ISSN (Print): 2077-7973
ISSN (Online): 2077-8767
DOI: 10.6977/IJoSI.201512_3(4)

International Journal of Systematic Innovation

VOL.03, NO.04

December, 2015

Published by the Society of Systematic Innovation

Opportunity Identification & Problem Solving

ISSN (Print): 2077-7973
ISSN (Online): 2077-8767
10.6977/IJoSI.201512_3(4)

The International Journal of Systematic Innovation

Editorial Office:
The International Journal of Systematic Innovation
6 F, # 352, Sec. 2, Guanfu Rd,
Hsinchu, Taiwan, R.O.C.
e-mail: editor@systematic-innovation.org
web site: http://www.IJoSI.org

IJoSI

INTERNATIONAL JOURNAL OF SYSTEMATIC INNOVATION

10.6977/IJoSI.201512_3(4)

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A TRIZ-Based Systematic Problem Solving Approach for Heat Treatment Processes for Screw Manufacturing – A Case Study of Oil Mist Purifying Equipment

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(Received 24 December 2015; final version received 22 February 2016)

Abstract

The screw manufacturing industry is an important industry for Taiwan. However, as the costs of processing pollutants increases, further study is required. This paper uses a TRIZ-based systematic approach and demonstrates a series of TRIZ tools for problem solving. In fact, TRIZ includes many tools and it is very useful as researchers can use diverse methods combining many tools to solve problems with different approaches. In this paper, we focus on a systematic approach consisting of some TRIZ tools such as problem definition, function analysis, cause and effect chain analysis, effects database along with Pugh's Matrix to solve the targeted problem and to evaluate the possible solutions. A TRIZ-based systematic approach for problem solving is demonstrated using a case study of suggestions to improve oil mist purifying equipment. The procedures proposed can be used as general problem solving procedures. Therefore, it contributes a feasible reference method for improving manufacturing process or equipment in screw industry or other industries.

Keywords: Function Analysis, Knowledge Effect Database, Pugh Matrix, Oil Mist Purifying.

1. Introduction

The screw manufacturing industry is an important industry for Taiwan (Chen, 2012). In 2012, the production value was more than 420 Million US Dollars. 93% of production is for export worldwide. The export quantity was 1.38 million metric tones. There are more than 1,300 factories and 24,000 workers in the industry. The market shares were 40.66% to the USA, 8.96% to Germany, 5.22% to the Netherlands, 4.78% to Japan, 4.04% to the UK and 36.34% to other countries (ibid). The market shares for 2012 are shown in Figure 1.

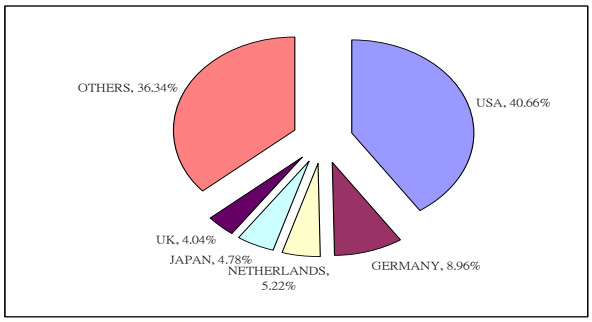


Fig. 1 Worldwide market share in 2012 (Chen, 2012).

In screw manufacturing process, a problem occurs frequently when an oil mist purifying unit catches fire occasionally and must be stopped for cleaning after periods of operation. The production will be interrupted by this problem as the heat treatment operation needs to stop operation. Therefore, it is necessary to improve waste processing equipment. Therefore, in this paper, we want to focus on implement a systematic approach consisting of some TRIZ tools such as problem definition, function analysis, cause and effect chain analysis, effect database along with Pugh's Matrix to solve the targeted problem and to evaluate the possible solutions. This paper uses a series of TRIZ tools for problem solving. In fact, TRIZ includes many tools and it is very useful as researchers can use diverse methods combining many tools to solve problems with different approaches. In this paper, the authors only adopted some tools because the object of this paper is to demonstrate a systematic quick approach with some TRIZ tools to effectively solve practical problem in industry. A case study is demonstrated to suggest methods to improve oil mist purifying equipment.

The first section of the paper gives the background of the screw industry and details the importance of the waste process. The second section gives brief introductions of the TRIZ tools adopted in this paper such as Function Analysis, Cause and Effect Chain Analysis and the Pugh Matrix (Burge, 2009). The third

section explains the problem solving methodology used in this paper. The fourth section provides a case study that uses the proposed methodology. The last section is the conclusion and suggestions for future work.

2. Related Work

TRIZ is a Russian term - Teoriya Resheniya Izobreatatelskikh Zadatch - which means the Theory of Inventive Problem Solving (Altshuller, 1996). It was invented by the Russian inventor, Genrish Saulovich Altshuller. He proposed a step by step problem solving method (ibid). Recently, there have been many industrial studies of the improvement of manufacturing processes or equipment. Sheu and Hou used a TRIZ-based integrated trimming process to redesign the problematic processing machine for real-world semiconductor equipment (Sheu & Hou, 2013). Song et al. used TRIZ-based tools, such as function analysis techniques, the Laws of Technical Systems Evolution and Su-field analysis, to predict prioritized directions of innovation and to create the most promising practical concept design using lab-on-a-chip technology (Song et al, 2012). Yeh et al. (2011) proposed a methodology that uses a four-phase QFD along with TRIZ-based tools such as a contradiction matrix and inventive principles for process improvement for R&D for notebooks (Yeh et al, 2011). Typically, the first step in TRIZ-based problem solving is to generalize a specific problem to a TRIZ problem. The second step is to find the TRIZ solutions. The TRIZ solutions are then applied to the specific solution. The TRIZ method is shown in Figure 2.

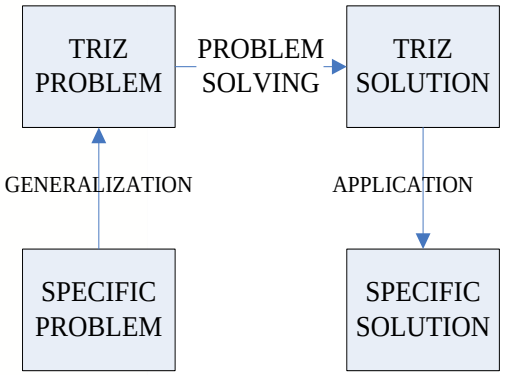


Fig. 2 The typical TRIZ method (Altshuller, 1996).

2.1 Function Analysis

Function Analysis models a system to identify the relationships between components (Mann, 2009). The action between a tool and an object is stated. The typical relation for a tool-act-function on an object along with the symbols for the possible functions in Function Analysis is shown in Figure 3.

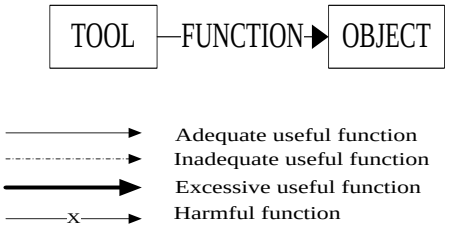
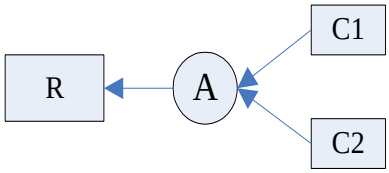


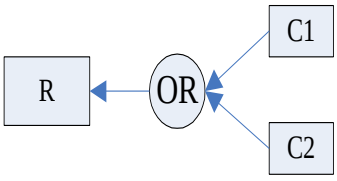
Fig. 3 Symbols of tool-act-function on object along with possible functions (Sheu & Hou, 2013).

2.2 Cause and Effect Chain Analysis

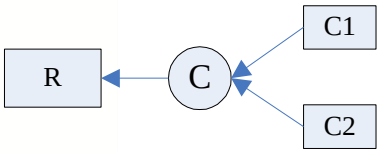
Cause and Effect Chain Analysis (Ikovenko, 2014) is used to find the target disadvantages from surface disadvantages. When the causes of problems and the relationships between causes are known, problems can be solved by addressing one or more causes. A problem can be a result of causes with AND, OR, COMBINE, STRAIGHT and NOT. The possible relationships between causes and the result are shown in Figure 4.



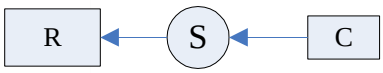
AND Case :
R is caused by C1 and C2. The result may be eliminated if either C1 or C2 is removed.



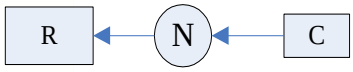
OR Case :
R is caused by C1 or C2. Removing both of the causes will eliminate the result.



R is caused combination of C1 and C2. The result may be eliminated if conditions of C1 and C2 are right.



Straight Case:
R is caused only by C. The result may be eliminated if C is removed.



NOT Case:
R is caused by missing C. The result may be eliminated if C is present.

Fig. 4 Possible relations among causes and result (Ikovenko, 2014).

2.3 Knowledge Effects Database

A Knowledge effects (Yeh et al, 2011) base standardizes problems to generic functions and generic attributes so that similar problems in different fields can be easily used to solve particular problems. A commonly used TRIZ effects database is available at http://www.oxfordcreativity.co.uk/.(Oxford Creativity – TRIZ Effects Database, 2014)

2.4 Pugh's Matrix

The Pugh's Matrix was invented by Dr. Stuart Pugh at the University of Strathclyde in Glasgow, Scotland (Burge, 2009; DeCarlo et al, 2012). This paper uses this tool to eliminate the inferior solutions proposed by a Knowledge Effects Database. The three steps for Pugh's Matrix are:

1. Determine a baseline (Datum)
2. Select the concepts to be evaluated
3. Define the evaluation criteria

3. Research Process

Figure 5 shows the research processes that are proposed in this paper. The problem is firstly defined and then the component and function relationships between the components are identified using Function Analysis. In order to determine the root causes of the problem, Cause and Effect Chain Analysis is used to identify the causes. When the causes are identified, a Knowledge Effects Database is used to find the suggested solutions. Pugh's Matrix is used to narrow down possible solutions to the application. Feasible solutions are then identified for further study.

The processes are shown in Figure 5.

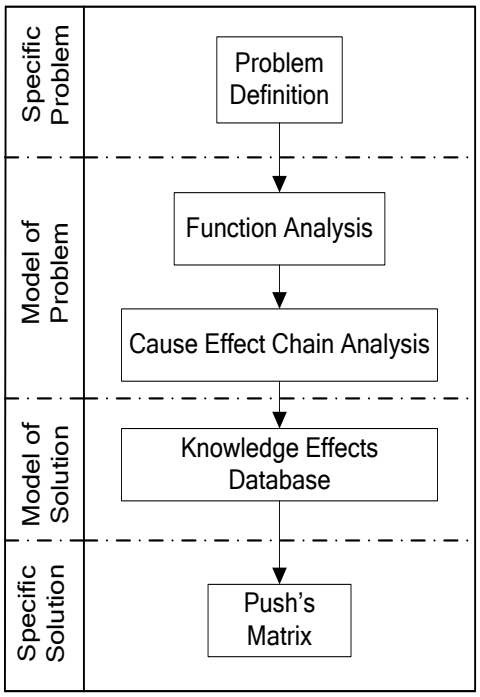


Fig. 5 The Proposed Process.

4. Case Study

A case study is used to illustrate the process of problem solving. The problem for the case study was that an oil mist purifying unit catches fire occasionally and must be stopped for cleaning after periods of operation. As the heat treatment operation runs continuously, any stop for cleaning means lost production. This study suggests new design concepts for a new oil mist purifying machine that can be operated without downtime and which does not catch fire.

The old oil mist purifying system has an electro-static cleaning system. A function-oriented search was conducted to understand it. U.S. Patent 5,925,170 (Nojima, 1999) gives useful technical information. The cleaning unit is similar to the proposed unit, as shown in Figure 6.

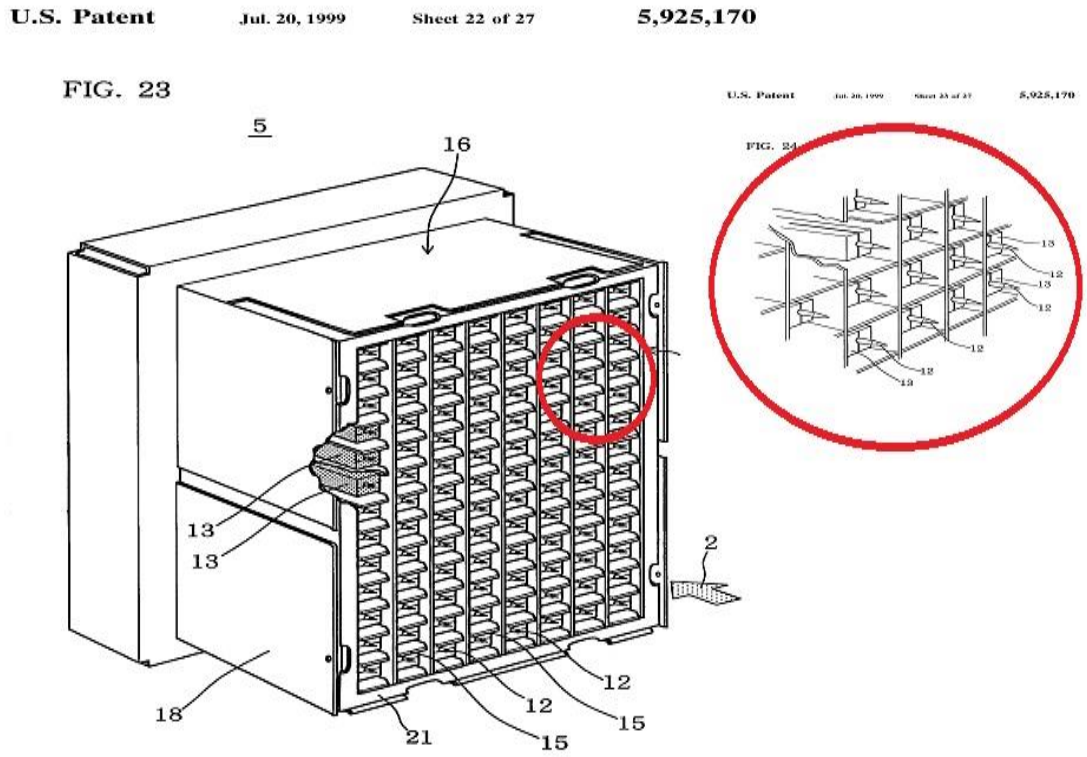


Fig. 6 Electro-Static Type Smoke Cleaner (Ikovenko, 2014).

The smoke to be cleaned consists of water vapor, oil vapor and odor. The particles are different sizes. Water particles are the largest. These are removed by passing through a filter. The oil particles then undergo electro-static cleaning. The particles are charged and then attracted by the cathode wall. Then odor is cleaned by passing through an active carbon filter. After these three cleaning stages, the air is clean and can be released into atmosphere. The process is shown in Figure 7.

