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QUALITY FUNCTION DEPLOYMENT: CASE STUDY ON ROADMAP FOR IMPELLER DESIGN

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Abstract

Quality Function Deployment (QFD) was conceived in Japan in the late 1960's and used extensively by Toyota. QFD is a customer oriented approach to product innovation. It is the structured approach which define customer needs and translating them into specific plans to produce and to meet those needs. It is a quality tool that helps to translate the Voice of the Customer(VoC) into new products that truly satisfy their needs. The VoC is the term used to describe the stated and unstated customer needs. The quality improvement are based on the feedback of customers about new and existing product in the market and from benchmarking of competitors. In this paper, QFD technique is applied to the product (Impeller) to design, develop and implementation of the product quality. In the design of a new Impeller, QFD gave the most important parameters from customer point of view and then find out engineering characteristics. These important parameters are then put into House of Quality matrix [HoQ] to get the relation matrix between voice of customer and engineering characteristics. From the result of QFD applied to Impeller which short out the parameters those are," Regulate uniform flow of oil through impeller vanes, Holes, Thickness of vanes, Draft angle & no. of vanes, Constant RPM to motor, Cost, Total life span (hrs.), Less energy consumption". This are require modification according to voice of customer and used for new design.

Keywords - Customer needs, HoQ matrix, Impeller, QFD, Quality assurance, Technical needs

1. INTRODUCTION

Quality function deployment (QFD) is one of the TQM technique. It is introduced in Japan in 1960's by Yoji Akao. QFD is a customer oriented approach to product innovation. It guides product manager and design teams through the conceptualization, creation and realization process of new products. It is a quality tool that helps to translate the voice of the customer into new products that truly satisfy their needs. The voice of customer is captured in a variety of ways: interviews, market surveys, focus groups, customer specifications, direct discussion, field report etc. This understanding of the customer needs is then summarized in a product planning matrix or "HoQ matrix". These matrices are used to translate higher level i.e. customer needs (what's) into lower level i. e. product requirements or technical characteristics (how's) to satisfy these needs. QFD is applied in the early stages of the design phase so that the customer wants are incorporated into the final product. Furthermore it can be used as a planning tool as it identifies the most important areas in which the effort should focus in relation to our technical capabilities.

There are six basic elements of QFD, which are :

1. Determining the customer requirements (what).
2. Determining the technical requirements (how).
3. Relationship between the customer requirements and technical characteristics.
4. Correlation between each of the technical measures or needs.
5. Target values for the requirements.
6. A quantification of the importance of the requirements.

2. METHODOLOGY

The Quality Function Deployment methodology involves four basic phases that occurs over the course of the product development process. Those are:

1. Product planning (HoQ matrix)
2. Product designing
3. Process planning
4. Process Control (Production)

The flow of these four phases are given below:

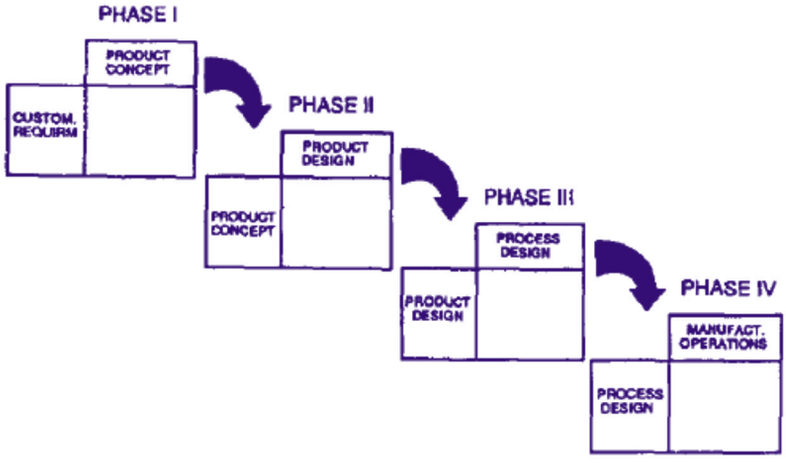


Figure 1: Four phases of QFD

2.1 Product Planning

Product Planning, is also called as "House of Quality". In this we plan the product according to the customer requirements or needs which are taken by the market survey, and from those needs we choose some of the important needs as an objectives. Once customer needs are identified, preparation of the "HoQ" matrix begins. The sequence of preparing the HoQ matrix is as follows:

1. Customer needs or requirements are stated on the left side of the matrix, in the below given matrix section 'A' contains customer needs. These are organized by category based on the affinity diagrams. Insure the customer needs or requirements reflect the desired market segment. 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.

