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Determining and ranking criteria of product design using consolidated QFD approach and fuzzy logic in tire industry

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Abstract

Nowadays, world is changing fast and communication is increasing day to day. Achieving to information is getting easier and competition for more selling is increasing and you can't submit customer, a production which doesn't have necessary quality from the customer's perspective. It sounds that most successful managers are considered one principle that is included: providing services based on customers' opinion. Quality Function Development is one of the strong instruments for customer voice and translating it to technical criteria that can assist organization systematically to determine design necessity for product development toward obtaining customer satisfaction. The first QFD matrix is named quality house which transferring customer needs to technical necessities. Determining importance of needs and filling house quality is so crucial. To determine these relations, experts have to consider high accuracy. On the other hand, based on increasing use of fuzzy linguistic variables in this paper, these variables were used in relation of house quality that caused increasing in accuracy in obtained results. This paper is a real case in tire industry in Iran.

Keywords: Customer requirement, technical characterize, house quality, fuzzy logic, ranking

Introduction

Organizations would be more successful which are more successful in the competition of flustered and competitive environment, recently. In other term, based on new philosophy of marketing that means customer-orienting, customers put the center of attention and look at problems in customer expression. Today, expression of customer satisfaction is one of the current expression in formal environments. But undoubtedly, establishing customer satisfaction and even encouraging them with services and production quality, at first, need getting familiar with their needs and desires and then transferring these desires to the situation which services and production are produced. This subject, according to increasing complexity in economic, cultural and social systems, doesn't happen spontaneously but needs systematic approaches and techniques which change these conceptions to organizational processes .Today, modern management techniques are central to the work toward obtaining competitive advantages with customer-orienting view (Bottani, Rizzi, 2006).

In this regard, one of the most important management and quality techniques which provide interaction possibility among production and marketing and selling department is QFD technique. QFD as one of the modern methods of quality engineering, is started with market study and get familiar with customers and in investigating process and their analysis either identify the needs or requirements of customers, try to consider them in all design and production processes. QFD process is a kind of production and services methodology and its input is customer voice. Needs and requirements of customer are the development leverage of production requirements or new and revised services. QFD processes needs inputs and decisions which are done by team work in the best way. As a result, this process trends to omit many of operational obstacles which are established in giant organizations and helps to understand customer wants by marketing knowledge and engineering needs.(Chen, Weng, 2006)

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Quality Function Deployment (QFD)

QFD, which originated in Japan in 1972, was designed to improve quality in product development. It has been a successful tool in assisting product developers inincorporating customer requirements (CRs) systematically into product and process development (Akao, Y. 1990). QFD brings customer's needs down to the level of detailed operations, especially.

Currently, two main QFD approaches have been popularized: the American Supplier Institute's (ASI) Four-Phase approach and the GOAL/QPC Matrix of Matrices approach. Based on(Revelle, J. B., Moran, J. W., & Cox, C. A. 1998),the difficulty with using the Matrix of Matrixes is that itmay become more of a maze instead .In other word ,QFD is an implementation to translate customer needs into product technical requirements of new products and services that have been developed from Japan in the late 1960s to early1970s(Chen, L. H., & Lu, H. W. 2001). The main conception of traditional QFD considered four relationship matrices that included product planning, part planning,process planning, and production planning matrices, respectively (Akao, Y. 1972). Each translation used a matrix, also called house of quality (HOQ). In the first place, the product planning matrix is established. The customer needs translated to the second QFD as inputs for the development of product design requirements. Secondly, in the part planning matrix, important design requirements are linked to partcomponent characteristics deployment. Furthermore, the part component characteristics are similarly linked to manufacturing operations. In the production planning matrix, the process parameters and control limits are determined in the same way. (Park, T., Kim, 2008)

House of Quality Matrix

A House of Quality Matrix is a diagram, whose structure resembles that of a house, which aids in determining how a product is living up to customer needs. Although quite intricate, it is capable of storing a lot of information and comparing large amounts of data that it shown in figure 1. (Lin, Y.H, Cheng,2010)

