Songklanakarin J. Sci. Technol.
34 (6), 663-668, Nov. - Dec. 2012

SJST SONGKLANAKARIN JOURNAL OF SCIENCE AND TECHNOLOGY
http://www.sjst.psu.ac.th

Original Article

Application of a quality function deployment technique to design and develop furniture products

Chatree Homkhiew, Thanate Ratanawilai*, and Klangduen Pochana

Department of Industrial Engineering, Faculty of Engineering, Prince of Songkla University, Hat Yai, Songkhla, 90112 Thailand.

Received 12 September 2011; Accepted 18 September 2012

Abstract

It is important for furniture manufacturers to develop an effective organization, produce high-quality products, and develop new product designs which correlate with customer requirements to obtain more satisfactory output. Quality function deployment (QFD) was employed to design and produce new types of prototype plywood wardrobe. Customer product requirements were transformed into *House of Quality* of QFD. These require applied techniques to design the new forms of the product through changes in, for example, product shape, pattern, color, functionality, and quality of materials used. Product satisfaction was evaluated by customers composing of groups of product users and sales agent stores. The results revealed that the average satisfaction value of the new prototype increased from 2.71 to 4.08 points over the current products (an increase of about 54.87%). Hypothesis testing of customer satisfaction between the current and the new designs was found to significantly increase with regard to the QFD approach.

Keywords: quality function deployment, house of quality, voice of customer, plywood wardrobe, product design

1. Introduction

Manufacturing operations in the Thai furniture industry are currently very competitive. The problems caused by economic stagnation have resulted in the current situation that industries of all types have to develop a better organization, produce higher quality products, and better respond to the needs of the customers. In recent years, the competition in furniture manufacturing has grown dramatically. It is necessary for entrepreneurs to improve the quality of their products and to develop processes including quality management to obtain new product design and development. The importance of developing products that meet the customer's needs is a priority in the product development process. It also is important to match the customer's needs with the product characteristics, which can be achieved by using the quality function deployment (QFD) method (Bergquist and Abeysekera, 1996). The use of QFD would enlarge the chance of success, produce higher quality products, and decrease the cost and the time consuming in the product development (Vairaktarakis, 1999; Benner *et al.*, 2003). A plywood wardrobe was selected as a study vehicle for this research because of its high sales numbers and its most complicated shape compared to other products, such as showcase, office desk, and counter. The ultimate goal of this research is to design and produce a new type of prototype plywood wardrobe for the furniture industry.

2. Methods

2.1 Sample group

To accomplish the goal of this research, the house of quality of the QFD technique was chosen and employed (see Figure 1). Fundamental data were collected through questionnaires where the study groups consisted of product users

* Corresponding author.
Email address: thanate.r@psu.ac.th

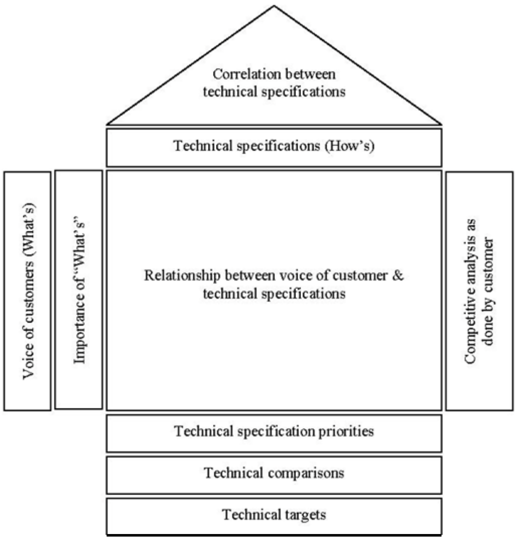


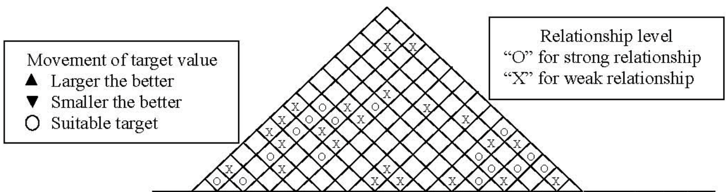
Figure 1. Illustration of the *House of Quality*.

and sales agent stores. Due to the unknown number of customers, the sample size to explore the needs of customers and the rating of customer satisfaction through four questionnaires have been calculated with respect to Equation 1:

$$n = \frac{P(1-P)Z^2}{d^2} \tag{1}$$

where n is the sample size, P is the expected proportion at 30%, Z is a normal random variable, and d is the margin of error in estimating P (Cochran, 1953).

