VOL. 11, NO. 12, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

INCORPORATING CUSTOMER REQUIREMENTS IN ASSESSING CRITERIA BASED ON TRIZ - A CASE STUDY

Faiz Mohd Turan
Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, Pekan, Pahang, Malaysia
E-Mail: faizmt@ump.edu.my

ABSTRACT

In order to remain competitive in today's technologically driven world, companies try to determine the optimal settings of design attribute of new products from which the best customer satisfaction can be obtained. Identification of customer requirements is the starting point of design process. Most of design approaches focus on technical domains to define customer requirements. However, the success of product design nowadays goes beyond technical features; it often depends heavily on multi-facets of customers' needs including various business parameters. In this paper, a method of incorporating customer requirements for criteria assessment in design evaluation process has been developed. The first stage of the methodology selects the criteria and identifying parameters. The second stage calculates the weight of TRIZ (an acronym for the Theory of Inventive Problem Solving). Case examples from industry are presented to demonstrate the efficacy of the proposed methodology. The result of the example shows that the application of TRIZ in assessing criteria by incorporating customer requirements provides an alternative to existing methods.

Keywords: customer requirement, criteria assessment, TRIZ.

INTRODUCTION

Affective design has been shown to excite psychological feelings of customers and can help improve the emotional aspects of customer satisfaction (Jiang, 2015). It is an important design strategy to enhance customer satisfaction of new products in customer-driven product development (Dreyfuss, 1955). Design attributes, such as shape and color, evoke the affective responses of customers to products (Keller, 1993). Products with good affective design can help attract customers and influence their choices and preferences, such as loyalty and joy of use (Creusen, 2005; Noble, 2008). The process of affective design includes identifying, measuring, analyzing, and understanding the relationship between the affective needs of the customer domain and the perceptual design attributes in the design domain (Lai, 2005).

A successful product design today has to provide the necessary functions, to offer sufficient business returns, to generate enthusiasm in the market and to comply with various regulatory standards such as sustainability and safety (Wang, 2011). In fact, product design has long been considered as a fusion of different disciplines and a multiple dimensional task, involving the participation of engineers, industrial designers, and business managers along with customers' participation (Barnes, 2009). The interdisciplinary nature of design cutting across diverse fields in engineering, business, science and arts has become more prominent than ever. However, because engineering, business and art are three distinctive academic areas, most education programs cannot address the design issue in a holistic manner. In lieu of a common foundation to address the design issues, it is unavoidable that there are disconnections behind the knowledge, education, tools and skills of design. The disconnections in these three areas, technical, business and aesthetic can sometimes become extremely difficult to overcome in theory and practice.

To achieve a holistic design with the consideration of design from all three areas of engineering, business and art, it is imperative to incorporate comprehensive customer requirements and preferences into design (Luo, 2008). Traditional engineering design methodologies focus more on technical requirements which are often represented in quantitative and explicit form (Pugh, 1996). On the other hand, customers' perceptions and preferences like appearance, aesthetics, affection, usability and comfort of products are considered as subjective, and hence called subjective characteristics (Finger, 1989a). They often are ignored in the technical design literature. The inability to include the subjective and qualitative customer preferences has limited the progress of holistic design methodology (Turan, 2014). To certain extent, it can be attributed to the gap between theory and practice. This is particularly true in today's dynamic marketplace. The success of product design cannot depend only on technical merits or business analysis. Instead, the qualitative and subjective factors such as affection, aesthetic appearance, and easy-to-use can be just as important, if notmore. Thus, it becomes imperative that design methodology should include not only quantitative data but also subjective customer preferences (Brown, 1995).

In the research of product design, the understanding of comprehensive consumer requirements and preferences becomes more critical because customer centric product design and manufacturing has become the mainstream in academia and industrial practice (Tseng, 1998).

