Determination of Technical Requirements and Priority of The Critical Part In The Quality Function Deployment Phase I and Quality Function Deployment Phase II Methods In Product Development : A Literature Review

Rosnani Ginting¹, Bayu Suwandira¹ and Alfin Fauzi Malik¹

¹Industrial Engineering Department, Faculty of Engineering, Universitas Sumatera Utara, Medan, Sumatera Utara 20155, Indonesia

E-mail: rosnani@usu.ac.id

Abstract. There are many benefits found in implementing QFD. This method sets the standards for planned design and quality, making the product competitive. This literature study aims to make an analysis and synthesis of existing knowledge related to the topic to be studied in order to find gaps for the research to be carried out. Deployment's Quality Function is a structured approach to finding customers, understanding their needs and ensuring that their needs are met with product specifications. In QFD Phase I, it is used to translate customer needs into product design attributes which we will refer to as technical measures. QFD phase 1 (product planning) is also called The House of Quality. The output obtained in QFD Phase I is used as input for QFD Phase II, where this stage is used to translate important technical actions into part characteristics that are considered the most important to meet customer needs. This paper tries to see the extent to which the two methods are applied by analyzing several relevant journals. The author hopes that this paper can be used as a future reference for researchers in product design.

1. Introduction
In 1972, Dr. Shigeru Mizuno and Yoji Akao started to develop the Quality Function Deployment method. Then in 1978 the Japanese people specifically began to form a research group that studied Quality Function Deployment. QFD is used to translate customer desires into technical specifications. It is a relationship between customer - design engineer - competitor - manufacture. It provides us with information from product planning and development concepts to efficiency-enhancing manufacturing processes [1].

Quality Function Deployment (QFD) was introduced to Europe and America in 1983. In the late 1960s, Japanese companies walked out of post-World War II imitation mode and copied to a more original product development mode, making important consideration an design quality. To understand issues critical design before the production process is carried out, it is used to ensure that the criteria for design consumer requirements are met, but do not change customer needs into subsequent process control and initial design. Then, there is an opportunity to create a QFD to check the adequacy of the design itself in customer requirements meeting and to translate these requirements into the production process [2].
To maximize customer satisfaction, the QFD method has been widely applied based on time, cost, quality and others which are considered as constraints. Time, cost, and quality are important factors in the company's existence in the industrial world. In several previous studies, the quality factor is the biggest factor in helping companies to obtain customer satisfaction, while the time and cost factors receive less attention, if any, are not taken into account and discussed in detail [3].

There are many benefits found in implementing QFD. This method establishes planned design and quality standards, makes competitive products, develops new products that differentiate the company from competitors, analyzes and collects market quality information that communicates information regarding the quality of subsequent processes, designs goals into manufacturing, identifies control points, reduces quality problems. early, reduce design changes, cut development time, reduce development costs, and expand market share. There is a reason why QFD can be so popular in Japan in terms of manufacturing and service. Many benefits have been reported by many researchers regarding the application of QDF in real time [4]. This method serves to convert customer desires into parameters and values so that they can be applied to the product accurately [5].

This literature study aims to make an analysis and synthesis of existing knowledge related to the topic to be studied to find gaps for the research to be carried out.

2. Research Methodology
The method used in writing this article is a literature review, which is a literature search both internationally and nationally conducted using the Google Scholar website, the EBSCO database, and ScienceDirect. This paper describes several literature works on the Qulity Function Deployment method, especially in Quality Function Deployment phase I and Qualiy Function Deployment phase II. The collected journals are journals that discuss Qualiy Function Deployment phase I and Qualiy Function Deployment phase II.

In writing review literature there are several stages which are divided into five stages, namely

- Define the topic to be reviewed
- Identify relevant and clear literature
- Conduct a literature review
- Write down the results of the review
- Apply the study to be carried out in the literature [6]

3. Result and Discussion
3.1. Quality Function Deployment
Quality Function Deployment is the most complex and systematic method by translating consumer desires in designing products according to consumer needs [7]. QFD is a tool used to help companies move in a more proactive direction. QFD is a approach structured to finding customers, understanding their needs and ensuring that their needs are met with product specifications. Several other experts also argue that QFD is a communication tool and planning that structures the manufacturing cycle from product planning to product development [8]. Quality Function Deployment is a technique utilizing to guarantee the quality in each creating items stages, beginning by the plan quality itself [17].