The first questionnaire was used for surveying customer needs, as shown in Figure 2 as "customer requirement". At 90% confidence interval, it was found that at least 58 customers are needed to be surveyed regarding to Equation 1 in order to obtain the customer needs' information. The second questionnaire was conducted to obtain the significance level of needs indicating in Figure 2 as "imp". The third questionnaire was used to achieve the satisfaction rating of the case study factory in comparison to other



		Technical requirement (How's)	Weight	Size	Strength	Number of color	Convenient door and drawer	Product corner	Diversity of product	More functionality	Number of assembly part	Modern material	Brightness	Durability of color and material	Quality of the used material	Ease of cleaning surface	Quality of supplier	Case study factory	Other factories	Goal	Improvement ratio	Important ranking
			▼	O	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	Rating				
			Format									Material										
Customer requirement (What's)		IMP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5
Format	Shape safety	4.14						9										2.2	2.3	2.3	1.05	4.33
	Beauty	4.12		3		9		3				3	9					3.1	3.4	3.4	1.10	4.52
	Ease of use	4.12		1			3											3.1	3.6	3.6	1.16	4.78
	Functionality	4.06		1					1	9								3.7	4.0	4.0	1.08	4.39
	Modern format	3.89				3		3		1		3						3.2	3.1	3.2	1.0	3.89
	Suitable size	3.80	9	9	3				3	3	3							4.7	4.6	4.7	1.0	3.80
	Diversity of format	3.64		3		3			9	1								3.6	3.4	3.6	1.0	3.64
	Beautiful tracery	3.63				9						3	9					2.8	3.2	3.2	1.14	4.15
	Suitable weight	3.39	9	9				3			9							3.6	3.4	3.6	1.0	3.39
	Uncomplicated form	3.39	1								1							4.3	3.5	4.3	1.0	3.39
	Modern part	3.35				1						9	1					3.1	3.9	3.9	1.26	4.21
	Assembly part	3.30	3	3							9							1.1	1.3	1.3	1.18	3.90
Material	Material safety	4.29													9		3	3.1	3.1	3.1	1.0	4.29
	Quality of materials	4.24			9								1	9	3	1		3.5	3.4	3.5	1.0	4.24
	Ease of cleaning	4.07		3												9		3.2	3.3	3.3	1.03	4.20
	Quality part	3.64			1									3	3			3.1	3.8	3.8	1.23	4.46
Sig. of absolute technical requirement			79.8	122.6	54.02	104.8	14.34	74.37	48.55	58.44	80.4	75.57	86.48	51.54	64.71	42.04	12.87					
Sig. of relative technical requirement			8.22	12.63	5.56	10.79	1.47	7.66	5.0	6.02	8.28	7.78	8.91	5.31	6.66	4.33	1.32					
Technical requirement target			Suitable weight with size	Wardrobe sizes are 4 - 7 feet	Able to carry at weight 100 kg	More than two color	All moveable parts can easily use	Change sharp corner to larger curve	Can select various color and size	Can use more than one function	Number of assembly parts more than 10 pieces	Use modern material of era	Brightness and appealing	The color will not pale within 2 years	Use materials safety more than 90%	Surface of material must smooth	Suppliers have high standard and certification					

Figure 2. Illustration of the HOQ with "What's" versus "How's".

similar industries, shown in Figure 2 as "rating". Lastly, the forth questionnaire was established to compare satisfaction of customers between the current plywood wardrobe and the newly developed one. At 95% confidence interval, the last three questionnaires require the same number of 323 samples according to Equation 1.

2.2 Procedure

Three main steps to carry out the house of quality (HOQ) of QFD technique are described as following:

Step 1: Customers' voices collection

In order to design and produce the new type of prototype wardrobe and its abilities to satisfy customer needs, the customer requirements are gathered. To obtain this information, two main groups from both product users and sales agent stores were investigated by the first open-ended questionnaires. A total of 58 questionnaires were collected equally; 29 each from product users and sales agent stores. This kind of primary information, which consists of personal ideas of each customer, is not an official language and hence needs to be revised for grouping and resolving confusion. Arrangement and analysis can be done by using an affinity diagram (see Figure 3) and a tree diagram (Cohen, 1995).