In engineering design, customer preferences are expressed in functional requirements or design parameter language (Pahl, 2007). Customer preferences elicitation task can be considered as the specification definition procedure, i.e., customers only need to specify the alternative of each product attribute. This process is also referred to as product configuring, with the purpose of

ARPN Journal of Engineering and Applied Sciences

translating subjective customer needs into tangible specifications (Suh, 1990). However, the configurator based customer needs elicitation system requires customers to express their needs in aspecific design parameter domain. The methods cannot capture customers' perceptions and preferences on the subjective characteristics (Finger, 1989b).

Customer preferences elicitation and modelling is also an active research topic in marketing science. Conjoint analysis is perhaps the most widely used tool to elicit customer preferences. It is commonly adopted to determine how people value different features which constitute an individual product (Green, 1971). In this method, the respondent is required to express his preference or choice among products shown to him. Then conjoint analysis estimates psychological tradeoffs that the respondent makes when evaluating several attributes together by the revealed preferences. However, conjoint analysis focuses more on products' physical attributes since they are well defined and the same for every customer. Thus, it is hard to directly elicit customers' subjective preferences.

CHALLENGES

Incorporating the comprehensive customer requirements into design can be a challenging task due to the following reasons (Lilien, 1992; Suh, 1990);

(a) The difficulty of characterizing the customer subjective preferences: product subjective characteristics are not as well defined as components or tangible attributes. Each individual customer's perceptions to the product depend largely on complicated internal and external factors and differ from person to person. For example, when selecting a cell phone, different customers may have totally different perceptions of aesthetics, comfort and easy-to-use to the same product. The levels of subjective preferences and the corresponding scales may vary significantly across customers.

(b) The wide variation complexity of customer preferences: customer preferences and requirements are context-dependent (Wang, 2008). Customers may vary in their preferences and decision making criteria due to the purchase situation changes. The external factors like mood, emotion or impulsive feeling can also affect their preferences and requirements.

(c) The difficulty of eliciting and integrating the subjectivepreferences into design: one of the reasons that design teamsremain to be disconnected lies in the difficulties in elicitingcustomer needs towards product's subjective characteristicswhich are usually latent, as opposed to known function-based physical requirements. Although various techniques such as weighting ratio and data mining can identify personal profiles based on previous purchasing history and personal backgrounds to extrapolate personal preferences, however, these approaches tend to be heavily skewed towards product functional attributes. Thus, the links between customer needs and products' subjective characteristics often become disconnected. Though the design research has recently been getting attention, the established research on product design focuses primarily on engineering design and business strategy perspectives. There still lacks efficient ways of incorporating subjective and qualitative design parameters into the design process.

METHODOLOGY

The general framework of the approach is as depicted in Figure-1.

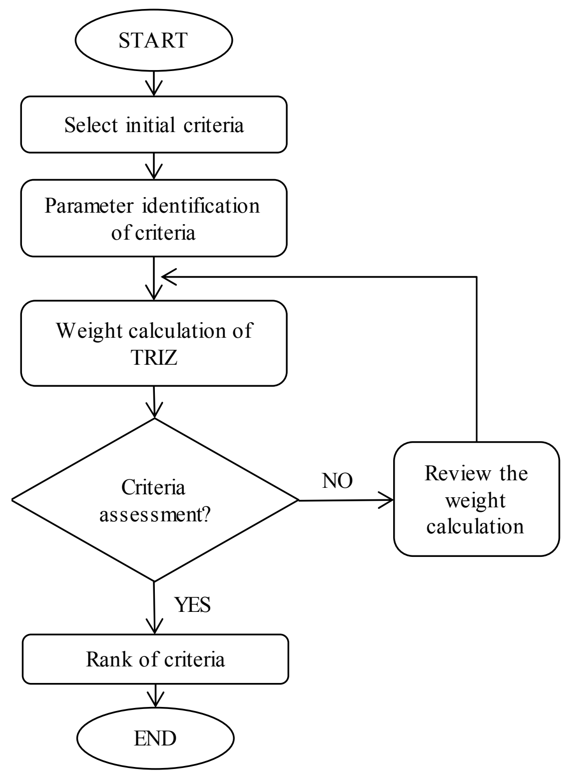

Figure-1. General framework of proposed approach.

