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Designing a Multifunctional Vacuum Sealer using TRIZ Principles

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Abstract: Preservation techniques assures the safety, stability, cleanliness and nutrition of products. An effective preservation technique includes vacuum packaging. However, issues pertaining to the difficulty of opening these vacuum sealed packages do exist, sometimes severely to a point where it causes wrap rage or package rage which is a usual term for being frustrated when opening hard-to-open packages. Various injuries have also been reported concerning individuals who attempt to open these vacuum sealed packages. These packages also pose a threat to the environment as they are thrown away and mostly end up in landfills. A solution could lie in the design of an appropriate vacuum sealer that addresses these issues. Thus, this study aims to innovate and design a multifunctional vacuum sealer using TRIZ techniques. Several function models were investigated along with the cause and effect chain analysis, upon which 3 major engineering contradictions were established. These contradictions were resolved with the recommendation of 3 inventive principles, namely local quality, taking out and universality. Finally, researchers proposed a zip lock sealing machine with a zip lock sealing feature (local quality) tear notch (taking out) and 4-in-1 process (universality) which unifies the alignment, zip sealing, cooling and cutting process. The new design's impact reflects on enhancement on numerous characteristics associated with human limitation, safety and health as well as environmental issues.

Key words: TRIZ, design innovation, vacuum packaging, vacuum seal, multifunctional

INTRODUCTION

There are many methods used to preserve food. Some of these methods can be used to enhance the quality of conventional products or even develop new products (Soccol *et al*., 2005). Preservation methods ensure the safety and stability of products in order for them to present sufficient nutritional properties (Soccol *et al*., 2005; Leistner, 1992). One of the effective types of methods to preserve food is through vacuum packaging. Vacuum packaging is a form of modified atmosphere packaging found around the world. Vacuum packing removes atmospheric oxygen from the sealed primary package. Oxygen has been known as a primary source of most products, thus removal of oxygen can often extensively help prolong product life. Researchers contend that while vacuum packaging and refrigeration can go hand-in-hand as an effective technique to preserve germination capacity, it was found that vacuum packaging by itself was more than enough (Croft *et al*., 2012).

Literature review: Many retail stores sell products in vacuum sealed packaging. Although, this type of packaging is strong, easy to set in a display, discourages theft and allows consumer to view the product easily but there are several problems, i.e., at times there are difficulties faced in opening the packages and often the methods used can be dangerous. It was reported that consumer reports magazine acknowledged a certain phenomenon known as package rage (frustration from failure in opening difficult-to-open packaging) through an event known as the Oyster awards specifically for products that contend for the most difficult-to-open packaging (ABC News, 2006).

A study conducted on people over 50 years old discovered that 99% out of 2000 people agreed that packaging has become increasingly difficult to open in the past 10 years (Anonymous, 2006). Besides that, the packaging itself may have sharp edges that can cause consumers to sustain injuries. Users at times also tend to utilise possibly hazardous utensils like razor blades, box cutters, scissors and ice-picks in their efforts to cut these sealed packages (BBC News, 2004). A British study concluded that about 60,000 people are treated at hospitals year in and year out because of injuries from opening plastic packages (Moore, 2003). Some of the

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injuries included finger cuts, hand cuts, wrist sprains, hand bruises and shoulder muscle strains (Anonymous, 2006). According to the US Consumer Product Safety Commission in 2004, it was approximated that efforts to open difficult-to-open packages instigated around 6500 visits to hospital emergency units (Wenzel, 2008). Furthermore, threat to the environment is present due to the end user's method of handling used packages by simply tossed in the trash and ended up in landfills.

Consumer packaging serves to contain products to avoid contamination. A packaging technique must protect the product, be adaptable to production-line speeds, promote or sell the item and provide reusable value to the consumer. Based on the aforementioned justifications, some of the problems of vacuum sealed packaging include:

- Its difficulty to be opened with bare hands
- Its threat to the environment since the most common material used for vacuum packaging in the market is plastic. After obtaining the product, the plastic is tossed into the trash and eventually ends up in landfills. Plastic is a hazardous waste

One of the product challenges faced would be to propose a design of an appropriate vacuum sealer that addresses all the aforementioned issues. Hence, the aim of this study is to innovate and design a multifunctional vacuum sealer.

MATERIALS AND METHODS

The TRIZ approach was used for this study, since it is known as a powerful problem-solving tool created from the research of inventive patterns from international patent literature (Yeoh, 2014; Yeoh *et al*., 2015). Similar approaches used in previous studies have also proven that TRIZ tools are capable of further innovating even the most basic products such as screwdrivers and knobs (Ng and Jee, 2016; Ng *et al*., 2016a, b). Upon the identification of the main problem, there are 3 major TRIZ tools used in this project, namely the function analysis, cause and effect chain analysis and engineering contradiction. Upon identifying the engineering contradiction(s), the system parameters will be identified and cross-referenced in the contradiction matrix in order to know the recommendations of the TRIZ inventive principles.

