إقـــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Polyethylene Terephthalate (PET) Perform Design: A Quality Function Deployment (QFD) Approach

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وإن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

DECLARATION

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification

Student's name: **اسم الطالب: رائد "محمد زياد" هاشم أبو شهلا**

Signature: **التوقيع:**

Date: **التاريخ: 2014/1/18م**

The Islamic University of Gaza

Deanship of Postgraduate Studies

Faculty of Commerce

Business Administration Department

Polyethylene Terephthalate (PET) Preform Design: A Quality Function Deployment (QFD) Approach

---

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Business Administration.

By:

Raed Abu Shahla

Supervised By:

Prof. Salah R. Agha

Dr. Rushdy A. Wady

2013-2014

بسم الله الرحمن الرحيم

الجامعة الإسلامية – غزة
The Islamic University - Gaza

مكتب نائب الرئيس للبحث العلمي والدراسات العليا هاتف داخلي 1150

الرقم ج س غ/35/ Ref

التاريخ 2013/10/12 Date

نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة الدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **رائد محمد زياد هاشم أبو شهلا** لنيل درجة الماجستير في **كلية *التجارة*/ قسم إدارة الأعمال** وموضوعها:

Polyethylene Terephthalate (PET) Preform Design: A Quality Function Deployment (QFD) Approach

وبعد المناقشة التي تمت اليوم السبت 07 ذو الحجة 1434 هـ، الموافق 2013/10/12م الساعة الواحدة ظهراً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

د. رشدي عبد اللطيف وادي	**مشرفاً**	....
أ.د. صلاح رمضان الأغا	**مشرفاً ورئيساً**	....
أ.د. يوسف حسين عاشور	**مناقشاً داخلياً**	....
د. عبد أحمد الشكري	**مناقشاً داخلياً**	....

وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في **كلية *التجارة*/ قسم <u>إدارة الأعمال</u>.**

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

مساعد نائب الرئيس للبحث العلمي و للدراسات العليا

أ.د. فؤاد علي العاجز

ص.ب. 108 الرمال، غزة، فلسطين هاتف Tel: +970 (8) 286 0700 فاكس fax: +970 (8) 286 0800 P.O. Box 108, Rimal, Gaza, Palestine
public@iugaza.edu.ps www.iugaza.edu.ps

بسم الله الرحمن الرحيم

﴿ قُلْ هَذِهِ سَبِيلِي أَدْعُو إِلَى اللَّهِ عَلَى بَصِيرَةٍ أَنَا وَمَنِ اتَّبَعَنِي وَسُبْحَانَ اللَّهِ وَمَا أَنَا مِنَ الْمُشْرِكِينَ ﴾

(يوسف ١٠٨)

صدق الله العظيم

Dedication

I proudly dedicate this thesis to my mother, to my father, as I always feel their prayers in all aspects of my life, to my lovely wife and children "Lama, Mohammed and Sema", to my brothers and my sisters, and finally to Eng. Badreddin Elredaisi, for their endless support.

Raed Abu Shahla

Acknowledgment

I would like to express my deepest appreciation to my supervisors "Prof. Salah R. Agha" and "Dr. Rushdy A. Wady" for their valuable guidance and encouragement. This work would not have been accomplished without their support and encouragement.

Deepest thanks for the teaching staff in the Faculty of Commerce at the Islamic University-Gaza for their support and contribution.

Deepest thanks for the work team staff in Elredaisi Industrial Company, Makka Cola Company, and Yazegy Group soft drinks producers for their support and contribution.

Deepest thanks for the viva committee "Prof. Yousif Ashour and Dr. Abed Schokry" for their support and contribution.

Abstract

The plastic industry has been one of the modern industries in Palestine. The plastic industry faces many challenges that affect it especially during the design phase. The design process is considered as the most important step in any manufacturing process. In the plastic industry, usually the customer requirements are not treated systematically (PFI, 2012).

This research is a case study that use the analytical method which describes and assesses the impact of application of Quality Function Deployment (QFD) on designing a new 52 gram Polyethylene Terephthalate (PET) product in *Elredaisi Industrial Company L.T.D " Badreddin Elredaisi Company*".

The main objective of this study is to achieve customers satisfaction by designing a new 52 gram PET product and matching its requirements with the necessary corresponding design requirements, which in turn match with the necessary corresponding production requirements, and so on, to ensure that the needs of the customers are met.

QFD has become a widely used tool in the design and development of products and services. It helps design teams to gather needs of the customer and organize this data.

QFD methodology was applied in this study using a set of matrices, often called the House of Quality (HOQ), to translate customer requirements into a functional design. Additionally, the Analytic Hierarchy Process (AHP) methods were used to compare and evaluate the results.

For data completion, the constructed interviews were conducted with the customers of *Elredaisi Industrial Company Ltd.*, to get the customers' requirements, design, target value of the design requirements and the relationship between the customers' requirements and the design requirements to determine the requirements of designing the new 52 gr. PET preform.

This study presents the proposed design requirements in accordance to customers' requirements. The study points out the need for more standardization of users' needs, and ranking of criteria do not mean neglect any of these criteria or customers desires or reduce the importance of any of them.

الخلاصة

تعتبر الصناعة البلاستيكية واحدة من الصناعات الحديثة في فلسطين. حيث تواجه الصناعة البلاستيكية العديد من المعوقات المؤثرة، خصوصا في مرحلة التصميم حيث تعتبر عملية التصميم أهم مرحلة في أي عملية تصنيعية. وفي الأغلب في مجال الصناعة البلاستيكية لا يتم تحديد ومعالجة متطلبات ورغبات الزبائن بصورة منهجية ومنظمة (الإتحاد العام للصناعات الفلسطينية، ٢٠١٢).

يعتبر هذا البحث دراسة تطبيقية تستخدم نظرية البحث التحليلي لتطبيق QFD في تصميم منتج 52 gram PET preform في شركة الرديسي للصناعة م.خ.م (شركة بدر الدين الرديسي سابقا).

تستخدم أداة QFD في نطاق واسع في عمليات تطوير المنتجات والخدمات، حيث تساعد فرق التصميم في تحديد احتياجات الزبائن من خلال جمع معلومات عن احتياجاتهم وترتيبها.

يهدف هذا البحث إلى تحقيق رضا الزبائن من خلال تصميم منتج 52 gram PET preform يتم من خلاله تحقيق التوافق بين متطلبات الزبائن ومتطلبات التصميم والإنتاج اللازمة لضمان إرضاء الزبائن.

لقد تم تطبيق إجراءات مصفوفات QFD في هذه الدراسة. والتي تسمى عادة HOQ وتستخدم في تحويل متطلبات الزبائن إلى تصميم وظيفي يعطي نتائج تحليلية دقيقة، وتصنف تلك النتائج حسب الأهمية. بالإضافة إلى المقارنة التحليلية والتقيمية بين النتائج المحصلة من نظرية HOQ و AHP للحصول على نتائج ذات مغزى.