2. Section 'B' in below matrix, gives the Planning matrix which 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.

3. Section 'C' in below matrix, contains manufacturer needs which is 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. Section 'D' in below matrix, gives the relationship matrix which develop relationships between customer requirements and product requirements or technical characteristics. Use symbols or direct rating such as 9:3:1:0 or 5:3:1:0 respt. for strong, medium, weak & no relationships. Be sparing with the strong relationships symbol.

5. Section 'E' in below matrix, gives the correlation matrix to determine the positive and negative interactions between product requirements or technical characteristics using symbols for strong or medium, positive or negative relationships

6. Section 'F' in below matrix, gives the technical matrix which is used for development of preliminary target values for the product requirements or technical characteristics. 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.

7. The matrix finalize the product development strategy and product plans. Determine the required actions and areas of focus. Finalize target values. Maintain the product planning matrix as customer requirements or conditions change.

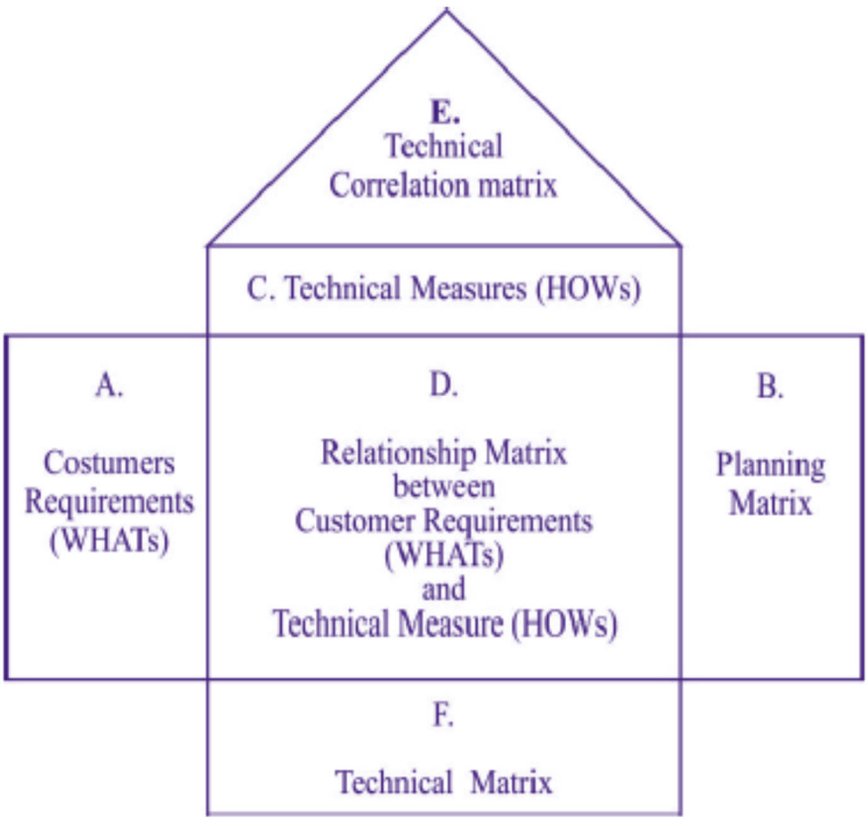


Figure 2: House of quality matrix

2.2 Product Designing

The second phase is product designing which is led by the engineering department. This phase requires creativity and innovative team ideas. During this phase product concepts are created and specifications of part are documented. Then the parts that are determined to be most important to meet customer needs are then deployed into process planning.

2.3 Process Planning

After product design, process planning comes next & is led by manufacturing engineering. During this phase required manufacturing processes, machines and tools are flowcharted and process parameters or target values are documented.

2.4 Process Control

After the process planning, final phase is process control or production planning. In this phase performance indicators are created to monitor the production process, maintenance schedules & skills training for operators. Also, the decisions are made as to which process poses the most risk & controls are put in place to prevent failures.