Step 2: Customer requirements ranking

Based on the basic data obtained from the first step, two more questionnaires were produced to convey the significance level of needs and the level of satisfaction on the current plywood wardrobe of the case-study factory comparing to other similar industries. A total of 323 samples were used on each questionnaire focusing on two main categories; format and material of the product. The respondents were given an evaluation choice on a scale from 1 to 5, with 5 being most important and 1 being less important. The geometric mean equation was used to calculate the primary data from these two questionnaires (Kengpol, 2004). In order to complete this task, the needs' importance weights were multiplied by improvement ratio values, resulting in the important ranking.

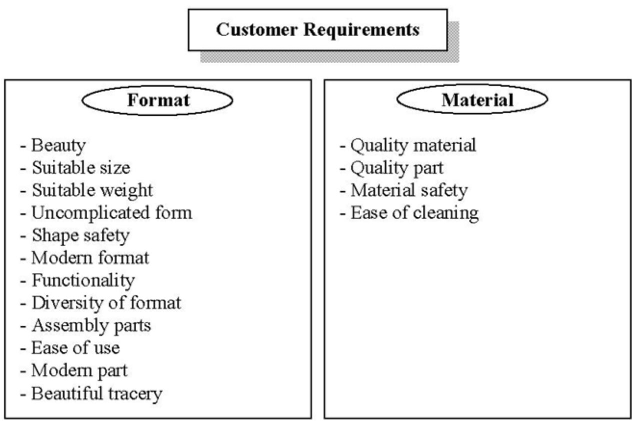


Figure 3. Illustration of the affinity diagram.

Step 3: Product planning matrix, or *House of Quality* development

The first matrix of the QFD method is called the *House of Quality* which is constructed to analyze and translate the customer requirements (What's) into technical requirements (How's). The basic structure of the HOQ is presented in Figure 1 (Partovi and Corredoira, 2002). The building of the first HOQ consists of 6 basic sections (Vairaktarakis, 1999), thus:

Section 1: The customer requirement and the significance level of needs are gathered from the existing needs of customer. This information was identified through a survey with the first and the second questionnaire. The most mentioned items were listed as the "customer requirement" (What's) (Boonyanuwat *et al.*, 2008).

Section 2: The levels of satisfaction of the case-study factory comparing to other similar industries, depicted on the right hand side of Figure 1 and exhibited in Figure 2, were assigned by the respondents of the third questionnaire. The goal of satisfaction level in each customer requirement was selected from the maximum value between the value of the case-study factory and the other similar industries. The improvement ratio for each customer requirement can be evaluated by dividing the goal value with the rating of satisfaction value of the case-study factory. Lastly, the important ranking value for each customer requirement was determined by multiplying the improvement ratio with the significance level of needs.

Section 3: Technical requirement (How's) is the result of group brainstorming from various sections in the factory including ownership and the management team, marketing, production, design, and delivery departments. Two classifications were categorized; format and material. A cause-effect diagram was applied to analyze the relationship of the technical requirements to meet the customer requirements (see Figure 4). As a result, the target value of the technical requirements was set to measure and determine the direction of the goal of improvement.

Section 4: Rating of the relationship between the customer requirements and the technical requirements was evaluated by a group of product development team. The relationship matrix was then constructed to provide a listing of how the technical requirements represent each customer's needs on a scale of 1, 3, and 9. The rating scale 1 represents a slight or possible relationship, 3 represents a moderate relationship, and 9 stands for a strong relationship (Boonyanuwat, *et al.*, 2008).