Stage 1

Criteria selection:

(a) Selecting initial criteria based on technical documents and the results of a prior survey.

(b) Parameter identification of selected criteria according to voice of customers.

Stage 2

Weight calculation of TRIZ for criteria:

To choose a design, an initial set of criteria should be identified based on the characteristics of the requirements. Figure-2 shows how the weight of criteria of TRIZ is calculated. The maximum number of criteria is 40.

VOL. 11, NO. 12, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

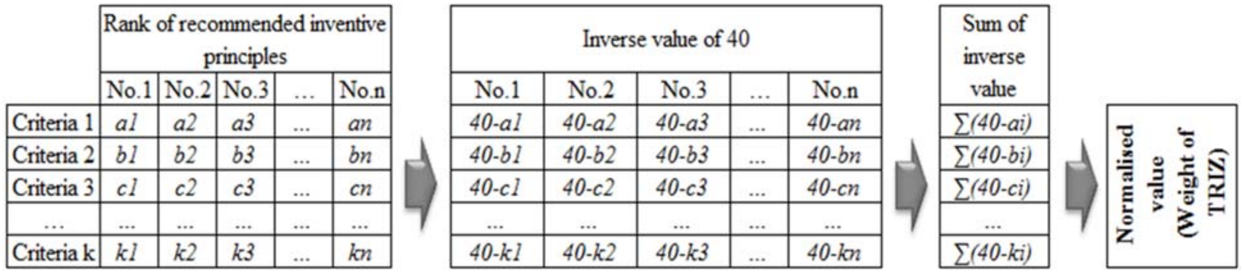

Figure-2. Weight calculation method for TRIZ.

CASE STUDY

In the case study, the criteria and alternatives formulation will involve initial criteria selection from technical documents and survey results from questionnaires. The application is to select the best potentiometer design among six developed concept designs, which have been designed by the design engineers. These alternatives are depicted in Figure-3. From the point of view of the design engineers, all six alternatives could potentially be manufactured. There are five decision makers whose views are deemed important and they should be taken into account for making a decision. They are the OEM customers, distributors, sales department, manufacturing department and top management group.

The proposed method will rank the criteria in order to optimise the process of design evaluation by desirgn engineers. Table-1 lists the initial criteria for the case study. Initially, there are total of 32 criteria being selected by the design engineers based on technical documents and the results of a prior survey.