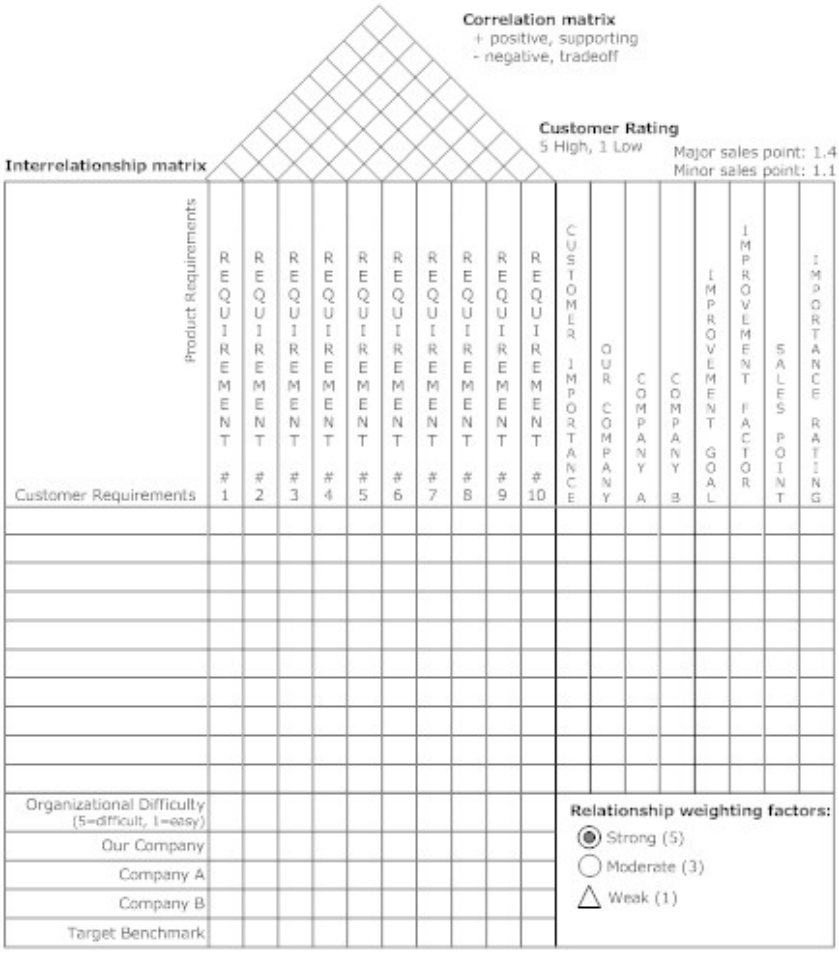

Figure 1. House of Quality

Typical Uses

The best way of using house of quality matrix iswhen you are planning on making improvements to an existing product or you would like to analyze a products' ability to meet customer needs and compare to competition.(Martins, Aspinwall, 2001)

Best Practices

• Identify a product. Choose a product you want to focus your House of Quality Matrix on.

• Obtain customer opinion. Whether through surveys, opinion polls, or interviews, in order to create this matrix ,you must know what your customers want. Make sure that you know what they expect or want from your product and how important each aspect is to them.

• Fill in the required information. The section on the far left of the matrix is reserved for customer needs, what the product should satisfy. On the far right should be what the competition provides. Along the top should be a list of the product's capabilities meant to fulfill customer needs. In the bottom section should be the targets, the things your company must acquire for the product, long term goals, and your standing amongst the competition.

• Fill out the matrix. The middle section is where you can show how much your product is meeting the needs of your customer. Choose three symbols to use to fill in the middle section. The symbols should represent that an aspect of your product meets the customer's requirement well, average, or poorly. Use them to fill out the middle section. Then fill out the top section using the same symbols you already developed to show conflict among product requirements.

• Create a key. Create a key that tells what each of your symbols stand for.

• Draw Conclusions. Use your matrix to decide what your product needs and what improvements would be would the investment. Also use it to set goals and plan for the future.

Fuzzylogic

Fuzzy logic is a form of many-valued logic; it deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets (where variables may take on true or false values), fuzzy logic variables may have a truth value that ranges in degree between 0 and 1.(Leslie,2013) Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.(Zaheh,1996) Furthermore, when linguistic variables are used, these degrees may be managed by specific functions. Irrationality can be described in terms of what is known as the fuzzy objective.

The term "fuzzy logic" was introduced with the 1965 proposal of fuzzy set theory by Zadeh. Fuzzy logic has been applied to many fields, from control theory to artificial intelligence. Fuzzy logics however had been studied since the 1920s as infinite-valued logics notably by Łukasiewicz and Tarski (Novek, 2005).

Methodology

Suggested method in this paper to determine and rank technical criteria affected on increasing in car tire quality is according to following processes:

Determining important customer desires and put them in house quality using fuzzy logic.

Determining technical criteria related to customer desires and put them in house quality.

Determining the relation between technical criteria and customer requirements using experts opinions and fuzzy linguistic variables.

Determining the relation between technical criteria(correlation matrix) using experts opinion and fuzzy linguistic variables.

Quantifying step 4 and 5 using fuzzy logic.

Determining the importance of each of technical criteria using following relations:

$$RI_j = \sum_{i=1}^{n} wi^* \times R_{ij}$$

$$RI_j^* = RI_j + e^{Tk_J} \times RI_k$$

Results and Discussion

In the first step, questionnaire is distributed which 10 needs are identified as most important ones. In the next step, respondents are asked to express importance of each need using fuzzy linguistic variables in fig 2.(Pelletier,2000)

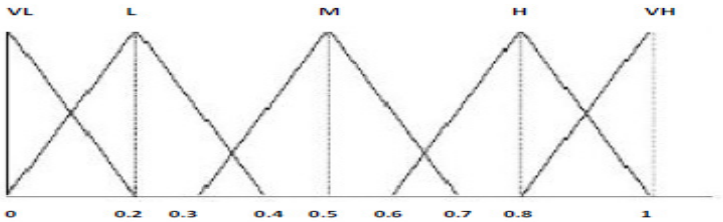

Figure 2. Fuzzy Variable Linguistics

Table1. Costumer Requirement's and their weight

Costumer Requirement's	Fuzzy Importance
Adhesion to the road surface	(0.68,0.88,0.97)
Vehicle steering	(0.60,0.80,0.94)
Long durability	(0.74,0.94,0.99)
Variety in surface design and beauty	(0.38,0.58,0.76)
Proper price	(0.53,0.73,0.86)
Resistance to puncture	(0.67,0.87,0.89)
Ability to handle high speeds	(0.73,0.93,0.99)
High balance	(0.64,0.84,0.96)
Not sound when driving	(0.63,0.83,0.95)
Services after selling	(0.52,0.72,0.85)

After getting average, results about weights of CR's shown on table 1.