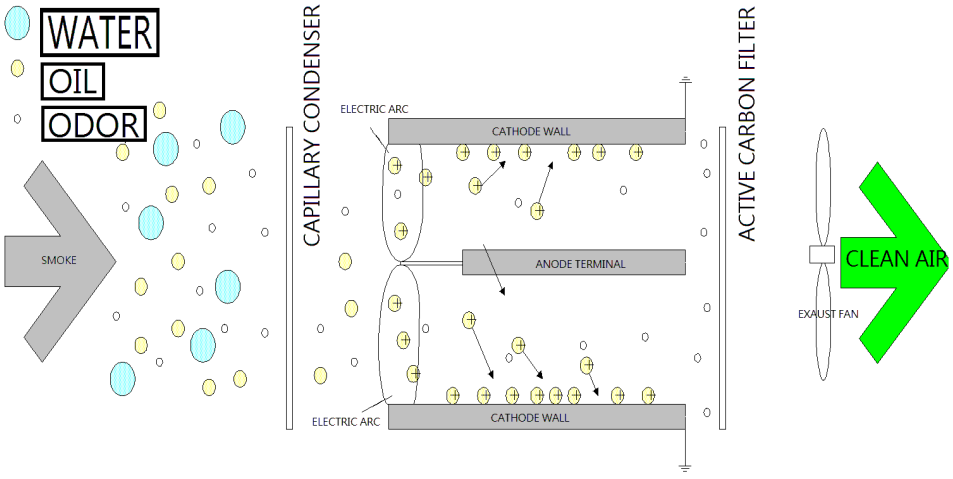


Fig. 7 Graphical Illustration.

4.1 Function Analysis

Function Analysis is used to identify the functions and the relationships between components, as shown in Figure 8. When a fire occurs,

- The water condenser solidifies water vapor.
- The anode creates a spark.
- The spark creates a positive charge.
- The positive charge ionizes the oil vapor.
- The cathode tube absorbs the oil vapor.
- The spark and the oil vapor together produce a fire.
- The active carbon filter absorbs odor.
- The water condenser solidifies water vapor.
- The cathode tube is cleaned manually.
- Oil vapor is harmful to the environment.
- Odor is harmful to the environment and to humans.

These tool-function-object statements allow a Function analysis diagram to be drawn and this is shown in Figure 8.

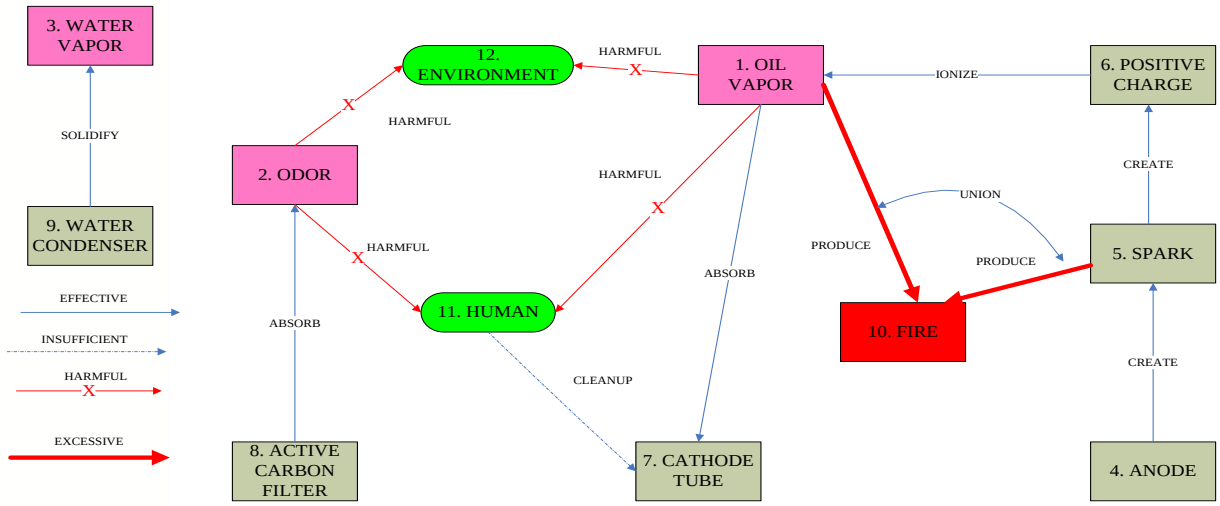


Fig. 8 Function Analysis.

4.2 Cause and Effect Chain Analysis

The target disadvantage in the system is that the unit catches fire occasionally. Heat, fuel and oxygen are the three necessary elements for ignition. The system is an open-air unit so there is oxygen everywhere in the system. The oil accumulates on the electrostatic unit. When the cleaner runs for a while, the oil that accumulates becomes thicker. The electrostatic unit cannot be cleaned during operation. The high temperature is a by-product of the emission of charges.

These statements a low a cause and effect chain analysis to be derived. The key disadvantages of the system are:

1. The electrostatic unit cannot be cleaned during operation.
2. The emission of electric charge causes high temperature.
3. Oxygen.

If any one of the key disadvantages can be eliminated, the risk of fire is eliminated. The cause and effect chain analysis diagram is shown in Figure 9.

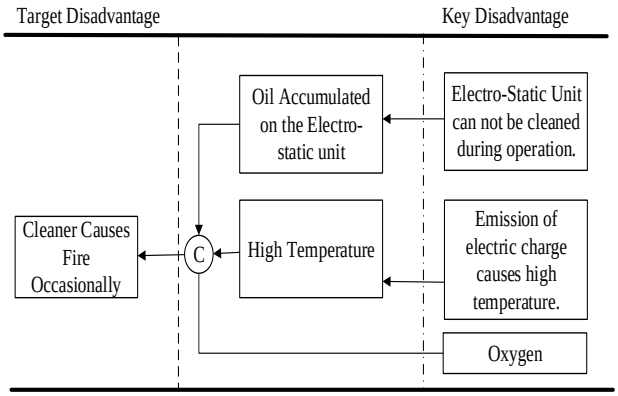


Fig. 9 CECA diagram of Smoke Cleaner Causing Fire.

4.3 The Knowledge Effects Database

To identify other solutions for cleaning smoke, the knowledge effects database was searched with the function query, Function Clean and Object Gas. The snapshot for the query is shown in Figure 10. 59 suggestions for clean gas were identified, as shown in Figure 11.

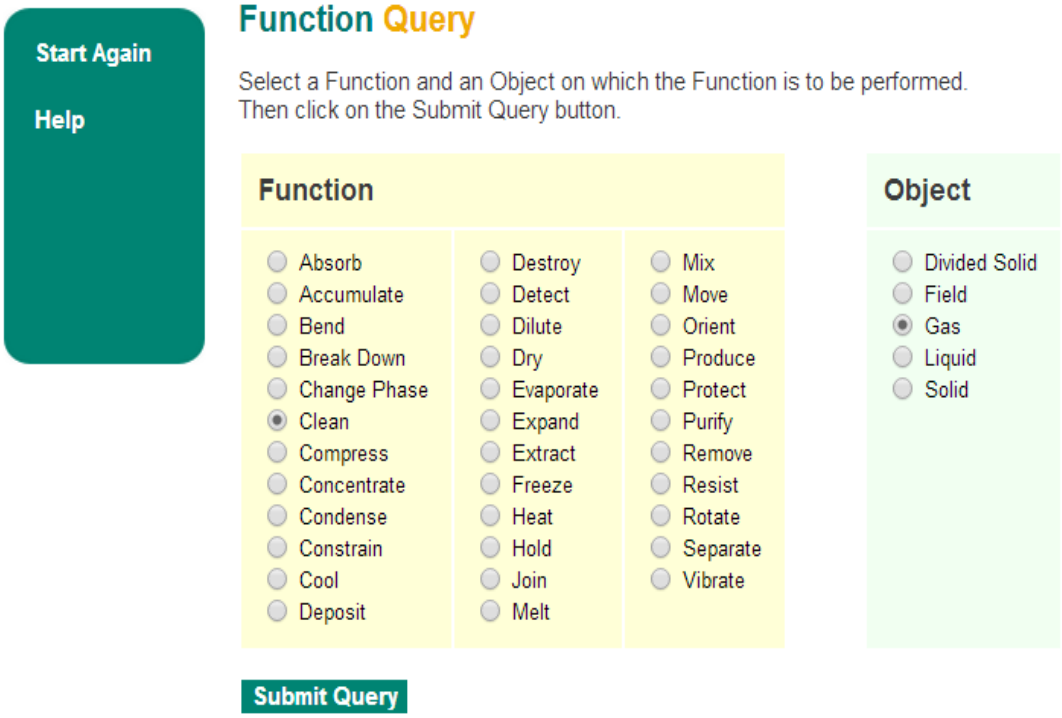


Fig. 10 The snapshot of query in this study.

Fig. 11 Suggestions for Clean Gas from Knowledge database.

4.4 Pugh's Matrix

To minimize the number of suggestions, the effects with 4 criteria were evaluated.

The scalability of the operation: As the cleaning process requires large scale cleaning, it is necessary to determine whether the effects can be used on a large scale.

Ease of Operation: To make the system as simple as possible, it is necessary to determine whether the effects are easy to operate.

The disadvantage of the previous system is that it catches fire occasionally so it is necessary to determine whether the effects are fireproof.

As the heat treatment process runs continuously, it is necessary to determine whether the process is interrupted.

The effect is evaluated with respect to the 4 criteria and assigned values of 1: positive, 0: neutral and -1: negative. The evaluated results are shown in Figure 12.

Table 1 The evaluated results with Pugh's Matrix.

No.	Effects	Scalability of operating area	Ease of operation	Fireproof	Avoidance of interrupting process	Sum
	Weighting of effects	0.2	0.2	0.3	0.3	1.0
1	Absorption	1	1	1	1	1.0
2	Adsorption	-1	1	1	0	0.3
3	Sorption	0	1	1	0	0.5
4	Activated Alumina	0	1	1	-1	0.2
5	Activated Carbon	1	1	1	-1	0.4
6	Aero Gels	-1	-1	1	-1	-0.4
7	Ceramic Foam	-1	1	1	-1	0.0
. . .	. . .	. . .	. . .	. . .	. . .	. . .
53	Setting	-1	-1	1	1	0.2
54	Sorption	-1	-1	1	0	-0.1
55	Sponge	1	1	0	0	0.4
59	Supercritical Fluid	0	0	-1	-1	-0.6
57	Thermophoresis	0	1	-1	-1	-0.4
58	Valve	0	0	1	-1	0.0
59	Zoelite	-1	-1	1	-1	-0.4

The Pugh's Matrix analysis shows that there are 4 effects that have a sum of 1.0. These effects are Absorption, Cyclone Separation, Phase Change and Capillary Condensation. These 4 suggestions are feasible and can be used to perform more experiments to determine the most feasible solution.

The absorption effect is commonly used in cleaning applications. The oil mist is absorbed by surface-active agents, so the oil mist can be cleaned continuously.

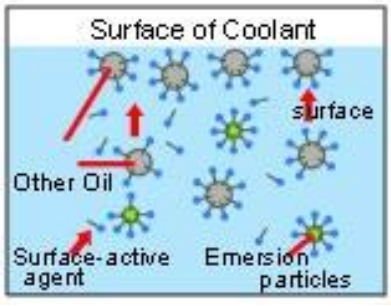


Fig. 12 Absorption by surface active agents (Surface Active Agent, 2015).

Cyclone separation is used to separate oil mist from air.

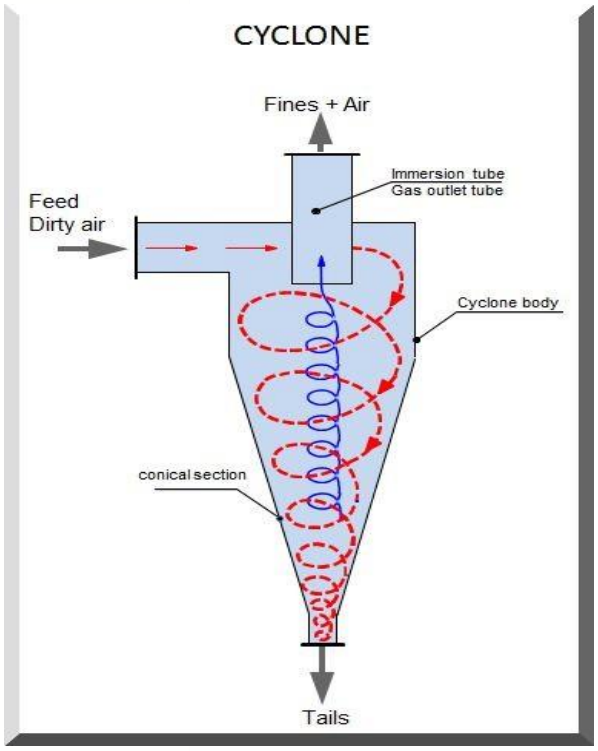


Fig. 13 Cyclone separation (Separators in the Cement Grinding Circuits, 2015).

Phase change allows airborne oil mist to condense into large particles and be separated from air.

Capillary condensation swaps a single air pipe for smaller pipes so the surface area is increased. The increased surface area helps to remove oil mist faster.

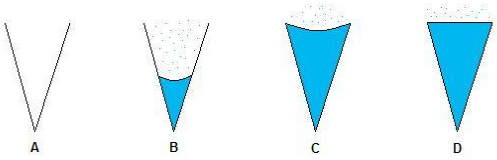


Fig. 14 Capillary Condensation (Capillary Condensation, 2015)

5. Conclusions and Future Works

It is necessary to minimize the cost for cleaner screw production. The screw manufacturing industry faces severe competition in the market and it is necessary to improve waste processing equipment. This paper demonstrates a TRIZ-based systematic approach for problem solving and there is a case study of suggestions to improve oil mist purifying equipment. This provides a feasible reference method for improving the manufacturing process or equipment in the screw industry. The process for improving equipment by using tools such as Function Analysis, Cause and Effect Chain Analysis, a Knowledge Effects Database and Pugh's Matrix is also shown. In fact, TRIZ is a very useful method to solve industrial problem and it contains many other powerful tools such as Ideal Final Result, Su-Field analysis and standard solutions, Trimming and Trends of Evolution evaluation. The procedures proposed in the paper only adopt some tools but it also can be used as a general problem solving method. Therefore, in this paper, we provide a feasible reference for improving manufacturing processes or equipment for the screw industry or other industries.

This paper shows a superficial use for function-oriented search. In future works, other TRIZ tools, such as ideal final results, Trim, ARIZ or Trends of Evolution may be used to identify further possibilities. Biomimetics can also be used, as these are naturally proven ways for filtering and cleaning waste.

References

Altshuller, G. (1996). *And Suddenly the Inventor Appeared: TRIZ, the Theory of Inventive Problem Solving.* Technical Innovation Center, MA.

Burge, S. (2009), "The systems Engineering Tool Box", Access Date: November 25, 2015, from http://www.burgehugheswalsh.co.uk/uploaded/documents/Pugh-Matrix-v1.1.pdf.

