APPLICATION OF THEORY OF INVENTIVE PROBLEM SOLVING FOR SYSTEMATIC INNOVATION: CASE STUDY OF WATER DISPENSER DESIGN

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ABSTRACT: This paper analyzed an application of the Theory of Inventive Problem Solving (TRIZ) method in providing systematic innovation process of consumer product. The TRIZ tools namely contradiction matrix and 40 inventive principles were employed in this project. The contradiction matrix was applied for problem identification purpose whereas the 40 inventive principles were employed to generate conceptual solutions for the problem. The application of both tools was demonstrated through a case study of water dispenser. Based on the case study, the utilization of the TRIZ tools resulted in the development of new water dispensing bottle design which was able to offer a simple and cost effective solution while retaining the current principle of operation especially during the water bottle changeover process.

KEYWORDS: *TRIZ, Contradiction Matrix, 40 Inventive Principles, Water Dispenser.*

1.0 BACKGROUND

TRIZ is a Russian acronym for "Theory of Inventive Problem Solving" [1]. It is a systematic innovation theory developed by Genrich S. Altshuller after analysing thousands of patents in the 40s. TRIZ has been successfully implemented by big companies, such as Samsung, General Electrics (GE), Intel, and many others to assist with product and technological innovation [2].

TRIZ is based on "contradictions that can be methodically resolved through the application of innovative solutions" [3]. TRIZ has three premises; an ideal design; contradictions that help to solve problems; innovative process which can be structured systematically [3].

Contradictions are technical compromises or trade-offs that lie in an engineering system where some design parameters have become worsen in order for the problem to be solved. TRIZ has been demonstrated for ceramics processing in 70 ways, whereby its aim is "to teach ceramics processing to the next generation of scientists and engineers but closely allied to classification is the question of creativity and inventiveness and how they are fostered". The contradictions refer to simplified ceramics processing classification, increased inventiveness, and good practice [4].

A case study of a notebook design in research and development was presented by Yeh, Huang and Yu [5] through an integration of quality function deployment (QFD) and TRIZ. QFD has been implemented in four phases to identify major contradictions. At each phase of the QFD, major contradiction has been identified and TRIZ has been applied to resolve the contradiction. The final outcomes are three breakthrough solutions generated from the TRIZ 40 Inventive Principles.

Moreover, TRIZ has also been illustrated in the design of a passively compliant robotic joint [6]. Based on their report, TRIZ was demonstrated as a systematic methodology for enhancing creative capability in the design of an innovative robotic joint. Two contradictions have been identified from five literature studies. TRIZ Inventive Principles have been applied to resolve the contradictions and a prototype has been developed and experimentally tested.

TRIZ has also been adopted in a design of an implanted biomedical device, a tracheal stent that fulfills the need of each patient and approve by physicians at the same time [7]. The contradiction occurs due to required customization of the tracheal stent on patients but such tracheal stents come in many materials, shapes, and characteristics. A parametrization tool has been implemented that guides modification of the general dimensions of stents to fit each specific patient. The QFD method has been applied prior to TRIZ to visualize and summarize the design attributes.

Based on the discussion from the aforementioned literatures [3 – 7], resolving contradictions through TRIZ can lead to innovative solution. Thus, based on the TRIZ method, this paper aimed to identify the contradictions that occurred in developing solutions for problems involving consumer products. The application of the TRIZ tools was shown through a case study to solve the contradiction that occured in the bottle changeover process of a water dispenser. Implementation of TRIZ contradiction matrix tool was first conducted to resolve the contradiction. Finally, solution generation for the contradiction was performed using TRIZ 40 inventive principles to come up with an ideal water dispensing design.

2.0 RESEARCH METHODOLOGY

Figure 1 shows a general framework of the problem solving process in this study [1]. The framework comprises four steps, which conceptually follows similar classical TRIZ problem solving method as shown in Figure 2. The first step in problem solving process is problem definition. In this step, the problem should be clearly defined and what benefits are expected if the problem is solved. The information about limitations of the existing condition and the requirements of the solution are also essential so that the problem formulations can be clearly stated.