In the next step, 9 technical criteria related to customer needs using expert opinion are identified which are:

Number of tire layer (TC1)
Dimension of saydval (TC2)
Patren of tire (TC3)
Consumable compound of tire (TC4)
Uniformity of tire components (TC5)
Dimension of tire (TC6)
Appropriate cooking (TC7)
Appropriatecord steel (TC8)
Improving in serving andcustomer complaints system(TC9)

Next step in the process of making quality house is to establish relation matrix that expressesrelation importance weight between customer need and technical criteria. Finding these communications is a complicated matter . So , expert team is used in the context. Team opinions are interred in HQ matrix as a unit measure after agreement about each of matrix components. Table 2 shows relationship matrix after expert team agreement.Some of the technical criteria of production have correlation. It means that changes in one, has an effect in another one and vice versa.In order to determine the correlation between technical criteria, experts team again is used. Result of this agreement between experts about the average of theserelations is displayed in table 3. At last, using mentioned relations, importance of each technical requirement is obtained and with defuzzying ,the researchers rank criteria which this ranking is expressed .

Table 2.Relationship in Matrix

		Technical Characteristic								
		TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9
Customer Requirements	CR1			(0.8,1,1)	(0.8,1,1)		(0,0.2,0.4)	(0.6,0.8,1)	(0.3,0.5,0.7)	
	CR2		(0.3,0.5,0.7)	(0.6,0.8,1)	(0.6,0.8,1)	(0.8,1,1)	(0.3,0.5,0.7)		(0,0.2,0.4)	
	CR3	(0.8,1,1)	(0.3,0.5,0.7)	(0,0.2,0.4)	(0.6,0.8,1)	(0.6,0.8,1)	(0.3,0.5,0.7)	(0.8,1,1)	(0.8,1,1)	
	CR4			(0.8,1,1)						
	CR5	(0.8,1,1)	(0.6,0.8,1)	(0.6,0.8,1)	(0,0.2,0.4)			(0.6,0.8,1)	(0,0.2,0.4)	
	CR6				(0.3,0.5,0.7)				(0.6,0.8,1)	
	CR7	(0.8,1,1)	(0.6,0.8,1)		(0.6,0.8,1)			(0.6,0.8,1)	(0.3,0.5,0.7)	
	CR8	(0.8,1,1)	(0.6,0.8,1)			(0.8,1,1)	(0.6,0.8,1)		(0.3,0.5,0.7)	
	CR9		(0.6,0.8,1)	(0.8,1,1)	(0.6,0.8,1)					
	CR10									(0.8,1,1)

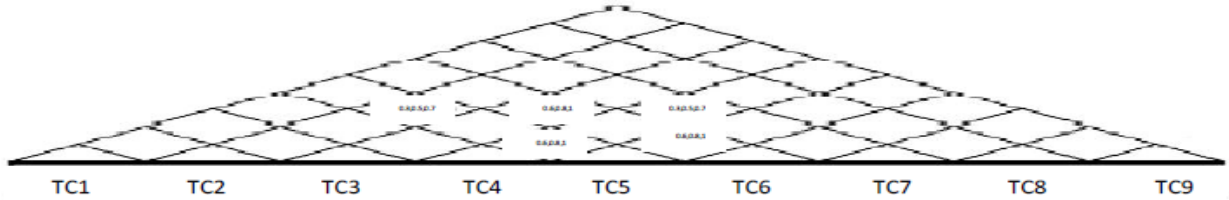

Figure 3.Relationship between CR's

Conclusions

In this paper, according to importance of responsiveness to customers and their needs, the researchers present method based on QFD approach which most important needs of customers arerespectively:

First:Long durability

Second:Capable of high speeds.

Third:Resistance to puncture

Forth:Adhesion to the road surface

Based on obtained results of HQ ,most important technical criteria to satisfy these requirements are respectively:

First:Consumable compound of tire.

Second:Dimension of terd.

Third: Dimension of saydval.

Forth: Appropriate cooking.

Fifth: Patren of tire.

To reach this goal, each of tire factories which trends to increase their facility quality ,has to concentrate on these 3 first components .According to this fact that this paper is practical, factories can use its results to improve their productions. The present researchers suggest to other researchers rank these technical criteria with evaluation expenses of each technical criteria and their ability to implement using multicriteria decision technique and other mathematic techniques. Also, to other interested researchers recommend to work on the right part of HQ and compare and rank factories.

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