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# APPLICATION OF AHP AND TOPSIS INTEGRATED METHODOLOGY ASSESSMENT OF CUSTOMER IMPORTANCE RATINGS IN QUALITY FUNCTION DEPLOYMENT

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**Abstract:** In order to cater to the demands of customers from the products that they ought to have specifications that are near to customer's preferences to a higher degree, scope of the product improvement efforts has always been a priority for manufacturing organizations. . QFD is a tool for quality improvement of a product according to customer demand. The aim of this study is to develop a methodology to evaluate weights of importance rating based on Technique for Voice Preference by Similarity to Ideal Solution method (TOPSIS). In this paper, some important criteria which affect the process of product design and manufacturing has been taken into consideration, that is, product quality, service quality, and price. The relative weights for each criterion based on Analytic Hierarchy Process (AHP) have been calculated and then these weights are used as input to the TOPSIS method to rank customer voice.

**Keywords:** Quality Function Deployment, Fuzzy Logic, AHP, TOPSIS, House of Quality.

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## INTRODUCTION

Quality Function Deployment (QFD) has been widely recognized as an essential tool in product development or customer driven services (Akao, 1990; Prasad, 1998; Ho et al, 1999;. Han et al, 2004;. Wang and Xiong, 2011; Raharjo et al, 2011).. QFD has been widely implemented in different areas of engineering. The most important strength of QFD is its focus on customer needs and the consistent translation of their needs at each stage of the product development process. QFD stands for Quality Function Deployment. Quality Function Deployment is a structured method in which customer requirements are translated into appropriate technical requirements for each stage of product development and production (Koronacki, J.&Thompson, J.R. 2001). The QFD process is often referred to listen to the voice of the customer, is considered to be concurrent engineering tools. Basically, the customer requirements involved QFD (product specification), to the product design parameters mathematically. The result is a product design driven by mathematics. Quality control was firstly used for production and manufacturing areas as well as for inspection area, but soon it expanded to all areas of many organization (Jiang et al., 2007). When using methods such as QFD, the organization's product improvement plan is more structured (Gremyr & Raharjo, 2013). Today, QFD is successfully applicable in various manufacturing industries as a powerful decision making tool (Ginnand Zairi, 2005). The QFD starts by collecting the voice of customers and develops by forming matrices (Jiang et al., 2007). Paying no attention to this issue results in implementing the project over a longer period of time with low quality and higher cost. Also in some cases, it leads to no business justification of the project (Cheng et al., 2009; Diani & Shiruiyezad, 2012).
An optimized design is the first step in the development of products, and many EDR needs to be considered. There are different product design quality models available in the literature. Among many analytical techniques, scrolling function model quality (QFD) is particularly famous for its successful applications to transform customer satisfaction in design stage. Technique for order preference by similarity to ideal solution method (TOPSIS) has been used to help decision-making in many fields. Furthermore, the integration of QFD TOPSIS and can achieve good performance in many tasks. In addition, the product design quality researchers have become increasingly aware of the decision problems. The purpose of this article is to clarify the analysis aggregated using QFD and TOPSIS and solve the problem of quantitative decision to the quality of product design.

## AHP

AHP, which was first developed by Saaty includes experts' opinions and assessment notes in a simple elementary hierarchy system by the decomposition of complicated problems of higher hierarchies to the lowest. Yahya and Kingsman are the first researchers known to use AHP to deter priorities mines in the selection of suppliers. Similarly Network Analysis Process (ANP) is also a multi approach attribute to decision making that allows the transformation of qualitative values to quantitative. From AHP is a special case of ANP and does not contain feedback loops between the factors, the ANP is used to determine the selection of suppliers for longer periods.