تم استخدام أداة المقابلات للحصول على متطلبات الزبائن اللازمة في تصميم منتج 52 gram PET preform وفي مقابل ذلك، متطلبات التصميم من خلال الطاقم الهندسي الموجود في الشركة لتحقيق تلك الرغبات والمتطلبات.

تقدم هذه الدراسة متطلبات التصميم المقترحة على أساس تحقيق رغبات ومتطلبات الزبائن. وكذلك تشير هذه الدراسة إلى أهمية الحاجة إلى عدم إهمال أي من هذه المتطلبات مهما كان تصنيف أهميتها لدى الزبون.

Table of contents

List of Tables

List of Figures

Abbreviations

American Chemistry Council	ACC
Analytic Hierarchy Process	AHP
Action Research	AR
British Plastic Federation	BPF
Customer Attributes	CAs
ConcLirrent Function Deployment	CFD
Consistency Index	CI
Customer Importance Ratings	CIRs
Consistency Ratio	CR
Customer Requirements	CRs
Expert Choice	EC
Enhanced QFD	EQFD
Fuzzy QFD	FQFD
Goal Programming Model	GP
High Density Polyethylene	HDPE
House of Quality	HOQ
House of Values	HOV
Linear Programming	LP
Liter	lt.
Limited Company	Ltd.
Multi Criteria Decision Making	MCDM
Ministry of National Economy	MNE
New Product Development	NPD
Office of the Quartet Representative	OQR
Palestinian Central Bureau of Statistics	PCBS
A type of plastic closure	PCO
Product Development	PD
Polyethylene Terephthalate	PET
Palestinian Federation of Industries	PFI
The Portland Trust Organization	PTO
Quality Assurance	QA
Quality Characteristics	QCs

Quality Function Deployment………………………………………………..	QFD
Research and Development ……………………….……………….……	R&D
Requirements and Constraints ……………………..……….……………...	RCs
Supply Chain Management …………………………………..…………	SCM
Strengths, Weaknesses, Opportunities and Threats ……………………….	SWOT
Technical Attributes ……………………………….………………...	TAs
Technical Importance Rating ……………………………………..….	TIR
Total Quality Management…………………………………….….…….	TQM
United States of America ………………………………...…………...	USA
The University of Texas at Austin ……….……………………….……….	UTA
Voice of Customer…………………………………………..…………..	VOC

Chapter 1

This chapter provides information about introduction, problem statement, question, goal and objectives, importance, previous studies, and study contribution.

1.1. Introduction

This study mainly focuses on the quality function deployment (QFD) method in a PET preform design applications, as one of Total Quality Management (TQM) methods. The main idea of QFD approach is building a design strategy over the Voice of Customer (VOC) to reach customer satisfaction. The customer requirements should be carefully studied and defined to take the first steps in the study before going further in the next phases. The next phases of QFD are converting the customer requirements into corresponding technical requirements in order to combine both design and production issues in the same study. Additionally, the competent of products in the market are studied on a technical basis in order to create comparison possibilities for the new design. This methodology integrates the customer requirements and competent product specifications into the industrial design process. So, the product will be likely to capture a reasonable customer attraction on the market (Cristiano et al., 2000; Chan and Wu, 2002).

The strategic approach, led by *Elredaisi Industrial Company LTD. (Badreddin Elredaisi Company)* that is one of the most popular companies in the sector of plastics manufacturing in Gaza Strip (PFI, 2012), is providing a reasonable solution by producing the needed amount of plastic preforms that are used in blowing (PET) bottles locally in Gaza Strip, to compensate needed amounts of the plastic preforms that are imported from many different markets (Elredaisi Industrial Company, 2013).

1.2. Problem Statement

There is a gap between the actual or perceived customer requirements and what any company can introduce to achieve customer satisfaction. QFD ensures that all activities and operations of a company are driven by the VOC. This study seeks to reduce this gap by examining and investigating the application of QFD method using House of Quality

(HOQ) model to design a new PET plastic preform as a case study in *Elredaisi Industrial Company LTD.*, by focusing on developing all factors in order to achieve objectives that add values to customers.

1.3. Study Question

What are the key inputs influencing the applications of QFD [the process of designing a new PET plastic product] and its effects on customer’s satisfaction in *Elredaisi Industrial Company LTD.*?

1.4. Study Goal and Objectives

1.4.1. Study Goal

The aim of this study is to design a new 52 gram PET preform and matching its requirements with the necessary corresponding design requirements, which in turn match with the necessary corresponding production requirements, and so on, to ensure that the needs of the customers are met and they are satisfied.

1.4.2. Study Objectives

- Identify the customer's requirements,
- Identify design requirements that meet the customer requirements,
- Propose a new design of new PET preform based on customers' requirements using QFD method,
- Suggest solutions for improving the weaknesses points in PET production line in the company to achieve customer satisfaction.

1.5. Study Importance

The current internal crisis and its consequences have rapidly and greatly hurt the private sector interest in Gaza Strip for the last two decades. Such as, the first Intifada, Alaqs'a Intifada involving the crisis of siege imposed on Gaza Strip, closing all import and export ports by the Israeli occupation forces for more than five years and the war on Gaza (Dec 2008) codenamed Operation Cast Lead. The long term of these conditions and obstacles have introduced need to identify opportunities for the private sector in Gaza Strip to cope with the current complicated business environment through identifying business alternatives. As the negative results of these conditions are especially appeared when most manufacturing companies in Gaza Strip depended on foreign suppliers in importing its needs of raw materials and semi-products such as nylon bags, plastic bottles, boxes and cans that are used in packaging their products, one of the effected manufacturing sectors by these conditions are the factories of soft drinks such as PEPSI Cola, 7UP and MACCA cola. That is because; they import its requirements of plastic preforms and other raw materials from some regional and international markets such as Turkey, Egypt and Occupied Palestinian Lands (1948) (PFI; PCBS; PalTrade, 2012).

This study helps plastic manufacturers in the region to improve their production practices, by meeting the expectations of customers to gain a competitive advantage and translate customer requirements into the final product or service characteristics.

The study provides good information about QFD applications for new researchers in Gaza Strip. It can be used as a good reference for Gaza's libraries about developing the plastic manufacturing sector. Additionally, using the method of QFD in Plastic manufacturing companies in Gaza Strip, will gain good benefits about the applications of QFD to reduce the gap between its customers desires and the introduced products and services, prioritize spoken and unspoken customer wants and needs, translate these needs into technical characteristics and specifications, and build and deliver a quality product or service by focusing everybody toward customer satisfaction.

1.6. Previous Studies

1.6.1. Shamsuddin Ahmed, (2010). "**Application of QFD in product development of a glass manufacturing company in Kazakhstan**"

The purpose of this paper is to demonstrate how quality function deployment can be used to improve the quality of tinted glass produced by a glass manufacturing company in Kazakhstan. As a case study, this paper examined the aspects of product development and product improvement of a glass manufacturing company by using QFD. A HOQ matrix was developed to identify customer wants and product attributes needed to satisfy customer requirements.

