

Full Length Research Paper

The study of green product design and development by applying TRIZ innovation principles

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Accepted 25 January, 2011

In order to comply with both the present situation and the trend of environmental protection, the Green Design principles should be applied to make products endowed with life and value of existence, when developing the new products. Affected by the convenience of transportation and the promotion of national income, it has become a fashion for Chinese people traveling abroad. Therefore, there should be a business opportunity in the innovative design of portmanteaus. The study aims to discover the new design of portmanteaus through innovation principles and customer needs and explore the feasibility of doing this. This study takes the advantage of TRIZ Innovation Principles to make research and development of the products. It uses TRIZ Principles and Contradiction matrix to make analyses, guide the researchers to absorb the experience ahead, give the inspiration of creation, and standardize the process of research and development, thus to reduce the time of researching. The researchers can understand the current situation, the trend of product research and development, and the customer needs by the methods of patent retrieval, interview and questionnaire, in order to provide more competitiveness for the product and technology.

Key words: TRIZ, inventive design, green design, green product, innovation.

INTRODUCTION

Although the quality and quantity of environment resource has enough capability for effective supply, it is not inexhaustible; accordingly, it has limit in self-purifying pollution (Sang, 2009). In the past, unrestrained exploitation with the purpose of commercial profits and economic growth ignored the environment bearing capacity and the impact on the environment brought by both the producing process and the products (Robert and Patrick, 2009). Nowadays, the increasingly more awareness of times trend and environmental protection makes the research and development of green products of much more importance. As a result, the companies have to produce the goods not only in accordance with customer needs, but also applying the green design principles into the production to give life and value of existence to the goods.

In "Consumption of Natural Resources, by 2050 Humans Needs Two Planets to Just Meet Needs" translated and edited by Li Yuqin, Cai Qinyi, and Bai Yingqiu, the authors mentioned that "Living Planet Report 2006" indicated that, by 2050, humans would need two planets'

worth of natural resources; WWF Director-General James Leape said, "For more than 20 years we have exceeded the Earth's ability to support a consumptive lifestyle. We have to make their consumption patterns, and the natural world to recover and absorb the waste of energy, to achieve a balance. If do not do so, we will face irreversible damage" (Li Yuqin, Cai Qinyi, Bai Yingqiu, 2006). Hence, in order to reduce the consumption of natural resource, prevent the utilization of poisonous materials, and discharge the pollutants, green design, production, sale, and consumption should be advocated on the basis of protecting the offspring benefit.

Victor, Andrzej and Yury (2010) argued that, with more awareness of environmental protection, it was no longer a problem of resource recycling and recovery; instead, it stressed the significance of decreasing the consumption of materials and resources, discharging the amount of pollutants, and, moreover, every single components of products being classifiably recovered and recycled, thus eased the destroy to the natural balance and ecological equilibrium, and guaranteed the green products being

acceptable by the public (Victor, Andrzej and Yury, 2010)

Due to the fact that there are abundant influential factors in relation to the environment during the entire process of producing, manufacturing, serving and discarding, it is impossible to achieve green design completely if all the environment elements are concerned in the product design (Sadek, 2010). Consequently, it is an essential concept of green design to emphasize on choosing the influential factors of environment as the foundation of product design in accordance with the requirement of environmental protection on the basis of remaining the function, the quality, and the useful life of the product. (Bruwer and André, 2010)

With the convenience of transportation and the promotion of national income, Chinese people begin to pay attention to the life quality on mental level. Meanwhile traveling abroad allows people to relax both the body and the mind as well as broaden their horizon; therefore, it has become a fashion for Chinese people to travel abroad (Carson and Wildman, 1988). As the statistics from Ministry of the Interior to the Immigration Department, there were 6,110,016 Chinese people who traveled abroad in 1992; the total population traveling abroad from January to November in 2008 was summed up to 11,402,689. It is evident that most Chinese people have the experience of traveling abroad. It is a necessity to have a portmanteau during traveling; thus there is certainly a business opportunity. However, most of them have already obtained portmanteaus. Consequently, in order to expand the new opportunity, the products which give satisfaction to the customers should be developed (Alam, 2009). If the new product allows continuing the use of the old portmanteaus, it can not only save the materials regarding to the environmental protection policy, but lighten the economy burden for the customers (Jose, Vargas and Mohammad, 2009). Hence, this study aims to discover the new design of portmanteaus through Innovation Principles mode and Customer needs and to explore the feasibility of doing this.

The production of green products relies on the application of green design. There are lots of methods of green design, i.e., Brainstorming, Quality Function Deployment, TRIZ, and Taguchi Methods. This research is expected to attack the limitations and eliminate the obstacles in R&D process through designing green products by TRIZ. Thus the problem-solving ability is fostered, and the professional capacity is promoted by this system, to which companies can refer when researching and developing green design.

This research applies TRIZ innovative method into the R&D of portmanteau curling device and proves the workability of the producing process, hoping that the companies in the future can follow the principle to develop the new product. The major subjects of this research are:

- (1) Adapting the structure and properties of “portmanteau curling device” according to TRIZ Innovative Principle,
- (2) Analyzing the data according to contradiction matrix, and
- (3) Using the case study to indicate if the inventive principle corresponding with a single engineering parameter (when lacking contradiction information) is feasible in R&D.

