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Research Paper

Engineering

KEYWORDS : QFD, AHP, Matrix, Inventory, Ratio Analysis

Improvement of Quality Acceptance Criteria in Two-Wheeler Segment Using Qfd & Ahp

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ABSTRACT

This project aims at examining the applicability of Quality Function Deployment (QFD) and Analytical Hierarchy Process (AHP) to shift customer expectations and design quality in Two Wheeler Segment. For this purpose we determined customer needs and product requirements through direct interviews, observation and data analyses. We quantified and prioritized the customer needs on the hierarchy diagram providing accurate ratio-scale priorities. Following the categorization and prioritization of customer needs, the requirements were then converted into quality characteristics. Consequently in this project, QFD and augmented it with the AHP can be successfully applied in the segment and findings demonstrate that some solutions can be suggested for optimization of the product effectively.

1 Introduction:

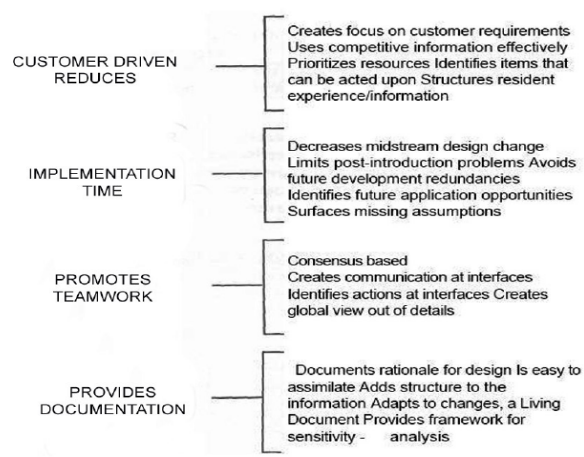
In the highly competitive environment today, it is imperative for companies to continually know about the changing Experiences of its customers. Quality function deployment (QFD) is a powerful technique to know the customer requirements and accordingly design new products and services. It is also useful to modify the features and designs of its existing products according to the changed requirements of the customers. QFD helps to understand the importance that customers attach to their various expectations. It is a challenge to understand what the customers exactly want. In most cases, the number of customers may be too many, having different expectations, some of which may be contradictory to those of other customers. For example, some customers expect high mileage from an automobile, while others want more power. Another set of customers may want both mileage and power. The designers of the engine of the automobile have to satisfy the expectations of this whole group of customers in the best possible way. Customers have their own unique way of expressing their expectations, when required about. QFD helps to convert these Expectations, called 'voices of customers' (VOCs), into engineering or technical requirements.

QFD has emerged as a useful tool not only in manufacturing, but also in services set-ups. In fact, it is a major constituent of the Six Sigma philosophy.

2 Objective of project:

This project aims at examining the applicability of Quality Function Deployment (QFD) and Analytical Hierarchy Process (AHP) to shift customer expectations and design quality in Two Wheeler Segment. For this purpose we determined customer needs and product requirements through direct interviews, observation and data analyses. We quantified and prioritized the customer needs on the hierarchy diagram providing accurate ratio-scale priorities. Following the categorization and prioritization of customer needs, the requirements were then converted into quality characteristics. Consequently in this project, QFD and augmented it with the AHP can be successfully applied in the segment and findings demonstrate that some solutions can be suggested for optimization of the product effectively.

3 benefits of qfd



1. Focus with priority
2. Understand the causes
3. Understand the situation
4. Market-in vs Product-out
5. Define the process
6. Better communication
7. Listen to the "customer opinion"

4 limitations of the study:

Determining of limitations of the study is important for evaluating right results. For this reason, we limited the project with some factors which we meet during the project process.

The limitation of the study is that the company was not actively involved. Interviews were realized in the company's local showrooms with sales persons. We discuss about the company's customer profile and something about the product which we work on.

5 understand the situation:

Go to Gemba: to gain knowledge by direct sensory experience in the "actual place" where your customer benefits from your product. Where does the customer have the problems that you can help them with? We want to capture the "raw" information about this special place. Companies that don't go to the Gemba are missing something: the details. The Japanese have a world to describe "the true source of information" –Gemba. In manufacturing, Gemba refers to the shop floor. When there is a problem, the engineers go directly to the work area and use their own eyes to see, their own ears to hear, their own hands to touch, etc. They rely on direct experience to understand the relevant situation we might help them realized. Unlike other customer information gathering techniques, such as focus groups and surveys, here we

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do not ask questions about problem without technology or marketing. We do not remove customers to an artificial site such as a meeting room, and we do not rely on customers' memories to report problems to us. Rather, we employ all of our senses and field research methods for the larger purpose of trying to understand where and how we might help customers (Mazur 2008).