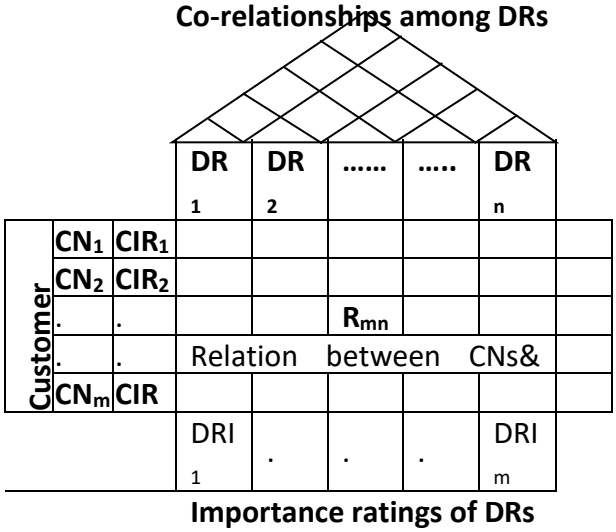
**TOPSIS**

TOPSIS is a useful and practical technique for classification and selection of a certain number of alternatives externally through distance measurements. The entropy method is often used to assess the weights TOPSIS method. The method of TOPSIS was first developed by Hwang and Yoon (Hwang & Yoon, 1981) and classifies the alternatives according to their distances from ideal and negative ideal solution, ie a better alternative has both the shortest distance between the ideal solution and the farthest away from the negative ideal solution. The ideal solution is identified with a hypothetical alternative that has the best values for all the criteria considered negative while the optimal solution is identified as a hypothetical alternative that has the worst criteria values. Actually, TOPSIS has succeeded in testing the selection options / suggestions with the limited number of other methods (E & Kang, 2000; Yong, 2006) because it is intuitive and easy to understand and to do. In addition, TOPSIS has a sound logic is the logic of human choice (Shih, Syur & Lee, 2007) and has proven to be one of the best methods to address the issue of classification reversal (Zanakis, Solomon, Wishart & Dublish 1998 ).

**Methodology**

Quality Function (QFD) is a split tool for the development of products from customer needs, resulting in a systematic technical specifications which are a guide to manufacturing activities. QFD translates customer needs into appropriate specifications for each functional area within the company, R&D to engineering, production, distribution, sales and services. According to Cohen (1995) and Han (2001), there are six stages of the hierarchical framework of QFD as follows (Figure 1):

1. Voice of customer – developing, categorizing and prioritizing customer requirements.
2. Competitive analysis – comparing the performances with competitors and set target levels for customer requirements.
3. Voice of organization – translating the voice of customers to the voice of organization.
4. Design Targets – specifying target values for design requirements and determining the project costs.
5. Relationship Matrix – evaluating impact of design requirements on customer requirements.
6. Correlation Matrix – specifying tradeoffs and selecting the appropriate design requirement.




Prioritizing the needs of the customer can be regarded as a decision-making multi-criteria complex problem. The AHP, a multi-criteria decision-making method has been used in weighing customer needs [16]. The integration of AHP to determine the trade-off weights to customer needs has been proposed by Aswad (1989) and Akao (1990) [1]. Armacost et al. (1994) applied the AHP to generate importance ratings to customer needs on a case study of the industrialized housing. In the above application of AHP for prioritization of customer needs, the pair wise comparisons for each level, with regard to customer satisfaction objective, are carried out using a nine-point scale. The nine-point scale developed by Saaty (1980) [10] expressed preferences among the options as either: Similarly, moderately strong, very strong or extremely preferred.

**Fuzzy AHP steps**

Some calculation steps are essential and explained as follows:

- Establishing the hierarchical structure constructing the hierarchical structure with decision elements, decision-makers are requested to make pairwise comparisons between decision alternatives and criteria using a nine-point scale.
- Calculating the consistency to ensure that the priority of elements is consistent, the maximum eigenvector or relative weights and max λ is calculated.

I.C. = (λmax – n)/(n-1) < 0.10 (1)

Where n is the number of components evaluated in the pairwise comparison matrix, and λmax is the largest eigenvalue characterizing the previous matrix. When the calculated CR values exceed the threshold, it is an indication of inconsistent judgment. In such cases, the decision makers would need to revise the original values in the pairwise comparison matrix. Finally, it is necessary to aggregate the relative priorities of the decision elements to obtain an overall rating for decision alternatives. The numerical analysis method is employed to calculate the

eigenvalue vector and the maximized eigenvalue for an understanding of the consistency established and the relative weight among elements.