GREEN PRODUCT AND GREEN DESIGN

Green product

The Green-living Website (2009) defines the green products as (1)“the products, service and relevant activities to measure, prevent, limit, reduce and correct the environment’ destruction of its air, water and soil, to solve the problems of wastes, noise and ecosystem, to need products, services and activities as well”; (2) the green product should be a sort of product and service in consideration of life cycle and to the advantage of the environment; and (3) it should be in accordance with the premise of low pollution, reclaim ability, and resource saving (Emel, Derya and M, 2009).

Green design

Green design is known as Ecological Design and Design for Environment. The correlative definitions are explained as follows.

Zheng Yuanjin et al. (1995) held the point of view that, for green design, the consideration of environment was involved in all procedures of the production including Product planning, material selection, product function, structure, using, manufacturing, packing, transportation, and disposal.

Fiksel (1996) defined the design for environment as systematic consideration of design performance with respect to environmental, health, and safety objectives over the full product and process life cycle.

Yarwood and Eagan (1998) defined the design for environment as systematically employing environmental design application into product design.

To sum up, green design refers to the concern of 6R consciousness, that is Reduce, Re-use, Recycle, Redesign, Reduction, and Re-concept, during the procedure of designing and manufacturing products.

TRIZ INNOVATION PRINCIPLES

Significance of TRIZ

TRIZ mode, a Theory of Invention Problem Solving, is one of the most frequently used methods recently. It is

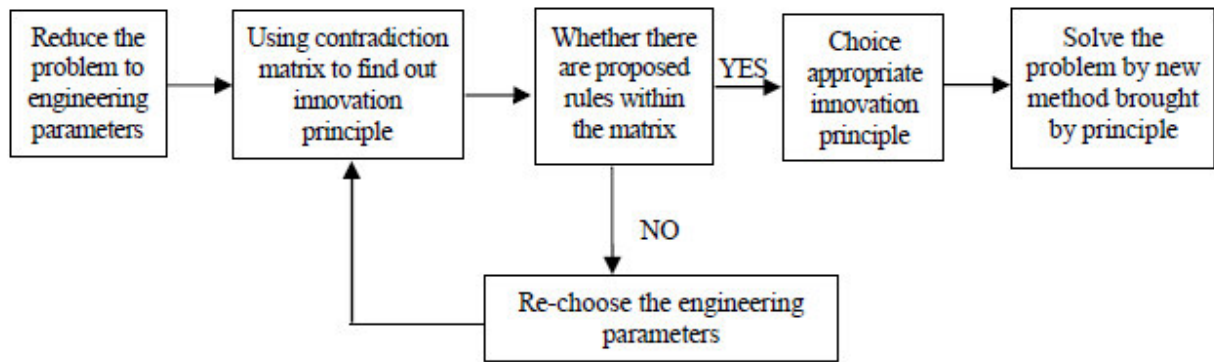


Figure 1. TRIZ Contradiction matrix for the use of flowcharts. Data Source: Althshuller (2000).

collected and concluded by a Soviet scholar Althshuller and his partners after having investigated more than 400,000 patent cases. (Althshuller, 2000)

TRIZ contradiction table and 40 innovation principles

The 40 Innovation Principles were collected and concluded by Althshuller after having investigated a large quantity of patent cases. Nevertheless, these principles only provide basic concepts and directions. The details and contents need to be constructed and reckoned. The 40 innovative Principles are set out as:

(1) Segmentation, (2) Extraction, (3) Local quality, (4) Asymmetry, (5) Merging, (6) Universality, (7) Nesting, (8) Counterweight, (9) Prior Counteraction, (10) Prior Action, (11) Cushion in Advance, (12) Equipotentiality, (13) Inversion, (14) Balling, (15) Dynamicity, (16) Partial or Excessive Action, (17) Another Dimension, (18) Mechanical Vibration, (19) Periodic Action, (20) Continuity of Useful Action, (21) Rushing Though, (22) Convert Harm into Benefit, (23) Feedback, (24) Mediator, (25) Self-service, (26) Copying, (27) Cheap Short-living Objects, (28) Replacement of Mechanical System, (29) Pneumatic or Hydraulic, (30) Flexible or Thin Film, (31) Porous Material, (32) Color Changes, (33) Homogeneity, (34) Rejecting and Regenerating Parts, (35) Transformation of Properties, (36) Phase Transition, (37) Thermal Expansion, (38) Strong Oxidants, (39) Inert Environment, and (40) Composite Material.

The Procedure of Problem Solving through the 40 Innovative Principles by Althshuller is shown as Figure 1.

Single engineering property corresponds to the innovation principles

When using Contradiction matrix, the proposed rule is

frequently an empty matrix to provide innovative principles. Under this circumstance, “The Corresponding Inventive Principles of Single Engineering Properties” (Chen and Liu, 2001) can be used to assist the creative work, and the details are shown as Table 1.

The occurrence rate to improve or prevent the deterioration of the engineering parameters can be learned through calculating all the corresponding innovative principles in the Contradiction Matrix. The higher rate of occurrence, the more possibility of problem solving ability there is by using this principle. Single Engineering Properties Correspond to User Flow of Innovation Principles is shown in Figure 2.

PATENT

Definition of the patent

When a new product or method is invented or created, and it can be re-produced or repeated and has utility value in industry, it is applied to the government for the protection and respect of personal interests and copyright; then, after the investigation by the government, the applicant has the patent of producing, marketing, or using the invention within a given time (Alam et al., 2010). This is the so-called patent (Patent Law, 2001).

Categories of patent

There are three categories of patent, namely invention patent, utility patent, and design patent (Emel, Derya and M., 2009). The category of applications is determined by the pattern of the product. The details are as follows.

