Optimizing Smartphone's Back Panel Material Selection: A Comprehensive Analysis Using House of Quality (HOQ)

Abstract. This study aims to analyse the characteristics of the back material used in Organization Z's smartphones compared to those of other market competitors, following customer requirements. It also seeks to identify the most suitable material to increase customer satisfaction. Using the main tool of Quality Function Deployment (QFD), the House of Quality (HOQ), absolute and relative weight values were identified. These values were based on customer requirements, which were obtained from a customer survey, and on technical descriptors. These values guided the selection of an optimal material. Among the materials studied, alkali-aluminosilicate sheet glass emerged as the most suitable, exhibiting the highest absolute and relative weights. This chosen material, alkali-aluminosilicate sheet glass, was expected to meet customer demands most effectively. Overall, the study yielded valuable insights for decision-making and improving customer satisfaction in Organization Z's smartphone offerings.

Keywords: House of quality, Absolute weight value, Relative weight value, QFD and HOQ matrix.

1. Introduction

Quality function deployment (QFD) helps for the development of the product [1, 2]. QFD's main tool is House of Quality (HOQ) [3]. HOQ is one of the most used techniques and the initial phase of QFD [4, 5]. In the management sector, HOQ helps for decision-making [6]. HOQ is used to determine how perfectly the product fulfils the customer requirements [7]. Customer demands for the higher quality and features [8] and HOQ helps to find out the critical factors and the customer needs [9, 10]. HOQ can be used as a quality tool [11].

Organization Z was chosen for this research which is a smartphone manufacturer. The main objectives of this research were to analyze the organization's product with other market competitors to determine which material was able to meet the customer requirements and to make optimum decisions for selecting the material for the smartphone's back part. The back-part material of Z organization's smartphone was aluminium alloy. It was compared to the other materials to evaluate the competitiveness according to the customer requirements. HOQ matrix was used for the product's evaluation according to the customer requirements. HOQ is the most important part of QFD and is constructed to find out the relationship between customer requirements and the possible resources which can fulfil the customer requirements. It helps to design and develop a particular product. Different types of material were used as the smartphone's back part by different smartphone manufacturers. Customer survey was

conducted to find out the customer requirements. From the HOQ matrix, absolute weight value and relative weight value were determined where there was a clear overview of different materials of the smartphone's back panel according to the customer requirements. Hence, it was easily comparable between our product and other competitor's product. The appropriate material for the smartphone's back part was determined which could be able to increase customer satisfaction. The investigation yielded valuable insights for decision-making and improving customer satisfaction in Organization Z's smartphone offerings.

2. Literature Review

HOQ tool was used in various purposes such as organizing the manufacturing apps [12], material selection [13], service improvement [14] etc. Some of the recent information where applied HOQ tool is mentioned in table 1. All of the following literature has used the HOQ for analyzing the current scenario of their product or service and helping them to develop their product or service to enhance customer satisfaction. In this research, HOQ was used for analysing and to make optimum decision for smartphone's back panel.

Table 1: Related Work on HOQ Tool

Author Name	Year	Details
Robecca & Putra	2019	This study endeavors to develop "Click Trash" bags intended for mountain climbers, serving as an alternative to traditional plastic bags. By employing Quality Function Deployment, customer needs are translated into technical specifications, ensuring the bags cater to climbers' demands for convenience, reusability, and minimizing environmental impact by preventing littering on mountains. [15]
Kurniawan & Wijayanti	2020	The research crafted a House of Quality matrix to develop language instructional aids for deaf elementary students in Indonesia. It highlights the importance of visual and interactive mediums such as apps and educational games to enhance Indonesian language proficiency. This strategy targets user needs, particularly focusing on comprehension, writing, and speaking skills. [16]
Habib, Tufail, et al.	2021	In this study, the Quality Function Deployment (QFD) methodology is employed to improve the design and manufacturing procedures of locomotive bogie frames. Through the application of four phases of the QFD technique, efforts are directed towards optimizing and standardizing the manufacturing process, with the goal of decreasing costs, shortening production cycles, and enhancing both design and quality. [17]
Richard, Thomson, et al.	2022	The report aims to collect data from Tix.id users to assess the variance between their perceptions and expectations. By employing gap analysis, the study will derive insights to construct a House of