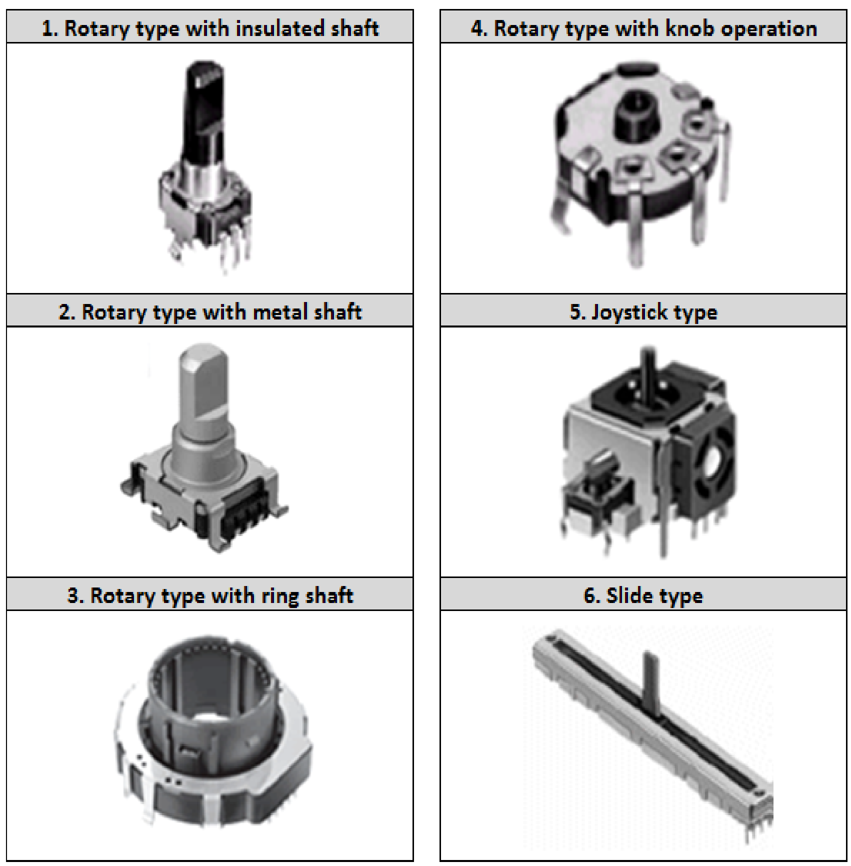

Figure-3. Design alternatives.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-1. Initial criteria.

No.	Voice of customers	Relevant criteria
1	Product's cost/price?	Cost
2	Existing customer? Potential customer?	Customer
3	Type of materials used to produce this product?	Materials
4	Quality and reliability of the product?	Quality and reliability
5	Product's weight?	Weight
6	Total life of the product?	Product life span
7	Maintenance level in producing the product?	Maintenance
8	Does the product fulfil world's environmental standard?	Environmental
9	Disposal related to product assembly process?	Disposal
10	Product's performance?	Performance
11	Facilities used in producing the product?	Manufacturing facilities
12	Product's aesthetic?	Aesthetics, appearance and finish
13	Packing style for finished products?	Packing
14	Product's size?	Size
15	Standards and specifications of product?	Standards and specifications
16	Is the product competitive?	Competition
17	Does the product going through all required test?	Testing
18	Is the process of producing this product reliable?	Processes
19	Storage of finished products?	Shelf life (storage)
20	Quantity of each lot/batch?	Quantity
21	Product's service life?	Life in service
22	Safety level in producing the product?	Safety
23	Is there any patent conflict?	Patent, literature and product data
24	Internal constraints?	Company constraints
25	Shipment condition?	Shipment
26	Is the documentation available/completed?	Documentation
27	External constraints?	Market constraints
28	Is the process comfortable (human factors)?	Ergonomics
29	Time consuming?	Time-scales
30	Product's installation into the counter part?	Installation
31	Follow the procedure/legal aspect?	Legal
32	Any effect from political and social issue?	Political and social implications

RESULTS

Based on the TRIZ contradiction principle, the undesired effects (UDEs) are eliminated first. Then, experts in the multidisciplinary team identify those parameters to be improved and those parameters that worsen for each criterion and finally, determine the recommended inventive principles using the TRIZ contradiction matrix. Table-2 depicts the weight calculation results of TRIZ for all criteria using the new proposed method.

ARPN Journal of Engineering and Applied Sciences

Table-2. Weight calculation results for TRIZ.

