Applying QFD in the Design Process of a Comfortable and Sensible Brassiere for Middle Aged Women

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Abstract

The purpose of this study was to develop a design process for a functional and sensible brassiere for middle - aged women. As a methodology, an engineering design process QFD (Quality Function Deployment) was adopted to translate the consumer's needs into product design parameters. The customer needs for the wear comfort of brassieres were extracted from a survey of 100 women aged 30 - 40. To select which items were critical and which could be traded off for other attributes or benefits, the importance ratings for the customer needs were determined. Customer needs were translated into technical language by various physical test methods and wear tests. The customer competitive assessment was generated by wear tests of 10 commercial brassieres under controlled environmental conditions of 28± 1℃, 65± 3%RH. The relationship matrix between the customer needs and the means of delivering the needs was developed. Using the QFD methodology, design elements for developing a brassiere for middle-aged women could be analyzed and organized efficiently.

Key words: Quality Function Deployment, QFD, Product development, Design process, House of Quality, Brassiere

1. Introduction

Quality Function Deployment (QFD) is a product development tool used to ensure that the Voice of the Customer is heard and translated into products. QFD provides a multifunctional team with the information necessary to design and manufacture a successful product. The process that a project team goes through to organize this information also provides the basis for making decisions on what product features and benefits should be incorporated into the product. These decisions are a function of what customers want, balanced by the company's limitations or needs[1].

However, the use of QFD for apparel is not found

easily in the literature, except for a few hypothetical examples[1) 2)]. Brassieres are apparel items that require an organized approach in the engineering design process. Thus, in this study, QFD was adopted to develop the requirements for a comfortable and sensible brassiere for middle-aged women. The applicability and usefulness of QFD in the development of the brassiere was also examined.

2. Methodology

The customer needs for the wear comfort of brassieres was developed through one-on-one surveys of 100 women aged 30 - 40. The study was carried out at the locker room of a swimming center in Taejon from Dec. 1998 - Feb. 1999. Once the customer needs (called WHATs in the QFD methodology) were identified, a questionnaire to determine the importance rating of each customer need was developed. Thirty women participated in identifying which needs are critical, and which could be traded off for other attributes or benefits. In order to make rational tradeoffs, we identified areas of conflict or areas of mutual reinforcement among customer needs. A detailed comparison of each customer need against every other customer requirement was made by experts. The analysis was documented in the side roof on the left of the WHATs in the House of Quality.

HOWs are the translation of customer needs into technical language. To find the physical parameters and test methods that reflect customer needs, various forms of tests were conducted. The empirical analysis of the nude body and the reformed body wearing various brassieres was obtained from 3D shape measurements using phase-shifting moire topography. We measured the mechanical and surface properties of the constituent materials for the brassieres using Kawabata Evaluation System for Fabrics[3)].

The relationship matrix between the WHATs and the HOWs was established by the research team based on the collected data. These relationships were designated as strong (9 points), medium (3 points), or weak (1 point). When there was no relationship, the matrix cell was left blank.

The customer competitive assessment was generated by wear testing 10 commercial brassieres. Twenty-five women aged 30-40 were asked to wear and evaluate the brassieres using the descriptors for customer requirements. Each woman rated each of the 10 commercial brassieres on a 7 point scale for each WHAT, with 7 being the highest rating and 1 being the lowest. The environmental conditions were controlled at 28± 1℃, 65± 3%RH.

3. Results

1)WHATs & Their Importance Rating

The consumer needs were grouped into categories called primary WHATs as shown in Table 1. Primary WHATs for morphological properties (fit / reform the shape of breast), aesthetic properties, pressure sensation, and displacement of the brassiere due to movement were extracted by a Factor Analysis. A subsequent analysis of the verbatim consumer responses revealed three other primary WHATs: strap-related properties and thermal properties, overall sensation. The actual Voice of the Customer is in the second column in Table 1. They are called the secondary WHATs.

The customer importance of four of the secondary WHATs averaged ratings of 4 or higher, and indicate that a good brassiere design for middle aged women should focus on these. These were "good stretchability", "shape of bra matches shape of breast", "wire is comfortable", and "good overall wear comfort".