Chen, J. N. (2012). The report of prosperity of Taiwanese Fastener Industry. Retrieved September 24, 2014, from http://www.tw-fastener.org/infomation.html

Capillary Condensation. Retrieved November 15, 2015 from https://en.wikipedia.org/wiki/Capillary_condensation#/media/File:Capillary_condensation.jpg

DeCarlo, D., Samuel, P. & Silverstein, D. (2012). *The Innovator's Toolkit:50+ Techniques for Predictable and Sustainable Organic Growth.* John Wilsey & Sons, Inc., Hoboken, New Jersey.

Ikovenko, S. (2014). MA TRIZ Level Lecture Note.

Mann, D. (2009). *Hands-on Systematic Innovation*. Agitek International Consulting, Inc.

Nojima, K. (1999). Electric Dust-Collection Unit and Air-Cleaning Appapatus Using the Same (US Patent Number 5,925,170). Retrieved October 15, 2014 from http://patentimages.storage.googleapis.com/pdfs/US5925170.pdf

Oxford Creativity – TRIZ Effects Database. Retrieved September 25, 2014 from http://www.oxfordcreativity.co.uk/

Song, M. J., Lee, J. G., Park, J. M. & Lee, S. (2012). Triggering navigators for innovative system design: The case of lab-on-a-chip technology. *Expert Systems with Applications, 39*(16), 12451–12459.

Sheu, D. D. & Hou, C.T. (2013). TRIZ-based trimming for process-machine improvements: Slit-valve innovative redesign. *Computers & Industrial Engineering*, *66*, 555–566.

Surface Active Agent. Retrieved November 15, 2015 from http://www.enomotoweb.com/english/micro.htm

Separators in the Cement Grinding Circuits Retrieved November 15, 2015 from http://www.thecementgrindingoffice.com/cyclonesdevelop.html

Yeh, C. H., Huang, J. C. Y. & Yu, C. K. (2011). Integration of four-phase QFD and TRIZ in product R&D: a notebook case study. *Research in Engineering Design, 22*(3), 125-141.

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10.6977/IJoSI.201512_3(4).0002
Michael Yongmou Liu, Bill Yuanbo Liu/ Int. J. Systematic Innovation, 3(4), 10-14 (2015)

Definition of System Innovation Degree and its Measuring Method

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Abstract

In classic TRIZ, Genrich S. Altshuller proposed five levels of innovation (LOI), but in practice, people usually are confused on how to evaluate the degree of an innovation when the solutions are within the same innovation level which is vertical and qualitative designed.

To distinguish the difference of the innovations who belong to the same innovation level, authors propose a new concept, in horizontal and quantificational way, S*ystem Innovation Degree* (SID), and a proposal for measuring the SID with the support of International Patent Classification (IPC).

Finally, with a case study, the paper shows how the SID and its measuring method work.

Keywords: Levels of system innovation, International Patent Classification, Method to evaluate the degree of an innovation.

1. Introduction

It is well known that Genrich S. Altshuller has proposed the five levels of innovations (LOI) as following:

Level 1: Technology Transfer—a simple improvement of a technical system—requires knowledge available within the trade relevant to that system.

Level 2: Knowledge Exchange—an invention that includes the resolution of a technical contradiction—requires knowledge from different areas within the industry relevant to the system.

Level 3: Knowledge Collaboration—an invention containing a resolution of a physical contradiction—requires knowledge from other industries.

Level 4: Knowledge Innovation—a new technology is applied which contains a resolution of contradictions with better approach to Ideal Final Result—this new technology includes a breakthrough solution that requires knowledge from different fields of science.

Level 5: Innovation Networks—discovery of a new phenomenon or substances—this new knowledge provides for the development of new technologies with utilization of the new phenomena, resolving existing contradictions with better approach to the Ideal Final Result (Kraev, 2006).

With the problems of the first level, the object (device or method) does not change. At the second level, the object is changed but not substantially. At the third level, the object is changed extensively and at the fourth, it is totally changed. In the fifth level, the entire technical system is changed in which this object is used.

We know that levels of innovations proposed by Genrich S. Autshuller could be used to 1) determine the stage of a technical system in the S-curve and 2) indicate the level of innovations is high or low. But we should understand sometimes that the level of innovations is high or low doesn't means that the innovation is good or not good for the enterprises, the reason is some high level of innovation will lead high cost and long time to realized.

According to the definition of the levels of innovations proposed by Genrich S. Autshuller, People can vertically distinguish the levels in different degrees, while, if there are two or more innovations labeled in the same level, how can people evaluate the degree of these innovations objectively?

It is clear that the classic levels of innovation need to be improved by a new method which could distinguish the degrees of innovations in horizontally.

Even though some people thought that distinguishing of the different levels of innovation is more important than the distinguishing within the same level (Tan, Ru, and Babbitt, Tr., 2008), but in the most of enterprises, the innovation usually is an asymptotically process with the limited of resources or some economic factors, in another word, people usually

will choose the solutions within the same level of innovation, which indicates that distinguishing the degrees within the same level is meaningful.

2. Method Propose

In order to evaluate the degree of an innovation which is within the same innovation level, we introduce a new concept which we called as System Innovation Degree (SID). It is of measurement to the innovations which locate at the same level of innovation defined by Genrich S. Altshuller.

With the help of SID concept, people could evaluate the degree of some innovations in the same level of innovations ,in another word ,SID could be used to evaluate the degrees of an innovation in horizontally and quantificational, which is entirely different from the 5 levels of innovation, the SID and 5 levels of innovation are shown in Fig.1.

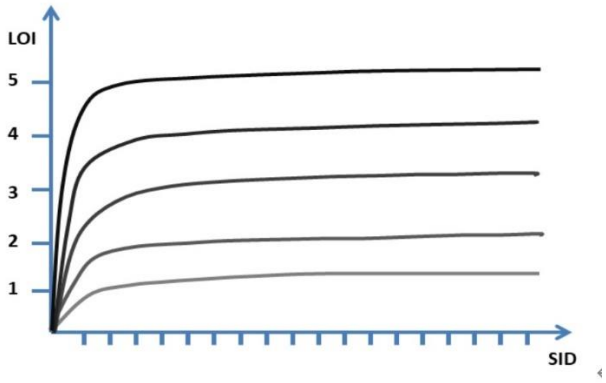


Fig. 1 Degrees and Levels of Innovations.

To the concept of SID, we should put forward a method for measuring. A lot of proposals could be used to measure the SID. Such as the ideality of the solutions, the cost of the solutions or the functionality improves of the solutions, etc. But as people known, these proposals will got the different results based on the different calculate factors (ideality), different market price (cost) or different viewpoints (functionality improves). Based on the universality, authority and consistency, we propose a reference proposal by means of IPC (International Patent Classification) to measure the SID of the solutions.

We know that the objective of the IPC is being a means for obtaining an internationally uniform classification of patent documents. It's primary purpose is to establish an effective search tool for the retrieval of patent documents by intellectual property offices and other users, in order to establish the novelty and evaluate the inventive step or no obviousness (including the assessment of technical advance and useful results or utility) of technical disclosures in patent applications (International Patent Classification Guide, Version 2013).

The layout of classification symbols in IPC is including four levels: Section, Class, Subclass and Group.

Section: This Classification represents the whole body of knowledge which may be regarded as proper to the field of patents for invention, divided into eight sections. Sections are the highest level of hierarchy of the Classification. The eight sections are titled as follows:

A HUMAN NECESSITIES
B PERFORMING OPERATIONS; TRANSPORTING
C CHEMISTRY; METALLURGY
D TEXTILES; PAPER
E FIXED CONSTRUCTIONS
F MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING
G PHYSICS
H ELECTRICITY

Subsection: Within sections, informative headings may form subsections, which are titles without classification symbols. Example: Section A (HUMAN NECESSITIES) contains the following subsections:
AGRICULTURE
FOODSTUFFS; TOBACCO
PERSONAL OR DOMESTIC ARTICLES
HEALTH; LIFE SAVINGS; AMUSEMENT

CLASS: Each section is subdivided into classes which are the second hierarchical level of the Classification.
SUBCLASS: Each class is comprised of one or more subclasses which are the third hierarchical level of the Classification.

GROUP: Each subclass is broken down into subdivisions referred to as "groups", which are either main groups (i.e., the fourth hierarchical level of the Classification) or subgroups (i.e., lower hierarchical levels dependent upon the main group level of the Classification).

COMPLETE CLASSIFICATION SYMBOL

A complete classification symbol comprises the combined symbols representing the section, class, subclass and main group or subgroup. Example is shown in Fig. 2 (International Patent Classification Guide, Version 2013):

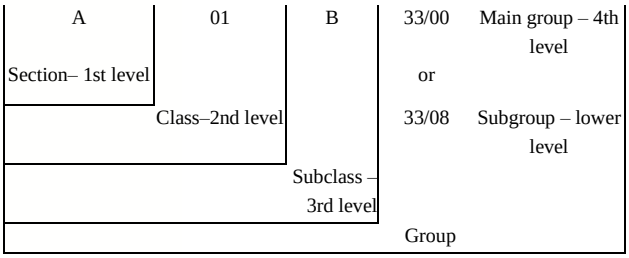


Fig. 2 Full structure of IPC class.

Based on the definition of IPC, we could determine the value of a SID for a solution using the following procedure.

First of all, we should identify the IPC number of the existing system and the solutions from the IPC. Once we finger out numbers of the existing system and the solutions, we could begin to calculate the value of SID for each solution separately in allusion to the existing system. The calculating could be done from the highest level of IPC-Section to the lowest one because the IPC is a hierarchical classification system. We could choose the subject of the existing system as the main subject, we set up this subject as number 1 in spite of this subject is belongs to A, B, C, D, E, F, E, G or H, and take the solution as the number n in clockwise; here n is countered from main subject according the IPC classification. Shown in Fig.3, thus the value of this SID of the solution in the section level equals n-1. Or $n_S = n$-1. For example, if the problem is belong to Section A, HUMAN NECESSITIES, while the solution belongs to Section E, FIXED CONSTRUCTIONS, then the value of SID of the solution in section level equals E-A , i.e. n_S=5-1=4. This calculating process of SID could be repeated in order for the other hierarchical levels in IPC (Section, Class, Subclass Group and subgroup). Finally, when we finished the counter in whole levels of IPC, we will get a summation: $N=n_S+n_C+n_{SC}+n_G+n_{SG}$, this summation N is the value of SID for this solution. See Fig.3 for the details.

It is similar to the levels of innovations proposed by Genrich S. Autshuller, the value of SID of a solution is large or small doesn't means the solution is better or not. A solution is better or not usually will be determined by non-technical factors in enterprise.

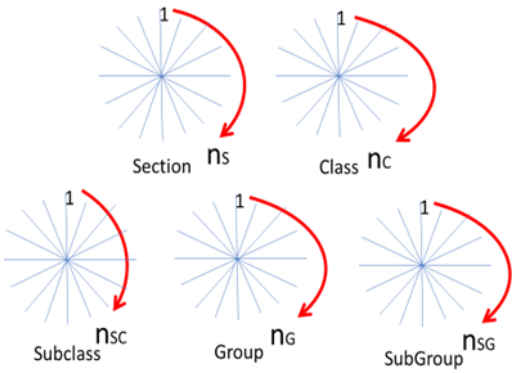


Fig. 3 Value of SID Calculating Method based on IPC.

3. A Case Study

Here, we introduce a real example to show how the SID works in the real innovation world.

Fig. 4 Wind Turbines in Working.

Project name: Wind Turbine Improvement;

Project Description: Wind turbine works the opposite of a fan. Instead of using electricity to make wind, a turbine uses wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The electricity is sent through transmission and distribution lines to a substation, then on to homes, businesses and schools.

Project Goal: Improves the productivity of the three blades wind turbine without increasing the cost.

To simplify the process, we take the technical contradiction (TC) overcoming as our example of SID measuring. It is well known the solutions with technical contradiction overcoming are belong to level #2 in LOI proposed by Genrich S. Altshuller

After analysis, we got the first pair of TC_1, which is shown in Fig.5 .Of course, there are a series of pairs of TC, and the solving process is of analogical. It is unnecessary to go into details.

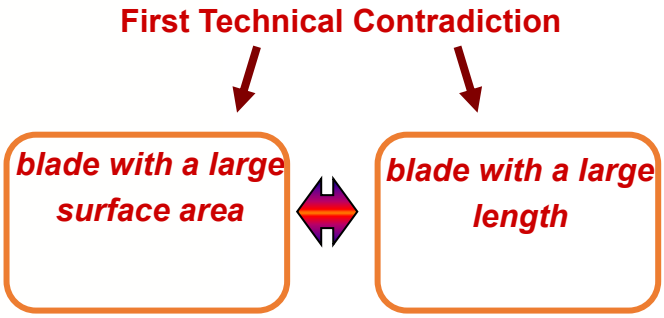


Fig. 5 The TC1 in Wind Turbine.

By means of Altshuller's Matrix, we got four recommendations, shown in Fig. 6.

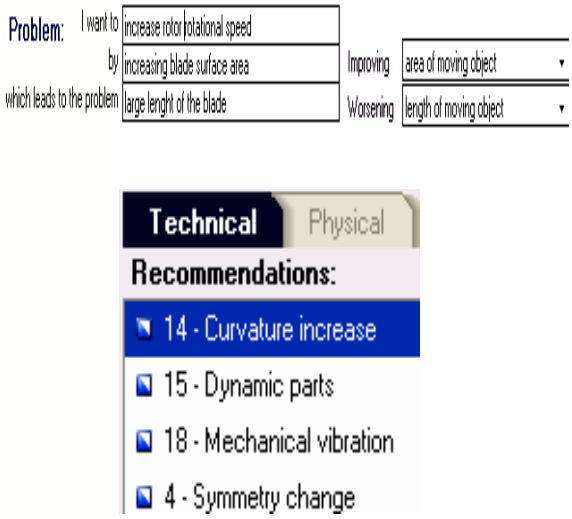
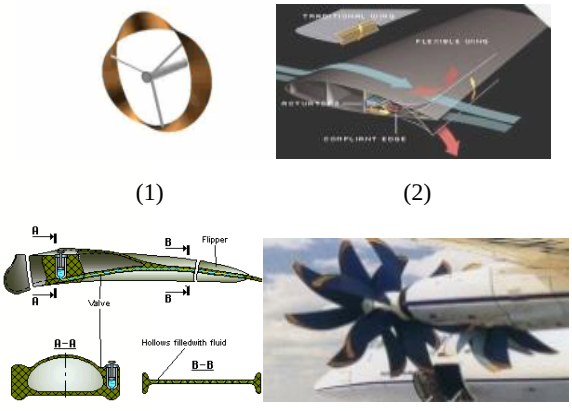


Fig. 6 Recommendations for TC1.

Based on these recommendations, finally we got the following solutions**,** shown in Fig.7 **(**Wind Turbine project, Isak Bukhman).



(1) (2)

(3) (4)

Fig. 7 Final Solutions for TCs in Wind Turbine.

(1) Blade in form of MOBIUS Belt; illuming from 14 **Curvature increase**
(2) Flexible Wing – Blade; illuming from **18 Mechanical vibration**
(3) Variable-rigidity flipper – blade; illuming from 15 **Dynamic Parts**
(4) Doubled propeller – Doubled blades; illuming from **4 Symmetry Change**

According to IPC, We can find out that the IPC Number for wind turbine is F03 D 1/00. Based on this IPC number and Table1, we can get the value of the SID for each solution by the method mentioned in this paper, the result is shown in the Table 2.

