stopper), as well as retain ease of use to the users and potentially reduce the overall product cost as lower number of subcomponents are required in the new proposed product assembly.

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