In 1984, Toyota had adopted the QFD and reported a 61% decline. After that Clauing and Hauer published The House of Quality in May-June 1988 in Harvard Business Review. QFD received a lot of attention because it was adopted by companies such as Ford, General Motors and IBM [9]. Quality Function Deployment has finally spread throughout the world and is now being used in various industries.

The very rapid development of QFD has resulted in many applications in the manufacturing industry. Finally, QFD was officially introduced to service sectors such as education, banking, government, accounting, nursing, health and research. It is now difficult to find industries for which QFD has not been implemented [10]. In the process of designing and developing a product / service, it usually begins with a planning matrix called house oof quality [11].
There are four phases in QFD, namely Phase I which is used to translate customer needs into technical requirements, then Phase II is used to translate technical requirements into design designs, then Phase III is used to translate design designs into process planning, and Phase IV is used to translate process planning becomes a daily production requirement [12]. Each phase or matrix represents a part of the product requirements for which product development will be carried out. [13]. The QFD approach may likewise be extremely useful for scholastics intending to approve recuperation viability in the administration business [18].

3.2. Quality Function Deployment Phase I
Quality Function Deployment Phase 1 begins with building a Quality House. Quality Function Deployment phase 1 or the product planning phase, also known as The House of Quality. The success of the entire QFD process depends on the data received.

In this phase, a model is made that is able to identify how far customer expectations are on the quality of a bicycle product that can satisfy consumers. In this case, this is done by connecting the Design Requirements (DRs) with Customer Requirements (CRs) / Voice of Customers (VoC).

- Development of a Product Planning Model
  The product planning development model is carried out by designing a QFD and Kano integration framework model. The goal is none other than the total satisfaction of CRs and the Kano achievement levels of DRs that can be obtained.

- Customer Requirements
  Recording data on the level of importance and level of satisfaction and the average value of both for each customer requirement.
  - Recording data satisfaction level and dissatisfaction level
  - Voice of Customer data using a questionnaire (questionnaire that has received validation from experts in this field).
  - Attribute classification data is based on the Kano theory classification using the Kano questionnaire (DRs).
  - Obtain data on the relationship between customer requirements and technical attributes / responses (the relationship between CRs and DRs).
  - Obtain correlation data between attributes (correlation between DRs and DRs).
  - Get Important Weight Phase 1

- Design Target Value
  The target value in phase one is expected to be able to get the CRs satisfaction degree and fulfilment level of each DRs [14].

The steps for QFD Phase I can be seen in Figure 1.
The procedure for using the HoQ matrix is:

- **Identification of the respondent's wishes (customer needs)**
  Respondent's desire (Customer needs) in the House of Quality contains a list of the structure of consumers' desires for the product or service that is planned. Consumer needs can be identified by conducting interviews.

\[
\begin{align*}
  n &= \frac{T-t_0}{t_1} \\
  T &= \text{time available for research} \\
  N &= \text{total respondents} \\
  t_1 &= \text{time of each sampling unit} \\
  t_0 &= \text{time for sampling} \ [16].
\end{align*}
\]

- **Identify the level of importance (customer importance)**
  The level of consumer importance (customer importance) is a place to record how important each need or benefit is to the consumer. The level of consumer interest is determined by providing a scale of importance. The measuring scale used ranges from 1 to 5. The following is the formula for determining the Level of Consumer Interest (TKK):

\[
TKK = \frac{\sum x}{N}
\]

Information :
\[
\begin{align*}
  TKK &= \text{Level of Importance of Consumers} \\
  \Sigma x &= \text{Total importance score} \\
  N &= \text{Number of respondents}
\end{align*}
\]

- **Determine the technical characteristics of the product (Technical Response)**
  Voice of Customer (VOC) has qualitative and quantitative components (the component in question is consumer desire) which is then translated from the voice customer into the voice developer (the desire of the company). The change in quality characteristics will be linked in a matrix and quantitative data will become the company's targets and benchmarks.
Determination of characteristics obtained from interviews with supervisors / people who are experts in their fields

- Establish the relationship between technical characteristics
  The relationship in the House of Quality is usually called the relationship between technical characteristics. The relationship between technical characteristics becomes the roof of the house of quality. This relationship illustrates the relationship between quality characteristics.