Table 1 IPC Section and Subclass number for IPC F03 D 1/00.

IPC Section and its number	IPC Subclass and its number
A–4	A–24
B–5	B–25
C–6	C–26
D–7	D–1
E–8	E–2
F–1	F–3
G–2	G–4
H–3	H–5
	–
	Z–23

Table 2 SID Value of Each Solution.

#	Solutions	Relevant IPC No.	SID	Calculating Procedure
1	Blade in form of MOBIUS Belt	B63H 1/26	94	=(5-1)+(63-03)+(5-1)+(1-1)+(26-00)
2	Flexible Wing - Blade	B64C 3/44	136	=(5-1)+(64-03)+(26-1)+(3-1)+(44-00)
3	Variable-rigidity flipper - blade	F03D 7/00	6	=(1-1)+(03-03)+(1-1)+(7-1)+(26-00)
4	Doubled propeller – Doubled blades	B64D 27/00	91	=(5-1)+(64-03)+(1-1)+(27-1)+(00-00)

Now, according the value of SID, we can easily ranking each solution which belongs to the same levels of LOI. This kind of evaluate criteria is objectively.

4. Conclusion

Traditional or Classic TRIZ proposed five levels of innovations, but it is not enough to distinguish the difference of the innovations which belong to the same levels in practice. The distinguishing of those innovations is important for enterprises sometimes.

The paper also proposed a reference method to measure the difference of innovations which belong to

the same level of innovations based on IPC and hope it will be helpful to distinguish the innovation solutions impersonal.

References

International Patent Classification Guide (Version 2013).

Kraev, V. (2006). Kraev's Korner: Levels of Innovations. *The TRIZ Journal* (www.triz-journal.com).

Tan, P., Ru, H. and Babbitt,W. (Trans.) (2008). *The Innovation Algorithm: TRIZ, systematic innovation and technical creativity* (Genrich Altshuller). China: Huazhong Uni. Press. (Original work published in 1999)

Wind Turbine project, Isak Bukhman, Baosteel TRIZ adv. Course 2007.

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Bill Yuanbo Liu is a student in master degree program of accountancy at Purdue University Calumet in United States. He has a Bachelor's degree of Science in Management. In 2010, he had a patent with published number of CN101940832A. Now he is focusing on the study in application of Six Sigma.

10.6977/IJoSI.201512_3(4).0003
Hsiu-Jung Chou, Chia-Hsun Lin/ Int. J. Systematic Innovation, 3(4), 15-26 (2015)

A Case Study of Innovation of the Versatile Hat

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(Received 9 March 2014; final version received 8 December 2014)

Abstract

Nowadays, we live in an era of rapidly changing trend of fashion. We expect to keep consumers from overspending and being awkward to storage and maintenance of hats. Therefore, "convenience" and "economy" are our main theme of this innovation. The principles of this innovation are to save storage space, reduce spending, and have storage easier. The Versatile Hat comprises the crown of the hat and at least one brim. There are three types of attaching parts at the bottom of the crown, namely buttons, Velcro, and studs; additionally, corresponding attaching parts are at the bottom of the brim so as to incorporate the brim into the crown. This ingenious design can create multi-pattern hats simply by attaching the same crown into different brims; these replaceable brims make the Versatile Hat a snap-on product. That is to say, one Versatile Hat provides many different patterns of hat to match various clothing and different occasions. For storage space, users need only one small space to lie just one crown of the hat rather than several crowns. This creative design can meet modern people's demand perfectly by providing multi-pattern hats without overspending and also reducing storage space.

Keywords: Versatile Hats, Patent, Innovation.

1. Introduction

Nowadays, we live in the highly competitive twenty-first century. Enhancing competitiveness is of vital importance if the products are expected to gain a foothold in the market. Therefore, "creativity" and "innovation" are two essential elements for the products. In the background of rapidly changing trend of fashion, hats are no longer only the aristocracy's accessories for important occasions. On the contrary, hats are now one of the popular accessories in most people's daily life; it is now in widespread use by people of all ages. This innovation is to provide consumers a superior hat product other than the current conventional hats in the market.

Hats are very common accessories for nowadays people when they attend any social occasions; it is used mainly in fashion trend and clothes matching. As different clothes are required to fit in with different occasions or sports activities, the hats need to correspondingly match the garment. In the current market, there is a great diversity of hat products for users' options to meet different occasions. Most users usually own numerous hats to match their different clothes styles, such as basketball cap, round hat, and beanie. Hats lovers all understand to store a hat properly is to have the hat lay in storage space by keeping the crown from being squashed. Improper storage of the hats will result in the distortion of hat shapes.

Hats are traditionally assumed to be the garment for our heads. Most of the hat products in the market are able to cover the entire top of our heads, the main function is to protect our heads. However, hats can be also a part of our apparel besides above basic function. According to different cultures, the etiquette of wearing a hat is also different. Hats are more significant in western culture because wearing a hat was one type of status symbol in old-time culture; it signified a certain status and image. Different styles of hat or different ways of wearing a hat could have different signification in old-time western culture.

Therefore, the hat products in the market provide different function by its different designs of brims. For instance, the peaked cap and the sun hat are with bigger brim to protect our heads and eyes from the sun; they are particularly suitable for sports activities. The lady hats with wavy brim are suitable to match the dress. The hats made of hard plastic material are mainly used in construction site. Spontaneously, most people usually own various different hats for different functions in daily life. This results in problems of space occupying and

awkward maintenance of hats, and it usually costs users a considerable sum of money to own numerous hats.

There is a wide diversity of hat products in current market. People usually need to purchase various styles of hats to match their assorted garments and fit in with different occasions. The storage of numerous hats at home usually occupies space; furthermore, improper storage might have hats covered with dust easily. Besides inconvenient storage, if the hat is purchased for single-use purpose, it is not only unfavorable to the environmentally-friendly consciousness but also unfavorable to the principle of economy. Especially in such period of economic downturn, price is usually the first priority for consumers' purchase plans. The current hat products in the market are not only single function but also expensive.

Most hats are with the edge sticking out or even sloping downward, which is called the brim of a hat or the peak of a cap. The function of brim is to protect our heads and eyes from the sun; moreover, it can be used to protect the hair style, to hide the bald patch, to match the garment, and to be part of team uniform or religious clothing. There is a wide category of hat products. To classify hats by practical applications, there are full-face and open-face helmets for motorbike riders; sun hats for anyone who needs to protect their heads from the sun; dust helmets or safety helmets or construction helmets for workers in the workplace. To classify hats by particular users, there are cowboy hats, sailor hats, army caps, police hats...etc. for different professions. To classify hats by patterns, there are berets, peaked caps, scarf hats, skullcaps, lady hats…etc. There is a great variety of hats in both categories and materials.

Due to the inconvenience of the hat products in the current market, this innovation is to improve the structure of the current hat products and remove the disadvantages by creative design with our practical experience of producing hats samples. The Versatile Hat is designed to solve the problems of current hat products such as single function, expensive price, space occupying, inconvenient storage, and awkward maintenance. Therefore, this innovation is with benefits of changeable patterns, cost effective, convenient storage, and space efficient. By the combinations of the crown and the various designs of brims to turn into multi-functional hats so as to conform to the purposes of practicality, convenience, and economy. Therefore, the paper shows how to design versatile hats and develop strategies for marketing issues. The research flowchart is shown in Fig. 1.

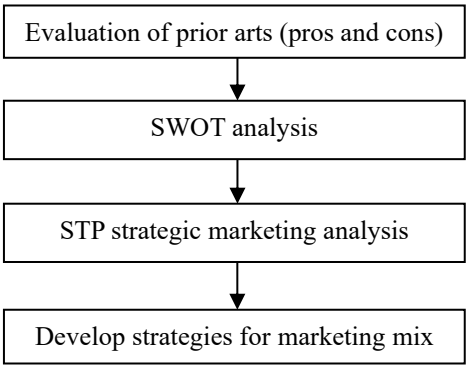

Fig. 1 Research flowchart.

2. Literature review

Hats are generally used to protect our heads and eyes from the sun in our daily life. In addition, it is even more frequent to be used to match garments of all kinds. Many people have experiences of looking at the shop windows full of a great variety of hat products but unable to purchase numerous types you like due to limited budget. For this reason, the inventor is expecting to provide an innovative hat which brings greater satisfaction to consumers. That is to say, consumers will own several patterns of hats by just purchasing one hat at a time instead of purchasing several single-pattern hats. This innovation, the Versatile Hat, with changeable patterns, will fulfill people's needs in owning multipattern hats without overspending no matter the users are adults, children, male, or female.

2.1 The basic of innovation

Design for daily-life products is usually created and developed according to the market demand. Most of daily-life products generally look special in the appearances; even for some products, people are not able to realize its function at the first look. The fun and creativity of product design not only bring the pleasure and entertainment to our life but also enhance our commoditization. A good product design is able to enhance life quality for people. Although the product design might be only a small part of our life, it can bring more fun and convenience to us. Nowadays, people are receiving more pressure from either their work or life; with the benefits of a good product design, to a certain extent, it will relieve some stress and bring more pleasures to people. Furthermore, a good product design might increase our efficiency at both work and life. It is definitely worth further studies of effect brought by product designs on both our mental and physical conditions.

A fertile imagination and innovative ability are significant for design of daily-life products. In the broad sense, innovation includes creativity, innovative

mechanism and enterprising spirit; the fruitful results of innovation are the achievements of creativity in all kinds of different industries and territories. The innovative ability is a major indicator of knowledge economy and social development. In addition, creativity is the education indicator of learning outcome. In the narrow sense, creativity is the knowledge base of innovation while innovation is the concrete practice of creativity. Creativity and innovation are two sides of one coin, both complement each other (Ministry of Education, 2002).

Some innovations enhanced our work quality and life quality, or strengthened our competitive position; some other innovations brought essential effects to our economy, society, and techniques. However, innovation does not need to be the completely new products or brand new ideas; it can be simply the current products added with new package or new style or new function; it can be the current method with improvement. In other words, total quantity remains the same while the structure varies, or the structure remains the same while the total quantity varies. Innovative products can be the unusual, valuable, practical or appropriate products, or other particular meaning. Being an unusual product or not can be judged by comparison with other similar current products. Being a valuable product or not can be judged by the benefits or the meanings of the product, and to whom the benefits or meanings are (Liu, 2011).

Innovative ideas are not only making improvement or association with daily ideas or daily products, it can be the extension of an idea or thinking through mind mapping. Mind mapping is one method to substantiate radiant thinking, so it is one method conforming to humankind's thinking. There is a great benefit to the mapping function of mind mapping; one of the substantial benefits is to bring out the potentialities of the human brain. The application of mind mapping can help students to enhance creative thinking and problem-solving abilities of the whole brain. In other words, mind-mapping is a visual or pictorial thinking method. It is a meshed organization chart spreading outward from the center, which can extend thinking boundlessly. Therefore, mind mapping can be a quick and accurate learning tool. To integrate and associate with all lines, colors, written words, figures, signs, pictures, and key words; to express all the concepts we learn in visual and pictorial mapping so as to bring out the boundless potentialities of the human brain (Hsu, Chang, and Hsieh, 2008).

To launch the daily-life products into the market, creative thinking is certainly needed besides innovative ability. Parnes (1967) believed that the major purpose of Teaching for Creativity is to stimulate and develop students' creativity. According to Parnes (1967), the teachers who teach for developing students' creativity can stimulate children to develop their productivity, and allow students to express their opinions and thoughts freely. Furthermore, these teachers are capable to teach students to learn to listen rather than just de-liver opinions. Therefore, the teachers who teach for developing students' creativity do not have to deliver information or knowledge to students in a creative method. However, if we want to form an atmosphere where creativity can be learned easily, building an environment where students can express thoughts and ideas freely is vital. In addition, encouraging sense of humor, allowing evolvement of thoughts, and valuing both quality and quantity of thoughts at the same time are also required. After the integration of creative thinking, it will turn into creativity, the spirit of daily-life products. Creativity is the combination of three elements; namely differentiation, aesthetics, and message of the products. The essential of creativity is to create a new and meaningful art by using an interrelated, trustworthy, and superior method to associate with the unconnected objects and happenings in the past. Such new relation enables to unfold certain fresh messages of the products (Education Wiki, 2013).

To compare the significance of hats in the past and nowadays through creative thinking, we found the fact that hats are more significant in western culture because wearing a hat was one type of status symbol in old-time culture; it signified a certain status and image. Nowadays, hats are very common accessories when people attend different social occasions; it is used mainly in fashion trend and clothes matching. As different clothes are required to fit in with different occasions or sports activities, the hat needs to correspondingly match the garment.

To store a hat properly could occupy space inefficiently. Users need to have the hats lie in storage space and keep the crown from being squashed. Improper storage of the hats might result in the distortion of hat shapes and the hat might not be able to recover to its original shapes. For this reason, the Versatile Hat is designed to improve the structure of the current hat products and remove the disadvantages. This innovation provides users an option of saving storage space and having storage easier besides matching various garments delightfully, especially for users who are fond of fashion and changing styles. This innovative hat is favorable to environmentally-friendly consciousness and also the principle of economy due to

reducing spending and storage space. Enhancing the practical value of products and being multi-functional are exactly our purposes of this innovation.

2.2 Research of hats

Hat is one of important accessories to our garments since ancient times, it has been existing and developing successfully at the same time with clothing till the present. Along with the development of material culture, our life styles have been changing accordingly. Spontaneously, it led into a wide development of hat products gradually. Owing to this fact, hat has become one of essential accessories to our garments in daily life. However, being an accessory of garments, hats are not restricted by the garments styles. On the contrary, hats have been changing and developing according to noticeable fashion trends; the rapid changes of hat fashion are even greater than the garment fashion.

The quality of a hat is usually reflected from its specification, pattern, materials, and production. To be more specific, the specification needs to meet the required standard; the pattern needs to be aesthetic and elegant with symmetrical and reasonable structures; materials need to conform to the requirement. The colors of single-color hats need to be consistent on the whole hat while the colors of multi-color hats need to be harmonious. The warps and wefts of the hats should be smooth without deflection. The materials should be without any obvious defects, for example, the leather surfaces should be without shedding or scars or insect bites. Accessories of hats should be complete. The brims of hats should be with certain reinforcement for added stability.

Each detail of the hats needs to be qualified. For example, the stitching should be tidy and should match the colors of hats harmoniously; the stitching should not be undone or with continuous skipped stitches. The circumference of a hat should be without obvious deflection or any concavity, the brim should be with proper look. The surface of body of woven hats should be without any concavity, convex, uneven tightness, or uneven decorative design. The stuffed cotton inside the cotton hats should be even; spacing of stitches on the hat should be proper; accessories on the hats should be positioned well and harmoniously if there is any; embroidery should be made correctly without crease. Hats need to look smooth and beautiful without any folds inside the crown; more-over, it should look tidy without any stains, folds, or damages (Chinese Encyclopedia Online, 2013).