(1) Invention Patent: In Article 19 of the Patent Law, a patent for an invention should be applied for if it is a highly advanced creation based on a technical concept which exploits the law of nature. Hence, the technical concept is presented through product, method, or use of product. The patentable things could be objects and

Table 1. Part of table that single engineering properties corresponds to innovation principles

Grade Parameter		A	B	C	D	E	F	G
		19 or more	16 - 18 times	13 – 15 times	10 - 12 times	7 - 9 times	4 - 6 times	1 - 3 times
1.	Weight of moving object	35		28	26.18.02.08. 10.15.40.29.31	27.34.01.36. 19.06.37.38	03.32.22.24. 39.05.13.11	12.21.20.17.04 .30.16.14.25.23
2.	Weight of non-moving object	35	28.10.19.01.26	26	27.13.02.18	06.15.22.29	39.32.09.14 .40.05.08.03	17.25.30.20.16. 11.36.37.24
3.	Length of moving object	01.29	15	35.04.17	10.28.08.14	19.24.13.26	16.02.34 .09.07	37.39.18.32.36. 05.12.22.25.23. 40.06.38
4.	Length of non-moving object			35	28.14.26.01.10	07.15	03.02.29.18. 30.24.32.16	17.40.08.13.27. 09.37.38.39.06. 25.23.19.31.12. 11.05
5.	Area of moving object		15	17.26.13.02	10.29.30.04	01.14.19.32. 34.28.03	18.39.16.35	07.05.25.36.33. 22.40.11.06.31. 38.23.24.09.12
6.	Area of non-moving object			18.35	39.30.17.04.36	39.30.17.04.36	32.15.07.01.38	28.26.37.22.09. 29.03.14.13.27. 25.23.19.31.06
7.	Volume of moving object		35	02.10.29	01.15.34 04.06.07	13.40	16.28.14.39. 17.18.26.22 .30.25.37.36	24.38.11.12.32. 19.09.23.27.20. 21.05.03
8.	Volume of non-moving object	35		02		18.14.34	10.04.39.19 .31.37.30.06. 01.16	25.17.07.24.15. 26.27.03.09.32. 38.40.08.28.22. 36.05
9.	Speed	28.35	13	34	10.38.15	08.02.18.19	32.03.29.14 .04.26.01.30	16.21.36.24.27. 06.11.12.05.33. 23.25.09.20.22. 07.40

Table 1. Cont'd.

10.	Force	35.10.36	37.18	28.19	15.01.02	03.21.13.40	14.26.16.17.08	12.11.34.29.09. 24.20.05.23.27. 30.32.38.39.04. 06.25
11.	Tension/pressure	35.10	36.37		02.14	19.03.18.40.01	06.15.13. 24.27.25	33.04.16.32.22. 28.21.29.39.11. 09.23.38.12.08. 34
12.	Shape	01	10.14.15.35	29.34	32.13.40.04	02.28.22	30.05.26.18 .07.17.03	16.06.08.25.37. 27.39.19.36.09. 12.11

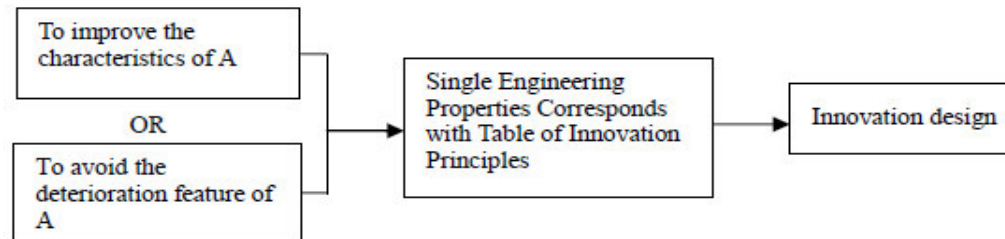


Figure 2. Single engineering properties corresponds to user flow of innovation principles. Data source: Chen and Liu (2001).

methods where the “objects” include articles (with a specified form), materials (include chemicals, medicines, food & beverage and collections), and microbe (the substances with life); while the “methods” mean manufacturing, processing and using {application}. (Patent Law, 2001)

(2) Utility Patent: According to Article 97 in the Patent Law, the improvement or creation of shape, structure or device is suitable for utility patent. (Patent Law, 2001)

(3) Design Patent: Article 106 in the Patent Law indicates that any new design of shape, pattern,

color or their combination of a product, which creates an aesthetic feeling, fits for design patent. (Patent Law, 2001)

CASE

An analysis of issued patent

Searching “portmanteau from 2003 to 2009” in the patent retrieval system of the Republic of China (Taiwan), the patents for portmanteau protective function are shown in Table 2.

To sum up, patent 092206483 is water-proof; patents

094119632, 093206775, and 096214202 protective to some extent; 098213780, 094201717, 095219252, 097220738, 098205213, and 098203243 crash-proof, 096214202 and 096214202 abrasion resistant and scratch resistant, 0992206483, 094119632, 098205213, and 098213780 attachable, 093206775, 094201717, 095219252, and 097220738 detachable, and 097220738 foldable. The research focuses either on the functions of water proof, anti-crash, or easy storage. Meanwhile, regarding the fact that most people have obtained portmanteaus and people’s awareness of environmental protection is increasing, the study aims to create a brand new green product which adds functions on the base of old products and enables them to be detachable to suit

Table 2. Patents relevant to portmanteau.