- Constructing a fuzzy positive matrix a decision maker transforms the score of pair-wise comparison into linguistic variables via the positive triangular fuzzy number (PTFN).

**TOPSIS Method**

The method is first TOPSIS proposed by Hwang and Lin 1987. In general, TOPSIS has two main functions: one is to calculate the largest distance from the negative ideal solution; another alternative is to choose optimization which has the shortest distance from the ideal solution. In case of the decision problem analysis TOPSIS is an effective and practical method used for hierarchization by preference systems.

TOPSIS method was successfully applied to solve multi-criteria decision making problem in various industrial field. The success of the decision-making techniques based on TOPSIS is set for optimization of technical evaluation advice. TOPSIS is used to manage competitive competition in the market. TOPSIS integrated with other methods have been developed to handle multipurpose reactive power compensation problem. The method is described below:

Step 1: To determine the objective.

Step 2: Formation of decision table based on matrix in which each row of the matrix is allocated to one alternative and each column to one attribute.

$$A = \begin{bmatrix} C11 & \cdots & C1n \\ \vdots & \ddots & \vdots \\ Cm1 & \cdots & Cmn \end{bmatrix}$$

Step 3: To calculate normalized matrix using:

$$R_{ij} = \frac{m_{ij}}{\sqrt{\sum_{j=1}^{M} m_{ij}^2}}$$

Step 4: Now evaluate the relative weights ($w_{ij}$) of attributes.

Step 5: Find weighted normalized matrix $V_{ij}$

$$V_{ij} = w_{ij} R_{ij}$$

Step 6: Evaluate the best positive idea and worst negative ideal.

$V^+ = \max\{V_1^+, V_2^+, \ldots\ldots\ldots\ldots Vj^+\}$ $j=1,2\ldots\ldots.n.$

$V^- = \min\{V_1^-, V_2^-, \ldots\ldots\ldots\ldots Vj^-\}$ $j=1,2\ldots\ldots.n.$

*Step 7:* Develop the distances between each alternative. The distances of each alternative from ideal solution can be calculated by the equation given below:

$$P_i^+ = \sqrt{\sum_{j=1}^{M} \left(V_{ij} - V_j^+\right)^2}$$

$$P_i^- = \sqrt{\sum_{J=1}^{M} (V_{ij} - V_j^-)^2}$$

Step 8: Find the closeness of alternatives

$$C_i = \frac{P_i^-}{(P_i^+ + P_i^-)}$$

Rank the alternatives the preference order can be find in step 8, which is close to the ideal solution and far from the negative ideal solution. Recommend the best alternative. The preferred alternative is the one with the maximum value of $C_i$.

**Integration QFD – AHP-TOPSIS Model**

The model is furnished below:

| Customer Voice |
|---|
| ↓ |
| *Development of House of Quality* |
| ↓ |
| *AHP Pairwise Comparison* |
| ↓ |
| *Prioritize alternative* |
| ↓ |
| *Benchmarking* |
| ↓ TOPSIS ↓ |
| *Input Data for Engineering Design Requirement* |
| ↓ |
| Rank the alternatives through best positive idel |
| ↓ |
| Optimal Design outputs |

## CONCLUSION

The problem selection of product design quality formulated as multi-objective optimization problem amount of competitor quality indicators. This work has proposed with a new integrated model QFD-AHP and TOPSIS method for product design quality in manufacturing selection performance. In order to translate the product CR technical requirements, the weights of the appropriate criteria of EDRs are obtained using the QFD model. Then we developed the HoQ model for dealing with various kinds of uncertain CRs information. Moreover, the approach has been widely used TOPSIS to indicate the design solution level to answer performance difference. After the weights are obtained by QFD, the aggregate performance of each alternative is easier catch up.

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