By the research of the hats, we can learn how the hats were created and evolved in old-time development. Wearing a hat was one type of status symbol in old-time culture; it signified a certain status and image. Different hats or different ways of wearing a hat could have different signification in old-time. The purpose of hats is the same as our clothing, especially in different ceremonies. For example, the hats for a wedding dress, a morning coat, or a funeral dress and garment. In terms of social etiquette, the hats can be one for an evening dress, a cocktail party garment, or a casual dress. Different materials and patterns are required for different specifications and designs. Nowadays, the hats for formal occasions have been changing as well.

For modern people, hats are used mainly in fashion trend and clothes matching. By studying the development of hats in different regions at different period in history, we can understand the information of old-time social structure, aesthetics, skill and craft standards, and living conditions, etc. at that period. Furthermore, we will be able to reproduce the hat designs and production skills at that time by assimilating the ideas and information from the study of development history of hats. By understanding better the clothing and hats development in history will be beneficial for our study of human history and might facilitate the future development of humankind.

After searching related or other similar patents of hat products through Taiwan Patent Search online, we found eleven related patents about multi-functional hats in Utility Model Patent such as patent number M380004 “Scarf with Function of Hat”, M314532 “Hat body Structure of Leaf Hat Type Assembly”, and M384550 “Multifunction Hat Assembly” etc.; however, those related patents on Taiwan Patent Search website are not the same as this Versatile Hat in this report. The eleven patents of other hats are listed below (see Table 1).

Table 1 Searching results of related patents of hats.

Title of Utility Model Patent	Patent Number	Inventor
Advanced-Structure of Sun Hat	M414103	Chen, Jing Cheng
Structure of Sun Hat	M412632	Lan, Yu Xiang
Advanced Hat with Disposable Lining	M403903	Huang, Xiu Rong
Hat with Hair Decoration	M388858	Hua, Hai Li
Scarf with Function of Hat	M380004	Liu,Chih Chen

		Chuang, Ting Chieh Wu, Tsung Han Chou, Chun Hung
Hat	M376174	Ho, Xiu Lang
Hat with Cooling Fan	M381294	Huang, Ren Yi
Hat with Function of Producing Water	M380723	Chen, Rui Wen
Aromatic Hat	M263002	Wang, Bo He
Hat body Structure of Leaf Hat Type Assembly	M314532	Ho, Pei Lin
Multifunction Hat Assembly	M384550	Xu, Zhi Feng

Source: Taiwan Patent Search (2013). Retrieved from: http://twpat2.tipo.gov.tw/tipotwoc/tipotwkm.

This innovative hat of "Hat Body Structure of Leaf Hat Type Assembly" can be assembled by users easily at any time (see Fig. 2).

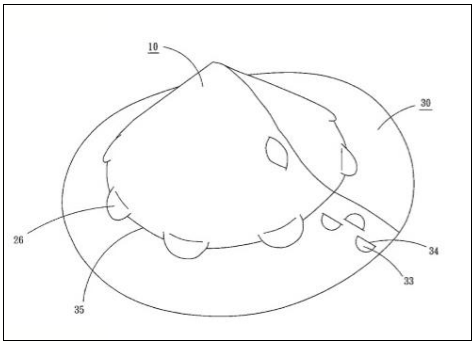

Fig. 2 Assembly of Hat (M314532).

Such assembly not only brings entertainment to users, but brings convenient storage because users can disassemble it when the hat is not in use. Therefore, entertainment and convenient storage are the added value of this innovative hat (see Fig. 3). However, the disadvantage of this patent is that it is made of cardboard and it is not water-proof and can be easily damaged.

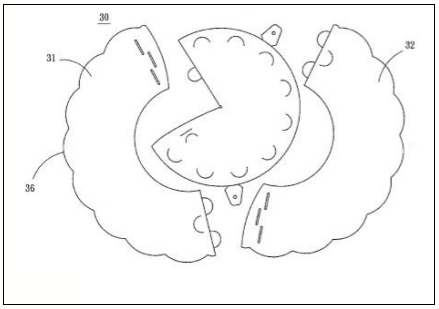

Fig. 3 Disassembly of Hat (M314532).

This innovative "Scarf with Function of Hat" can be adjusted to be either a scarf or a hat according to users' demand. It has a brim to protect the eyes from the sun as well (see Fig. 4). However, the disadvantage of this patent is that it has very few varieties of styles.

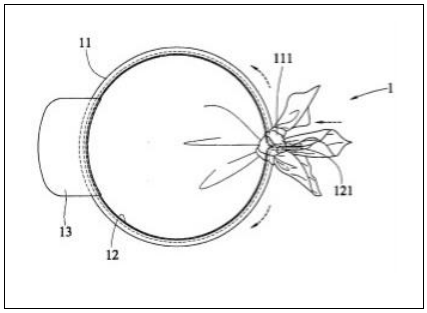

Fig. 4 Scarf with Function of Hat (M380004).

This innovative product of "Multifunction Hat Assembly" can be simply a hat with the function of protecting our eyes from the sun (see Fig. 5).

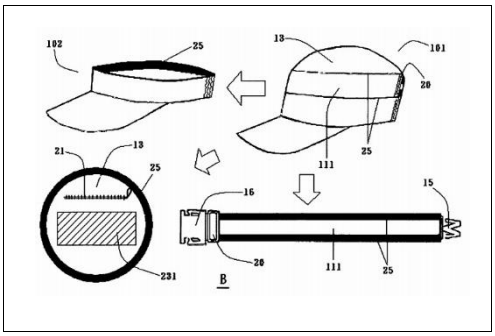

Fig. 5 Multifunction Hat Assembly (M384550).

Furthermore, it can be a waist bag for users to pack belongings (see Fig. 6). However, the disadvantage of this patent is that not many people like to have things tie around them or considering using a hat as their fanny pack/waist bag.

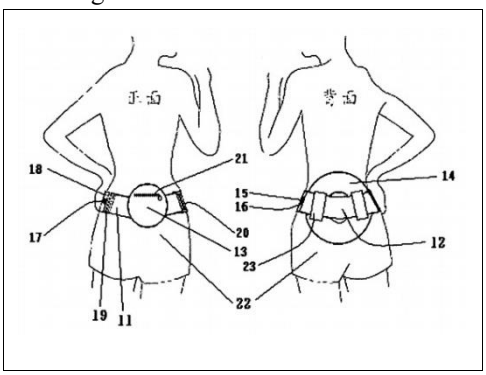

Fig. 6 Multifunction Hat Assembled to be a waist bag (M384550).

2.3 The features of the innovation

Hat function is available anytime wherever the users need a hat.

(1) Features: more than one way of wearing this hat. By separating the crown from the brim, the crown can be the lining of a helmet, and the brim attached with the circumference of the hat can be a sports hat, for example, a hat for golfing.

(2) Advantages: customized hat with various patterns and functions; it can be matched with different garments easily and is suitable for consumers of all ages.

(3) Disadvantages: this innovation is restricted by different materials. If materials of the crown and brim are distinctly different, they cannot be interchanged in such way due to not matching each other.

After comparing with other existing patents of innovative hat products, we found that the Versatile Hat is with benefits of function, value, convenience, and creativity that cannot be found in other existing patents. This fact makes the strengths and opportunities of the Versatile Hat more visible to consumers. By lessening its weaknesses and threats and enhancing its visibility, we aim to possess certain market share with this innovative hat in both domestic and worldwide markets.

2.4 Theories of strategic marketing

Nowadays, people live in the era of rapid changes. The living expense has been rising continuously while people's income has been stagnating for years. Consequently, the affordable-price products have been growing rapidly. In this report, the theories of SWOT analysis, STP strategic marketing analysis, and 4P marketing mix are applied to further discuss the market of the innovative hats.

Weitz and Wensley (1984) defined "marketing" as having the appropriate allocation of resources so as to achieve sustainable competitiveness under the scope of existing market. Kotler (1994) defined "marketing strategy" as the extensive guiding principle for business units when they expect to achieve the market objective in their target market; it usually includes policies of marketing expenditure, marketing mix and marketing allocation of resources…etc. Overall speaking, marketing strategy is to allocate the limited resources effectively and optimize the use of resources. To achieve this strategic objective, certain theories of marketing analysis need to be applied accordingly. Generally speaking, marketing comprises three phases. The first phase is environmental scanning, SWOT analysis is often applied in this phase. The second phase is marketing strategy; STP strategic marketing analysis is often applied in this phase. The third phase is marketing mix, which is the further marketing strategy, it can be also regarded as a frame of guiding principle in the process of strategic planning, and marketing mix (4P) is often applied in this third phase. Further information of these three theories is introduced as below.

2.4.1 SWOT analysis

SWOT analysis is conducive to identify whether the business strategy is favorable to the business or the organization, it is used to identify the internal factors of strengths and weaknesses, and external factors of opportunities and threats (Proctor, 1997). External factors of opportunities and threats are formed by affairs generated by the economy, society, culture, demographic variable, environment, politics, law, technology, and competitive tendency; the affairs might be favorable or unfavorable to the organization. Internal factors of strengths and weaknesses are the results of how the policies or projects in the organization are implemented; for example, the resources inherent in the organization or activities of functional management in the organization. According to Barney (1991), one organization's basis of resources is the analysis basis of internal strengths and weaknesses; it is also the basis of one organization's sustainable competitive advantages. To discuss SWOT analysis from the aspect of basis of resources is one type of strategic marketing (Fahy and Smithee, 1999; Valentin, 2001).

2.4.2 STP strategic marketing analysis

STP strategic marketing involves three elements, namely "Segmentation, Target Market, and Positioning". The market differentiation strategy is applied in more and more products, which indicates that STP is the mainstream of future marketing strategy. Three elements of STP marketing are introduced below (Lin, 2002).

(1) Segmentation

Markets can be separated into several segments, each segment is made up of customers with similar needs or demands. Segmentation is to identify different groups of purchasers by similar hobbies, needs or similar reaction to advertisement. Once the segment is identified, a marketing plan can be created to meet different groups' needs effectively so as to reinforce the adaptive capability of marketing mix in the market. Therefore, segmentation is fundamental to the market targeting and market positioning.

(2) Target market

Target market is a group of customers towards whom the organization decided to aim its marketing efforts.

(3) Positioning

Positioning is to create the important and unique benefits for the products or services into the market, and deliver these messages to the target consumers. In other words, positioning is to identify the possible positioning concept in the target market, and afterwards select the proper positioning concept according to organization's inherent resources and capability. Furthermore, to develop and deliver the selected positioning concepts through marketing mix (Lin, 2002).

2.4.3 STP strategic marketing analysis

According to Kotler (1994), marketing mix is one strategic marketing tool used by organizations to control all the variables in target market when the organizations aim to achieve the marketing objectives. Generally speaking, marketing mix is the 4P marketing mix introduced by American scholar McCarthy (1960), which comprises product, price, place, and promotion.

(1) Product

Product can be an idea, a tangible product, a service, or any combination of above-mentioned three elements. It can be anything provided in the market to meet consumers' various demands or needs or wants; which can meet individual or organization's objectives. The scope of products is beyond the tangible objects. In a broad sense, products involve services, happenings, people, places, organizations, ideas or concepts besides tangible objects, or any combination of above terms.

(2) Price

According to Monroe (1990) and Kotler (1994), price is the amount of money paid by consumers to purchase products or services. Price is also the amount of currencies paid by consumers to obtain their required products or services. Therefore, price can be the ratio of amount of currencies the seller gains to amount of products or services the purchaser gains.

(3) Place

The place element is also named distribution channel. It is a process formed by all the activities of transporting products or services from manufacturers to consumers or organizations. Under the current economic system, the intermediaries are a bridge between manufacturers and purchasers. The manufacturers sell products to purchasers through intermediaries; meanwhile, the intermediaries also deliver the information of purchasers' preferences to manufacturers. In the entire process of distribution channel, the intermediaries provide functions of transactions, logistic, and the facilitation of transactions. Moreover, the intermediaries are capable to provide benefits of improving efficiency of transaction, adjusting the differences of quantity and category, and creating efficacy.

(4) Promotion

Promotion represents the various marketing communications conveyed to target consumers from organizations; the organizations can be either non-profit organizations or profit organizations. Overall speaking, the organizations can operate a promotion to convey related information of products or organizations to consumers through their own sales representatives, public relations, advertisement, or direct marketing. The purpose is to enhance the image of products and organizations, and to enhance visibility so as to increase the sales volume as well. Kotler (2001) believed that promotion is one of the fundamental elements for marketing activities; which includes all kinds of incentive tools but mostly temporary. The purpose of promotion is to encourage consumers or distributors to generate immediate buying behavior and higher buying power. Promotion tools comprise three types, namely promotion to consumers, promotion of transactions, and promotion of the organization and its sales representatives.

3. Introduction of Technical Designs

3.1 Technical Designs

The Versatile Hat comprises one crown of the hat and at least one brim. There are attaching parts at the bottom of the crown, and corresponding attaching parts at the bottom of the brim so as to incorporate the brim into the crown. This ingenious design can create many different patterns of hats while the same crown of the hats attaches to different brims, these replaceable and changeable brims make the Versatile Hat a snap-on product. The design of attaching parts of buttons, Velcro, and studs ingeniously provides users a multi-pattern hat once users attach the crown and brim together. The purpose of this innovation is to provide one multi-functional and multi-pattern hat to consumers. By simply attaching various brims to the same crown can become a changeable and multi-functional hat with advantages of convenient storage, easy maintenance, and affordable prices.

3.2 Technical methods

In this report, the Versatile Hat is well illustrated in four patterns, which are baseball cap, cowboy hat, cloche hat, and sun hat with UV-resistant function. With the design of attaching parts (buttons, Velcro, and studs) to connect the crown and the brim, a hat can fit in with different occasions is simply created. Therefore, reduced

spending on hat products for consumers and affordable prices are the noticeable benefits of this innovation. Detailed explanation of these four patterns is illustrated from Table 2 to Table 5 and Fig. 7 to Fig. 18 as below.

(1) A fashionable baseball cap in Fig. 9 is created by connecting the crown in Fig. 7 with the brim of baseball cap in Fig. 8 through the attaching studs. The yellow small dots in the brim are the protrusions of studs.

(2) A characteristic cowboy hat in Fig. 12 is created by connecting the crown in Fig. 10 with the brim of cowboy hat in Fig. 11 through the attaching studs. The yellow small dots in the brim are the protrusions of studs.

(3) A beautiful cloche hat in Fig. 15 is created by connecting the crown in Fig. 13 with the brim of cloche hat in Fig. 14 through the attaching studs. The yellow small dots in the brim are the protrusions of studs.

(4) A sun hat with UV-resistant function in Fig. 18 is created by connecting the crown in Fig. 16 with the brim of sun hat in Fig. 17 through the attaching studs. The yellow small dots in the brim are the protrusions of studs.

Table 2 Baseball cap.

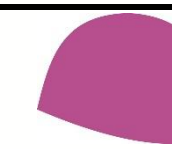

Fig. 7 Crown of baseball cap.

+

Fig. 8 Brim of baseball cap.

=

Fig. 9 Baseball cap.