The second TRIZ problem solving process involves development of TRIZ model of the problem. In this paper, TRIZ technical contradiction was used to model the problem. The term contradiction is applied in TRIZ to represent the compromise in which designers need to decide upon when implementing a solution. For example, the design intents to improve the weight (reduce the weight) of a product by reducing the product thickness for better maneuverability may also cause deterioration on the product strength in handling the given load. Thus, the contradictions occurred in TRIZ is solved simultaneously to obtain the best solution without having to make a trade-off or compromise in the design.

The next step involves an application of 40 Inventive Principles to solve problem of the developed model of. In the last TRIZ process, the final result of the specific solution which generally covers the solution idea is generated from the selected potential solution obtained in previous step.

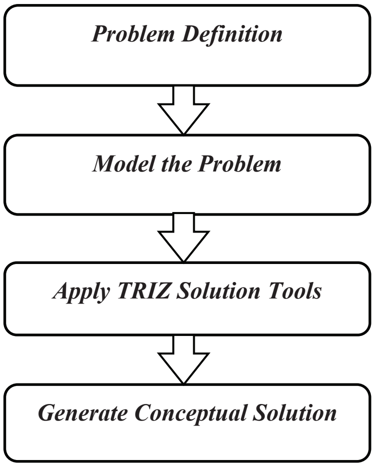

Figure 1: TRIZ problem solving process flow

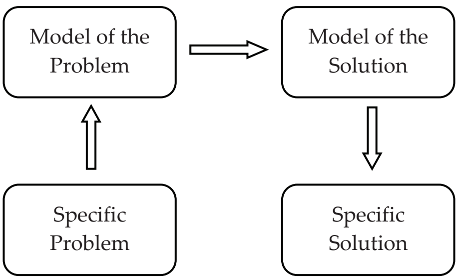

Figure 2: Classical TRIZ problem solving method

3.0 CASE STUDY ON WATER DISPENSER

An application of TRIZ method in solving problem and developing innovative solution in this paper is demonstrated through a case study on water dispenser equipment. A water dispenser unit is daily consumer equipment that provides clean drinking water to the user. In general, there are two types of water dispensing unit; one which uses a dedicated water bottle to supply water (manual refilling method) and the other is the one which is integrated with water pipe as the source of water supply (automatic refilling method). The design of the dedicated water dispensing product is relatively cheaper compared to the integrated dispenser-piping design. However, it requires users to selfchanging the water bottle after it is empty. As shown in Figure 3, the manual water dispenser encompasses four main components, the refill bottle, dispenser insert, dispensing units (for hot and cold water) and dispenser main body.

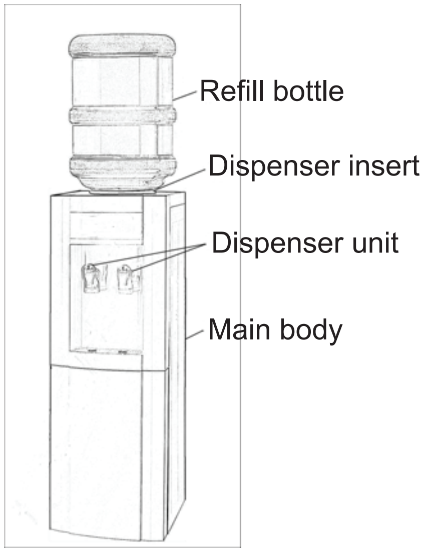

Figure 3: Main components of manual water dispenser

The refill bottle helps to provide high water consumption capacity that is able to cater for many users which is very economical to be used in offices and public places. The issue arises during the refilling process due to the weight of the replacing full water bottle with normal capacity of 5-gallon (22.7 L) . With approximate weight of 23 kg, the refill bottle imposes negative refilling process issue to the consumer particularly women to lift the heavy refill bottle and place it in the correct position on the top of the water dispenser. Thus, the solution to solve the contradiction is determined through implementing TRIZ method.