- **Design/methodology/approach**– Data were collected using a combination of Delphi method, unstructured, and semi-structured survey. Principal component and Pareto analysis were used to identify the ranking of customer wants needed to improve the acceptability of the product in the market.
- **Findings**– The paper suggests that satisfying all customer needs require the deployment of all the technology and resources available to the company. It illustrates the possible courses of action company management can take based on prevailing market conditions.
- **Research limitations/implications**– The research shows the specific requirements of customers for tinted glass used in industrial settings. From supply chain perspective, downstream customer opinions were used to identify the desired product attributes.
- **Practical implications**– Since no studies to date have been conducted on the glass manufacturing industry in the Central Asian region, this paper could help glass manufacturers in the region to improve their production practices.
- **Originality/value**– The paper is of value to those glass producers interested in the glass manufacturing industry in Central Asia.

Conclusions and recommendations

Bearing in mind that the company is the only manufacturer of tempered glass in Central Asia region, it is important that the company identify areas of improvement in order to remain competitive because of the possibility that new firms may enter the tempered glass market. Principal component and Pareto analysis were used to indicate the importance of the product attributes with respect to customer wants. The closeness between the customers wants and the product attributes identified by the cluster plot show that they are both equally important in order to make the company more competitive. Decision tree is used to illustrate the sequence of reactions by management to possible market conditions.

Management may decide to expand the business by deploying more resources in order to satisfy customer requirements. Alternatively, the company may decide to maintain the status quo position if it considers that majority of the customers is satisfied with its product, thereby ensuring steady flow of income. Customer satisfaction in supply chain management is driven by the voice of customers in QFD.

For instance, in this study, the HOQ identifies the supply chain management features and measures the current supply chain management that customers need. The current product design attributes, after our analysis identify the new customer requirements in supply chain management. The QFD design features that contribute significantly get a higher weight than those that contribute to a lesser degree. Consequently, in supply chain management the customer's requirements are embedded in order to make it customer-friendly. The correlation matrix indicates the importance of supply chain management features. In total, QFD encapsulates the customer requirements, their importance, and the pressing supply chain management features that are necessary to meet the demands of customers.

The Scree plot and Pareto diagram were used to identify the order of importance of customer wants so that management can decide which ones need immediate attention. For example, it is shown that the first four customer wants (good service quality, thickness of glass, different light-conductivity levels, and low warmth-conductivity level) are dominant in the QFD and constitute 65.85 percent of the variances of the entire customer wants, while the first two customer wants (Good service quality, and Thickness of glass) explain 43.27 percent of the variances. Implementing the engineering characteristics identified in the QFD would improve customer satisfaction and position the SAT-Glass as an industry leader in the foreseeable future. SAT-Glass should increase the variety of glass thickness.

This would increase the range of applications for which the product can be used and enhance its appeal to customers. Second, the company should produce more levels of "light-conductivity" glasses. Third, in order to be competitive in local and international market, SAT-Glass should expand its color range.

1.6.2. C.C. Usama-Alvarez et al., (2010). "**Identification of design requirements for rugby wheelchairs using the QFD**".

Rugby wheelchairs are typically customized and designed based primarily on the athlete's "body measurements". To date, relationships between anthropometric data and performance characteristics for individual athletes have not been addressed in an optimal manner in wheelchair design. This study addresses the application of quality function deployment method for rugby wheelchairs design. Discussion of the QFD analysis results will identify relevant performance parameters to be used as a reference in the customization of "low, mid, and high pointer' wheelchairs as well as the specific design features that are required to be parameterized in order to achieve the desired performance output for each category of athletes.

- **Design/methodology/approach–** Analysis and discussion of the different design features that are required to be parameterized in order to enable effective customization of the wheelchair to achieve the desired performance output of each category of athletes.
- **Findings–** This study develop wheelchair designs and other specific requirements in rugby wheelchairs sports are currently customized according to the athletes specific anthropometric characteristics to satisfy feel requirements, which in the case of wheelchairs athletes translates into kinesthetic feedback on ease of propulsion activity.
- **Study limitations/implications–** Little technological development in wheelchair sports equipment and scientific research specific to rugby wheelchair design has been performed to date.
- **Practical implications–** This study deals with the characterization phase of rugby wheelchair design development by using the quality function deployment method to systematically evaluate and relate relevant technical attributes in terms of design and performance that are of key importance in the design and customization of rugby wheelchair for an individual athlete.
- **Originality/value**– This design approach could provide manufacturers with an intelligent tool to deliver a fully customize product in terms establishing identified

relationships in parametric from and optimizing the design settings using the design settings using the design for experiments approach.

Conclusions and recommendations

The research identified the design attributes that are of highest importance in the design and customization of rugby wheelchairs for specific athlete and sport requirements "high, mid and low pointer category". These findings provide a platform for a comprehensive sensitivity analysis of wheelchairs designs and there effects on the performance characteristics. Outcomes from this research can be translated into specific design customized solution capable of meeting the needs of a specific athletes and sport.

The following list of dimensions is required to be considered for a parametric design model: seat height rear, balance point depth, camper angle, back rest angle, seat height front, and wheelchair total mass.

1.6.3. Miguel, (2007). "**Innovative new product development: a study of selected QFD case studies**"

The purpose of this study is to investigate whether the use of quality function deployment (QFD) may contribute to developing innovative products. Its point of departure is the author's earlier research that investigated the application of QFD to product development in companies operating in Brazil.

- **Design/methodology/approach –** A case study approach with companies from different industries is employed in this paper. A questionnaire was used to gather data from four companies by checking some aspects of QFD projects with regard to innovation. Typical QFD projects with respect to product typology (platform or derivative) and their level of complexity are also analyzed.
- **Findings –** The main results indicated that QFD may assist in developing innovative products, but is limited to additions to existing lines, product repositioning, and product improvement.

- **Research limitations/implications –** One constraint was the limited number of companies and projects analyzed so that replications among other samples are needed to validate current findings.
- **Practical implications –** Although QFD is extensively explored in the literature, this study is one of the few published studies that report and discuss the relationship between QFD and innovation.

Conclusions and recommendations

This work raised a number of questions that cannot be answered here. These questions basically address issues with respect to the relationship between QFD applications, type of products, level of complexity, and the degree of innovation. It is believed that an attempt to respond to these questions in the future might contribute to an understanding of factors that support innovation in new product development.

Nevertheless, the findings in this paper can assist in answering those questions more precisely. Based on the companies studied, the paper concludes that the use of QFD is somewhat related to the development of innovative products. Usually, companies develop a new product platform, project complexity is moderate to high, and with respect to the degree of innovation QFD projects might result in a range of outcomes (little, moderate, or great innovation, but not extreme innovation).