Table 3 Cloche hat.

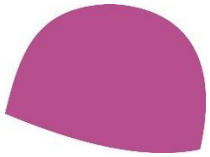

Fig. 10 Crown of cowboy hat.

+

Fig. 11 Brim of cowboy hat.

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Fig. 12 Cowboy hat.

Table 4 Cloche hat.

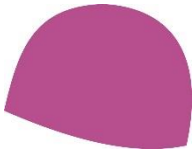

Fig. 13 Crown of cloche hat.

+

Fig. 14 Brim of cloche hat.

=

Fig.15 Cloche hat.

Table 5 Sun hat with UV-resistant function.

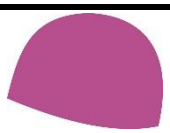

Fig. 16. Crown of sun hat

+

Fig. 17. Brim of sun hat

=

Fig. 18. Sun hat with UV-resistant function

4. SWOT Analysis

4.1 Strengths

To create diversified patterns of hat, the inventor has started to develop various patterns and styles besides selecting different fabrics and colors for hats. We aim to develop diversified patterns to fit consumers of all ages. Users will find the hats natural, lively, and pleasant while wearing it. Furthermore, the elastic environmental fabrics are applied for this Versatile Hat, this will help users with disheveled hair to save time to arrange the hair before going out. With this Versatile Hat, users can own several patterns of hat at the same time to fit in with different occasions. Additionally, easy and convenient assembly enables users to be ready to go out in a short time lively and pleasantly. The strengths of this innovative hat are:

(1) Multi-changing patterns and colors
(2) Easy and convenient assembly
(3) Suitable for consumers of all ages
(4) Customized patterns to be unique

4.2 Weaknesses

The innovation needs two patterns to become changeable hats. If the materials or the sizes of two patterns are distinctly different, it is difficult to interchange. Therefore, two patterns of hats need to be the same materials and sizes. The weaknesses of this innovative hat are:

(1) This innovative hat is restricted by the materials because hats in different materials cannot be interchanged, especially materials like knitting and weaving.

(2) When users want to select a hat in different colors of fabric to match their garment, users need to purchase extra accessories to meet this requirement, for example, a hat with decorative diamond.

4.3 Opportunities

Young people are looking for fashion and changing variety, and prefer various patterns and colors. On the contrary, the middle-aged and old-aged people are simple and industrious, and usually prefer to save time at shopping by purchasing enough items or patterns at a time. Therefore, our target customers are people of all ages as long as they like hats. The opportunities of this innovative hat are:

(1) Target market is large.

(2) Patterns of hats can be always increased and updated according to the latest fashion.

(3) Customized patterns and colors are available.

(4) UV-resistant function is added in the materials.

4.4 Threats

Many people might think that hats are suitable in only winter. However, besides protecting our eyes and heads from the sun in summer, hats can also frame our faces and enhance our styles and images. The threats of this innovative hat are:

(1) Hats are not necessity.

(2) Patterns of hats are easy to be imitated and modified.

(3) There is a wide variety of hats in the market, and distribution channels are too extensive.

5. STP Strategic Marketing Analysis

5.1 Segmentation

(1) Demographic Variable: along with the changing fashion trend, nowadays male consumers also start to wear various hat products to match their garments. Therefore, this innovative hat is not restricted by male or female users. In terms of age, the Versatile Hat is suitable for consumers of all ages. In terms of occupation, this innovative hat can be customized so it is not restricted by any occupation.

(2) Psychographic variable: this innovative hat is designed to be convenient assembled and easy disassembled; so it is easy for storage in terms of life style.

(3) Behavior Variable: in terms of benefits, owning one Versatile Hat means owning four different patterns of hats; additionally, this product is changeable and can be quickly interchanged.

5.2 Target Market

The main and secondary target market of this product are:

(1) Main target: 15~25 years old young people.

(2) Secondary target: 26~38 years old female consumers.

To understand the thoughts of the target market on the design of the product, this study conducted a depth-interview analysis on 73 male and female possible users of the product, ranging from 15~40 years old. Based from the interview, it was found that more than 70% thinks that the product is unique and has a variety of styles and functions compared to the hats available in the market and thus, is more creative and is more useful. Half of the respondents expressed that they will be more than willing to purchase the product if ever it become available in the market.

5.3 Positioning

With its strengths and differentiation, positioning of this innovation is to provide consumers a diversified hat with benefit of easy storage.

6. Marketing Mix Analysis

6.1 Product

Besides the customized patterns to meet different consumers' demand, this innovation hat is also convenient for storage and hard to distort the shape. The most noticeable feature is the fact that owning one Versatile Hat means owning four different hats. As long as the users want to change the pattern of the hat, simply change the brim wherever the users are as this product is easy and convenient to be carried (see Fig. 19 to Fig. 21).

(1) The attaching parts of button design of Versatile Hat are used in hat products in current market (see Fig. 19).

Fig. 19 Attaching parts of button design of the Versatile Hat in current market.

(2) The attaching parts of button design of Versatile Hat are used in baseball hat in current market (see Fig. 20).

Fig. 20 Attaching parts of baseball hat of the Versatile Hat.

(3) The attaching parts of button design of Versatile Hat are used in bucket hat in current market (see Fig. 21).

Fig. 21 Attaching parts of bucket hat of the Versatile Hat.

6.2 Price

To make this innovative hat an affordable product to consumers of all ages, prices are set in three types:

(1) Basic pattern: lower price with lower profit. The basic pattern has two patterns of hats for interchanging.

(2) Customized pattern: this pattern highlights its unique design and exclusive production; price is relatively higher than basic pattern and with higher profit. The customized pattern has two or more than two patterns of hats for interchanging according to customer's requirement.

(3) Deluxe pattern: this pattern can particularly satisfy consumers' need for owning multi-pattern hats at one-time purchasing; price is the highest among three types and also with highest profit. The deluxe pattern has more than two patterns of hats for inter-changing.

6.3 Place

(1) Physical Channel

a. Night Market: one of Taiwan's distinct features, and also the tourist attractions in Taiwan. Night markets are not only everywhere in cities, but also spreading in countryside.

b. Hypermarket: most modern people in the cities usually choose to shop in hypermarkets no matter for important festivals or daily-life products. The benefits attract many people to hypermarkets are its convenience and fast service especially people in cities are usually busy. Example of hypermarket: Carrefour.

(2) Virtual Channel

a. Virtual TV Channels: television is available in most households nowadays. Moreover, virtual TV channels are available most of the time, numerous people would be attracted to purchase on TV after those skillful pro-motions.

b. E-commerce: with the highly widespread internet nowadays, many physical shops transformed to E-commerce business model. To provide consumers a convenient platform to order customized hats, marketing through internet is a perfect sales channel. By establishing a website, offering customized service

anytime to numerous consumers at the same time can be effectively implemented.

6.4 Promotion

The product aim to enhance the visibility and loyalty of the Versatile Hat through below three types of promotions:

(1) Building a website on social networks for consumers to deliver opinions and information.

(2) Building a website for this innovative hat and selecting social media for advertisement.

(3) By word of mouth marketing.

7. Conclusion

The academic contribution in this paper reveals the whole process of innovation of the Versatile Hat including analysis to the prior arts, STP strategic marketing analysis, SWOT analysis, and developing strategies for Marketing Mix. The purpose of the Versatile Hat is to provide a new option for consumers who are looking for fashion trend. The basis of this new option is to provide a hat with benefits of space efficient and easy storage. When the consumers purchase one Versatile Hat, they own multi-pattern hats at one-time purchasing. Users are able to match their garments by selecting one proper hat from various patterns and fit in with different occasions accordingly. Moreover, the storage space needs to be only for one Versatile Hat rather than for several conventional hats, that is to say, the Versatile Hat is also of convenient maintenance.

Nowadays, the living expense has been rising continuously while people's salaries have been stagnating for years. In such period of economic downturn, this innovative hat offers a choice for consumers to reduce spending on hats without diminishing hat patterns. To stay in the lead in highly competitive industry, good products need to get ahead not only in the markets, but also in costs, and services aspects. This innovation has obtained patent number M416353 from the Utility Model Patent in Taiwan, and also won several prizes in international contests. The Versatile Hat will not only remove the disadvantages of current conventional hat products, but also add advantages that cannot be found in conventional hat products. With the explanation and illustration in above-mentioned paragraphs, the benefits of this innovative hat can conclude as:

(1) By the design of attaching parts on the crown and corresponding attaching parts on the brim, the crown can match various brims to become multi-pattern hats. This interchangeable structure enables this innovative hat to be greatly practical accessory in different occasions.

(2) Due to the interchangeable structure of this innovation, consumers can save spending on purchasing several different patterns of conventional hats, and also can save storage space for too many hats.

To be a good product with competitive advantages in the market, differentiation and sales skill are no longer enough. Service needs to be regarded as one main product so as to maintain in the lead in the market as well. By continuous enhancement of products' value is the only way to satisfy customers. Innovation is beyond one idea or concept. We aim to develop this Versatile Hat to the market through industry-academy cooperation or transfer of technology in the near future, and cooperate with the manufacturer in the aspects of design and sales.

References

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Chinese Encyclopedia Online (2013). Retrieved from: ttp://wikiyou.tw/%E5%B8%BD%E5%AD%90/

Chou, H. J. and Lin, C. H. (2014). The Study of the Innovation of the Versatile Hat, Symposium of Systematic Innovation of Great China and the 6th Annual Meeting of the Society of Systematic Innovation, Tainan, Taiwan.

Education Wiki (2013). Retrieved from: http://content.edu.tw/wiki/index.php/%E5%89%B5%E6%84%8F%E6%80%9D%E8%80%83%E6%95%99%E5%AD%B8.

Fahy, J. and Smithee, A. (1999). Strategic marketing and the resource based view of the firm. *Academy of Marketing Science Review, 10*, 1-20.

Hsu, L. L., Chang, M. Y., and Hsieh, S. I. (2008). Mind Mapping: A New Tool for Enhancing Student Learning Strategy. *The Journal of Nursing, 55*(2), 76-80.

Kotler, P. (1994). *Marketing Management Analysis, Planning, Implementation and Control*, 9th Ed. New Jersey: Prentice-Hall.

Kotler, P. (2001). *A Framework for Marketing Management.* New Jersey: Prentice-Hall.

Lin, C. H. (2002). *Marketing Management*. Best-Wise Publishing Co., Ltd.

Liu, H. C. (2011). A Product Metaphor Model for Innovative Design, National Taipei University of

Technology. Department of Industrial Design & Graduate Institute of Innovation and Design, 1-83.

McCarthy, G. (1960). *Basic Marketing: A Managerial Approach.* Rich and D. Irwin.

Ministry of Education (2002). White Paper on Creative Education, Department of Secondary Education of Information and Technology, Taiwan, 2.

Monroe, K. B. (1990). *Pricing Making Profitable Decisions*, 3th Ed. McGraw-Hill.

Proctor, T. (1995). Establishing a strategic direction: a review. *Management Decision, 35*(2), 143-154.

Sheu, D. D. (2011). *Mastering TRIZ innovation tools: Part I*. Agitek Consulting.

Taiwan Patent Search (2013). Intellectual Property Office, Ministry of Economic Affairs, Taiwan, R.O.C., Retrieved from: http://twpat2.tipo.gov.tw/tipotwoc/tipotwkm.

Valentin, E. K. (2001). SWOT analysis from a re-source-based view. *Journal of Marketing Theory and Practice, 9*(2), 54-69.

Weitz, B. A. and Wensley, R. (1984). *Strategic Marketing: Planning, Implementation, and Control*. Kent Publishing Company.

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10.6977/IJoSI.201512_3(4).0004
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Enhancing the Quality of Rice Milling by Systematic Innovation Techniques

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(Received 3 September 2015; final version received 15 March 2016)

Abstract

Rice is a key food of humankind, the third largest food crop in the world, behind only corn and wheat. The process of removing the rice husk, the rice skin portion, and the rice germ to make white rice is called rice milling. This empirical study applied some tools (Cause-and-Effect Diagram, QFD, FAA and TRIZ) to improve the quality of rice milling. At first, this study used Yixing Rice Milling Company in Taiwan to illustrate the process of fully automated rice milling. There are eight steps in the rice milling process system: testing, drying, refrigeration, hulling, milled rice, rice washing, color sorting, and packaging. Second, using risk assessment theory, the eight steps of the process were evaluated to determine which steps were the most vulnerable to risks. Four key factors in poor milling quality were identified: the hue recognition subsystem, the cold storage structure, ventilation, and the air pressure nozzle subsystem. Finally, the four key factors were improved with systematic innovation methods (TRIZ). We then made recommendations for improving the quality of rice production operations to Yixing Rice Milling Company.

Keywords: automated rice miller, risk assessment theory, related factors, key factors, systematic innovation technique

1. Introduction

Rice is a key food, the third largest crop on earth, behind only sugarcane and maize, according to 2012 FAOSTAT data ("Rice," n.d.). There are more than 140,000 varieties of rice plants in the world. The simplest way to classify rice is according to their starch content. Rice starch consists of amylose and amylopectin. The lower the amylose content, the higher the viscosity of the boiled rice. Based on the differing proportions of amylose and amylopectin in rice, its varieties can be divided into three categories: indica rice or Raimi (Oryza sativa hsien), Japonica rice or Penglai rice (Oryza sativa keng) and glutinous rice (Oryza sativa var glutinosa) (Owen, 1996).

Rice without the rice husk is called brown rice. Because of its rough fiber that resists moisture, boiled brown rice is usually hard and without viscosity. Its taste is not popular. In order to satisfy the public taste, brown rice will generally be ground and peeled (removal of the bran layer) before sale. It is then known as embryo rice. Because rice germ is rich in nutrients, has a high fat content, and easily becomes moldy during storage, the rice germ is usually removed before the rice is sold. After the germ of the embryo rice is milled away, the rice becomes white rice. The grain texture of rice white is clear and crystalline, and its taste is preferred by the public.

The process of removing rice husk, the skin portion, germ, and making white rice is called rice milling.

This research first used the example of fully automated rice milling performed at Yixing Rice Milling Company in Taiwan. The rice milling process system has eight steps: inspection, drying, refrigeration, hulling, milled rice, rice washing, color sorting, and packaging. Second, using risk assessment theory, the eight steps of the process were evaluated to determine those steps that were most vulnerable to risk. After analyzing these steps, factors that cause poor milling quality were identified. Using these factors, the key factors were revealed. Finally, using a systematic innovation approach, the key factors in poor quality rice milling were addressed to help the rice miller improve rice production operations.

2. Evaluating the rice milling process and determining key factors

2.1 Evaluating the rice milling process

In this study, the factory manager, engineers, and workers of Yixing Rice Milling Company were first invited to describe and discuss the eight steps of the rice milling production process. Using two indexes which refer to the degree of severity and the probability of an event occurring, a risk assessment for rice milling production process at the company was performed. Three steps, drying, refrigeration, and color sorting appeared to have the greatest risk. After addressing potential problems, the quality of rice milling should increase.

