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Design and Development of the Refrigerator with Quality Function Deployment Concept

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ABSTRACT : In the era of high competition, it's essential to attain superlative quality standard at all level in the organization and regular improvement and implement in the established system of quality. These qualities improvement are based on the feedback of customer (says voice of customer) about new and existing product in market and from benchmarking of competitors. With thin systematic methodology, a high quality and low cost product that more fits the consumer needs is to be designed and consequently the competitiveness of the product to improved. Most of organizations have made changes according to product development. Quality Function Deployment (QFD) is a quality tool that helps to translate the Voice of the Customer (VOC) into new products that accurately assure their needs. In this paper, QFD apply to a product like refrigerator to design development and implement of the product quality. In the design of a new refrigerator, apply QFD to find out the most important parameter and functions from customer point of view and then find out engineering characteristics. These important parameters are then put into house of quality and make relation matrix between voice of customer and engineering characteristics. From the result of QFD applied to refrigerator are short out the parameter which are require modification according to voice of customer and the result has used for new design.

Keyword : Quality Function Deployment, Refrigeration Process, Customer Demand and Quality Assurance.

I. INTRODUCTION

Quality function deployment (QFD) is a technique introduced in Japan by Yogi Akao in 1966 and used extensively by Toyota (and since by many other companies around the globe). The technique aims to capture what the customer needs, and work to how it might be achieved. According to Akao (1990), QFD "is a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demand into design targets and major quality insurance point to be used throughout the production phase".

Quality function Deployment (QFD) is a structured approach to defining customer needs or requirements and translating them into specific plans to produce to meet those needs. The 'voice of customer is the term to describe these stated and unstated customer needs or requirements. The voice of customer is captured in a variety of ways: direct discussion or interviews, surveys, focus groups, customer specifications, observation, warranty data, field report etc. This understanding of the customer needs is then summarized in a product planning matrix or "house quality". These matrices are used to translate higher level "what's" or needs into lower level "how s" - product requirements or technical characteristics to satisfy these needs.

While the Quality Function Deployment Matrices are a good communication tool at each step in the process, the matrices are the means and not the end. The real value is in the process of communicating and decision making with QFD. QFD is oriented toward involving a team of people representing the various functional departments that have involvement in product development: Marketing, Design Engineering, Quality Assurance, Manufacturing/ Manufacturing Engineering, Test Engineering Finance, Product Support, etc.

The active involvement of these departments can lead to balanced consideration of the requirements or 'What's" at each stage of this translation process and provide a mechanism to communicate hidden knowledge - knowledge that is known by one individual or department but may not otherwise be communicated through the organization. The structure of this methodology helps development personnel understand essential requirements, internal capabilities and constraints and design the product so that everything is in place to achieve the desired outcome-a satisfied customer. Quality Function Deployment helps development personnel maintain a correct focus on true requirements and minimizes misinterpreting customer needs. As a result, QFD is an effective communications and a quality-planning tool.

There are six basic elements of QFD, which are :

1. Determining the customer requirements (The QFD what).
2. Meeting how the requirements can be achieved (The QFD How) of the customers are critical to final product control.
3. Relationship between the requirements and how they are to be met.
4. Target values for the requirements.
5. Relationships between how the requirements are to be met.

6. A quantification of the importance of the requirements.

II. MATERIAL AND METHODOLOGY

The basic Quality Function Deployment methodology involves four basic phases that occur over the course of the product development process. During each phase one or more matrices are prepared to help plan and communicate critical product and process planning and design information. This QFD methodology flow is represented below.

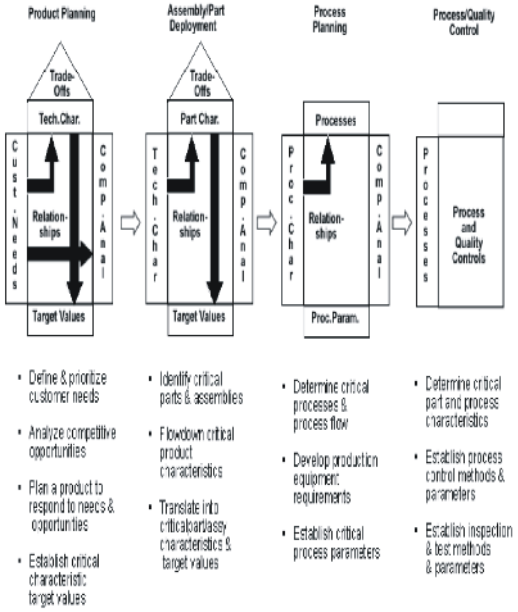


Fig. 1. Four Phase QFD Approach.