Patent title	No.	Patent claim	Patent specialty	Year	Innovation principle
Trolley case with rain-proof cover	092206483	There is a back behind the case, in which has an extendible handle. An opened bag is designed and a cart and a rain-proof cover are separately fixed to the both sides to the bottom part of the back. The cover can be hidden in the bag as one end of the cover is connected to the inside of the bag. In the connection part, there is a whole cover which exposes the two carts. The whole cover has an open edge in one side of the back.	Rain-proof cover, trolley, cover can be hidden in the bag to the back, the cover can expose the carts	2003	3. Local quality 6. Universality 7. Nesting 10. Preliminary action 17. Another dimension
Portmanteau with protecting cover	094119632	The case is equipped with a handle to drag, at least one bag on the surface and several carts. One of the bags is equipped with a separate protecting cove, which has one open edge in one side and is made of water-proof material. A handle hole is devised on the protecting cover to fit into the handle and the inside of cover which fits into the bag is designed with a combining machine. It makes the covers hidden inside the bag because the open edge of cover is located to the case.	Bags on the surface of case, a separate water-proof cover inside the bag	2005	3. Local quality 6. Universality 7. Nesting 10. Preliminary action 17. Another dimension
Improving the structure of rain-proof cove	093206775	The case contains a cover whose size is suitable for the case. It is made of flexible and roll-able material which is both thin and water-proof. One open edge inside the cover is connected to the handle through a hole, whose frame is wrapped with elastic material. The bottom of the cover has several accesses for the raised components such as case supports. The specialty is that: it is same as the previous portmanteau whose connections between open edge and handle are distributed in the both side of the case, this, but moreover, the connections here are equipped with sockets and studs, which can be joined easily	The cover is made of flexible and roll-able material which is thin and water-proof, the holes frames in cover is wrapped with elastic material, there are holes for case supports	2004	1. Segmentation 3. Local quality 10. Preliminary action 30. Flexible or Thin Film
Protecting cover of Suitcase	094201717	There is a base for the trolley at the back of the case; An extension trolley from the top of the case to the base. The specialty is that a bag is attached to the back side in which is a crash-proof flake. It is made of ethylene vinyl acetate copolymers (EVA).	A bag at the back of case in which is EVA crash-proof flake	2005	10. Preliminary action 11. Beforehand cushioning 24. intermediary
Protecting cover of Suitcase	095219252	This protecting cover includes front cover and fixing components. The front cover can pull over the front board of suitcase. The fixing components are on the edge of front cover, serving the function of fixing the cover to the suitcase.	The front cover can pull over the front board of suitcase and be fixed on the suitcase	2006	10. Preliminary action 11. Beforehand cushioning 24. intermediary

Table 2. Cont'd

Protecting cover of Suitcase	097220738	A kind of foldable protecting cover to protect a suitcase, which contains: A basic plate with connective part and an inner part, which can cover one side of the suitcase. There are other several side plates connecting to the basic one, with which can cover the suitcase.	A foldable protecting cover with connection parts and basic plate.	2008	10. Preliminary action 11. Beforehand cushioning 15. Dynamics 24. intermediary
Hard shell case with wheels	098205213	It includes: Hollow frames, with a first frame, corresponding second one, and third and fourth ones between the previous two. The case shell is fixed to one side of the frame. A pair of protective shell is fixed to the other side of the frame, opposite to the case shell. These protective shells spread in the third and fourth frames and form an open edge and extend to the closure part of the first and second frame. The case lid is between the protective shells and can protect the open edge. A hinge is fixed to the first frame, opposite to which there is a movable side either closing to or far away from the second frame. A section of wheels is related to the fourth frame and is devised to the case shell and one of the protective shells	The case lid is between a pair of protective shells and can cover the open edge.	2009	10. Preliminary action 11. Beforehand cushioning 3. Local quality 7. Nesting
Protective bag of suitcase	098203243	It is a rectangular-shaped bag that can contains a suitcase. The bottom part of the bag is an open edge; the top part has two holes covered with two lids. A third hole is in the side of bag and covered with lid, too. Inside the bag is a tape that extends from one side of the open edge to the other side through the bag. The two ends of the tape are fixed to the opposite side of the edge. The two ends are longer in length with joinable connectors. The tape described passes through the second and third hole.	Protective bag is a rectangular-shaped bag that can contains a suitcase. The bottom part of the bag is an open edge, inside which there is a tape fixed to the both two opposite sides.	2009	10. Preliminary action 11. Beforehand cushioning 3. Local quality 6. Universality 7. Nesting
Detachable suitcase	098203361	It contains: A case body, a base and a footstock. The footstock is equipped with two opposite side walls attaching to the edge of base, which forms a pressed line. The side walls can be folded along the pressed line to the base. Two supporting boards connected to the first side wall in the bottom side of boards thus they can be moved around the first side wall. There are also 4 zips in the second side wall that can connect the side wall and supporting boards to hold the first side wall of the footstock	The case contains both base and footstock. The footstock is with two side walls, connecting to the edge of base. There is pressed line in bass, two supporting boards, and 4 zips. The case is detachable	2009	10. Preliminary action 11. Beforehand cushioning 15. Dynamics
Crash-proof flake of trolley	098213780	There is a base for the trolley at the back of the case; an extension trolley from the top of the case to the base. The specialty is that a bag is attached to the back side in which is a crash-proof flake. It is made of ethylene vinyl acetate copolymers (EVA).	A bag at the back of case in which is EVA crash-proof flake.	2009	10. Preliminary action 11. Beforehand cushioning 7. Nesting 30. Flexible shells and thin films