2.2 Identifying vital factors from the three steps of great risk

This study used a Cause-and-Effect Diagram to analyze the three riskiest steps in the rice milling process and identified eight factors that cause poor quality rice milling: (A) refrigerated barrel structure; (B) air conditioner; (C) ventilation facilities; (D) hue recognition subsystem; (E) pressure nozzle subsystem; (F) Moisture testing; (G) Heat temperature; and (H) Rice transporting mechanism, as shown in Figure 1.

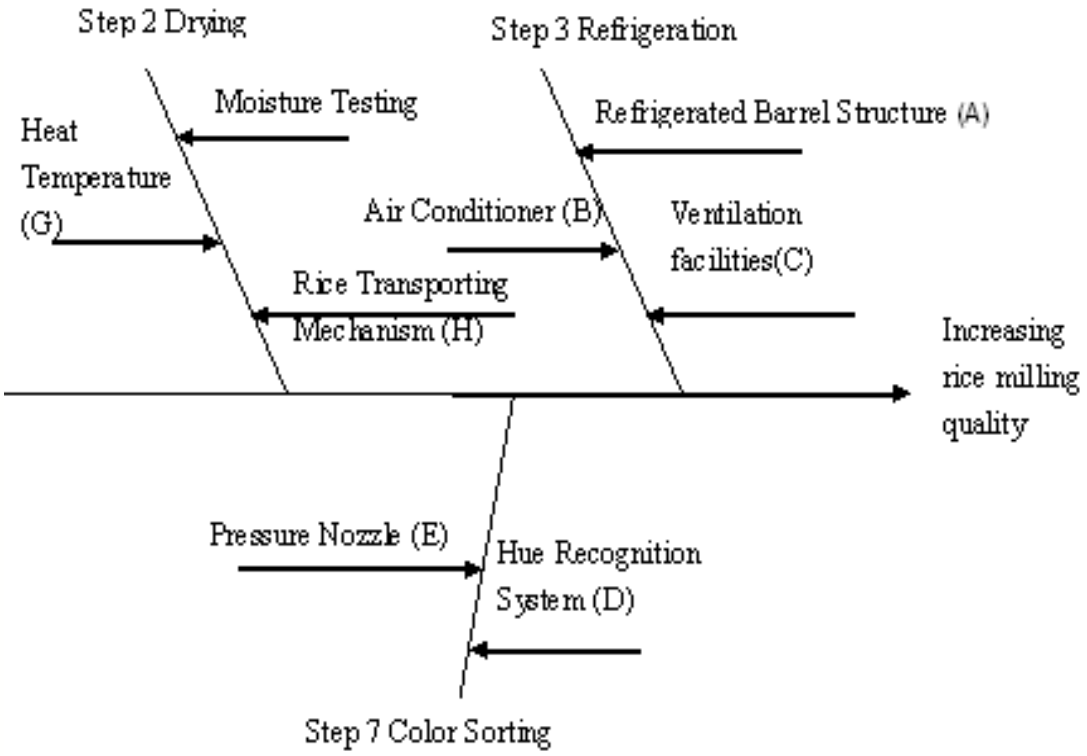

Fig. 1 Analysis of cause-and-effect diagram for enhancing rice milling quality.

2.3 Determining key factors

Using Quality Function Deployment techniques, we determined the key risk factors from among the eight risk factors. From the QFD (Quality Function Deployment) table (Table 1), we chose the four largest weight values (TWi): (1) hue recognition subsystem (D); (2) cold storage structure (A); (3) ventilation facilities (C); and (4) pressure nozzle subsystems (E). These became the four key factors for improving rice milling quality. The next step was to address the four key factors with a systematic innovation approach.

Table 1 Determining the key risk factors for enhancing the rice milling process.

Weight Definition w_i Very Strong 4.0 Strong 3.0 General 2.0 Weak 1.0 Unrelated 0.0		Important factors/Vital factors								
		Risk indexes δ_i	A. refrigerated barrel structure	B. air conditioner	C. ventilation facilities	D. hue recognition subsystem	E. pressure nozzle subsystem	F. Moisture testing	G. Heat temperature	H. Rice transporting mechanism
Riskiest steps	Refrigeration	0.53	4	3	4	2	1	0	1	1
	Color sorting	0.50	2	1	1	4	4	0	1	1
	Drying	0.43	1	0	1	2	1	4	4	4
Weight value (TW_i)			3.55	2.09	3.05	3.92	2.96	1.72	2.75	2.75
Key factors			2		3	1	4			

3. Addressing risk factors via a systematic innovative approach

TRIZ is derived from the Russian Theoria Resheneyva Isobretatelskehuh Zadach, translated into English as An Innovative Theory for Solving Problems, which means a new and different theory of solving problems. As long as the procedures of the theory are followed using its practical tools, improvements can be made.

The QFD table analysis showed that quality of the milled rice can be increased by focusing on improving four key factors, (1) the hue recognition subsystem (D); (2) cold storage structure (A); (3) ventilation facilities (C); and (4) pressure nozzle with four subsystems (E). Two of the key factors, namely the hue recognition subsystem (D) and the pressure nozzle subsystem (E), are part of the color sorting step of the rice milling process, which is performed by a color sorting machine (Figure 2). The color sorter is composed of subsystems of component combinations, which makes it suited to functional attribute and causal chain analysis via the TRIZ. Two other key factors, the cold storage structure (A) and the ventilation facilities (C) are part of the refrigeration step in the rice milling process. They were more suited to analysis by the contradiction matrix of TRIZ.

Fig.2 Color Sorter.

3.1 Improving the color sorting step

3.1.1 The overall process of two subsystem components in a color sorter

A color sorter structure is divided into two parts, the primary choice and the second choice. There are two subsystems. The first is the hue recognition subsystem with four main components, the rice flow speed control valve, the illumination lamp, optical lenses and cameras, and the hue decision processor. The second subsystem is the pressure nozzle subsystem which has two main components, the nozzle and compressors. When the grains of rice flow into the color sorting machine, the rice flow speed control valve of the hue recognition subsystem initializes. The grains vibrating in different rice chutes and are sequentially led into a 2/3 position on the left side of the primary groove. When the rice enters the primary groove, the grains of rice fall in a curtain-like waterfall from the groove of the subsystem, as shown in Figure 2. The amount of falling rice and the speed are controlled by the rice flow speed control valve. The higher (lower) the control valve setting, the closer (farther) the rice grains of the rice fall plane are, and the faster (slower) the rice flow. At the same time, the rice flow speed control valve controls the rice flowing into the color sorting machine from both the primary and second grooves.

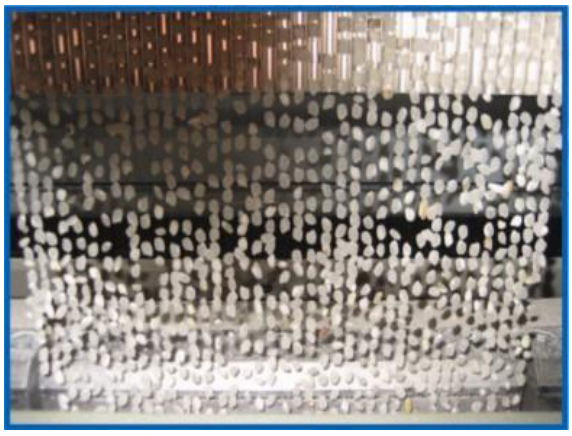

Fig. 3 The grains of rice fell down in a curtain-like waterfall manner from the groove of the color sorter.

At the moment the light was projected on falling rice waterfall plane by illumination lamp. Simultaneously each row of falling grains is imaged by the camera, and the resultant images sent to the hue decision processor. Based on the images, the hue decision processor identifies the color, transparency, and size of a grain of rice and determines whether the rice is acceptable. If the grains of rice are judged acceptable by the hue recognition subsystem, they fall into the acceptable rice collection area. This process is the primary choice process. If a row of grains is judged to be unacceptable, the pressure nozzle subsystem located at the bottom of the waterfall plane initiates and the nozzle blows the unacceptable rice into a temporary collection area using high-pressure air. When the unacceptable rice is blown out, acceptable rice may be blown into the temporary collection area. Therefore, a second color sorting known as the re-election is necessary.

Re-election begins when a bucket elevator machine sends the grains from the temporary collection area into the re-election groove that is on a 1/3 position of the right side of the groove. Again color sorting is conducted via the hue recognition subsystem and the pressure nozzle subsystem as in the primary choice. If the second choice also rejects the rice, the pressure nozzle subsystem blows them out into the unacceptable rice collection area. The primary choice groove is also used during the re-election process. The former was on the 2/3 of the left side, and the latter was on the 1/3 of the right side of the groove. Therefore, falling primary choice grains occupy in the 2/3 of the left side of the rice waterfall plane, while re-election rice grains fall on in the 1/3 of the right side.

Because of the different colors and translucencies of the rice varieties, before conducting color sorting, the hue decision processor should be adjusted to distinguish the color, transparency and size standard of the grains based on the variety of rice being processed. After the best grain color, transparency, and size standard of each variety of rice grains are determined, the color sorting can be performed. The overall flow diagram for judging the rice quality in the color sorting machine is shown in Figure 4.

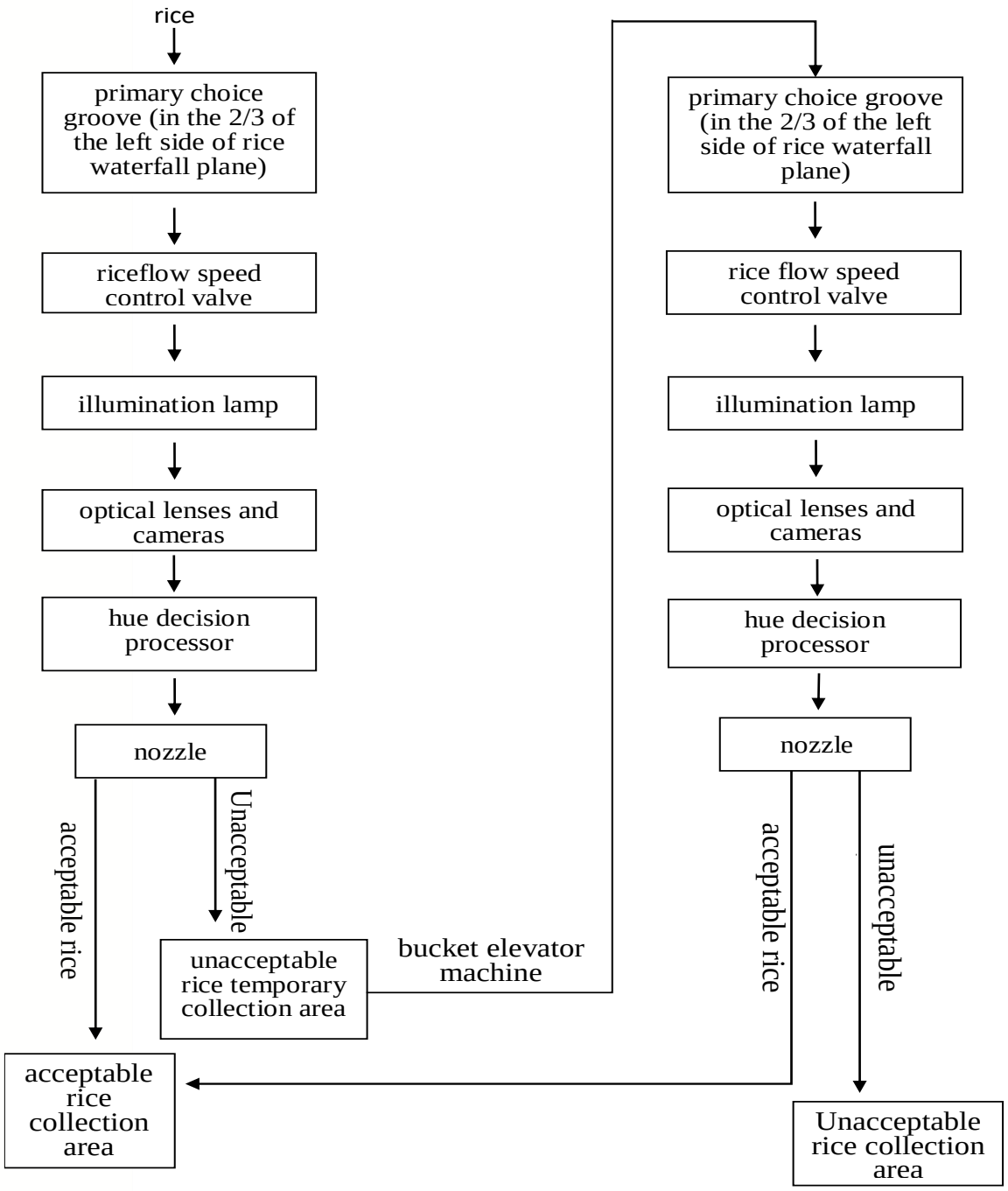

Fig. 4 Flow diagram for rice quality evaluation via color sorting machine.

3.1.2 Causal chain of functional attributes of the components of the color sorter

We next analyze the functional attributes of the components in the hue recognition subsystem and the pressure nozzle subsystem of the color sorting machine to determine the causal chain. During function attribute analysis (FAA), the components of the system or subsystem are dismantled to identify the relationships between the components and the main function or subsidiary functions of components. This enables determination of which relationships are helpful and which are functional, inadequate, or harmful. Functions that are over-functional, inadequate, or harmful are called negative functions. Using the negative functions of the relationship among the various components, we can find the conflicts among the functions and resolve them (Kowalick, 1996).

In this study, the functional attributes of the color sorter's components were plotted into a causal chain of functional attributes in frames, based on the overall sorting process. The functional attribute causal chain was analyzed as shown in Figure 5. In Figure 5, where the process contains negative functions, they are marked as with symbols representing insufficient, over-functional, and harmful. Components possessing negative functions are termed "color sorter important functional components" and marked with double borders. Five components, the rice flow speed control valve, illumination lamps, optical lenses and cameras, the hue decision processor, and the nozzles were so marked. The remaining components were termed secondary components and are covered by a single border.