6 customer OPINION:

A common misunderstanding among QFD and other quality professionals concerns what the "Customer Opinion" is. In the most cases, it is necessary to go beyond the started requirements in order to build a competitive and profitable product. Why? State or voiced requirements can be met by any competitor who has access to them. This has led to a commoditization of products that differ little within a certain price point. In such case, the way to succeed is by lowering price, which is not always a long term strategy for everyone.

The QFD approach is to uncover unspoken needs by analysis based on going to the Gemba and adding observational data, and even self-image and life style concerns even before our customer can articulate them to our competitors.

Then, we can clarify these with the customer, have them give us their priorities, and then quantify a competitive solution and assure its quality throughout the development and production process.

Many of the basic tools already mentioned, such as the gemba visit table and log, customer process model, customer voice table, affinity diagram, hierarchy diagram, and the analytic hierarchy process facilitate this analysis (Mazur 2008).

7 STEP BY STEP QUALITY FUNCTION DEVELOPMENT AND ANALYTIC HIERARCHEY PROCESS:

- Determination of the target of the project.
- Determination key customers.
- Meeting with customers, Gemba.

8 Organizing Customer Needs:

Once customer needs are gathered, they then have to be organized.

9 ANAYTICAL HIERARCHY PROCESS

SCOPE OF AHP:

The AHP proposes a methodology to organize the analytical thought, according to three basic principles, (Bautista 2007)

- The hierarchy construction principle:
- The priority setting principle
- The logical consistency principle:

2 Computational Details:

Assume that *n* decision factors are considered in the quantification process of the relative importance of each factor with respect to all the other ones. This problem can be set up as a hierarchy as explained in the previous section. The pair wise comparisons will then be made between each pair of factors at a given level of the hierarchy, regarding their contribution toward the factor at the immediately above level. The comparisons are made on a scale of 1–9, as shown in table 6. This scale is chosen to support comparisons within a limited range but with sufficient sensitivity (a psychological limit for the human beings to establish quantitative distinction between two elements was proved by psychometric studies). These pair wise comparisons yield a reciprocal (*n*,*n*)-matrix *A*, where *aii*=1 (diagonal elements) and *aji*=1/*aij*.

Multiplying the matrix by the vector of weights $\boldsymbol{w}=(w1,w2,\ldots,wn)$ yields:

$$Aw = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & \cdots & \cdots & a_{nn} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_1 \\ \cdots & \cdots & \cdots & \cdots \\ w_n/w_1 & \cdots & \cdots & w_n/w_n \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_n \end{bmatrix},$$

10 CALCULATIONS

- **Ranking of Customer Opinion with AHP**

A systematic method for comparing a list of objectives or alternatives

- When used in the systems engineering Process, AHP can be a powerful tool for Comparing alternative design concepts
- Reference : Ernest H. Forman, Decision by Objectives,
- A set of objectives has been established (VSD, OH), and that we are trying to establish a normalized set of weights to be used when comparing alternatives using these objectives.
- For simplicity, we assume that there are 4 objectives: O1, O2, O3, and O4.
- Form a pair wise comparison matrix A, where the number in the i^{th} row and j^{th} column gives the relative importance of O_i as compared with O_j
- Use a 1–9 scale, with

–a_ij= 1 if the two objectives are equal in importance
–a_ij= 3 if O_i is weakly more important than O j
–a_ij= 5 if O_i is strongly more important than O_j
–a_ij= 7 if Oi is very strongly more important than O_j
–a_ij= 9 if O_i is absolutely more important than O_j
–a_ij= 1/3 if O_j is weakly more important than O_i

Thus we might arrive at the following matrix:

$$A = \begin{bmatrix} 1 & 5 & 7 & 9 \\ 1/5 & 1 & 1/3 & 5 \\ 1/7 & 3 & 1 & 4 \\ 1/9 & 1/5 & 1/4 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 5 & 7 & 9 \\ 0.2 & 1 & 0.33 & 5 \\ 0.14 & 3 & 1 & 4 \\ 0.11 & 0.2 & 0.25 & 1 \end{bmatrix}$$

- The numbers in the first row are larger than the rest of the numbers. This indicates that the comparisons used in the original matrix are consistent.
- Now, we can compute a consistency measure using the Eigen values of the normalized comparison matrix.
- The next step is to compute the average Values of each row and use these as the Weights in the Objective Hierarchy.
- These weights would be used in summing the measures as required in the evaluation of the Objective Hierarchy.
- Ranking of Technical Requirements with AHP:
- Same procedure as mentioned above is used to set the hierarchy for technical requirements, part characteristics and process planning
- To normalize the weights, compute the sum of each column and then divide each column element by the corresponding sum
- Using an over bar to denote normalization, we get:

$$A = \begin{bmatrix} 0.689 & 0.543 & 0.815 & 0.474 \\ 0.138 & 0.109 & 0.038 & 0.263 \\ 0.097 & 0.326 & 0.116 & 0.211 \\ 0.076 & 0.022 & 0.029 & 0.053 \end{bmatrix}$$