Criteria	Rank of recommended inventive principles				Inverse value of 40				Sum of inverse value	Weight of TRIZ
Low performance	14	21	5	17	26	19	35	23	103	4.14%
Not environmental friendly	20	12	2	18	20	28	38	22	108	4.34%
Life in service issue	28	15	20	1	12	25	20	0	57	2.29%
Difficult to maintenance	1	3	10	29	39	37	30	11	117	4.71%
High cost	9	11	4	8	31	29	36	32	128	5.15%
Not competitive	6	12	9	0	34	28	31	0	93	3.74%
Late shipment	35	28	2	24	5	12	38	16	71	2.86%
Packing not suitable	28	32	1	0	12	8	39	0	59	2.37%
Total quantity/lot not match	-	0	0	0	0	0	0	0	0	0.00%
Insufficient facilities	5	0	0	0	35	0	0	0	35	1.41%
Size not match	34	5	1	0	6	35	39	0	80	3.22%
Weight not match	1	2	7	21	39	38	33	19	129	5.19%
Not attractive design	9	6	11	0	31	34	29	0	94	3.78%
Low grade of materials	1	5	17	11	39	35	23	29	126	5.07%
Shorter product life	8	1	26	3	32	39	14	37	122	4.91%
Not achieve minimum standards and specifications	10	19	1	0	30	21	39	0	90	3.62%
Too many movement	21	40	7	1	19	0	33	39	91	3.66%
Not meet customer requirement	5	28	4	23	35	12	36	17	100	4.02%
Low quality and reliability	13	12	11	0	27	28	29	0	84	3.38%
No good shelf life	34	5	1	0	6	35	39	0	80	3.22%
Difficult to assemble	13	11	3	0	27	29	37	0	93	3.74%
Time-scales issue	9	11	4	8	31	29	36	32	128	5.15%
Insufficient testing	13	17	4	0	27	23	36	0	86	3.46%
No good safety	5	35	0	0	35	5	0	0	40	1.61%
Company constraints	-	0	0	0	0	0	0	0	0	0.00%
Market constraints	3	16	28	0	37	24	12	0	73	2.94%
Patent cost	-	0	0	0	0	0	0	0	0	0.00%
Political and social implications	-	0	0	0	0	0	0	0	0	0.00%
Legal issue	-	0	0	0	0	0	0	0	0	0.00%
Installation issue	38	3	8	24	2	37	32	16	87	3.50%
Documentation not complete	1	38	13	22	39	2	27	18	86	3.46%
Disposal issue	2	3	15	14	38	37	25	26	126	5.07%

ARPN Journal of Engineering and Applied Sciences

Table-3 presents the summary of criteria that have been assessed based on TRIZ, including the relative weight or relative importance of each characteristic after incorporating the customer requirements. The weight obtained will be ranked, filtered and used by design engineers as a reference for the next process.

Table-3. Summary of criteria.

No.	Specifications	Weight
1	Weight	5.19%
2	Cost	5.15%
3	Time-scales	5.15%
4	Materials	5.07%
5	Disposal	5.07%
6	Product life span	4.91%
7	Maintenance	4.71%
8	Environmental	4.34%
9	Performance	4.14%
10	Customer	4.02%
11	Aesthetics, appearance and finish	3.78%
12	Competition	3.74%
13	Processes	3.74%
14	Ergonomics	3.66%
15	Standards and specifications	3.62%
16	Installation	3.50%
17	Testing	3.46%
18	Documentation	3.46%
19	Quality and reliability	3.38%
20	Size	3.22%
21	Shelf life (storage)	3.22%
22	Market constraints	2.94%
23	Shipment	2.86%
24	Packing	2.37%
25	Life in service	2.29%
26	Safety	1.61%
27	Manufacturing facilities	1.41%
28	Quantity	0.00%
29	Company constraints	0.00%
30	Patent, literature and product data	0.00%
31	Political and social implications	0.00%
32	Legal	0.00%

In this case study, design engineers used the Fuzzy-AHP as a method to select the best potentiometer design. Table-4 presents the overall prioritisation weight for each alternative using the value obtained from weight of TRIZ. The proposed method suggests Design 1 with weight of 0.1868 should be given the highest priority. Among the six alternatives selected in this study, the second most important alternative is Design 2 with a weight of 0.1850, followed by Design 6 (0.1732), Design 4 (0.1697), Design 3 (0.1605) and Design 5 (0.1248).

Table-4. Prioritisation weight for alternatives.

Total alternative weight		Ranking
A_1=	0.1868	1
A_2=	0.1850	2
A_3=	0.1605	5
A_4=	0.1697	4
A_5=	0.1248	6
A_6=	0.1732	3

In addition, another feedback from design engineers is that the design and process using the new proposed approach was completed earlier compared with their targeted time. Therefore, it can be identified that the new proposed approach has demonstrated its advantage by successfully improving the development time compared with the target.