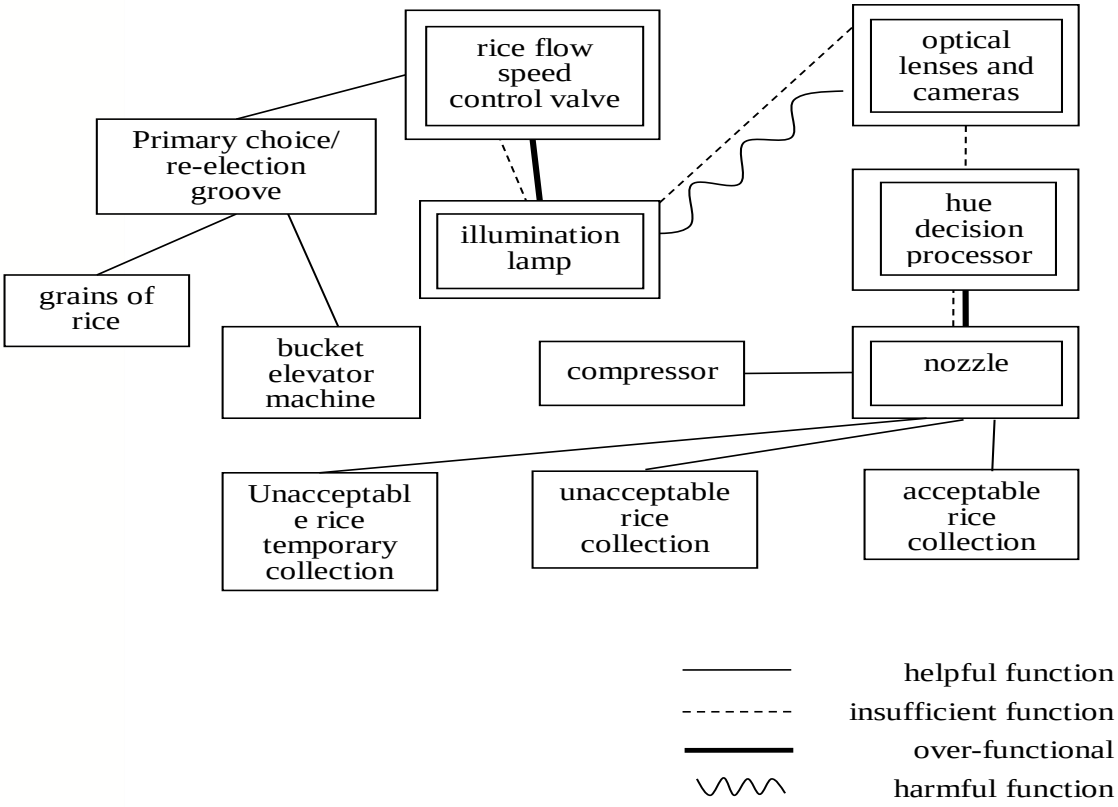

Fig.5 Analysis of functional attributes of the color sorter components.

3.1.3 FAA-based improvement plan for the color sorter

(1) Rice flow speed control valve

The rice flow speed control valve controls the flow of grains in the primary choice groove and the re-election groove. If the flow of rice is mishandled, the distance between the rice grains in the rice waterfall plane would be wrong, and insufficient/over-function would occur, involving the illumination lamps. Therefore, before the grains of rice enter the primary choice groove, a small portion of rice should be tested to determine the valve opening size to ensure the quality of color sorting.

(2) Illumination lamps

The illumination lamps project light onto the rice waterfall plane. Over time their illumination falls as their lamps wear out. Thus the optical lenses and cameras may not have enough light, producing a frequency spectrum shift. Moreover, the lamps, lenses, and cameras should not be placed too closely to one another. If the distance is too close, interference may occur, resulting in insufficient/harmful function. Our improvement plan involved regular checking and testing of the brightness of illumination lamps to ensure their output was 990 to 1100 lumens as specified.

(3) Optical lenses and cameras

The function of optical lenses and cameras is to image the rice waterfall plane. As the grains of rice fall, they throw off bran fiber. Over time this makes the lenses dirty and causes the hue decision processor to generate false judgments, an insufficient function. The improvement plan involved regularly cleaning the optical lenses to ensure that the camera is functioning properly.

(4) Hue decision processor

The hue decision processor identifies the color, transparency, and size of the rice grains in based on the imagery generated by the imaging system. If it is malfunctioning, it may produce false judgments of the rice color or quality, which in turn may cause the nozzles to function improperly. Our improvement plan was to make appropriate color adjustments for the quality of each batch of rice and test a small portion of rice first to ensure that the processor is functioning properly.

(5) The nozzles

Using high-pressure air produced by the compressor, the nozzle blows grains judged unacceptable by the hue decision processor into the poor rice temporary collection area or the unacceptable rice collection area. If the pressure of the nozzle is too high, acceptable rice around unacceptable rice may also be removed. Conversely, if it is too low, not enough unacceptable rice will be removed from the stream of rice, an over-/insufficient function problem. Our improvement involved checking and testing the nozzle and the compressor to ensure they were at the recommended pressure of 2.6kg/cm² to 2.8kg/cm².

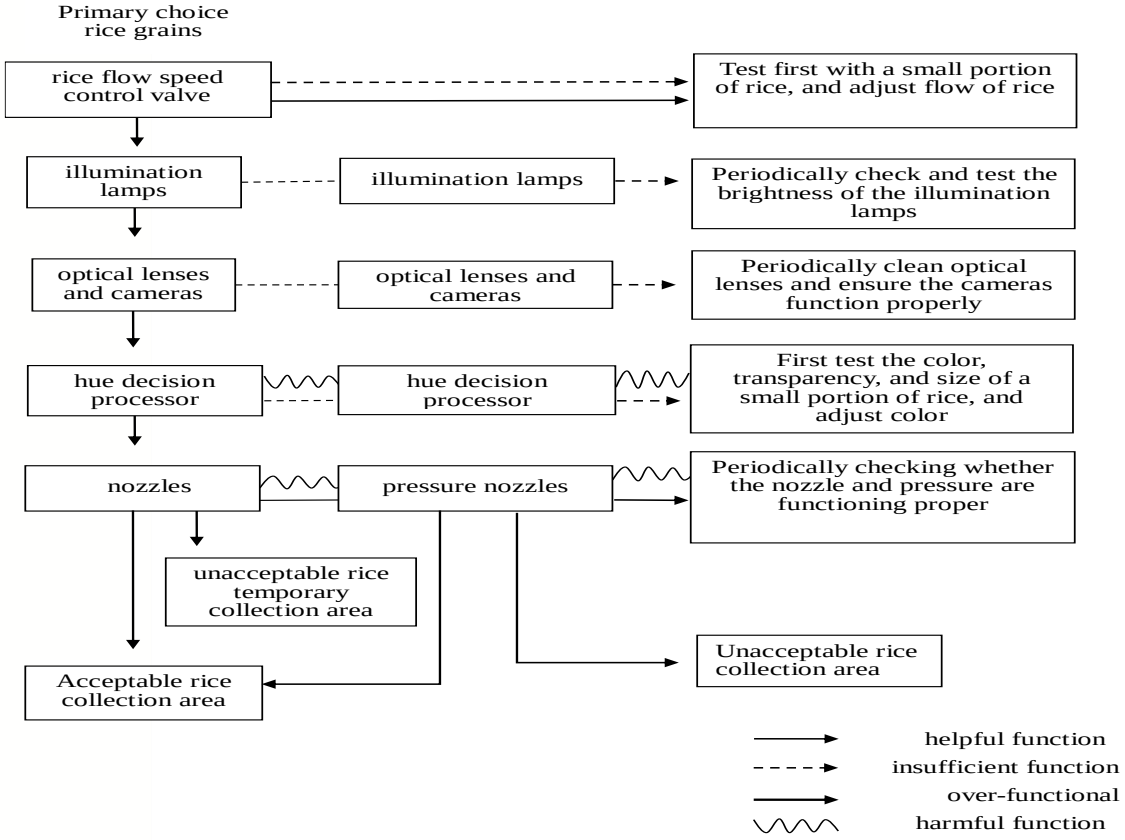

Fig. 6 Improvement plan of five problematic functional components in a color sorter.

3.2 Using TRIZ to improve the cold storage structures and ventilation pipelines

There are two kinds of contradiction matrices, technical and physical contradiction. A technical contradiction occurs when improving a parameter in a system negatively affects another parameter. For example, increasing lamp brightness contradicts the need to save electricity. Physical contradiction occurs when arrangements conflict, such as when an umbrella must be large yet space is lacking. Technical contradictions can be analyzed and resolved through a contradiction matrix, while physical contradictions can be resolved by using a different separation principle. The solution is the use of 40 invention principles (Hsia, Huang, and Chen, 2011).

Our study found that two other key factors in the quality of rice milling are the refrigerated barrel structure (A) and the ventilation facilities (C). The technical contradiction approach may be used to solve problems, as described below.

3.2.1 Refrigerated barrel structure (A)

Each refrigerated barrel consists of four large soldered steel plates and can hold 100,000 kg of rice.

Over time, the weight of the grains deforms the cold storage barrels. Cracks are produced at the seams and some of the rice is not refrigerated properly. This problem is a typical technical contradiction in a systematic innovation technique (TRIZ), specifically described as follows: "A refrigerated barrel saves more rice but does not exhibit structural deformation of the chilled barrel." Some of 39 engineering parameters were reviewed to solve this problem. The parameters which might improve the problem were item 11 "tension, pressure" and item 13, "object stability", while item 2, "fixed object weight", may reduce the problem. On the basis of this analysis, a technical contradiction matrix table was created as shown in Table 2. In Table 2 the helpful innovative principles were principles 1, 10, 13, 18, 26, 29, 39, and 40.

Table 2 Technical contradiction matrix table for the refrigerated barrel structure (A).

parameters that cannot be changed / parameters that may changed		Fixed object weight
		item 2
pressure, tension	item 11	13, 29, 10, 18
object stability	item 13	26, 39, 1, 40

Based on the above-mentioned eight innovative principles, the problem resolution plan was:

(1) Principle 10: pre-action: making changes before problems occur.

The problem resolution plan for this principle was that the internal steel plates of the four sides of the refrigerated barrel were riveted and the plates bound tightly with steel cables to reinforce the structure.

(2) Principle 26: copy: replacing the objects or systems which are expensive and have defects with simplified or inexpensive copies.

The plan called for the seams of the barrels to be welded to reinforce the structure.

(3) Principle 39: inert environment: to add a neutral substance or blunt additives in objects or in the system.

The problem resolution plan using this principle was to eliminate rust in the steel plate joints and to paint the exteriors of the steel plate to prevent rusting."

(4) Principle 40: composite materials: replace homogeneous materials with composite materials.

The company installed Teflon insulation inside the four plates of the refrigerated barrel to ensure energy savings.

(5) Four additional innovative principles were segmentation, reverse, vibration, and hydraulic. Because they had no significant application to the problem, they were not put to use.

3.2.2 Ventilation facilities (C)

There are 33 refrigerated barrels in the refrigerator. Cold air is generated by the refrigeration unit and circulated from each ventilation pipe to each refrigerated barrel. If the ventilation pipes become clogged or the ventilation gates fail to control the flow of cold air, cold air cannot enter barrels when needed. This is a typical technical contradiction, described as "barrels maintain long-term temperature, and ventilation facilities do not allow exceptions." The 39 engineering parameters were again used to review the problem. The parameter which may address the problem was item 13, "the stability of object" and the parameters which might prevent further deterioration were item 17, "temperature" and item 23, "material loss." The technical contradiction matrix table was created on the basis of the problem as shown in Table 3. The helpful innovative principles were principles 1, 2, 14, 30, 32, 35, and 40.

Table 3. Technical contradiction matrix table of ventilation facilities (C)

Parameters that cannot be changed / parameters that can be changed		temperature	material loss
		item 17	item 23
stability of object	item 13	35, 1, 32	2, 14, 30, 40

On the basis of the above-mentioned seven innovative principles, the problem resolution plan was:

(1) Principle 1: the role of segmentation: A composite object was made. Principle 2: separation/ extraction: involves refining, removing, or separating the beneficial parts or attributes out of an object. The temperature inside the refrigerated barrel should be controlled at 14-18 °C. If too high, rice quality declines. Based on these two principles, the problem resolution plan was to install temperature sensors in the 33 refrigerated barrels and a networked computer system was used in the monitoring room for displaying the temperature of each refrigerated barrel.

(2) Principle 30: flexible films and thin films: replacement of solid structures by flexible shells and

thin films. Using this principle, the resolution plan was when the temperature sensors were installed inside the refrigerated barrels, automatic gate controllers replaced less accurate manual turning on/off to ensure refrigeration quality.

(3) Principle 32, changing color: Color additives or light emitting elements are put to use to improve the visibility of objects. Based on this principle, the resolution plan was to install temperature stickers on common pipelines. If the temperature was unusual, staff can inspect the different colored temperature stickers to determine which ventilation pipeline has abnormal air supply.

(4) Principle 40, composite materials: replacement of homogeneous materials with composite materials. The problem was resolved by installing insulating films on the ventilation pipe exteriors to keep pipe air from leaking during the pipeline transportation process.

(5) Two innovative principles, "spherizing" and "physical or chemical state change" had no significant application to the problem and were not adopted.

4. Conclusion and Suggestions

This study has investigated the rice milling production process of Taiwan Yixing Rice Milling Company. The eight steps of rice milling production process were first analyzed using risk assessment theory to determine the three steps with the greatest risk, drying, refrigeration, and color sorting. Next, using a cause-and-effect diagram, we identified eight factors that cause poor quality rice milling in the three steps. We then analyzed the eight vital factors using quality functional deployment techniques to determine the four key factors: the hue recognition subsystem, the refrigerator structure, the ventilation facilities, and the air pressure nozzle subsystem. Finally, we used TRIZ to address the problems of the four key factors. This study emphasizes the four key factors involved in color sorting and refrigeration. We recommended that Yixing Rice Milling Company address them to enhance rice milling quality. We made five recommendations for color sorting (1) a small portion of grains entering the color sorting system should be checked first to test the rice flow speed control valve, and to adjust the size to ensure the quality of color sorting; (2) the brightness of illumination lamps should be periodically checked and tested to maintain them at the recommended 990 to 1100 lumens; (3) the optical lenses and cameras should be cleaned and proper camera function checked periodically; (4) the hue decision processor should be tested with a small amount of grain first to ensure that the processor can correctly identify the grain color, transparency, and size of the grain; and (5) the nozzles and the compressor pressured need to be periodically checked.

Two recommendations were made for the refrigeration system: (1) to reinforce the refrigerated barrel, its steel plates of the four sides of each refrigerated barrel were tightly bound with steel cables. Rust should be regularly removed from the plate joints, and Teflon insulation lining installed inside the four side steel plates of the refrigerated barrel to ensure no leakage of cold air. (2) Networked temperature sensors were installed in 33 refrigerated barrels. These enable temperature monitoring in the control room. Automatic gate controllers were used to replace less accurate and slower manual turning on/off. (3) Temperature stickers were affixed on common pipelines. If the temperature was outside normal parameters, the colors change, which staff can see.

Acknowledgments

The authors would like to express their appreciation to the Ministry of Science and Technology under Grant 104 -2622 -E -270 -002 -CC3 for the support of this research.

References

Hsia, T. C., Huang, S. C. and Chen, H. T. (2011). Enhancing the writing quality of aircraft maintenance technical orders and establishing a management mechanism for maintenance technicians using the Six Sigma Process. In David E. Malach (Eds.), *Advances in Mechanical Engineering Research,* Volume 3. Nova Science Publishers, Inc.

Kowalick, J. F. (1996). Use of functional analysis and pruning with TRIZ and ARIZ to solve "Impossible to Solve" problems. *Journal of TRIZ.*

Owen, S. (1996). *The Rice Book: The Definitive Book on Rice, with Hundreds of Exotic Recipes from Around the World.* St. Martin's Press.

Rice. (n.d.). In *Wikipedia*. Retrieved November 15, 2015, from https://en.wikipedia.org/wiki/Rice

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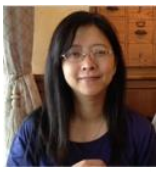

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