Finally, it is worth observing that there are some limits in terms of validity and reliability of any findings from this analysis – especially with respect to the interpretative nature of the data as well as the use of this narrowly based sample. The objective of this study was to investigate whether some experiences involved the use of QFD in innovative projects. This study's findings are not subject to generalization to other similar plants. However, the findings can be used to inform practitioners about the use of QFD in innovative projects. Of course, mere analysis of this sample is not enough to understand fully innovation practices in the field of new product development. Nevertheless, it might provide a general preliminary view of whether QFD application can assist and support the development of innovative products.

1.6.4. Mueller, (2011). "**International business curriculum design: identifying the voice of the customer VOC using QFD"**

Curriculum development in higher education must be continuously evaluated in this dynamic business environment, where business needs change day-to-day. The literature on the application of QFD to curriculum design is increasing, with student opinion representing the sole voice of the customer. The purpose of this paper is to present an alternative approach to QFD curriculum design by using a survey of employers, not students, to represent the voice of the customer.

- **Design/methodology/approach**– This paper applies the widely used quality management process of QFD to the curriculum development process of a major international business program.
- **Findings**– The findings illustrate the application of QFD's house of quality in international business curriculum development and best practices benchmarking.
- **Practical implications**– The results of this study are useful to any university to revise or design new academic programs. It presents a methodology to design curriculum based on the voice of the real customer: industry, without forgetting about the expertise of academicians.
- **Originality/value**– This study is intended to be one of the first in defining the customer as the industry, instead of just students or academic experts. The combination of all stakeholders in the curriculum design of international business will help universities make better decisions regarding international business programs.

Conclusions and recommendations

This study has several important contributions. First, it shows a real solution to the design of academic programs, where all the expectations of potential employers can be incorporated into curriculum development. Second, it presents a methodology for analyzing customer expectations. Third, the approach proposed on this paper provides an objective way to design academic curriculum and include a set of expectations generated by the market coupled with benchmarking and team analysis. Finally, it opens the window for future study in the area to include the uses of other innovative tools to solve real problems.

The application of QFD and benchmarking as a joint analysis tool is a very interesting approach, because the information is analyzed from different perspectives simultaneously. In addition, the resulting outcome from the QFD/benchmarking analysis is an academic program, which embraces customer expectations and the critical elements that potential employers are looking for. The determination of detailed skills for future professionals in the area of international business reduces the potential training costs for companies and reduces the gap between academia and business.

With the outcomes produced by this methodology, academic institutions' decision-makers can now have specifics on which to base decisions regarding the most appropriate courses and potential student's profiles. Areas designated as highly important for performance standards improvements can easily be addressed.

1.6.5. Ictenbas and Eryilmaz, (2011). "**Linking employers' expectations with teaching methods: quality function deployment approach**"

Meeting the expectations of employers' and related sector is important in gaining a competitive advantage and is thus an opportunity as well as a big challenge faced by universities. QFD is a methodology to translate customer requirements into the final product or service characteristics.

- **Design/methodology/approach**– This study is to evaluate different teaching methods in perspective of employers' expectations using the QFD approach.
- **Findings**– The findings will help the instructors to improve their courses to meet the employers' expectations.
- **Practical implications**– This study takes a sample Industrial Engineering course as an example and uses QFD methodology in assessing the effectiveness of teaching methods in the perspective of employers' expectations.
- **Originality/value**– This study is intended to gain a competitive advantage and is thus an opportunity as well as a big challenge faced by universities

The last step in QFD methodology is to prioritize the teaching methods which satisfy employers’ expectations successfully. To manage this, relationship weights are multiplied by customer importance ratings. The most effective teaching methods to meet the customer expectations are lecture, case study and project work. It is important that these methods are integrated into the course, so that employers’ expectations are met to the fullest.

Conclusions and recommendations

Universities will gain competitive advantage through determining the employers’ expectations. Evaluating the effectiveness of teaching methods in terms of meeting the employers’ expectations is a strategic issue to be handled by the instructors. In light of the findings, they can improve their courses.

In this study, QFD methodology was used to evaluate the teaching methods in the perspective of employers’. At first, customer requirements were defined, and then teaching methods were developed. Their relationships were determined. The final of teaching weights were calculated. Based on this analysis, the most effective teaching methods in terms of the meeting the employers’ requirements found as lecture, case study and project work.

1.6.6. Jannat Allahham, (2010). **"Vocational educational facility design: A fuzzy QFD (FQFD) Approach"**

One of the problems that face the construction sector in Palestine is achieving high satisfaction for users in terms of design. So, the appropriate design has many benefits especially on the performance of users.

This study is aimed to identify customer requirements in a specified vocational educational facility, design requirements that meet the customer requirements, Proposing a new design by preparing layout based on customers' requirements using FQFD and Compare the existing design with the proposed one.

- **Design/methodology/approach –** the methodology used in this study and provides the information about the study design, study strategy, and population. Also, it highlights the questionnaire design, FQFD method and model development. The population of this study is the customers which includes all 19 students and 2 teachers of carpentry specialization in the industrial secondary school in Dair-Albalah.

- **Limitations-** FQFD is not always easy to implement, particularly in large, complex systems**,** problems of FQFD can be categorized into three groups as: methodological problems and organizational problems and problems concerning product policy.

Conclusions

- The main objective of this study was to design an appropriate educational carpentry workshop using FQFD.
- FQFD is a valuable and very flexible tool for design. The practical applications of FQFD mentioned illustrate that it can be utilized in different ways and can be adapted to solve a great number of design problems.
- FQFD supports the customer requirements in the educational carpentry workshop (WHATs) and the design requirements (HOWs).
- Customer voice was evoked through interviews and from literature reviews that would effect on educational carpentry workshop conceptual design.
- A set of design requirements were proposed to satisfy the needs and their relationship with each of customer requirements agreed. Design requirements were ranked through FQFD method to guide the design of educational carpentry workshop. The three most important design requirements of educational carpentry workshop were: windows dimensions, windows type and windows distance from the floor.
- At the completion of this study a proposed layout for educational carpentry workshop were presented and a model was developed.
- From the comparison between the case study and the results of the study, FQFD has made a successful experiment with more objectivity.

- A model has been developed using LINDO software to identify the main design requirements of the educational carpentry workshop according to many conditions that achieve most customer requirements.

Recommendations

- Future studies can be pursued on developing a computerized intelligent decision support system for group decision making environment.
- Future studies and much better study are needed to demonstrate its usefulness in the detail design, procurement and construction phases as well.
- FQFD can be employed in any stage of the project.
- The FQFD process appears suitable for fast-track design/build contracts.
- The workshops' planning, design characteristics, and each property's relationship to the creation of the school plant should be among chief evaluation considerations.

1.6.7. Mark Hartley, (2007). "**Designing a supply chain management academic curriculum using QFD and benchmarking**"

The purpose of this study is to utilize quality function deployment QFD, benchmarking analyses and other innovative quality tools to develop a new customer-centered undergraduate curriculum in supply chain management (SCM).