Table 2. Cont'd

Abrasion resistant, scratch resistant and water-proof case board structure	096214202	Abrasion resistant, scratch resistant and water-proof case board structure includes the board itself wrapped with texture on the surface. The specialty is that the texture is covered with a piece of transparent membrane. After heating process, the membrane can form an original form.	The board of case is processed by transparent membrane that is abrasion resistant, scratch resistant and water-proof.	2007	10.Preliminary action 11.Beforehand cushioning 30. Flexible shells and thin films
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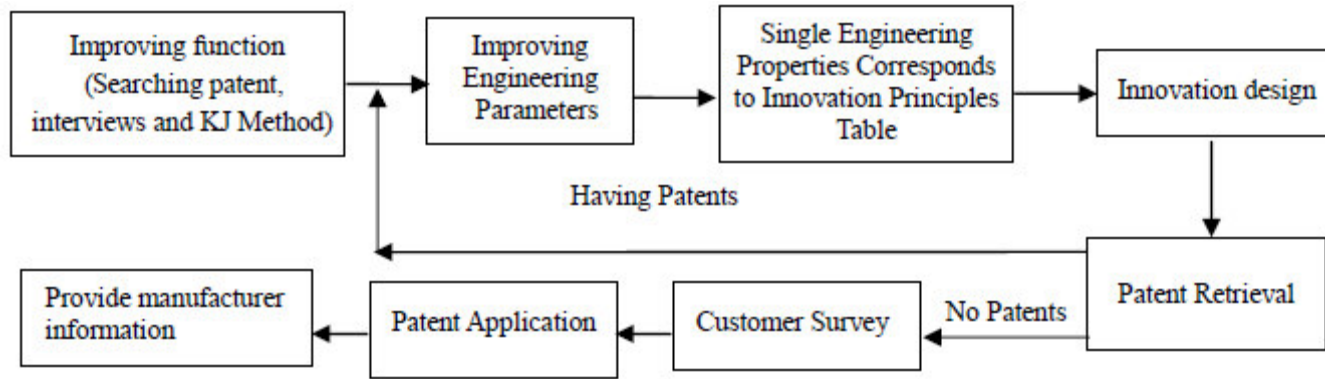


Figure 3. Innovation flow diagrams.

portmanteaus of any brand.

The innovative designing procedure of this study

Following the research motivation, this study aims to design "water-proof, crash-proof, antifouling, scratch resistant and easily-stored" portmanteaus according to the relevant patent, interviews, and KJ Method. The inventive principle corresponding with single engineering properties is suitable for this study, and the inventive procedure is instructed as Figure 3.

The improvements this study aims to achieve include (1) water-proof, (2) Collision-protection, (3) antifouling, (4) scratch resistant, (5) easily-stored, and (6) applicable to the old portmanteaus. The design would be carried out through the engineering parameters induced through patented products and the parameters improved by means of inventive principle corresponding with single engineering properties.

RESEARCH FINDINGS

(1) Suitable Engineering Parameters: The suitable engineering parameters, the occurrence rate of innovative principles in the Contradiction Matrix, and the occurrence rate of the corresponding principle of engineering parameters suitable for the functions are listed in Table 3.

(2) Suitable innovative principle of single engineering: The suitable engineering parameters and the occurrence rate of innovative principles in the Contradiction Matrix, collecting the occurrence rate of innovative principles, are displayed in Table 4.

From Table 4, the sorting of innovative principles

are as follows:

- (35)Transformation of Properties > (10)Prior Action > (2)Extraction > (27)Cheap Short-living Objects = (28)Replacement of Mechanical System > (1)Segmentation > (3)Local quality > (18)Mechanical Vibration > (15)Dynamicity > (13)Inversion > (40)Composite Material> (29)Pneumatic or Hydraulic > (32)Color Changes > (31)Porous Material > (16)Partial or Excessive Action > (14)Balling > (19)Periodic Action > (39)Inert Environment > (11)Cushion in Advance >(34)Rejecting and Regenerating Parts > (26)Copying > (24)Mediator > (25)Self-service > (30)Flexible or Thin Film > (6)Universality>(36)Phase Transition = (37)Thermal

Table 3. Suitable engineering parameters and occurrence rate of correspond to innovative principle.