Section 5: Priority relationships are composed of two sections, the significance levels of the absolute and the relative technical requirements. These are the measurement for the How's. The use of the significance value is to determine priorities and direction for improvements of the How's (Benner *et al.*, 2003). The value of the significance level of absolute technical requirement (SL_ABS) represents the technical requirements necessary to meet the customer needs, and can be calculated by:

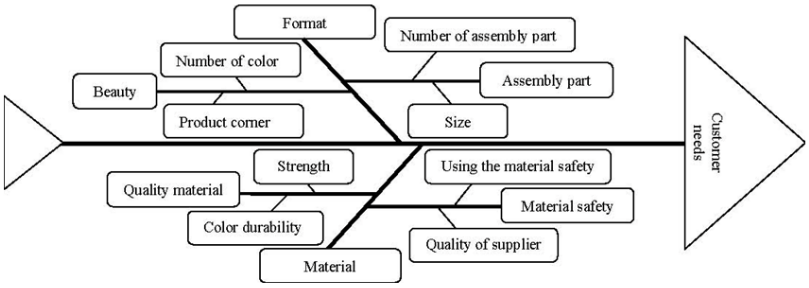


Figure 4. Illustration of a cause-effect diagram.

SL_ABS = Σ (value of relationship between customer requirements and technical requirements × important ranking value) (2)

The value of the significance level of relative technical requirements (SL_REL) can be calculated by:

SL_REL = (significance level of absolute technical requirement) × 100 / Σ (total of significance level of absolute technical requirement) (3)

Section 6: The technical correlations, assigned in the roof of the HOQ, are the result of group brainstorming to determine the relationship between the "How's" and to show what "How's" influence each technique (Benner *et al.*, 2003). These indications show that technical elements affect the performance of each other's, which is represented by the sign "X" for a weak relationship and by "O" for a strong relationship (Pinta, 2002). The application of HOQ matrix "What's versus How's" is presented in Figure 2.

3. Results and Discussion

3.1 Application of QFD

The HOQ of the QFD technique was applied to design and produce the new type of prototype plywood wardrobe. The result of the QFD technique takes note of the furniture characteristics that the customer's desire. For example, the five most important requirements were indicated depending on the highest value of the significant of relative technical requirement. These parameters include the weight, size, number of color, number of assembly part, and color brightness (Column 1, 2, 4, 9, and 11, respectively, in Figure 2). It can be seen that these technical requirements (How's) were highly related to the various customer requirements and would have a high impact to increase the satisfaction value of the prototype of plywood wardrobe. The prototype was therefore designed and manufactured based on the important requirements, particularly on the top five parameters as discussed above.

To determine customer satisfaction of the new prototype of plywood wardrobe over the current one, the forth questionnaire was used for evaluation. Since it was not possible for the total 323 respondents to examine and trial uses the product, the evaluations were therefore arranged through pictures and product descriptions. One major drawback is that, three items; material safety, ease of use, and suitable weight, could not be conducted under these product representations and had to be ignored. However, the pictures before and after the improvement were very carefully taken in order to cover the information needed, and the associated features were thoroughly described in order to ease the rating determination. Figure 5 shows comparisons of the average values of customer satisfaction for 13 of the 16 customers' needs; the other three criteria above being neglected. The average total satisfaction value for the new product increased over the current product by about 54.87%, as calculated and shown in Table 1. It is clearly found that customers appreciated the improvements in every item of the new product. This highlights the effect of new product features that better meet customer demands, leading to an increase in customer satisfaction. The result is one other supportive evidence that QFD analysis can yield some useful information what product properties are important when it comes to meet the demands of customers (Bergquist, 1996).

3.2 Hypothesis testing of satisfaction

To compare customer satisfaction before and after applying QFD technique, the percentage change values out of 13 customer requirements (what's) were considered as a study vehicle (see Table 1). The average customer satisfaction values showed that the assembly part and the diversity of formats gave the highest (115.38%) and the lowest (21.0%) values, respectively. Subsequently, hypothesis testing of the average customer satisfaction between the new and the current designs was statistically conducted at 0.05 significance level: H_0: *The average customer satisfaction of* x_i *is not different between the current and the new design.* H_1: *The average customer satisfaction of the new design is higher than that of the current design, with i =1 to 13.*

The result reveals that the average customer satisfac-

Table 1. Average percentage of changed values of customer satisfaction between current and new plywood wardrobe.