- Determine the level of between relationship product characteristics technical and consumer desires.
  The between relationship characteristics technical and consumer desires can be described in QFD. A brilliant idea in QFD is to use a matrix to study each relationship.

- Determining Competitive Satisfaction Performance
  The development team must be able to understand the competition. The sentence for understanding the competition sounds simple, but many development teams don’t study the other competitors carefully. Competitor satisfaction performance appraisal can be seen from the goal and ratio of improvements, sales points, raw weight, and normalized weight.

- Purpose and Improvement Ratio
  The objective of the planning matrix identifies the team’s thinking about the level of consumers desired to help fulfill all customer desires. The ratio of improvement is one of the objectives of the level of consumer interest and then determine the strategy of the goal.

\[
IR = \frac{\text{Goal}}{\text{Competitive Satisfaction Performance}}
\]

- Sales Point
  Sales points contain characteristic information on the ability to sell products or services based on how each customer desires. The scale used in the assessment is as follows:
  1 = The voice attribute doesn’t help sales
  1,2 = The voice attribute is sufficient to assist sales
  1,5 = The voice attribute is very helpful in sales

- Raw Weight
  Raw weight contains a set of values from the data and decision making on the planning matrix. Raw weight is a model of overall importance to the development team and customer needs.
  \[
  \text{Raw weight} = TKK \times IR \times \text{sales point}
  \]

- Normalized Weight
  Normalized raw weight contains raw weight values that are scaled from a range of 0 - 1 or expressed as a percentage
  \[
  \text{Normalized raw weight} = \frac{\text{Raw Wight}}{\text{Raw Wight Total}}
  \]

- Calculation of Weight of Interest
  The weight of importance shows the total level of importance of the respondent on an attribute of the assembly process.

- Calculation of relative importance weight (relative weight)
  The weight of importance shows the total level of interest of the respondent to an attribute calculated by the formula:

\[
\text{Relative weight} = \frac{\text{absolute weight of the need variable}}{\text{total weight absolute needs}} \times 100\%
\]

- Build a House of Quality (HoQ) matrix
  The HoQ matrix is often referred to as the quality control house. The performance measure of HoQ is obtained based on three aspects, namely the level of difficulty, the level of importance and the estimated cost. The calculation of these three aspects can be seen as below:
• Determination of the level of difficulty
  The level of difficulty is determined from the relationship of characteristics technical. The calculations are made by interpreting all the weighted values of the relationship then weight of each the dividing of the technical characteristics by the total weight of the above. Difficulty levels are given based on the percentage range obtained.

  \[
  \text{Level of difficulty} = \frac{\text{Weight of Each Technical Characteristics}}{\text{Total Technical Characteristics Weight}} \times 100\% \tag{7}
  \]

• Determination of importance
  The value of the degree of importance is calculated by first calculating the total weight for each relationship between product attributes and technical characteristics.

  \[
  \text{Degree of importance} = \frac{\text{Weights of each technical characteristic by attribute}}{\text{Total weight of each technical characteristic by attribute}} \times 100\% \tag{8}
  \]

• Cost estimation
  The basis for determining the estimated cost value is the difficulty level factor. These two variables have a relationship, namely: the more difficult a technical characteristic is to make, the higher the costs required. Cost estimates are expressed as a percentage and are subject to various considerations from the designer himself.

  \[
  \text{Cost estimation} = \frac{\text{Attribute}}{\Sigma \text{Technical Characteristic Weights}} \times 100\% \tag{9}
  \]

3.3. Quality Function Deployment Phase II
Quality Function Deployment Phase II is a continuation of Quality Function Deployment Phase I, in which requires creativity product design and innovation in product development.

