Design Cost Engineering Through Quality Function Deployment

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Abstract

Growing concerns regarding the environment impact of product has increase the awareness of the customer about the environment. The customer demand for environment friendly product is increasing rapidly. Hence the manufacturer has shifted the focus to the product which has less impact on environment. Therefore in the conceptual design of the product the environment, quality and cost aspects must be considered during the decision making process. In this research paper quality function deployment is applied on a product to improve the quality aspect using green parameters and multi attribute utility theory is used to optimize the cost of the product.

Keywords: Quality Function Deployment (QFD), Multi Attribute Utility theory (MAUT).

1. Introduction

Due to increase in awareness of customer about environment issues, eco-friendly products have gained more and more importance. Such interests in customers about environment issues have forced the manufacturer to consider the environment impact of the product during the design stage. When environment requirements are considered during the product design stage the cost becomes relatively low. In this research paper Green parameters are used to enhance the quality of the product using quality function deployment (QFD). After that the optimized estimated cost of the product on the basis of its feature attributes is evaluated with the help of multi attribute utility theory (MAUT) model.

2. Literature Review

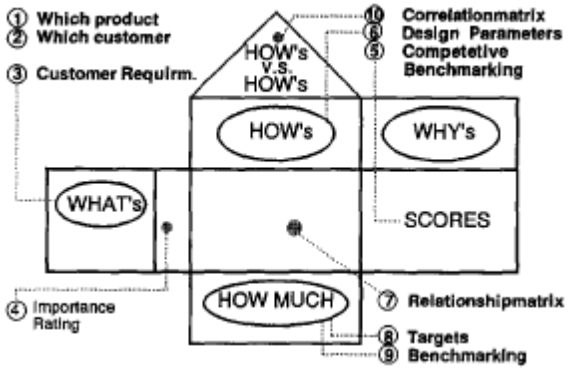
Technique for order preference by similarity to ideal solution TOPSIS was initially developed by Hwang and Yoon (1981), subsequently discussed by many (Chu, 2004; Peng, 2000). TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution (Jahanshahloo et al., 2006). All alternative solutions can be ranked according to their closeness to the ideal solution.

QFD begins with identifying customers and asking the question: "what customer want". Most of our customers' needs through marketing research and sales are collected (Fung et al., 2003). Quality attributes that extend to all stages of product development processes from design to final production was called Quality Function Deployment (Hwang and Teo, 2002). QFD is implemented by a series of matrices, the "quality tables", also called HOQ, which provide detailed guidance throughout the service development process (Cohen, 1995).

Multi attribute utility theory (MAUT) is a set of systematic procedures design for quantifying an individual's preference (Keeney and Raiffa, 1976). Ting et al. (1999) first constructed a cost estimation model by means of MAUT which also combines historic data to avoid the object judgment.

3. Methodology

3.1. QFD Matrix



The material which has low impact on environment and is cheap as compared to the material currently using in the product design is substituted to obtain less impact on environment as well as the reduction in cost. In this research paper the Mg-Al is

substituted for the material used in digital camera in its upper body. Mg-Al alloy is cheaper, thinner and recyclable. It reduced the weight of the upper body, reduces the volume of the camera body and increases the rate of recycling of material.

3.2. MAUT Model

Based on Ting et al. (1999) and Dong et al. (2003), cost is estimated through the following equations:

$$U(X) = \frac{\prod_{i=1}^{m}[\{W.wi.U(xi)\}+1]-1}{W}$$

$$1+W = \prod_{i=1}^{m}(1+W.wi)$$

$$\text{Cost Index(CI)} = ae^{b\,[U(x)]}$$

Where,

U(X) = Utility value of alternative depending on the level of each attribute
X = (x_1, x_2, x_3, $x_{4,}\ldots$ x_m)
W = Scaling Factor
w_i = Weight for attribute i
m = number of attributes
$U_i(x_i)$ = Utility value of attribute i at level x_i
Cost (X) = Estimative cost depending on each x_i
a, b = parameters of regression model
e = base of natural logarithm.

Feature levels of product design are selected on the basis of attribute of the product. The utility value of the attribute is calculated on the basis of its utility function type. After that the utility value is converted into cost index by using regression model.