		Quality (HOQ) for enhancing the application to better align with user expectations. [18]
Oktora, Adriyani, and Uly Amrina	2023	This study seeks to present alternative updates to product designs that align with consumer preferences, using the Quality Function Deployment methodology. Findings reveal that packaging design's technical response received the highest rating, followed by factors such as packaging material strength, selection, and quality. [19]
Alamsyah, Farid, and Danang Sutoyo	2023	The objective of this study is to develop Paddock Standard tools that fulfill the safety, comfort, and convenience requirements of users through the application of the Quality Function Deployment method. Following user testing of two design concepts and one combined concept, the A + B combined concept was chosen due to its improved functionality and positive reception by users. [20]
Soraya, Maya, et al.	2024	The research employs QFD to enhance the quality of building design by integrating user demands. It introduces a four-step architectural design framework incorporating QFD principles, addressing Design targets, Occupant requirements, Design techniques, and Facade design. Through the examination of case studies and survey data, the study showcases the efficacy of QFD in improving architectural design, particularly in facade design considerations. [21]
Koswara & Alifin	2024	The research endeavors to devise an innovative approach to crafting UI/UX for CRM, tailored to user needs. Data was collected from both Numazu IT company and its users via direct observation and surveys to assess user requirements, integrating Design Thinking and QFD methodologies. This study contributes to innovate UI/UX design techniques, specifically tailored for CRM systems, demonstrating enhanced user experience. [22]

3. Research Methodology

Data Collection

Z organization’s smartphone had an aluminium alloy back part. The manufacturer wanted to compare their product with other competitors and to analyse as per the importance of the customer requirements. A survey was conducted of smartphone users to determine the customer requirements. We had taken 100 samples which are sufficient according to literature [18]. The research was conducted on Bangladesh people from the age of 20 to 30 and who were using the mid-range budget phone. Maximum number of people, who were between the age of 20 to 30, were using the mid-range phone. We collected data by phone call, face to face and google forms. "What are your expectations from the back-panel material of their smartphone?" was the question asked to customers. All those requirements for the smartphone’s back part are mentioned in Figure 2. The technical descriptor is also known as HOWs. The technical

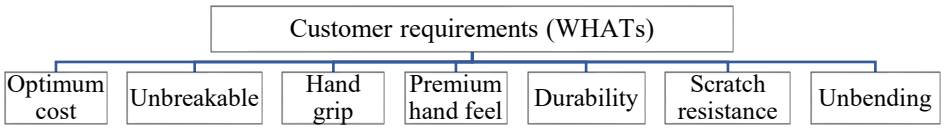

Figure 2: Customer Requirements for Smartphone's Back Part

descriptors showed the resources which can fulfil the customer requirements. "What are the available materials that the company can provide in their smartphone?" was the question asked to expert of the smartphone manufacturing company. We got a list of material from the feedback which are shown in Figure 3.