3. STRATEGY FOR QFD OF IMPELLER

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

3.1 Customer Requirements

The First step of this work is to get customer requirements from open market survey. 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. 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 14 questions in the form of VOC data collection & those are:

1] Weight
2] Size
3] Ease of maintenance
4] Availability
5] Ease of clean
6] Warranty
7] Technological Risk
8] Modularization
9] Ease of assembly
10] Reliability
11] Aesthetic
12] Service
13] Trading
14] Accessibility

3.2 Manufacturer Requirements

The Second step of this work is to get manufacturing requirements by manufacturer engineers. In this step, engineering characteristics are derived from expert's opinion & the surveys are required to fulfill customer's requirements. Once the engineering characteristics were developed, the correlation matrix was developed to determine the relationships between parameters, since they are often correlated to each other in a product. Here, the technical requirements of Impeller part are:

1] Constant RPM to motor
2] Less energy consumption
3] Cost
4] Draft angle & no. of vanes
5] Reduce design time
6] Thickness of vanes
7] Total life span (in hrs.)
8] Holes
9] Capacity
10] Casting (PDC)
11] Production Rate
12] Mach inability
13] Material
14] Regulate uniform flow of oil through impeller vanes

3.3 Planning Matrix

The planning matrix would be more useful if it could be based on real strategic marketing information. In this matrix market data strategic goals setting for the new product and computations for prioritizing the customer needs. 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, In this matrix, our product compared with the other competitors of the market. Here, we compared our component Impeller with:

Competitor- 1 Swaraj Engines and
Competitor- 2 Mahle Engine Components India Pvt. ltd.

3.4 Importance Rating Chart

In this chart, Importance rating is to be given to obtained the high value rating characteristics of customer preference. Here, we give the customer importance rating from 1to5 i.e.

1- Highest
5- Lowest

3.5 Relationship Matrix Between Customer Needs & Technical Needs

This matrix is about investigating the relationships between the customer requirements and the engineering characteristics in order to identify important product properties. The relationships is rated on a scale consisting of 0, 1, 3 and 9 where:

9 - Strong relationship
3 - Medium relationship
1 - Weak relationship and
0 - No relationship

3.6 Correlation Matrix

This matrix is about to determining the correlation between each of the Engineering characteristics. In this step, engineering characteristics also known as product characteristics (how's) derived from expert's opinion surveys are required to fulfill the customer's requirements. Once the engineering characteristics were developed, the correlation matrix (Roof of HoQ) was developed to determine the relationships between parameters, since they are often correlated to each other in a product. A relationship means the degree of intensity between characteristics and is illustrated with:

+ - Positive Correlation
⬭ - Weakly Positive Correlation
△ - Negative Correlation
Blank - No Correlation

3. 7 Technical Matrix

The next step in completing the HoQ was establishing the absolute and relative importance of each engineering characteristic. The absolute importance weights were calculated by multiplying the weight of customer requirements by the numerical relationship between the requirements and characteristics, then followed by summation. The relative importance was then calculated based on the absolute importance. Below given figure of HoQ matrix reports the absolute and relative importance of the engineering characteristics for the improvement of the design of Impeller to customers. The final importance rating of "hows" was determined based on relative importance, technical difficulty, and the correlation matrix. Considering these aspects, the final importance rating was computed as shown in fig. 3 which gives the results required to improve the design and quality of part Impeller.

3.7.1. Absolute Importance Weight

Example (1) : Absolute weight for constant RPM to motor in fig. 3 of HoQ matrix is :

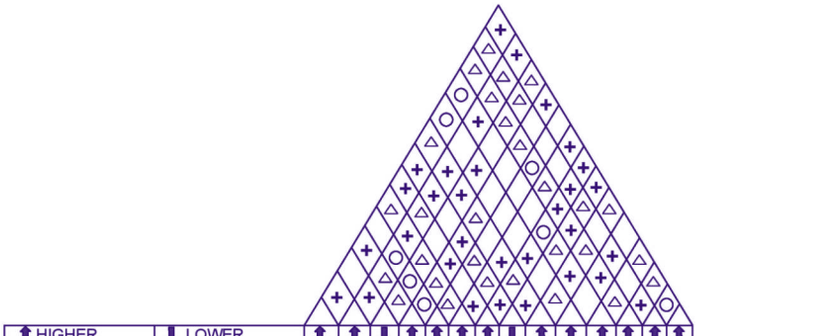
Absolute weight = Customer importance rating × Numerical relationship between the needs & characteristics

$= (1\times3) + (3\times3) + (4\times9) + (4\times0) + (2\times3) + (3\times0) + (2\times1) + (1\times3) + (5\times3) + (3\times9) + (5\times0) + (3\times1) + (4\times0) + (3\times1) = 107$

Total absolute weight = ∑ All absolute weights of 14 characteristics = 1372

Example (2) : Relative weight for constant RPM to motor in fig. 3 of HoQ matrix is :

Relative weight = [(Absolute weight × 100) ÷ 1372]
= [(107 × 100) ÷ 1372] = 7.7988 %