In this phase, carried out modeling of the data analysis needs of material or components capable of meeting the design criteria of the target value in the first phase. This is done by determination translating of Critical Parts Characteristics (PCs) into Design Requirements (DRs).

• Product Design Model Development
  The product design development model is carried out by designing a QFD and Kano integration framework model. The goal is none other than the total satisfaction of DRs and the Kano fullfilment levels of PCs that can be obtained.

• Design Requirements
  At this stage the following activities were carried out:
  • The fulfillment level data is obtained from the design target value in the first phase (DRs).
  • Attribute classification data based on the analysis process on Kano (PCs).
  • Getting data relationship between DRs and PCs.
  • Obtain correlation data between PCs and PCs.
  • Get Your Important Phase 2 Weight

• Parts Target Values
  At this stage, a decision category is made between the material / component requirements that the company can provide to the competitive factors of product design that consumers want (DRs satisfaction degree and fullfilment level of each part characteristics).

The steps for QFD Phase II can be seen in Figure 2.
Establish priority technical characteristics based on QFD Phase I

Defining Critical Part

Establish relationships between critical parts

Establish the relationship between technical characteristics and critical parts

Determination of the Technical Matrix

Determination of product quality improvement

Figure 2. Flowchart of phase II QFD [15]

Priority characteristics technical are determined by ranking based on the greatest weight of the level of difficulty, degree of importance and estimated costs. The procedure for using the Phase II QFD is as follows:

- **Determining Priority Technical Characteristics Based on QFD Phase I**
  The technical characteristics obtained from QFD Phase I are used as input to carry out processing in QFD Phase II. Priority characteristics technical are determined by ranking based on the greatest weight of the level of difficulty, degree of importance and estimated costs.

- **Defining Critical Part**
  After the technical requirements are obtained, the next step is to determine the critical parts. Critical parts are the characteristics of the most important parts or components on an object. Determination of technical requirements is based on discussions with experts / experts.

- **Establishing Relations Between Critical Parts**
  At this stage, the relationship between each critical part is determined to be analyzed whether there is a strong, moderate or weak relationship between the critical parts.

- **Establishing the Relationship between Technical Characteristics and Critical Parts**
  The next step in preparing a design deployment matrix is to compare the relationship between critical parts and technical characteristics.

- **Determination of the Technical Matrix**

- **Determination of the level of difficulty**
  The level of difficulty is determined from the critical part relationship. The calculation is done by translating all the weighted values of the dividing then relationship the weight of each critical part by the number of weights earlier.

  \[
  \text{Level of difficulty} = \frac{\text{Weight of Each Technical Characteristics}}{\text{Total Technical Characteristics Weight}} \times 100\% \quad (10)
  \]

- **Determination of importance**
  The value of importance of the degree can be calculated by first calculating the total weight for critical parts and each relationship between characteristics technical.

  \[
  \text{Degree of importance} = \frac{\text{Weights of each technical characteristic by attribute}}{\text{Total weight of each technical characteristic by attribute}} \times 100\% \quad (11)
  \]
• Cost Estimation
The difficulty level factor is used as the basis for cost estimation because the critical part more difficult a is to make, the more expensive the cost allocation will be. Cost estimates are expressed in percent and are subject to various considerations from the designer himself.

\[
\text{Cost Estimation} = \sum \frac{\text{Attribute}}{\text{Technical Characteristic Weights}} \times 100\%
\] (12)

From the two methods above, namely Quality Function Deployment phase I and Quality Function Deployment phase II, it can be concluded that in product design it is necessary to consider several supporting factors to meet customer needs, from translating consumer needs to the product design stage. This is done in order to get maximum product design results without losing market demand and product functionality.