Figure 3: Technical Descriptors of Materials

HOQ Matrix

The main components of HOQ are customer requirements, correlation matrix, technical descriptor, relationship matrix, technical evaluation and competitive assessment. HOQ matrix is shown in figure 4. The correlation matrix shows the interrelationship between the technical descriptors. Symbol was used to show the interrelation. A strong positive symbol was used to indicate the positive relation among the technical descriptors, which could be replaced by the number +3. Strong negative symbol was used to indicate a negative relation which could be replaced with the number -3. The box was left empty if there did not have any relationship among the technical descriptors. We got a positive correlation between glass and alkali aluminosilicate sheet glass. In the relationship matrix, different types of symbols were used to show the degree of influence between the customer requirements and technical descriptors. Tringle, circle and donut symbol were used. Tringle represented the weak relationship, circle represented moderate relationship and donut symbol represented strong relationship. Tringle, circle and donut would be replaced with number 1,3 and 9 respectively. The empty relationship matrix box shows that there did not have any relationship between customer requirements and technical descriptors. For alkali aluminosilicate sheet glass, it strongly fulfil the premium hand feel, scratch resistance and unbending factors but has a lower hand grip. Customer competitive assessment showed the other competitor's position according to the customer requirements. Rating from 1 to 5 was given to each customer requirements. 1 was given for the worst and 5 was given for the best. Ratings were given for the smartphone companies. For our smartphone, it used to meet the robustness and premium hand feel factor strongly and other customer requirements partially. For technical competitive assessment, the smartphone's material was evaluated according to each technical descriptor. Ratings were given for each technical descriptor of the smartphone's material. Minimum 1 Ratings were given for the worst and maximum 5 Ratings were given for the best. For our smartphone, highest Ratings were given for

aluminium alloy. For prioritized customer requirements contain target value, scale-up factor, sales point and absolute weight and percent. For importance to the customer, most and least repetitive requirements were considered as the most and least important respectively. Ratings were given from 1 to 10 where 1 was the least important and 10 was the most important. We got unbreakable, light weight, unbending and scratch resistance as the most important customer requirements. For the target value section, it helped to decide whether the smartphone's material would be improved or not. Ratings were given from 1 to 5 by consulting with experts where 1 was the least and 5 was the height. Product was decided to improve for light weight from 3 to 4, for durability from 3 to 4, for scratch resistance from 3 to 4 and for unbending from 3 to 5. For scale-up factor, it was the efforts needed to update the smartphone. It is the ratio of target value to the particular smartphone's rating which should be developed. We got the highest scale up factor for unbending. For the sales point, it helped to identify the impact on sell of the smartphone in the basis of customer requirements. Value was given for sales points between 1 to 2 by consulting with experts where 1 was the least and 2 was the height. For absolute weight, it was important for product development and used as the guidelines for product development planning. We got it by multiplying the importance to customer, scale up factor and sales point. We got the highest absolute weight for unbending. In the section on prioritized technical descriptors, there was a degree of technical difficulty, target value, absolute weight and relative weight. For degree of difficulty, helped to find out the difficulty of applying the technical descriptors. Ratings were given for the implementation from 1 to 10 by consulting with manufacturing experts where 1 was the least difficult and 10 was the most difficult. Alkali aluminosilicate sheet glass and ceramic material had the highest degree of difficulty according to the expert. The target values were given from expert's opinion. For the absolute weight of prioritized technical descriptors, the relationship matrix was replaced with the number and followed this formula.

Absolute Weight = ∑ (value of each technical descriptor's column for each customer requirements * the value of each row of the importance to customer column)

For example, Absolute weight of our product

=(3*6)+(9*7)+(3*7)+(3*5)+(3*4)+(3*5)+ (3*7)+(3*7) = 186

For the relative weight of prioritized technical descriptors, the relationship matrix was replaced with the number and followed this formula.

Relative Weight = ∑ (value of each technical descriptor's column for each customer requirements * the value of each row of the absolute weight column)

For example, Relative weight of our product

=(3*9)+(9*7)+(3*14)+(3*8)+(3*6)+(3*7)+ (3*14)+(3*18) = 291

From the matrix, we found absolute weight values from 242 to 176 for prioritized technical descriptors and relative weight values from 461 to 291.