Function	Improving engineering parameter	Single Engineering Properties Corresponds to Innovation Principles		
		More than 13 times	10 - 12 times	7 - 9 times
Water-proof	13. Stability of object	35. 39.02.01	40.13.18.32.30	27.15.03.22.28
	26. Amount of substance	35.03.29.18.10		14.27.40.31.28.15.02
	34. Repairability	01.10.02.11.35.13	32.02.29.19.24.15.16.27	25.28
	36. Complexity of device	01.26.28.10.13.35		34.27.15.17
Collision-protection	14. Strength	03.35.10.28.40.15. 14.27		26.09.18.02.32.01.29
	11. Tension/pressure	35.10. 36.37	02.14	19.03.18.40.01
	13. Stability of object	35.39.02.01	40.13.18.32.30	27.15.03.22.28
	15. Durability of M	35.19.03.10.27	28	02.06.18
	16. Durability of non- moving object	16	35.10	01.40
	23. Waste of substance	10.35.28.18.31.24	02.27.39.03	34.40.29.05.13
Collision-protection	26. Amount of substance	35.03.29.18.10		14.27.40.31.28.15.02
	34. Repair ability	01.10.02.11.35.13	32.15.16.27	25.28
Antifouling	13. Stability of object	35.39.02.01	40.13.18.32.30	27.15.03.22.28
	15. Durability of M	35.19.03.10.27	28	02.06.18
	16. Durability of non- moving object	16	35.10	01.40
	26. Amount of substance	35.03.29.18.10		14.27.40.31.28.15.02
34. Repair ability	01.10.02.11.35.13	32.15.16.27	25.28	
Scratch resistant	14. Strength	03.35.10.28.40.15. 14.27		26.09.18.02.32.01.29
	11. Tension/pressure	35.10.36.37	02.14	19.03.18.40.01
	15. Durability of M	35.19. 03.10. 27	28	02.06.18
	13. Stability of object	35. 39.02. 01	40.13.18.32.30	27.15.03.22.28
	16. Durability of non- moving object	16	35.10	01.40
	23. Waste of substance	10.35.28.18. 31.24	02.27.39.03	34.40.29.05.13
Easily-stored	26. Amount of substance	35.03.29.18.10		14.27.40.31.28.15.02
	34. Repair ability	01.10.02.11.35.13	32.15.16.27	25.28
	7. Volume of moving object	35.02.10.29	01.15.34.04.06.07	13.40
	26. Amount of substance	35.03.29.18.10		14.27.40.31.28.15.02
Easily-stored	33. Convenience of use	01.13.02.28.35.32	12.15.34.25	16.26.17.27
	34. Repair ability	01.10.02.11.35.13	32.15.16.27	25.28
	36. Complexity of device	01.26.28.10.13.35	02.29.19.24	34.27.15.17

Table 4. Occurrence number of innovative principles.

Innovative Principles number	occurrence number	Innovative principles number	Occurrence number	Innovative principles number	Occurrence number	Innovative principles number	Occurrence number	Innovative principles number	Occurrence number
35	381	10	316	2	273	27	219	28	219
1	215	3	192	18	180	15	173	13	165
40	157	29	119	32	117	31	109	16	96
14	81	19	73	39	72	11	65	34	48
26	47	24	46	25	25	30	40	6	31
36	26	37	26	17	21	9	14	4	10
7	10	12	10	22	4				

Expansion> (17)Another Dimension >(9)Prior Counteraction > (4)Asymmetry = (7)Nesting=12) Equipotentiality > (22)Convert Harm into Benefit.

(3) Innovative Design: As listed in Table 4, this research studies the ranking of the occurrence rate and designs a brand new portmanteau, in the hope of being in accordance with green product. Reference (35)Transformation of properties changes the status, density and elasticity as well as uses the advantage of (1)Segmentation and (3)Local quality to invent a scroll device to make the product as a combination. The combination equips the portmanteau different elements to achieve the aims of water-proof, crash-proof, antifouling, scratch resistant, and easily-stored in order to add the portmanteau functions to facilitate the implementation. Reference (10)Prior Action and (11)the innovative principles of Cushion in advance are to invent a scroll device that can be fixed to the portmanteau and save the waiting time for travelers. It can make up for the low strength of cases. Reference (28)Replacement of Mechanical System, the principle of substitution, uses the reference (15)Dynamicity, the characteristic of substitutability, and Reference (24)the innovation principle of media to connect

the suitcase with a detachable scroll device to improve the function from fixed to changeable. With nothing to replace the suitcase but only to add scroll device, the old portmanteau can be reused to reach the goal of environmental protection. Reference (30)Flexible or Thin Film, uses reference (6)Universality innovative principle to design a multi-functional membrane and reference (17)Another Dimension innovative principle to add a scroll device to substitute the single layer, which can isolate portmanteau with the external environment to protect the luggage of the efficacy and minimize the needs of other substances. Reference (25)Self-service achieves the purpose of no waste of materials.

(4) Patent Retrieval: Having searched in patent retrieval system for the suitcases between 2003 and 2009, there were 12 patented products. The design is not similar to any one of them.

(5) Customers feedback: Through brainstorming, interview and the information of products, the study aims to design the quality-oriented product by means of KJ methods (Kawakita Jiro, 1986). The categories of quality include function, portmanteau surface, and green need. The function

function can be further divided into volume, weight, water-proof, portable, and easily-dragged; the surface contains color, pattern, and price; and green need includes multi-functional, easily-stored, crash-proof, antifouling and scratch resistant, and the Customer Satisfaction Investigation. The questionnaire is divided into two parts, as the reasons preventing the customers from consuming and the suggestions, where the reasons include price, water-proof, storage, crashworthiness, pattern, etc.

a. Statistics of Returned Questionnaires: The survey lasted from 1st to 20th of January, 2010, based on the major shopping malls in Tainan. 600 questionnaires were randomly distributed and 575 were retrieved thus the retrieval rate was 95.83%. After being reorganized, the effective samples were 565 copies thus the effective rate was 98.26%. Statistics of the retrieved questionnaires and the structural analysis on the samples are displayed in Tables 5 and 6.

b. Item analysis: In order to make the questionnaires coherent and antifouling, volume, portable, easy to drag, weight, color, discriminative, the whole questionnaires were specially studied on the studied on the customer satisfaction questions

Table 5. Statistics of returned questionnaires.

Category	Release number	Recover number	Recover rate	Finishing effective sample	Efficient rate
Number	600	575	95.83%	565	98.26%

Table 6. Structural analysis on samples.