4. Conclusion
Getting the QFD right can yield very significant benefits. More than three decades ago, Japanese academia and industry began formalizing QFD techniques in the early 1970s. Because of its effectiveness in development product and management quality, many companies have successfully applied this method. QFD Phase I is used to translate product design attributes into customer needs that we will refer to as technical measures. QFD phase 1 or product planning stage is also called The House of Quality. The output obtained in QFD Phase I is used as input for QFD Phase II, where this stage is used to translate important technical actions into part characteristics that are considered the most important to meet customer needs. Through the search for various sources, a QFD summary has been created to serve as a reference to help researchers conduct their research. In particular, we present a brief overview of the historical developments of QFD and a categorical analysis of the functional areas of QFD, applied industries and the development of methodologies to facilitate reference. We intend to literature review update this in terms of coverage and suitability of categorization in the future to better serve the world of QFD, and QFD related information of hence any provision with the author will be greatly welcomed and greatly appreciated.

Acknowledgments
This study was funded by Research Institutions of University of Sumatera Utara, in accordance with project of Research Funding Scheme of Direktorat Riset dan Pengabdian Masyarakat (DRPM) DIKTI 2020.

References
[1] Jaiswal Eshan S 2012 A case study on quality function deployment (QFD) Journal of mechanical and civil engineering 3 (6) pp 27-35
[2] Akao Y ed 1990 Quality Function Deployment, Productivity Press (Cambridge : MA Becker Associates Inc)
[3] Singgih Moses L, Dyah L Trenggonowati and Putu D Karningsih 2013 Four phases Quality Function Deployment (QFD) by considering KANO concept, time and manufacturing cost International Conference on Engineering and Technology Development (ICETD)
[4] Hadi Hari Abdul et al 2017 The implementation of quality function deployment (QFD) in Tire industry ComTech: computer, mathematics and engineering applications 8 (4) pp 223-228
[5] Akao Y and Mazur G H 2003 The leading edge in QFD: Past, present and future International Journal of Quality & Reliability Management, 20 (1) pp 20-35
[6] Rahayu Titik et al 2019 Teknik Menulis Review Literatur Dalam Sebuah Artikel Ilmiah
[7] Jiang, J C, Shui M L and Tu M H 2008 QFD’s evolution in Japan and the west Quality control and applied statistics, 53 (3), pp 283-284
[8] Rahmawan Arief 2017 Implementation of Quality Function Deployment (QFD) in Agro-industrial Technology curriculum Agroindustrial Technology Journal I (1) pp 10-21
[9] Montiel Abello 2017 Quality Function Deployment: A review of methodology and case study
[10] Chan Lai-Kow and Ming-Lu Wu 2002 Quality function deployment: A literature review
    European journal of operational research 143 (3) pp 463-497
[11] Ginting Rosnani 2016 Quality Function Deployment (Medan: USU Press)
[12] Gupta Rupesh Shefali Gupta and Kuldeep Nagi 2012 Analysis & designing an engineering
    course using QFD International Journal of Modern Engineering Research 2 (3) pp 896-901
[13] Muda Nora and Noor Sulawati Mat Roji 2015 A Quality Function Deployment (QFD)
    Approach in Determining the Employer's Selection Criteria Journal of Industrial Engineering
[14] Trenggonowati Dyah Lintang 2017 Metode pengembangan produk qfd untuk meningkatkan
daya saing perusahaan Spektrum Industri 15 (1) pp 1-17
[15] Ginting Rosnani 2020 Perancangan dan Pengembangan Produk (Medan: USU Press)
[16] Wulandari Rika Amartha and Yuswono Hadi 2017 Determination of Part Specification and
    Critical Par for Food Package Improvement at MSME AE Jaya Batu by Using QFD Method
    Journal of Engineering and Management in Industrial System 5 (1) pp 20-26
[17] Wurjaningrum F 2008 Design of education service quality improvement of Airlangga university
    by applying Quality Function Deployment (QFD) model International Conference on
    Service Systems and Service Management pp 1-6
[18] Wu W Y, Qomariyah, A, Sa, N T T and Liao, Y 2018 The integration between service value
    and service recovery in the hospitality industry: An application of QFD and ANP
    International Journal of Hospitality Management, 75 48-57