- The numbers in the first row are larger than the rest of the numbers. This indicates that the comparisons used in the original matrix are consistent.
- Now, we can compute a consistency measure using the Eigen values of the normalized comparison matrix.
- The next step is to compute the average values of each row and use these as the weights in the Objective Hierarchy.
- These weights would be used in summing the measures as required in the evaluation of the Objective Hierarchy.

Ranking of Technical Requirements with AHP:

- Same procedure as mentioned above is used to set the hier-

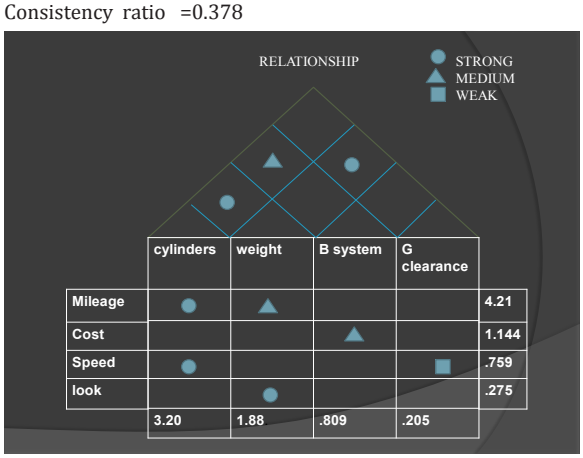
archy for technical requirements, part characteristics and process planning

RESULT:

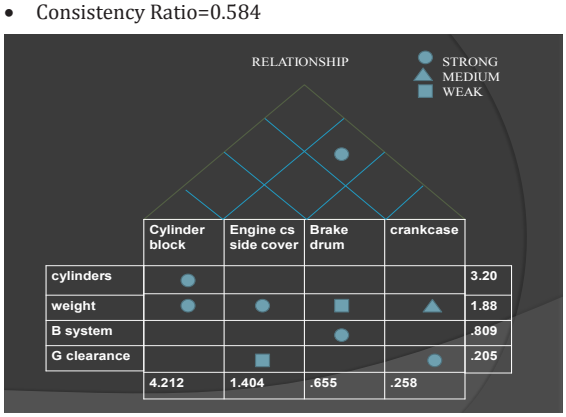
- Product Planning Phase Findings :
- Hierarchies are set using AHP approach
- Voice of Customer:
  - Mileage= 4.21
  - Cost= 1.144
  - Speed= 0.759
  - Look= 0.275
- Consistency index =0.132
- Consistency ratio =0.140

- Technical requirements:
  - No. of cylinders= 3.20
  - Weight= 1.88
  - Brake system= 0.809
  - Ground clearance= 0.205

Consistency index =0.341
Consistency ratio =0.378

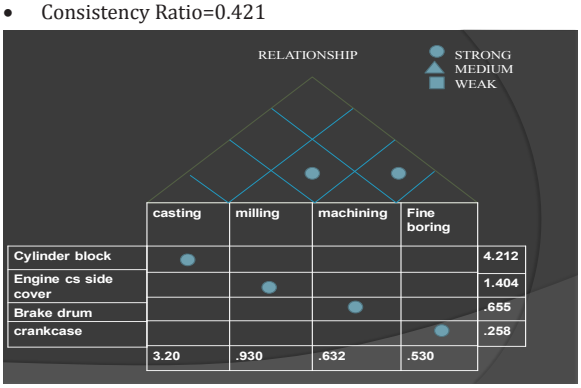


- Result: Product Design Phase
  - Parts Deployment
  - Cylinder Block=4.212
  - Engine crankcase side cover=1.404
  - Brake Drum=0.655
  - Crankcase=0.258
- Consistency Index=0.526
- Consistency Ratio=0.584



Result: Process Planning Phase

- Processes Used
- Casting=3.20
- Milling=0.930
- Machining=0.632
- Fine boring=0.530
- Consistency Index=0.379
- Consistency Ratio=0.421



11 CONCLUSION

QFD is a good system to be implemented in organization or industry, which can be seen from the example mentioned above. QFD does not design to replace the existing organization design process by any means, but rather support the organization's design process. And it also helps bring the customer's voice into the production process to reduce the unnecessary cost. Cutting production time is also very beneficial to the companies.

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