4. Case Study

An example of digital camera is illustrated in this research work in which some of the features of digital camera are considered during the product development process. Various feature levels are classified as per its attributes. As shown in table 1. After that design levels are selected in accordance with the designed attributes. On which multi attribute utility theory is applied to convert the utility value of the feature levels into the cost index with the help of regression model.

4.1. Application of MAUT Model:

This section describes a case study of estimating the cost of a digital camera with MAUT model. Attributes and feature levels for the product cost estimation of digital camera are shown in table.

Table1.
Attributes and feature level for the product.

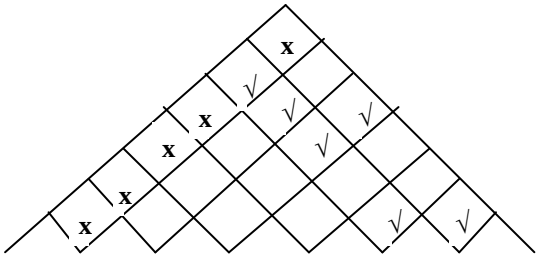
	Attribute					
Levels	Complexity	Quality	Material	Size	Material Amount	Disposal
1	Extemely Simple	Economic	ABS Plastic	Small	Small Amount	Small Amount
2	Simple	Medium	Mg-Al	Medium	Moderate Amount	Moderate Amount
3	Somewhat Simple	High	Mg-Al	Large	Large Amount	Large Amout
4	Simple-Medium	Special Perpose	ABS Plastic			
5	Medium		or			
6	Medium-Complex		Mg-Al			
7	Somewhat Complex					
8	complex					
9	Extreme Complex					

Various levels of the product design are selected on the basis of product attribute. As shown in table 1.

Table2.
Feature Levels for product design

Cost Attribute (i)	Weight (wi)	Highest Level (xi)	Utility Function type
Complexity for Product	0.7	9	Convex
Quality of Product	0.9	4	Linear
Material in Mfg.	0.6	5	Linear
Size of Product	0.4	3	Linear
Energy Consumption	0.6	3	Linear
Reverse Logistics	0.3	5	Linear

◉	Strong (9)
O	Medium(4)
Δ	Weak (1)
x	Strong Negative
x	Medium Negative
√	Strong Positive
√	Medium Positive



CUSTOMER DEMAND	**FUNCTIONAL CHARACTERISTICS**	Mega Pixel	Number of Colors	Material Used	Easy Dimensioning	Easy Functioning	Cost of Designing	Eco Friendly Product
Quality Picture	5	◉						
Attractive Appearance	2		◉	o	o			Δ
Weight Specification	3			◉	Δ		Δ	
Size Specification	1				◉		Δ	
Operating Complexity	2					◉	Δ	
Competitive Price	5	o	Δ	o	Δ		◉	o
Energy Saving	4					Δ	Δ	◉
	FUNCTIONAL SPECIFICATION	14 to 16 Mega Pixel	White, Black & Grey	Eco Friendly Product	Medium Size Preferred	Easy Manually Operated	Competitive Price	
ABSOLUT							55	58
RELATIVE IMPORTANCE (%)		21	8	18	8	7	18	19

Figure: House of Quality Matrix

Table3.
Utility Value U(x) calculation

Cost Attribute (i)	Design Level (xi)	Utility Value Attribute Ui(xi)
Complexity for Product	6	0.2296
Quality of Product	3	0.75
Material in Mfg.	2	0.2
Size of Product	2	0.67
Energy Consumption	2	0.67
Reverse Logistics	2	0.4
Cost (Rupee)	12990	
U(X)	**0.8365**	

With above data, regression model is constructed:
Cost (CI) = 6.816 e $^{[8.7 \times U(x)]}$
The estimative cost = 9870 Rupees.

4.2. Application of QFD

The house of quality represents the relationship between the customer demand and technical attributes.
Following symbolic notations are used in QFD model:

5. Conclusion

It can be concluded that when the changes in the designing level occur, the cost of the product get change. In this study, Quality Function Deployment is used to enhance the quality of the product using green parameters. And the MAUT model used to calculate the estimated cost during design stage of the product with the help of regression model. The slight changes in level of the product reduce the design cost of the product.

6. References

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