- **Design/methodology/approach**– The researchers used potential employers as the source for data collection. Then, they used QFD and benchmarking to develop a Voice of Customer matrix. Using information from the matrix, a new customer oriented SCM undergraduate programme was designed.
- **Findings**– The researchers outline a practical solution to the problem of designing academic programmes which satisfy the main expectations of potential employers (customers).

- **Study limitations/implications**– The study is specifically concerned with the design of an SCM curriculum, but the researchers argue that the design methodology could be applied in other academic contexts.
- **Practical implications**– The application of QFD and benchmarking as a joint analysis tool is an interesting approach in education because the information is analyzed from different perspectives simultaneously. The new programme successfully meets customer/employer expectations and requirements.
- **Originality/value**– This study demonstrates the effective application of quality design tools to enhance academic programmes. The approach can clearly be extended to other areas for the design of specific courses and programmes. The most important needs in programme design are those of identifying the programme's main customers and of clarifying their expectations.

Conclusions and recommendations

This study has several important contributions. First, it suggests a useful solution to the design of academic programs, where all the expectations of potential employers can be satisfied. Second, it presents a methodology for analyzing customer expectations. Finally, it opens the window for future study in the area to include the uses of innovative tools to solve real problems.

The resulting outcome from the QFD/benchmarking analysis is an academic programme which embraces customer expectations and the requirements that potential employers are looking for. Determining detailed skills for future professionals in the area of supply chain management reduces the potential training costs for companies and reduces the gap between academia and business.

With the outcomes produced by this methodology, academic institutions' decision makers can now have specific suggestions on which to base decisions regarding the most appropriate courses and potential student profiles. Areas designated as highly important for performance standards improvements can easily be pinpointed and addressed.

In today’s competitive world, customer satisfaction is a vital goal to be accomplished at an affordable cost. One important factor in customer satisfaction is the effective identification of customer expectations. This paper illustrates the use of an approach that takes advantage of benchmarking/QFD analysis in order to design an academic programme that satisfies the real needs of the market in the area of supply chain management.

While this study demonstrates the effectiveness of the applications of these techniques to applied in academic areas, the use of this approach can clearly be extended to other areas for the design of specific courses. The most important of these is to clarify who the customers are and what their expectations are. Future study can benefit from this study by: expanding the scope from academic programmes to industrial applications in order to comparatively analyze the applicability of the proposed tools; and applying the same methodology to other areas of academia such as study, for developing a model for the identification of customers, (student) needs and potential solutions.

1.6.8. Xie, Shen, and Tan, (2004). **"Benchmarking in QFD for quality improvement"**

The main purpose of this study is to study procedures and methods for successful benchmarking in QFD for quality improvement. It discussed the customer satisfaction benchmarking process in QFD and proposed the use of hierarchical benchmarks for strategic competitor selection and decision making. A case study was presented to illustrate the use of this method. This study may provide a road map to achieve world-class performance through benchmarking in QFD, especially for small to medium-sized enterprises or companies in developing countries.

Conclusions and recommendations

For successful customer satisfaction benchmarking in QFD, this study discussed the benchmarking process and suggested the use of hierarchical benchmark method. A benchmarking example was presented to illustrate the use of this method. It is hoped that this study would provide a road map to world-class performance through benchmarking in QFD, especially for SMEs and companies in developing countries.

For future study, the determination of weight for each different benchmarking hierarchy needs to be further studied. The benchmarking process in QFD and the use of hierarchical benchmarks also need to be reinforced in practical use. It would be beneficial to extend the hierarchical benchmark method to the technical performance benchmarking in QFD.

Study effort should also be put to experiment this method in other benchmarking process besides QFD.

1.7. The Study Contribution

The previous studies show the positive impact of QFD applications in many different fields around the world, such as sectors of service, education, manufacturing, process development management, technology design, quality systems, product development, and international business. It is also noted that there is lack of local studies and Arabic resources.

It is the first local study which applied in the field of plastics industry which faces special and complex conditions and challenges in Gaza Strip.

As a result of this study, designing activities of the estimated PET preform are driven by the VOC that aimed to reduce the gap between the actual customer requirements and technical attributes of the estimated PET preform. The study determined the key inputs influencing the applications of QFD [the process of designing a new PET preform] to ensure meeting customers' requirements and expectation in *Elredaisi Industrial Company LTD.*

This study prioritizes spoken and unspoken customer wants and needs, in addition to the design requirements to translate these needs into technical characteristics and specifications to build and deliver a quality product or service by focusing everybody in the company toward customer satisfaction.

Chapter 2

Literature review

This chapter provides information about QFD, HOQ chart, AHP, customer satisfaction, customer needs, and customer's key inputs.

2.1. Quality Function Deployment

Quality Function Deployment is derived from six Chinese characters with Japanese Kanji pronunciation *figure 2.1*: HinShitsu (quality), Ki Nou (function), Ten Kai (deployment). The Japanese characters for HinShitsu represent quality, features or attributes, Ki and Nou represent function or mechanization and Ten and Kai deployment, diffusion, development or evolution. Taken together, the Japanese characters mean “how do we understand the quality that our customers expect and make it happen in a dynamic way” (Cohen, 1995; Martins and Aspinwall, 2001; Chow-Chua and Komaran, 2002). Emphasis on quality plans is also the reason why it was named Quality Function Deployment by the Japanese (Akao, 1990; Leo Lo et al., 1994; Prasad, 2000). The translation is not exact or descriptive (e.g. hinshitsu is synonymous with qualities, not quality). It was therefore, just a matter of translation, but instead of using Attributes Function Development, say, the term Quality function Deployment evolved. However, the message is the same.

"Deployment" has a much broader meaning than its English translation. In Japan "deployment" refers to an extension of activities. Therefore, "quality function deployment" means that responsibilities for producing a quality item must be assigned to all parts of a corporation (Akao et. al., 1983).

QFD was developed in the late of 1960's and early 1970's in Japan by Professors Yoji Akao, Shigeru Mizuno and other quality experts as they wanted to develop a QA method that considers customer satisfaction of a product before it was manufactured at the time that quality control methods were primarily aimed at fixing a problem during or after manufacturing (Akao, 1997). This technique took more than ten years to reach the USA. The history of QFD in USA and Japan is summarized in *figure **2.2***.

Many companies have used QFD in all fields and realized significant benefits, and the tool continues to grow in popularity (Hauser and Clausing, 1996). QFD influence also goes beyond Japan and the USA. There are reported QFD applications and studies in many countries (Chan and Wu, 2002).