Typical single vacuum chamber machine: A singular chamber sealer necessitates a whole product to be located in the equipment. Similar to an external sealer, a plastic bag is normally utilised for the packaging process. When the product is in the equipment, the lid is shut and air is sucked out. Subsequently, a heat seal within the chamber would seal the package. Once the process is done, air is reintroduced into the chamber through an external vent. The pressure then compresses the residual air within the package. The product is then taken out after the lid is opened.

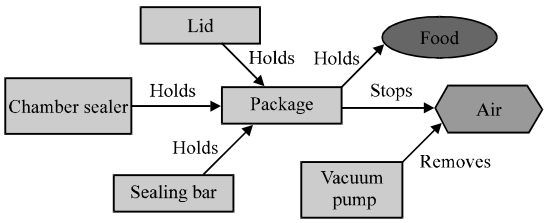

Fig. 1: Function model for sealing stage

Fig. 2: Function model for opening stage

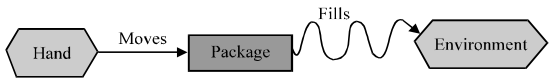

Fig. 3: Function model for disposing stage

Function analysis: The function analysis for this particular project can be divided into 3 stages, namely the sealing stage, the removing opening stage and the disposing stage. Figure 1-3 show the function models for all 3 stages. In the sealing stage, the package (which is unsealed) would be in the machine held by the lid, chamber sealer an sealing bar. The package would be holding the food and stopping the air while the sealing takes place and the vacuum pump would be removing the air from the package.

The next stage involves the opening of the vacuum sealed package by the user manually. The package once again would be holding the food. However, due to the nature of its sealing, the hand would insufficiently remove the package.

As for the disposing stage, the hand would now move the package away from the current location and the package would then be harmfully filling the environment (at landfills for example).

Based on the function analysis, the problems at the opening stage and disposing stage could be addressed. One of the ways could be to revisit how the vacuum pack sealing machine works and remodify it from there. However, a cause and effect chain analysis should be done first.

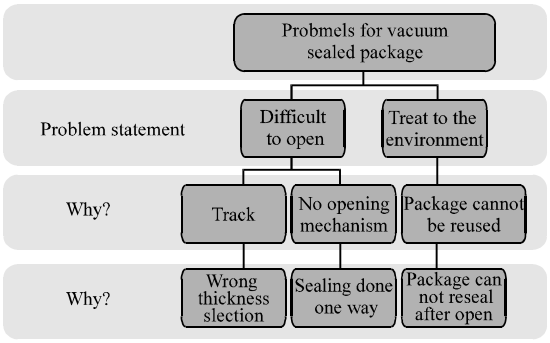

Fig. 4: The cause and effect chain analysis

Cause and effect chain analysis: Figure 4 shows the Cause and Effect Chain (CEC) analysis for the project. The problems that arose from the vacuum sealed package was the difficulty in opening the package and its threat to the environment. The difficulty in opening the package could be due to its thickness and this could be because the wrong thickness was chosen (perhaps the vacuum sealed package is too thick to be torn open manually). Another reason in the difficulty in opening the package lies in the lack of an opening mechanism and this could be because of the incapability of the machine to produce this opening mechanism, since most of the sealing is done one way.

Furthermore, the vacuum sealed package's threat to the environment is primarily because the package cannot be reused and is frequently disposed and ends up in landfills which is not sustainable for the environment. The package cannot be reused because it cannot be resealed upon being opened. Hence, the three major potential root causes for the problem include the wrong selection of thickness, one-way sealing and inability to reseal package after opened.

Engineering contradictions and system parameters: From the potential root-causes identified, there were about 3 engineering contradictions developed. The system parameters were identified based on the characteristics of the improving and worsening parameters in these contradictions. The 3 contradictions include.

Thick package, longer opening time: If the package thickness selected was large then the package would not easily spoil (#27: Reliability) but it would take longer to open the package manually (#16: Duration of action by a stationary object).

One-way sealing, no means to open: If the sealer machine only seals one way then the package can be effectively sealed (#32: Ease of manufacture) but the vacuum bag would not have an opening mechanism (#33: Ease of operation).

No resealing, threat to environment: If the package cannot be resealed after it is open then the entire package can be disposed easily (#26: Quantity of substance) but the disposed package threatens the environment (#31: Object-generated harmful factors).

Inventive principles and proposed solutions: Based on the identified system parameters from the previous section, several inventive principles from the matrix of contradiction can be recommended to aid the proposal of solutions for this project. Out of all the 40 inventive principles in TRIZ, only 3 of them were used for the proposed solution, namely local quality, taking out and universality.