3.1 Problem Definition using TRIZ

In TRIZ method, the problem was first classified based on the contradiction occurred. As for the water dispenser, the current design provides high drinking capacity and less refilling process. However, imposed refilling difficulty due to high force is required to lift the heavy refill bottle. Thus, based on the situation, TRIZ classified the contradiction as an engineering contradiction, whereby improving one parameter resulted in creating other negative parameter. Using TRIZ method, the specific problem is later converted into general problem based on the TRIZ 39 system parameters definition. The process to generalize the specific problem into more general term representing the situation enables more ideas to be generated by removing the creative thinking barrier caused by the influence of complex technical term. In TRIZ, the problem definition or engineering contradiction statement is formulated based on the "ifthen- but" principle. In general, the word "if" corresponds to the manipulating variable of the solution such as length, volume and shape while the word "then" corresponds to the positive or improving condition which the solution is intended to achieve such as increasing strength of the product. The last word to formulate the engineering contradictions statement which is "but" in the other hand corresponds to the negative or worsening condition when the solution is implemented, such as increasing the weight of the product [1].

Thus, the specific problem defined into engineering contradiction statement according to TRIZ method was formulated as follows:-

If the refill bottle volume is large, then more drinking water capacity is available but more difficult to lift the refill bottle.

3.2 Solution Generation using TRIZ

Based on the previous engineering contradiction statement, the improving parameter related to TRIZ 39 general system parameter was defined. Based on the TRIZ method, the improving and worsening condition for the problem can be linked with the TRIZ 39 system engineering parameters. The 39 system engineering parameters available in TRIZ include weight of stationary object, weight of moving object, speed, force, strength and shape. Based on the water dispenser problem statement and engineering contradiction statement, two (2) TRIZ engineering parameters were selected which were productivity (parameter no.39) to represent the improving aspect intended for the new design and the coupling worsening effect due to large refill bottle which reduced the ease of operation (parameter no.33) of the whole refilling process. The general parameters obtained were then arranged into the TRIZ contradiction matrix whereby potential solution could be obtained based on the TRIZ 40 inventive principles solution. TRIZ 40 inventive principles solution tool reflects 40 solution principles that are available to be selected. The selection of the solution principles was based on the recommendation after creating the contradiction matrix. Table 1 shows the contradiction matrix formed for the water dispenser problem based on the TRIZ 39 engineering parameters.

Table 1: Contradiction matrix for the water dispenser refilling process based on the TRIZ 39 Engineering Parameters [1]

Improving Parameter	Worsening Parameter	TRIZ 40 inventive solution principles
#39. Productivity	#33. Ease of Operation	#1. Segmentation #28. Mechanics substitution #7. Nested doll #10. Preliminary action (prior action – "do it in advanced")

Based on the contradiction matrix formulated as shown in Table 1, there were four (4) suitable inventive solution principles that could be applied to the problem such as segmentation and mechanics substitution. The next stage in the water dispenser problem solving process using TRIZ method was developing specific solution strategies to solve the occurred contradiction based on the four (4) recommended solution principles shown in Table 1 previously. After analyzing the four (4) solution recommendations namely segmentation, mechanics substitution, nested doll and preliminary action, two (2) possible specific solution strategies were able to be formulated which were related to inventive solution principle no. 1 (segmentation) and no. 10 (preliminary action). Based on the TRIZ general solution recommendations, specific solution strategies related to inventive solution segmentation and preliminary action formulated by the designer as shown in Table 2.