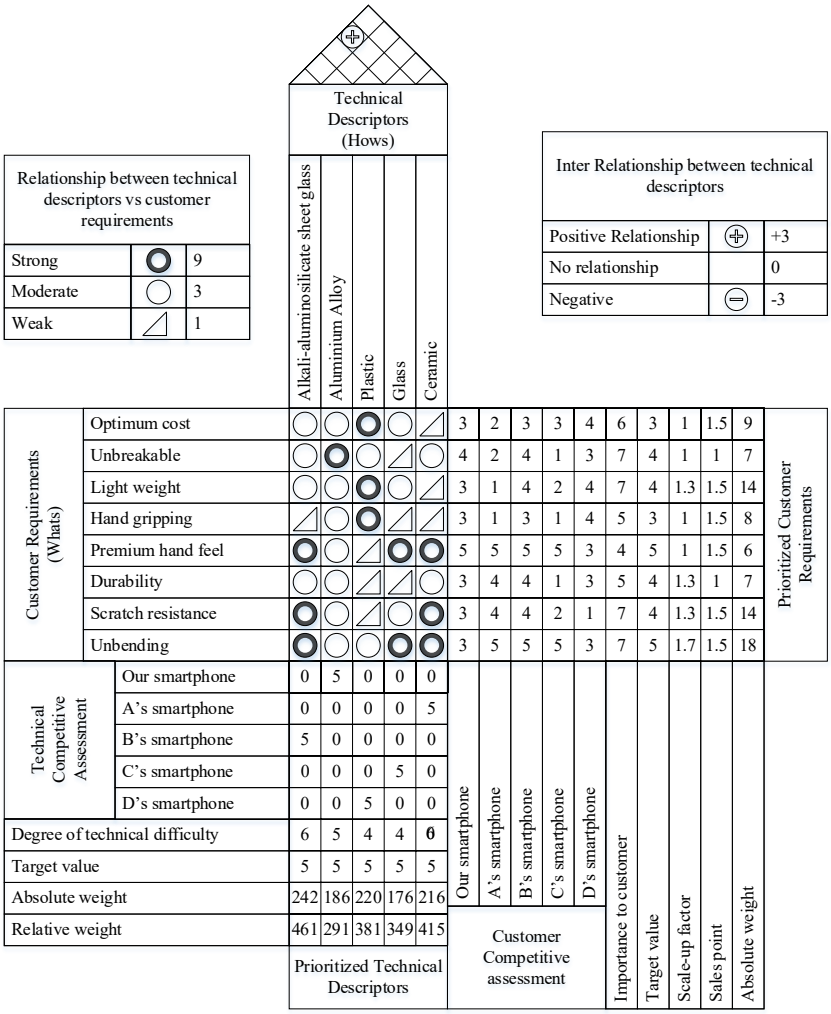

Figure 4: HOQ matrix for smartphone's Back Part Material Selection

4. Results and Discussion

We conducted survey on Bangladeshi market for obtaining the information of customer requirements. We did brainstorming with the expert for inputting values in this HOQ matrix. Enough samples were taken to make this research accurate. After analysing the data by HOQ matrix, we got some valuable information as final outcome. From the matrix, it is clear that alkali-aluminosilicate sheet glass is the most preferable material for the smartphone's back panel according to the customer requirements as well as the manufacturing organization's perspective. Our existing material is not able to fulfil the customer expectations properly which we can observe the information from the matrix.

5. Conclusion

An HOQ matrix was created to analyse and make decisions regarding the selection of the smartphone's back material to boost customer satisfactions. The use of alkali-aluminosilicate sheet glass instead of aluminium alloy in the smartphone's back part material will increase the customer satisfaction. This research adds to the existing body of literature on smartphone design and development. The methodology employed here could be applied to other analyses and decision-making processes in development contexts. However, there are research gaps, as this study specifically targeted the Bangladeshi market, focusing on users of lower to mid-budget smartphones and the customer's age were between 20 to 30. Results may vary depending on factors such as location, age, or budget range. As time goes on, the materials used for smartphone back panels are evolving and being updated. In the future, there will be numerous options available for these materials, suggesting that future research should take these advancements into account. This study provides insights for manufacturing companies to align their products with customer requirements, potentially boosting sales and economic gains.

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