Sample	Item	Times	Percentage
Gender	male	246	43.6
	Female	319	56.4
Whether been abroad	No	164	28.8
	Yes	501	71.2
Education level	Junior high school under	12	2.2
	Vocational high school	131	23.2
	University (Special)	373	66
	Institute	49	8.7
Age	20 under	17	3.0
	21 - 30	284	50.3
	31 - 40	160	28.3
	41 - 50	87	15.4
	51 or more	17	3.0
Occupation	Student	144	25.5
	Government employee	129	22.8
	Manufacturing	90	15.9
	Service industry	155	27.4
	Else	47	8.3
Average monthly incomes	20000 under	102	18.05
	20001 - 35000	280	49.56
	35001 - 50000	103	18.23
	50000 or more	80	14.1
Whether having portmanteau	Yes	402	71.2
	No	163	28.8

as thereference of selecting the questions. This research used Chiou Haw Zeng (2003) case study method and divided the top and the last 27% as the extreme groups. Comparing the two group's data for distinct difference, the reference was used to select the questions. Analyses indicate that all the questions have apparent difference.

c. Reliability analysis: The reliability of questions in this research was analyzed by L.J. Cronbach's α coefficient (Cronbach, 1957). According to Guieford's argument, $\alpha > 0.7$ implies high reliability, $0.35 < \alpha < 0.7$ moderate reliability, and $\alpha < 0.35$ low reliability (Guieford, 1965). Table 7 shows that the questionnaire is of high reliability (Cronbach $\alpha > 0.7$) and is coherent.

d. Descriptive statistics and independent t-test analysis: After analyzing the outcomes according to Table 8, the

mean values of quality need are all more than 4 points, except the values for color and pattern. In sequence by high to low, they are "portable, easy to drag", "easy to store", "crashworthiness function", "capacity of portmanteau", "water-proof function", "weight of portmanteau", "antifouling function", "scratch resistant function", "cheap in price", "color of portmanteau", and "pattern of portmanteau". Regarding "weight of portmanteau", there is a distinct difference between the people who have traveled abroad and those who have not that the former focuses on the weight as shown in Table 9 and Table 10. The points for water-proof, crashworthiness, antifouling, scratch resistant, easy to store, and applicability scroll device suitable for old portmanteaus are 4.14. Therefore, this innovative design is in line with customer needs; but

Table 7. Abstract of reliability analysis.

Subscale	Questionnaire	C- α value
Function	4	0.753
Suitcase surface	3	0.715
Green need	5	0.749
Scale	12	0.834

Table 8. Customer opinion questionnaire survey descriptive statistical analysis.

Question	Item count	Average	Standard deviation
Portable, easy to drag	565	4.490	0.646
Easy to store	565	4.434	0.653
Crashworthiness function	565	4.381	0.686
Capacity of portmanteau	565	4.373	0.690
Water-proof function	565	4.370	0.655
Weight of portmanteau	565	4.283	0.725
Antifouling function	565	4.221	0.733
Scratch resistant function	565	4.218	0.749
Cheap in price	565	4.042	0.822
Colour of portmanteau	565	3.880	0.783
Pattern of portmanteau	565	3.811	0.815
Applicability scroll device suitable for old portmanteaus	565	4.14	0.810

Table 9. There is or not to go abroad group statistics.

Question	Whether been abroad	Item count	Average
Antifouling function	No	163	4.166
	Yes	402	4.244
Scratch resistant function	No	163	4.178
	Yes	402	4.234
Capacity of portmanteau	No	163	4.325
	Yes	402	4.393
Portable, easy to drag	No	163	4.429
	Yes	402	4.515
Weight of portmanteau	No	163	4.160
	Yes	402	4.333
Colour of portmanteau	No	163	3.828
	Yes	402	3.900
Pattern of portmanteau	No	163	3.810
	Yes	402	3.811
Applicability of portmanteau	No	163	4.227
	Yes	402	4.104

Table 10. There is or not to go abroad independent-samples t-test.

Category	Question	Equal variance		Equal to the average	Question	Equal variance		Equal to the average t-
		L- test		t-test		L- test		test
		F-test	significant	significant (2-tailed)		F-test	significant	Significant (2-tailed)
Assuming equal variance Equal variance not assumed	Heap in price	0.144	0.704	0.504 0.501	Capacity of portmanteau	1.724	0.190	0.290 0.284
Assuming equal variance Equal variance not assumed	Water-proof function	4.234	.040	0.059 0.051	Portable, easy to drag	0.083	0.773	0.154 0.148
Assuming equal variance Equal variance not assumed	Easy to store	3.484	.062	0.071 0.065	Weight of portmanteau	3.193	0.074	0.010* 0.010
Assuming equal variance Equal variance not assumed	Crashworthiness function	3.178	.075	0.078 .072	Color of portmanteau	0.014	0.904	0.321 0.324
Assuming equal variance Equal variance not assumed	Antifouling function	0.383	.536	0.252 0.258	Pattern of portmanteau	0.036	0.850	0.988 0.988
Assuming equal variance	Scratch resistant function	0.314	.575	0.422	Applicability of portmanteau	1.235	0.267	0.103

e. Patent application: The design is not similar to any patented products in patent retrieval system. Therefore, this design is innovative and progressive. From the foregoing, the design also complies with Article 93 and 40 in the Patent Law; meanwhile the customer questionnaire indicates that this design complies with customer needs so that it is worthwhile for patent application. It passed the patent review, No. 098224474, and the main component signs are listed in Table 11. Figures 4 to 6 are the blueprints.