Customer needs (x_i)	Average customer satisfaction		
	Current design	New design	% change
(x_1) Assembly part	2.08	4.48	+115.38
(x_2) Functionality	2.07	4.34	+109.66
(x_3) Modern format	2.37	4.13	+74.26
(x_4) Modern part	2.44	4.17	+70.90
(x_5) Shape safety	2.44	4.12	+68.85
(x_6) Beauty	2.77	4.22	+53.34
(x_7) Quality part	2.52	3.83	+51.98
(x_8) Suitable size	3.14	4.35	+38.53
(x_9) Ease of cleaning	3.04	4.13	+35.85
(x_{10}) Beautiful tracery	3.13	4.06	+29.71
(x_{11}) Uncomplicated form	2.95	3.62	+22.71
(x_{12}) Quality materials	3.11	3.77	+21.22
(x_{13}) Diversity of formats	3.19	3.86	+21.00
Average	2.71	4.08	+54.87

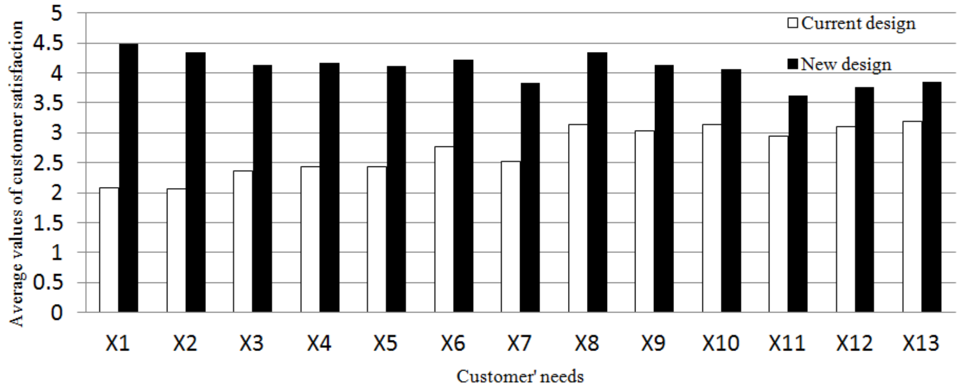


Figure 5. Average customer satisfaction of plywood wardrobe before and after improvement.

tion regarding the new design of each feature increased significantly, based on the QFD approach. Therefore, it can be claimed that other features, which have a higher percentage change value of customer satisfaction would also be significantly acceptable.

4. Conclusions

Quality function deployment technique can be used in the processing development of new prototype plywood wardrobe to improve customer satisfaction. Customer requirements were transformed into the *House of Quality*. The newly designed and developed products varied in shape, pattern, color, functionality and quality of the used materials. The product satisfaction was evaluated by customers comprising of groups of product users and selling agent stores. The results revealed that the average satisfaction values for all new types of products increased over those of the current products, from a level of 2.71 to 4.08 (54.87%). Hypothesis testing of the average customer satisfaction between the current and the new designs was found to significantly increase with regard to the QFD approach.

References

Benner, M., Linnemann, A.R., Jongen, W.M.F. and Folstar, P. 2003. Quality function deployment (QFD) – can it be used to develop food products? Food Quality and Preference. 14, 327-339.

Bergquist, K. and Abeysekera, J. 1996. Quality function deployment (QFD) – A means for developing usable products. International Journal of Industrial Ergonomics. 18, 269-275.

Boonyanuwat, N., Suthummanon, S., Memongkol, N. and

Chaiprapat, S. 2008. Application of quality function deployment for designing and developing a curriculum for Industrial Engineering at Prince of Songkla University. Songklanakarin Journal of Science and Technology. 30(3), 349-353.

Cochran, W.G. 1953. Sampling Techniques. John Wiley & Sons, New York, p. 76.

Cohen, L. 1995. Quality Function Deployment: How to make QFD work for you. Addison-Wesley, Reading, MA, U.S.A., pp.68-69.

Kengpol, A. 2004. Concurrent Engineering. King Mongkut's Institute of Technology North Bangkok, Bangkok.

Partovi, F.Y. and Corredoira, R.A. 2002. Quality function deployment for the good of soccer. European Journal of Operation Research. 137, 642-656.

Pinta, A. 2002. The improvement of product by using quality function deployment (QFD) technique: a case study of an educational wood toy factory. Master Thesis, King Mongkut Institute of Technology North Bangkok, Bangkok, pp. 68.

Vairaktarakis, G.L. 1999. Optimization tools for design and marketing of new/improved products using the house of quality. Journal of Operations Management. 17, 645-663.