Once customer needs are identified, preparation of the product planning matrix or "house of quality" begins. The sequence of preparing the product planning matrix is as follows:

1. Customer needs or requirements are stated on the left side of the matrix as shown below. These are organized by category based on the affinity diagrams. Insure the customer needs or requirements reflect the desired market segment (s). Address the unspoken needs (assumed and excitement capabilities). If the number of needs or requirements exceeds twenty to thirty items, decompose the matrix into smaller modules or subsystems to reduce the number of requirements in a matrix. For each need or requirements, state the customer priorities using a 1 to 5 rating. Use raking techniques and paired comparisons to develop priorities.
2. Evaluate prior generation products against competitive products. Use surveys, customer meetings or focus groups/clinic to obtain feedback. Include competitor's customers to get a balanced perspective identify price points and market segments for products strategy. Consider the current strengths and weaknesses relative to the competitive? How do these strengths and weaknesses compare to the customer priorities? Where does the gap need to be closed and how can this be done copying the competition or using a new approach or technology? Identify opportunities for breakthrough's to exceed competitor's capabilities areas for improvement to equal competitor's capabilities, and areas where no improvement will be made. This strategy is important to focus development efforts where they will have the greatest payoff.
3. Establish product requirements or technical characteristics to respond to customer requirements and organize into related categories. Characteristics should be meaningful, measurable and global. Characteristics should be stated in a way to avoid implying a particular technical solution so as not to constrain designers.
4. Develop relationships between customer requirements and product requirements or technical characteristics. Use symbols for strong, medium and weak relationships. Be sparing with the strong relationships symbol. Have all customer needs or requirements between addressed? Are there product requirements or technical characteristics stated that don't relate to customer's needs?
5. Develop a technical evaluation of prior generation products and competitive products. Get access to competitive products to perform product or technical benchmarking. Perform this evaluation based on the defined product requirements or technical characteristics. Obtain other relevant data such as warranty or service repair occurrences and costs and consider this data in the technical evaluation.
6. Development preliminary target values for product requirements or technical characteristics.
7. Determine potential positive and negative interactions between product requirements or technical characteristics using symbols for strong or medium, positive or negative relationships
8. Calculate importance ratings. Assign a weighting factor to relationship symbols (9-3-1, 4-2-1, or 5-3-1). Multiply the customer importance rating by the weighting factor in each of box of the matrix and add the resulting products in each column.
9. The matrix and finalize the product development strategy and product plans. Determines required actions and areas of focus. Finalize target values. Are target values properly set to reflect appropriate tradeoffs ? Do target values need to be adjusted considering the difficulty rating ? Are they

reasonable with respect to eh importance ratings ? Determine items for further QFD deployment. To maintain focus on "the critical view" less significant items may be ignored with the subsequent QFD matrices. Maintain the product planning matrix as customer requirements or conditions change.

III. STRATEGY FOR QFD OF REFRIGERATOR

For design of refrigerator using QFD, following steps are involved :

1. Survey planning and the implementation : The First step of this work is to get customer requirements from open market. There is no predetermination of what will be important to a customer. All narratives written by customer are analyzed and prevailing themes are identified. Based upon the frequency of the themes a formal attitude survey is design to collect the voice of customer data. Since there are so many feature of refrigerator to explore, the most frequently mentioned themes are good bases for forming the attitude questionnaire. The method of collecting information about the VOC and the VOE are through the questionnaire from the open market survey. The users are selected from open market. The questionnaire containing 20 questions in the form of VOC data collection and the 14 points has been selected

After the critical QFD method and machine quality improvement, feedback is used to modify the survey. Re-surveying provides more information about dissatisfaction and other service problems as they emerge.

Three normally used medium capacity refrigerator for household purpose, with same Capacity Range (Liters) are selected from following three manufacturing organization:

I. Samsung

II. Godrej

III. Videocon

These three refrigerators are similar characteristics, target the similar focus group of customer and are well recognized in market.

2. Types of data

There are two types of data used to find the customer requirements and methods used to obtain it are as follows :

Primary data : were collected from a formal market research, through face to face interview and using verbatim. Also some information came from interviews of technical venders selling and exporting machines and listening to comments of customer at retail stores.

Secondary data the secondary data used in analysis came from specialized magazines and research journals.

3. Organization for customer requirements

The requirements of customers are written in the customer language and organize them to reach a common understanding of customer wants. Some requirements are redundant as "dependability of refrigerator" and "not to failure during working"; such requirements in this situation were joined into single statement.

Other requirements such as quick cooling, Separator for Vegetable and Fruits, Number of Shelves and Boxes, type of door, power consumption were not taken into account in this analysis because they are considered almost as a standard in all three cases studied.

Following steps are performed during this exercise :

I. Survey from open market (user).

II. Survey from the manufacturers.

III. Date collection from both users and manufacturers.

IV. Grouping date into tree diagram and selecting major requirement of the TREE customers.

IV. THE PLANNING MATRIX

After collecting and analyzing information, it was decided to take only analysis of final user because there was not enou`gh information about the other customers.

The planning matrix would be more useful if it could be based on real strategic marketing information. There is a series of priorities for the customer requirements that are based on their importance to be development team's requirements are ordered by priorities, seeing the focuses into five priorities; they would improve 61.5% of customer needs. These customer requirements in the form of WHAT's and HOW's are shown in the matrix of QFD house.