Table 2: Specific solution strategy based on the TRIZ solution principles

TRIZ 40 inventive solution principles	Solution descriptions	Specific solution strategy
#1. Segmentation	a) Divide an object into different parts b) Make an object easy to disassemble c) Increase the degree of fragmentation or segmentation d) Transition to micro-level	a) Use many small refill bottles instead on one large refill bottle. The insert component is also redesigned to from 1 unit to multiple units.
#10. Preliminary action	a) Perform the required change of an object (either fully or partially) before it is needed b) Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery	a) Redesign the refill bottle with handle for ease of handling

Based on the specific solution strategies, new conceptual designs of the refill bottle and the dispenser insert component were developed (refer to Figure 4).

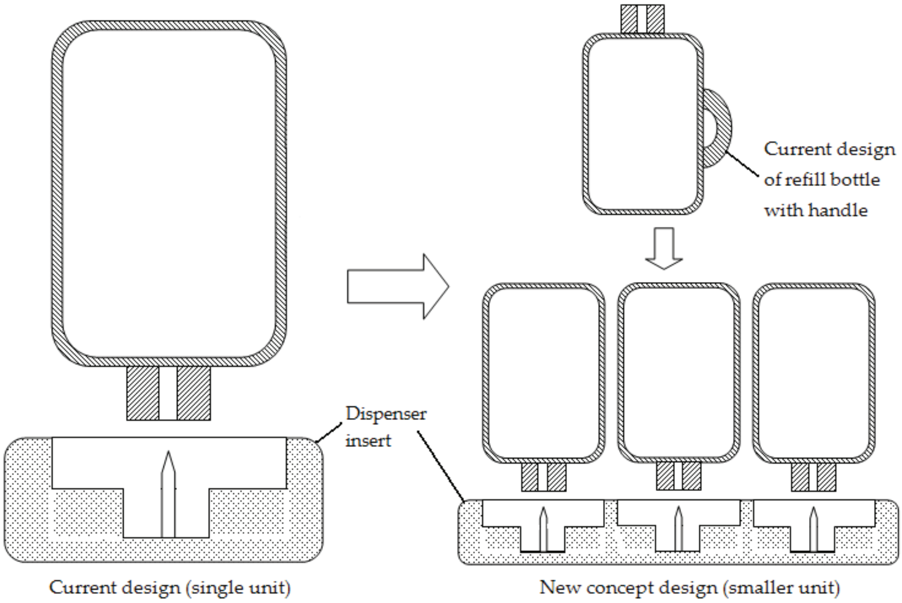

Figure 4: New conceptual design of refill bottle with handle and dispenser insert component for manual water dispenser

The new refill bottle conceptual design developed using the TRIZ tools was smaller in size compared to the initial bottle design. However, by using the new dispenser insert design, many smaller refill bottles could be attached to the dispenser at once to ensure that high water capacity was maintained similar to using single large refill bottle used previously. Another advantage of the new design was that the lifting process of the new smaller refill bottle required less lifting energy. Thus, it can be operated easily especially by women users. Additional advantage of the new design was reflected through the handling process which was also improved by the addition of handle to the bottle for a better grip and an ease of placing the bottle correctly to the dispenser insert section. In addition, the new redesign dispenser insert with undercut slot was also able to expedite and provide precise placement of the refill bottle onto the insert. The application of the TRIZ tools as demonstrated through the case study has provided systematic problem definition and idea generation processes to determine the required solution. Moreover, the solutions generated at the end of the conceptual design process were also able to solve the current problem without having to make a trade-off on the design performance which is usually challenging to be realized using conventional solution generation process.

4.0 CONCLUSIONS

In conclusion, the applicability of the TRIZ method in problem solving process has been demonstrated based on the case study of water dispenser design. It has been shown that the TRIZ method is able to provide innovative solutions to the sample problem through utilization of systematic approach which covers problem definition, idea generation and conceptual solution development. The structured problem solving process is also able to quickly assist in exploring possible solutions based on its proposed solution principle method. In addition, the solutions generated at the end of the conceptual design process are also able to solve the current problem without having to make a trade-off on the design performance which is usually challenging to be realized using conventional solution generation process.

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