Table 1. Customer needs and Importance Ratings for Wear Comfort of Brassiere

Primary WHATs	Secondary WHATs the "Voice of the Customer"	Importance Rating
Fit	Good Stretchability	**4.04**
	Shape of bra matches shape of breast	**4.19**
	Breast does not spill over cup	3.52
	Wire is comfortable	**4.17**
Reform shape of breast	Push breasts together	3.52
	Reduces breast vibration	2.96
	Volumes up	3.70
Aesthetic properties	Sexy	2.56
	Design is beautiful	3.07
Pressure Sensation	Does not compress armpit	3.59
	Does not irritate at bra tape	3.22
	Does not compress breast	3.33
Displace-ment of bra due to movement	Front of bra does not slide up	3.70
	Back & side of bra does not slide up	3.30
Strap-related Properties	Strap of bra does not slide down	3.52
	Strap is supportive	3.07
	Little compressed feeling on shoulder due to strap	3.26
Thermal property	Not warm & humid	2.81
Overall sensation	Good overall wear comfort	**4.09**
	Good tactile sensation	2.89
	High quality	2.63

2) Side Roof

The relationships between the WHATs were documented in the side roof to the left of the WHATs as shown in Figure 1. For example, "good stretchability" has positive relations with "shape of bra matches the shape of breast", "high quality", "does not compress armpit", "does not compress breast", "front of bra does not slide up", "good tactile sensation", and "good overall wear comfort". "Good stretchability" has a negative relationship with "reduces breast vibration", and "push breasts together".

3) HOWs and Relationship matrix

Table 2 shows how some of the customer requirements in the wear comfort of brassiere can be described by technical tests. Measurement scales of the HOWs could be a continuum or 7-point Semantic Differential scales. Some of HOWs require the development of a test method, such as determining low pressure sensations or aesthetic properties. In this study, we conducted wear tests to find relationships between customer needs and HOWs to obtain subjective evaluations. However, when any physical test method was available, we attempted a corresponding experiment. For example, curvatures of the underwires were measured and the relationship between the wearing comfort and the curvature of wires was examined. The results indicate that the underwire of brassiere with good wearing comfort had less change in the radius of curvature [4]. The relationship matrix betweer the WHATs and HOWs was developed through actual experiments (Fig. 2). Using fractional factorial techniques[5], we examined the effect of design parameters on subjective comfort sensation. We found that the stretchability of the main material of the brassiere and wire-related properties were the critical design parameters for overall wear comfort[6]. We also conducted psycho-

Table2. Matching Customer Requirements with Technical Language/ Tests for Wear Comfort of Brassiere

WHAT: Customer requirements	HOWs: Technical Tests
Good Stretchability	Tensile Property: Load cell (50kgf, Crosshead speed,100mm/min)
Shape of bra matches shape of breast	Measurement of volume & shape for breast, Pattern
Volume up	Analysis for shape of breast using 3D moire
Reduces breast vibration	Physical property of material, Measurement for vibration of breast by an accelerometer and a motion analyzer
Push breast together	Analysis for shape of breast using 3D moire
Sexy	Subjective Assessment
High quality	Subjective Assessment
Design is beautiful	Subjective Assessment
Does not compress armpit	Measurement of pressure
Does not irritate at bra tape	Mechanical properties (KES-FB system)
Does not compress breast	Measurement of pressure
Front of bra does not slide up	Wearing Test, Measurement of displacement
Back & sides of bra do not slide up	Wearing Test, Measurement of displacement
Strap of bra does not slide down	Wearing Test, Measurement of displacement
Strap is supportive	Measurement of pressure
Little compressed feeling on shoulder due to strap	Measurement of pressure
Not warm & humid	Temperature & humidity of microclimate
Good overall wear comfort	Subjective Assessment
Good tactile sensation	Surface properties (KES-FB system)
Wire is comfortable	Measurement of pressure, Strain & stress analysis, Curvature analysis
Breast does not spill over cup	Analysis for shape of breast using 3D moire

Physiological experiments to find the relationship between pressure and psycho-physiological responses. A positive relationship was found between the low frequency component of heart rate variability and overall wear comfort. As the level of pressure due to the side of the brassiere(wing) increased, β power and skin temperature increased [4].

To detect the morphological changes due to the type of brassiere, 3D body measurements were conducted using phase shifting moire topography. We found significant differences in the dimension of the width and height of the breast depending on the type of brassiere[4]. Whenever we found a strong relationship between the customer needs and corresponding experiments, the value of 9 was given on the relationship matrix as shown in Figure 2. For example, we found that strong relationships between overall wear comfort and mechanical properties of materials for bra, especially strtchability of side of bra, Lt & WT.

4) Correlation Matrix (Roof)

The roof shows where there are negative or positive interactions between different HOWs. More studies are required to determine the correlation matrix on the roof.