Regarding this innovation design of portmanteau scroll device, Figure 4 presents the merit that the cover (31) of the protective cover (3) can be rolled over the roll bar (22) of a Scroll device (2), which can be established to the bottom of portmanteau

(1); after spreading, the cover (31) turns into a rectangular covering the portmanteau (1) to prevent it from water or dust. It is portable because the cover (31) is rolled over the roll bar (22) and it is not easy to be lost. As a matter of fact, this design product is convenient and worthwhile.

Conclusions

The study focuses on the product research and development by means of TRIZ Innovation Principles and aims to figure out smooth research procedure as the reference for the product researchers. The conclusion is as follows:

(1) The study uses TRIZ innovation principle to improve the product structure and to improve the properties of the engineering parameters of the fitting as well as uses Contradiction matrix to make analyses, guide the researchers to absorb the experience ahead, give the inspiration of creating, and standardize the process of research and development, thus reduces the time of researching.

(2) The researchers can understand the current situation, the trend of product research and development, and customer needs by the method of patent retrieval, interviews and questionnaires, and in order to provide more innovative, fashionable, and customized products and prevent the waste of both material and human resource, thus

Table 11. Component symbol description.

No.	Component	Illustration
1	Portmanteau	With handle to carry
11	Handle	To connect and fix the case
2	Scroll device	Is fixed to the bottom of case, combining with support and roll bar
21	Support	A “Γ” shaped- frame whose top is fixed to the bottom of case, with a roll bar between supports
22	Roll Bar	Can be twirled on the support
3	Protective cover	A rectangular cover after being spread
31	Cover	One end of cover is connected to the roll bar; the other can be spread to a rectangular which can be roll onto the roll bar. The spread cover can cover the case and holes can be made to the top of the cover.
311	Hole	The holes can expose the handle if the case is covered. It is convenient for the users to get the handles. A ring is put on the same side as the handle in the cover.
32	Ring	to drag out the cover from scroll device
33	Split side	Connective part is on the split side.
34	Connective Part	This part can be zip, Nylon Fastener or loop which enables the users to spread the whole cover onto the case.

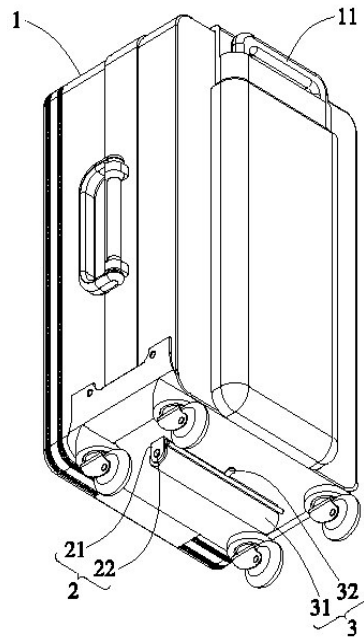


Figure 4. Entire 3D graphic.

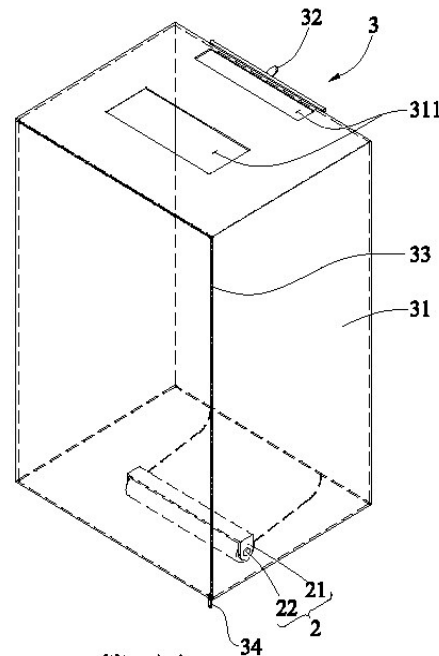


Figure 5. 3D graphic after spread.

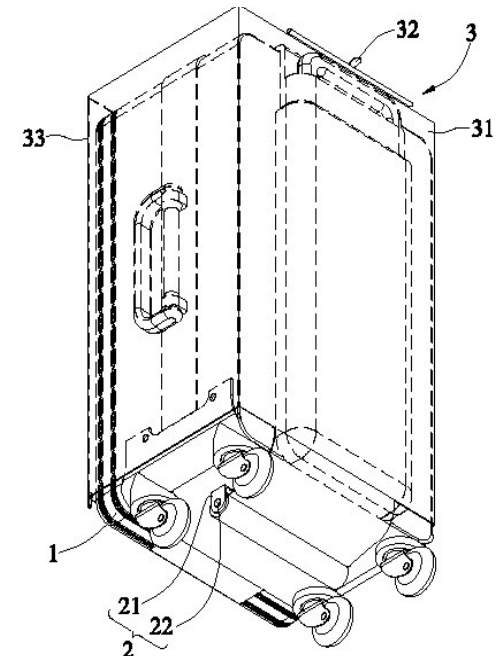


Figure 6. 3D graphic after covering the case.

and human resource, thus invent competitive products and technology.

(3) Unexpectedly, the research indicates that most customers emphasize the function of “easy to carry and drag”. The researchers who have intention to do the R&D projects in designing portmanteaus are suggested to analyze the function of current selling products, understand the customer needs through interviews or questionnaires, and list the needs as “functions to be improved”. Using this innovation procedure, the innovation, research and development will be smooth, and the products will become more competitive in the markets.

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