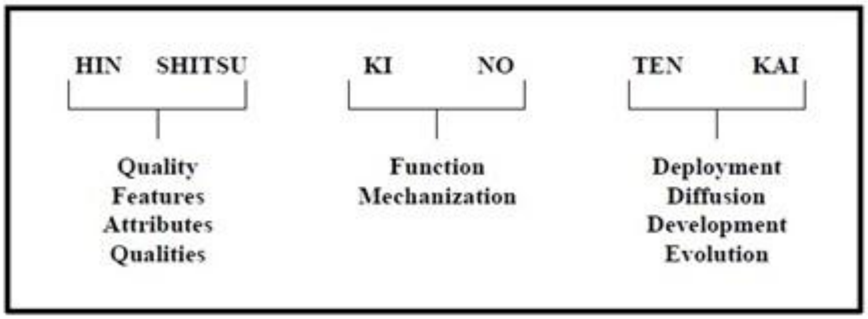


Figure (2.1): Translation of six Chinese characters for QFD [Shahin, 2008]

Cristiano et al., (2000) conducted a survey that compare between QFD phases in USA and Japan companies as shown in *figure 2.2*.

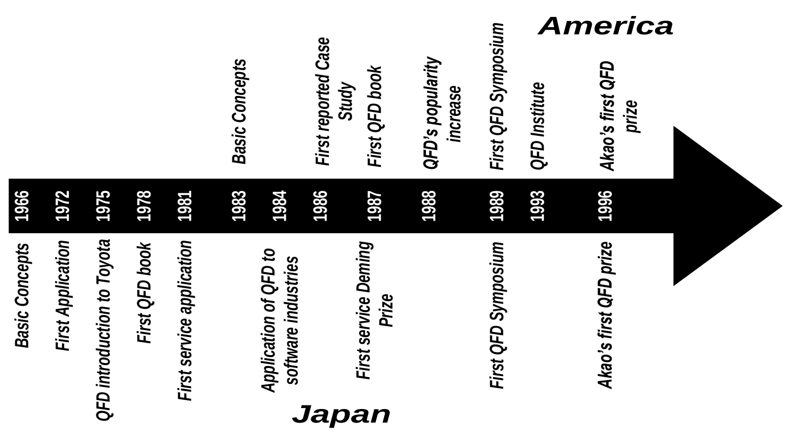


Figure (2.2): History of QFD [Cristiano et al., 2000]

It is now widely used not only in Japan, but also in Europe and the United States of America. The introduction of QFD, and other quality methods, especially in the USA, was a response to the growing success of the Japanese industry during the 1970s (Hauser and Clausing, 1996).

There are a number of tools that are increasingly recognized as essential, if companies are to radically improve their NPD process. One of these is QFD (Scheurell, 1994).

To design a product well, design teams need to know what they are designing, and what the end-users will expect from it. QFD is a systematic approach to design based on a close awareness of customer desires, coupled with the integration of corporate functional groups. It consists of translating customer desires (for example, the ease of writing for a pen) into design characteristics (pen ink viscosity, pressure on ball-point) for each stage of the product development. QFD is a way to assure the design quality while the product is still in the design stage. When appropriately applied, QFD has demonstrated the reduction of development time by one-half to one-third (Akao, 1990)**.**

QFD is a service planning and development support method, which provides a structured way for service providers to assure quality and customer satisfaction while maintaining a sustainable competitive advantage and it is a service planning and development support method, which provides a structured way for service providers to assure quality and customer satisfaction while maintaining a sustainable competitive advantage (Akao, 1990).

QFD differs from traditional quality systems which aim to minimize negative quality aspects such as poor service (Mazur, 1993). QFD focuses on delivering "value" by seeking out both spoken and unspoken customer requirements, translating them into actionable service features and communicating them throughout an organization (Mazur, 1993, 1997; Pun *et al.*, 2000). It is driven by the "voice of the customer" and because of that, it helps service providers to address gaps between specific and holistic components of customer expectations and actual service experience. In addition, it helps managers to adopt a more customer-driven perspective, pointing out the differences between what managers visualize as customer expectations and the actual customer expectations. QFD is developed by a cross-functional team and provides an excellent interdepartmental means of communication that creates a common quality focus across all functions/operations in an organization (Stuart and Tax, 1996). The unique approach of QFD is its ability to integrate customer demands with the technical aspects of a service. It helps the cross-functional team to make the key tradeoffs between the customers' needs and the technical requirements so as to develop a service of high quality. Hence, QFD is not only a methodological tool but a universal concept that provides means of translating customer requirements in each stage of service development (Chan and Wu, 2002).

A main goal of QFD is to translate customer demands into target values for the engineering characteristics of a product, prioritize spoken and unspoken customer wants and needs, build and deliver a quality product or service by focusing everybody toward customer satisfaction. By systematically and quantitatively employing the relationship between customer demands and engineering characteristics, those engineering characteristics that are most promising for improving customer satisfaction can be selected and target values can be set. In this way, QFD results in a more systematic attention for customer demands in the design and development process, or at least that is claimed. As (Fung et al., 1998) wrote: ‘‘Being an important business goal, customer satisfaction is a growing concern and prerequisite towards effective competitiveness’’. In addition to, enhanced customer satisfaction, organizational integration of expressed customer wants and needs and improved profitability. The intent is to employ objective procedures in increasing detail throughout the development of the product. QFD has helped to transform the way many companies to plan new products, design product requirements, determine process characteristics, control the manufacturing process and document already existing product specifications (Fung et al. 1998).

QFD was considered as a tool, or quality improvement tool. However, in the following it is specified that depends on its applications and due to its systematically process, QFD must be considered both as a tool and as a system. As QFD is a part of TQM, its influence actually permeates throughout the organization and synergistically encompasses many of the desired attributes, processes and tools of TQM. Companies that have experiences in applying TQM seem to employ QFD more easily than others (Smith and Angeli, 1995).

As it is depicted in *figure 2.3,* TQM activities, quality planning, QA, continuous quality improvement and quality function deployment are represented as part of a larger set of tools and strategies under the TQM umbrella. QA and continuous quality improvement activities focus on results. The tools include check sheets, graphs, histograms, Pareto diagrams, cause-and-effect diagrams, scatter diagrams, and control charts and diagrams. In contrast, quality planning and quality function deployment focus on design. They utilize new management and planning tools including affinity diagrams, relation diagrams, tree diagrams, matrix diagrams, and matrix data analysis (Oakbrook, 1999).