RESULTS AND DISCUSSION

Zip lock sealing machine: Based on the inventive principles proposed, the zip lock sealing machine design is born. This design combines principles of local quality, taking out and universality in order to create a multifunctional innovative vacuum sealer.

Principle #3 (local quality) zip lock sealing feature: The principle of local quality was used in the vacuum pack sealing machine by making part of the vacuum pack sealing machine useful in terms of creating a reusable vacuum pack. This is achieved by adding the zip lock sealing feature in the machine. As the double layer plastic films enter as shown in Fig. 5, the stainless steel sealing jaws clamp onto the zip lock with a heating element without crossing the boundary of plastic material's thermal properties. The zip lock is then sealed within the two layers of plastic films per selected sizing of the vacuum sealed bag. The fibre glass acts as an insulator to prevent the heat from spreading to the shafts.

L-shape sealers: Figure 6 shows the zip lock sealing components on the left hand side and the L-shape side sealing components on the right hand side. Figure 7 shows the final design of the Vacuum pack sealing machine with several sub systems such as roller system, actuator (force) system, cooling system, cutting system and spring system.

Principle #2 (taking out) tear notch: The principle of taking out was used where a small part of the package is cut and removed to create a tear notch. One special mechanism present in the machine is the capability to create a 3-side seal followed by cutting which includes a tear notch at the edge of the package.

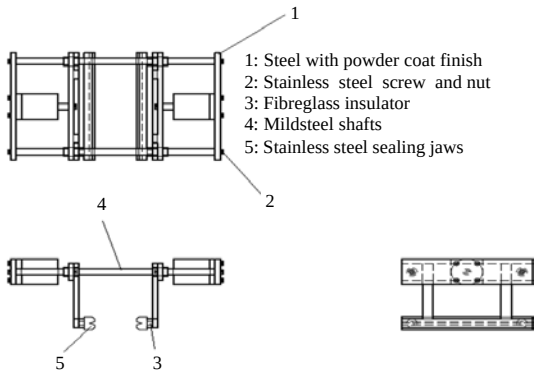

Fig. 5: Zip lock sealing machine from different view (top, front, side)

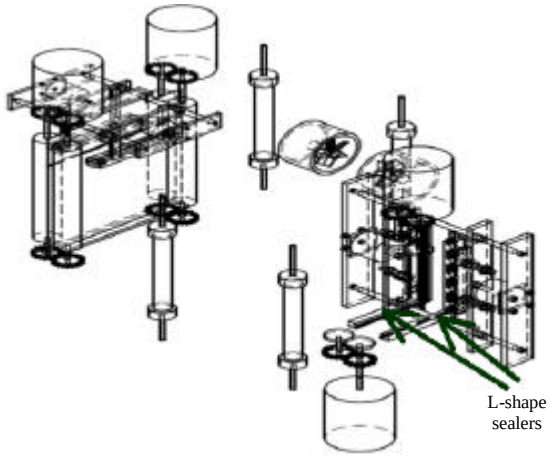

Fig. 6: Zip lock sealing (left) and L-shape side sealing (right)

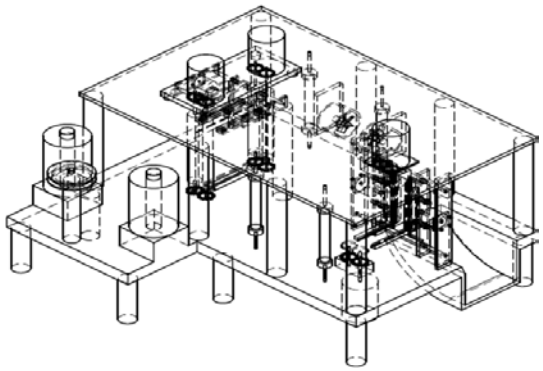

Fig. 7: Finalized design on vacuum sealed packaging system

Principle #6 (universality 4-in-1 process: The principle of universality was used by combining a number of processes within the conventional vacuum pack sealing machine. The process flow of the vacuum pack sealing machine consists of 4 major processes which are alignment, zip sealing, cooling and cutting. This 4-in-1 unique process occurs towards the end where the vacuum sealed bags are ready for distribution.

CONCLUSION

The impact of this product reflects on improvement on several aspects related to human limitation, safety and health as well as environmental issues. In terms of human limitation, the tear notch created by the vacuum pack sealing machine would require much less effort for users to tear open the package. Hence, injuries (minor or major) can be reduced. The additional feature zip sealing would make the package reusable and this is an environmentally friendly approach to minimise non-biodegradable wastes in landfills. Overall, the vacuum pack sealing machine is a worthwhile investment as it combines multiple functions such as sealing, cutting and zip locking.

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