CONCLUSIONS

The results of the examples presented in this research show that the idea of incorporating customer requirements in assessing criteria based on TRIZ, provides designers with another alternative to the existing methods, for the performance of design evaluation in the early stages of product development. This work is also the first work that uses the application of TRIZ in such way for design evaluation in product development.

In this research, the weight of criteria using proposed method will be accepted directly if it is consistent with the TRIZ contradiction principles or matrix. However, the difference from the viewpoint of each stakeholder was not considered. Thus, the proposed method could be enhanced by including the aggregation process of stakeholder viewpoints by using the appropriate method.

REFERENCES

Barnes, C., Lillford, S.P. 2009. Decision support for the design of affective products. Journal of Engineering Design, 20, 477-392.

Brown, S., Eisenhardt, K. 1995. Product development: Past research, present findings, and future directions. Academy of Management Review, 343-378.

Creusen, E. H., Schoormans, J.P.L. 2005. The different roles of product appearance in consumer choice. Journal of Product Innovation Management, 22, 63-81.

Dreyfuss, H. 1955. Designing for people. New York: Allworth Press.

Finger, S., Dixon, J. R. 1989a. A Review of Research in Mechanical Engineering Design. Part I: Descriptive, Prescriptive and Computer-Based Models of Design Process. Research in Engineering Design, 1, 51-67.

Finger, S., Dixon, J. R. 1989b. A Review of Research in Mechanical Engineering Design. Part II: Representations, Analysis, and Design for the Life Cycle. Research in Engineering Design, 1, 121-137.

Green, P. E., Rao, V.R. 1971. Conjoint Measurement for Quantifying Judgemental Data. Journal of Marketing Research, 8(2), 355-363.

Jiang, H., Kwong, C.K., Siu, K.W.M., Liu, Y. 2015. Rough set and PSO-based ANFIS approaches to modeling customer satisfaction for affective product design. Advanced Engineering Informatics, Available online 4 August 2015.

Keller, K. L. 1993. Conceptualizing, measuring, and managing customer-based brand equity. Journal of Marketing Research. 57(1), 1-22.

Lai, H. H., Chang, Y.M., Chang, H.C. 2005. A robust design approach for enhancing the feeling quality of a product: a car profile case study. International Journal of Industrial Ergonomics, 35, 445-460.

Lilien, G. L., Kotler, P., Moorthy, K.S. 1992. Marketing Model. New Jersey: Prentice-Hall Inc.

Luo, L., Kannan, P.K., Ratchford, B.T. 2008. Incorporating Subjective Characteristics in Product Design and Evaluations. Journal of Marketing Research, 182, 182-194.

Noble, C. H., Kumar, M. 2008. Using product design strategically to create deeper consumer connections. Business Horizons, 51, 441-450.

Pahl, G., Beitz, W., Feldhuson, J., Grote, K. H. 2007. Engineering Design: A Systematic Approach (3rd ed.). London: Springer-Verlag London Ltd.

Pugh, S. 1996. Total Design: Integrated Methods for Successful Product Engineering. Wolkingham, England: Addition-Wesley Publishing Company.

Suh, N. P. 1990. The Principles of Design. New York: Oxford University Press.

Tseng, M., Du, X. 1998. Design by Customers for Mass Customization Products. CIRP Annals - Manufacturing Technology. 47(1), 103-106.

Turan, F. M., Omar, B. 2014. A Three-stage Methodology for Design Evaluation in Product Development. International Journal of Computers & Technology, 12(6), 3602-3625.

Wang, Y., Tseng, M.M. 2008. Incorporating Probabilistic Model of Customers' Preferences in Concurrent Engineering. CIRP Annals - Manufacturing Technology, 58(1), 137-140.

Wang, Y., Tseng, M.M. 2011. Integrating comprehensive customer requirements into product design. CIRP Annals - Manufacturing Technology, 60.