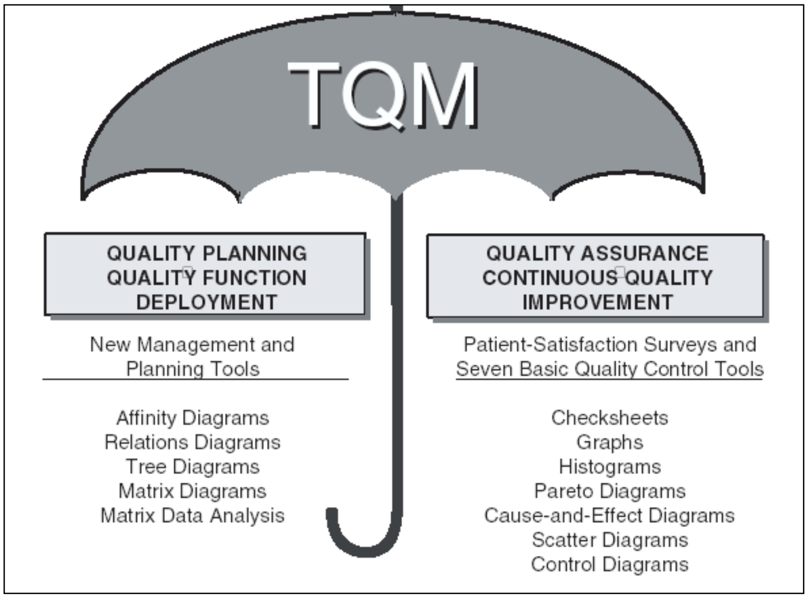


Figure (2.3): Total quality management umbrella [Oakbrook, 1999]

2.1.1. **Functional Fields of QFD**

QFD has been introduced successfully to both the manufacturing and service sector. The reported implementations are in various manufacturing and service areas such as Innovative NPD (Miguel, 2007), Product and services development management, Contract manufacturing, Manufacturing organization, Machine design planning (Abdul Rahman, 2003), Education, E-banking, Healthcare (Lim *et al.*, 1999), Hospitality (Stuart and Tax, 1996; Dube *et al.*, 1999), Public sector (Curry and Herbert, 1998; Gerst, 2004), Retail (Trappey *et al.*, 1996) Spectator event, Technical libraries, Information services (Chin *et al.*, 2001), Government, Banking, Education and research. Later, QFD's functions had been expanded to wider fields such as design, planning, decision-making and costing. Essentially, there is no definite boundary for QFD's potential fields of applications. Now it is hardly to find an industry to which QFD has not yet been applied (Chan and Wu, 2002).

Chan and Wu (2002) described the references in sectors such as telecommunications, transport, services, electronics and construction as shown in *figure 2.4*. However, the proportion of manufacturing to construction documents was 10 to 1.

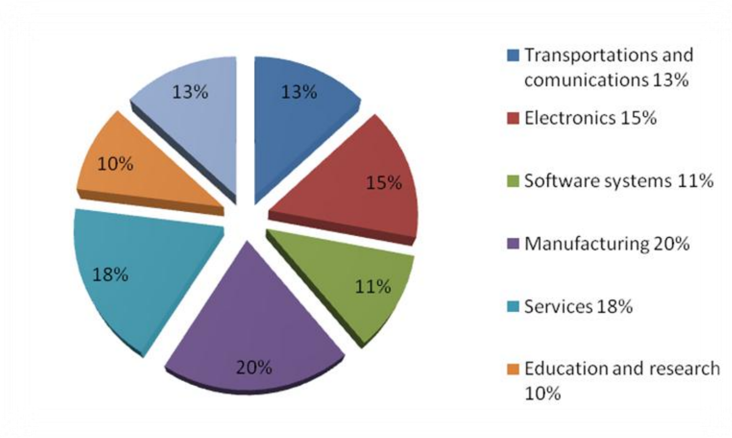


Figure (2.4): Percentage of publications of QFD in functional fields [Chan, 2002]

Cristiano et al. (2000) conducted a survey that compares between QFD phases in USA and Japan companies as shown in *figure 2.5*.

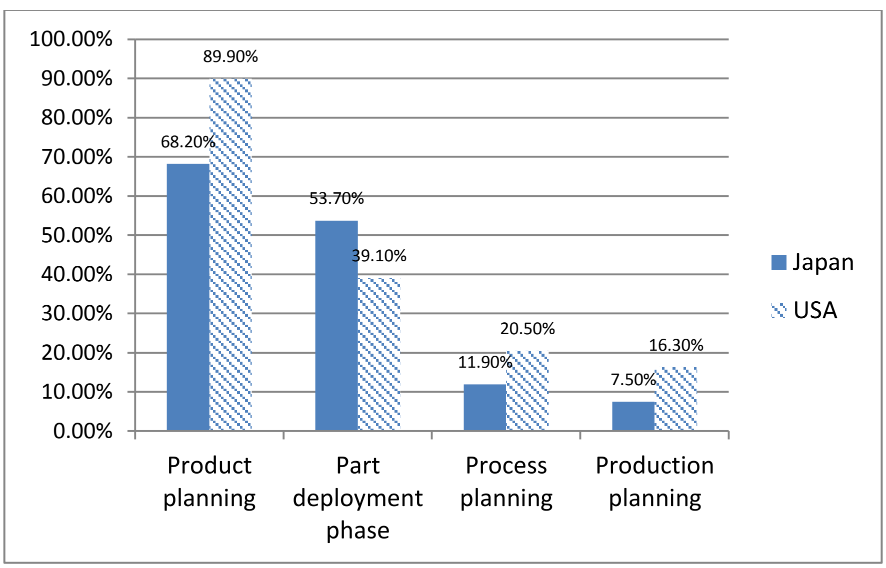


Figure (2.5): Advanced phases of QFD used in Japan and USA [Cristiano et al., 2000]

2.1.2. Kano Model of Customer Needs and Customer Satisfaction

"The Kano Model of customer satisfaction classifies products attributes based on how they are perceived by customers and their effect on customer satisfaction" (S. Burce Han et al., 2001). Noriako Kano, a Japanese quality expert, developed a model for customer satisfaction with three types of customer needs, which determine the customer's perception of quality.

The three types of needs are implied needs, stated needs and unconscious needs. Implied needs are fundamental needs, which the customer takes for granted. The needs are so obvious that the customer does not mention them. The presence of requirements that stand for a customer's implied needs does not increase customer satisfaction, but the absence of these needs will increase customer dissatisfaction. Stated needs are needs expressed by the customer. These needs can either satisfy or dissatisfy the customer, depending on in what way they are fulfilled by a product or service. Unconscious needs are beyond customers' expectations. By fulfilling customers' unconscious needs a company can gain a competitive benefit and more loyal customers. If a company succeeds in fulfilling customers' unconscious needs it can increase customer satisfaction. If a company does not fulfill its customers' unconscious needs it does not result in customer dissatisfaction, because the customers do not expect fulfillment of these needs. *Figure 2.6*, The Kano Model shows how the implied needs, stated needs and unconscious needs affect customer satisfaction depending on the degree of fulfillment (S. Burce Han et al., 2001).

It also shows how the different needs affect customer satisfaction depending on the degree of fulfillment. If the implied needs are not fulfilled the customers are very dissatisfied, but on the other hand fulfilled implied needs do not increase customer satisfaction. The figure shows that when the degree of fulfillment of implied needs moves slightly towards not at all, the customers become very dissatisfied. Even when the implied needs are fulfilled, they do not affect customer satisfaction in a positive way.

A lack of fulfillment of unconscious needs does not affect customer satisfaction, but if a company succeeds in determining its customers' unconscious needs it can lead to very satisfied customers. The figure shows that even a small increase in the fulfillment of unconscious needs will significantly increase customer satisfaction (S. Burce Han et al., 2001).