These priorities are as :

1. Less energy consumption

2. Long Life

3. No frost

4. Separator for Vegetable and Fruits

5. Quick Freezing Component

The priority is given to each preference (VOC) of customer demand on the scale of 1-5; VOC is correlated with the VOE and its importance rating is calculated the six high value rating characteristics of customer preference are selected importance rating is given to them by the relationship :

$$\sum_{i=1}^{n} RiWi = \text{importance rating}$$

where R is VOC and W is VOE.

In this case the targets are easy to find because most of the superior levels of customer satisfaction can be achieved with no dramatic change in the product moreover, in the most of the cases only the change is possible in one specific way and not in other.

Engineering Characteristics

1. Air Flow Type
2. Moisture or Humidity Control
3. Manufacturing cost
4. Service Life
5. Number of Refrigerator Door Shelves
6. Number of Shelves and Boxes
7. Number of Cabinet Shelves
8. Energy consumption (Star Rating)
9. Dimensions
10. Refrigerator temp. variation
11. Ergonomy.

To make rating of degree of technical difficulty a scale from 1 to 5 was used. In this stage the information available was not enough to ensure a reliable rating and many of the value were used with personal criterion. These values were allocated in QFD chart.

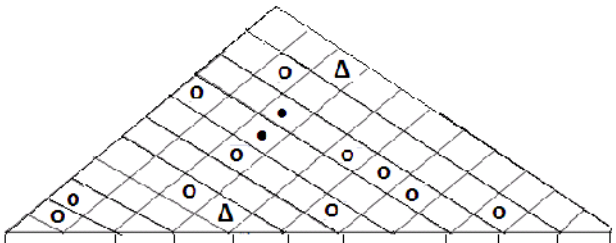
V. IMPORTANCE RATING CHART

Based on the engineering characteristics analyses following parameters are identified: Table

Engineering characteristics calculations are obtained from the three competitor manufacturers of refrigerator, and the best performance characteristics of each company are selected .then seven high value rating characteristics of customer preference are identified.

The result of present work *i.e.* application of QFD on a refrigerator toward design and development of the refrigerator are here. Based on the analysis of customer requirement and voice of engineering presented in house of quality matrix, 11 points have been found to major importance.

Matrix	Weights	
Strong	5	●
Positive	3	o
Poor	1	Δ



Customer Requirement	IMPORTANCE	Air Flow Type	Moisture or Humidity Control	Manufacturing cost	Service Life	Number of Refrigerator Door Shelves	Number of Shelves and Boxes	Number of Cabinet Shelves	Energy consumption (star rating)	Dimensions	Refrigerator temp. variation	Ergonomy
Long time freshness of food and beverages	8	●	●	o	o						●	
Less energy consumption	5			Δ					●		o	
Long Life	6			Δ	●						Δ	
Large space for beverages	3			o		●				o		
Separator for Vegetable and Fruits	3			o			●	●		o		
Capacity of refrigerator	2			●		o	o	o		o	●	
Capacity of Freezer	2			●			o	o		●	●	
Quick Freezing Component	3								o			
Door open sound or light	1			o					o			o
Warranty Period (Years)	5				●							
Colours	2											
Adjustable shell and shelves	4			o			o	o				●
Easy to clean	2											●
No frost	8	o	Δ	o					o			
Absolute Importance		64	48	109	79	21	39	39	61	33	81	33
Relative Importance		10.4	7.8	18.3	12.9	3.43	6.3	6.38	9.9	5.56	13.25	5.4

Table : 1.

Engineering Characteristics	*Absolute Importance*	*Relative Importance*
Air Flow Type	58	8.15
Moisture or Humidity Control	46	6.46
Manufacturing cost	131	18.40
Service Life	79	11.10
Number of Refrigerator Door Shelves	33	4.63
Number of Shelves and Boxes	54	7.58
Number of Cabinet Shelves	54	7.58
Energy consumption (star rating)	55	7.72
Dimensions	63	8.85
Refrigerator temp. variation	106	14.89
Ergonomy	33	4.63
	712	

VI. CONCLUSION

In this paper apply QFD to develop a design and development procedure for a product like a Refrigerator System. To determine the importance of various refrigerator parameter to users and then subsequently design both a lower cost alternative as well as a high performance model with QFD technique. In QFD projects involving designing existing products, the WHAT's are collected and processed just as though the product were new. However, the HOW's are the realization mechanisms. Target values are connected to the house of quality. The relation matrix is filled in, and the HOQ is analyzed. Customer requirements are recorded in the rows of HOQ matrix and the design characteristics are placed in the columns of matrix. Empty row in the relation matrix identify the unmet customer expectation and empty columns identify the mechanisms that meet no customer need. From this analysis conclude the seven most important parameter are consider to modification for improvement in design, these parameter are Air flow Type, Service life, Energy consumption, Number of Shelves and Boxes, Number of Refrigerator Door Shelves, Humidity control and Dimension.

On improving upon seven important engineering characteristics, we get a design of refrigerator that will meet the requirements of customers.

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