⬆ HIGHER ⬇ LOWER		Technical Requirement														Planning Matrix				
Relationship Matrix 0 - No Relation 1 - Weak Relation 3 - Medium Relation 9 - Strong Relation	Customer Importance Rating	Constant Rpm to Motor	Less Energy Consumption	Cost	Draft angle & No. of Vanes	Reduce Design Time	Thickness of Vanes	Total Life Spam	Holes	Capacity	Casting	Production Rate	Machinability	Material	Uniform Flow of Oil	□ - Our Company # - Competitor-1 ● - Competitor-2				
Customer Requirements																L				H
																1	2	3	4	5
Weight	3	1	1	3	3	1	3	1	3	1	1	0	1	3	3		#	□	●	
Size	3	3	1	3	3	3	3	1	3	1	1	0	1	1	3		#			
Ease of Maintenance	4	9	3	3	3	1	9	9	9	1	9	1	3	9	9			#		
Availability	4	0	0	1	0	0	0	0	1	0	1	1	0	0	0		#	●	□	
Ease of Clean	2	3	1	0	1	1	1	0	3	0	1	0	3	0	3	●	□			#
Warranty	3	0	3	1	0	1	0	3	1	1	1	1	1	0	1		●	□	#	
Technological Risk	2	1	0	1	3	1	0	1	1	0	0	9	0	1	1	#	□	●		
Modularization	1	3	1	3	3	3	3	3	9	3	1	3	1	1	3	●	#			
Ease of Assembly	5	3	3	0	9	3	9	0	9	0	1	0	1	0	3		●	#		□
Reliability	3	9	3	3	3	3	9	3	3	1	3	3	1	0	3	●	#	□		
Aesthetics	5	0	0	9	0	1	3	1	3	0	1	0	1	0	3			●	#	
Service	3	1	9	3	3	0	0	9	0	1	0	0	0	1	0		#	□	●	
Treading	4	0	0	3	3	0	0	3	0	3	0	9	0	0	0			#	□	
Accessibility	3	1	9	3	9	0	1	1	3	3	1	0	1	1	3	#	●	□		
Absolute Weight	45	107	108	126	143	60	149	112	156	43	74	77	44	57	116	Correlation Matrix + - +ve Correlation △ - Weakly + Ve ○ - -ve Correlation BLANK- No Corelation				
Relative Weight	-	7.798	7.871	9.183	10.42	4.377	10.86	8.163	11.37	3.134	5.393	5.612	3.201	4.154	8.454					

CUSTOMER IMPORTANCE RATING 1 TO 5
1- HIGHEST
5 - LOWEST

Figure 3: House of Quality matrix for the part Impeller

4. RESULT AND DISCUSSION

In the above figure of HoQ matrix, the last step in QFD methodology is to prioritize the parameters which satisfy customer's expectations successfully. To manage this, relationship weights are multiplied by customer importance ratings. The final weights of each technical requirement is given in fig 3, which conclude the eight most important parameters which are consider to modification for improvement in design, these parameter are," Regulate uniform flow of oil through impeller vanes, Holes, Thickness of vanes, Draft angle& no. of vanes, Constant RPM to motor, Cost, Total life span (hrs.), Less energy consumption."

This total "Eight" results helps to improve the Design & Quality of the part Impeller.

5. CONCLUSION

QFD is a quality design and improvement technique and relatively is closer to the customers than other techniques. Also, QFD can serve as a flexible framework, which can be modified, extended, and be combined with other quality design and improvement techniques. Customer driven, Competitive analysis, Reduced development time, Reduced development cost this are some important benefits of QFD. It is applicable in many areas some of those are, 'Restaurants', 'Bakery', 'Hotels', 'Education Institute' and 'Industry' for the improvement of the product according to the customer requirement. In this paper QFD apply to develop a design and development procedure for a product like a Impeller. In QFD projects involving designing existing products, the WHAT's i.e. customer needs are collected and processed just as though the product were new. However, the HOW's i.e. technical needs are collected by the experts' advice . Target values are connected to the house of quality. The relationship matrix is done, and the "HoQ" matrix is analyzed. From this analysis we conclude the eight most important parameter and those are consider to modification for improvement in design, these parameter are," Regulate uniform flow of oil through impeller vanes, Holes, Thickness of vanes, Draft angle& no. of vanes, Constant RPM to motor, Cost, Total life span (hrs.), Less energy consumption". On the improving upon "Eight" important engineering characteristics, we get a design of Impeller that will meet the requirements of customers.

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