5) Customer Competitive Assessment and Technical Competitive Assessment

The Customer Competitive Assessment was generated by wearing tests of commercial brassieres. The results are shown in Fig. 3 on the right hand side of the matrix. Middle aged women evaluated brassiere #7 as the most comfortable, while brassiere #3 was rated the lowest. The analysis of the Customer Competitive Assessment versus the importance ratings is especially helpful

Customer Requirement Relationship Matrix (Side Roof)	Secondary WHATs the "Voice of the Customer"	Import-ance Rating
● Strong Positive ○ Positive × Negative # Strong Negative	Good Stretchability	4.04
	Shape of bra matches shape of breast	4.19
	Volumes up	3.70
	Reduces breast vibration	2.96
	Push breast together	3.52
	Sexy	2.56
	High quality	2.63
	Design is beautiful	3.07
	Does not compress armpit	3.59
	Little compressed feeling on shoulder due to strap	3.26
	Breast does not spill over cup	3.52
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	Strap of bra does not slide down	3.52
	Strap is supportive	3.07
	Not warm & humid	2.81
	Good tactile sensation	2.89
	Good overall wear comfort	4.09

Fig. 1. Customer WHATs, Importance Ratings and "Side Roof" for Wear Comfort of Brassiere

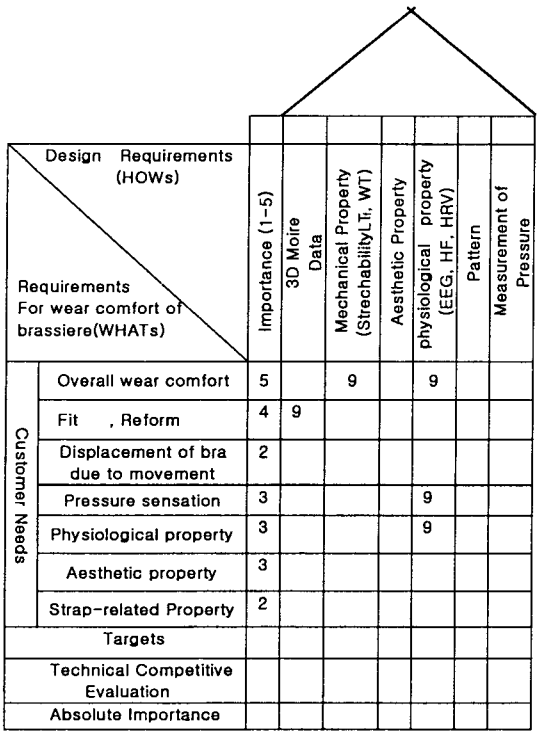

Fig.2 House of Quality for Wear Comfort of Brassieres.

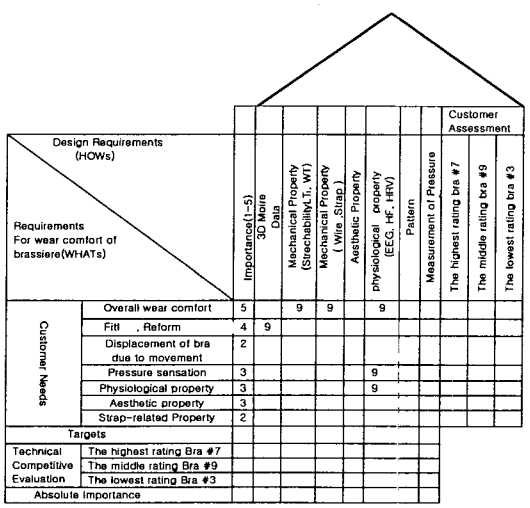

Fig.3 House of Quality for Customer Competitive Assessment and Technical Competitive Assessment

in determining where to put research efforts. If the company product is worse than the competition on one attribute, but the customer rating of the attribute is not high, then it may not be cost effective to spend resources improving this attribute. Three brassieres rated high, middle, and low in customer assessment coincided with the results by technical competitive evaluation. A comparison of the physical test evaluations in the Technical Competitive Assessment and the consumer evaluation in the Customer Competitive Assessment will tell a project team through the Relationship Matrix, whether they have identified the right HOWs.

4. Conclusion

The product development tool, QFD, was found to be applicable to the development of comfortable and sensible brassieres. We developed twenty-one customer needs and corresponding HOWs for the wear comfort of brassieres. However, the completion of the House of Quality requires more data. Refinement of measurement techniques and standardization of test methods are also necessary. It is hoped that the design process for the development of brassieres described here will stimulate research in the underwear industry to enhance the competitiveness of functional and aesthetic underwear.

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