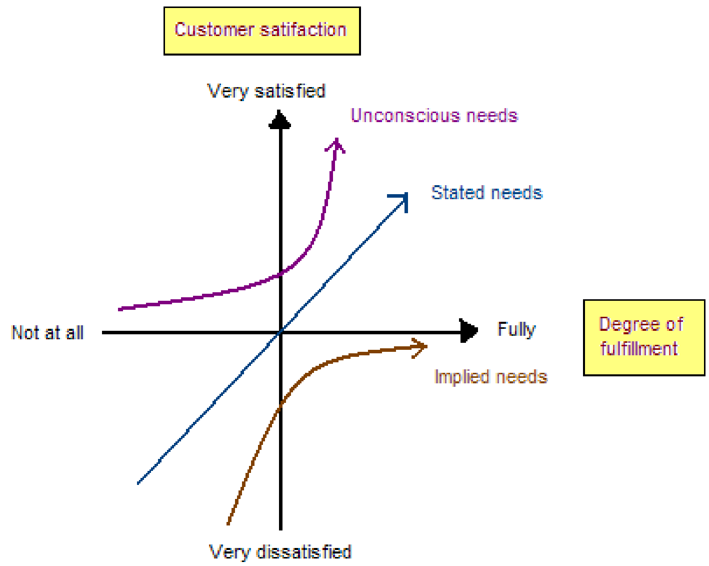


Figure (2.6): Kano model of customer needs and customer satisfaction

2.1.2.1. QFD and Kano's Model

Quality function deployment is becoming quite popular. By combing it with Kano's model method for understanding customer-defined quality the following benefits can be gained: There is a deeper understanding of customer requirements and problems Trade-offs within product development can be managed more effectively, there fewer start-up problems, competitive analysis is easier (improved market research), control points are clarified (reduced development time, better planning), effective communication between divisions (departments) is facilitated, and design intent is carried through to manufacturing (quality is built in 'upstream') (Matzler And Hinterhuber, 1998).

2.1.3. The QFD Phases

QFD uses some principles from Concurrent Engineering in that cross-functional teams are involved in all phases of product development as shown in *figure 2.7*. Each of the four phases in a QFD process uses a matrix to translate customer requirements from initial planning stages through production control (Becker Associates Inc, 2000).

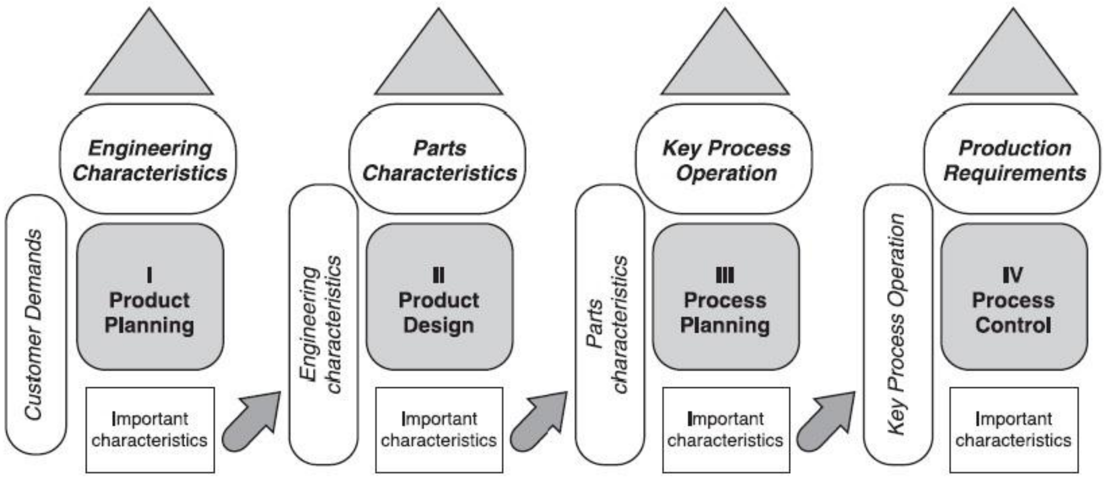


Figure (2.7): Four-phase model of QFD [Bouchereau and Rowlands, 2000]

Each phase, or matrix, represents a more specific aspect of the product's requirements. Relationships between elements are evaluated for each phase. Only the most important aspects from each phase are deployed into the next matrix.

Shahin (2008), Govers (2001), Bouchereau and Rowlands (2000), Cohen (1995) named the four phases of QFD as:

- **Product Planning:** Building the House of Quality. Led by the marketing department, Phase 1, or product planning, is also called The House of Quality. Many organizations only get through this phase of a QFD process. Phase 1 documents customer requirements, warranty data, competitive opportunities, product measurements, competing product measures, and the technical ability of the organization to meet each customer requirement. Getting good data from the customer in Phase 1 is critical to the success of the entire QFD process.

- **Product Design:** This phase is led by the engineering department. Product design requires creativity and innovative team ideas. Product concepts are created during this phase and part specifications are documented. Parts that are determined to be most important to meeting customer needs are then deployed into process planning, or Phase3.
- **Process Planning:** Process planning comes next and is led by manufacturing engineering. During process planning, manufacturing processes are flowcharted and process parameters (or target values) are documented.
- **Process Control:** And finally, in production planning, performance indicators are created to monitor the production process, maintenance schedules, and skills training for operators. Also, in this phase decisions are made as to which process poses the most risk and controls are put in place to prevent failures. The QA department in concert with manufacturing leads Phase 4.

2.1.4. Benefits of QFD

Hauser and Clausing (1996) compared startup and preproduction costs at Toyota auto body in 1977, before QFD, to those costs in 1984, when QFD was well under way. HOQ meetings early on reduced costs by more than 60 %. Also, Hauser and Clausing considered the difference between applying QFD in Japanese companies and not applying QFD in USA companies *(figure 2.8)*. As the *figure 2.8* shows, Japanese automaker with QFD made fewer changes than USA company without QFD. Some benefits of QFD are illustrated in *Table 2.1* (Shahin, 2008).

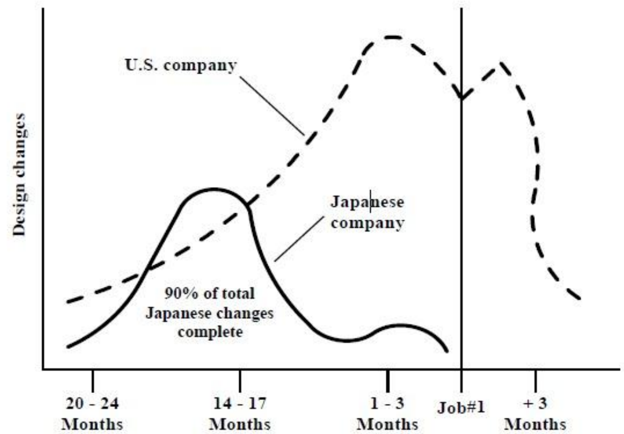


Figure (2.8): With and without QFD in Japan and America [Hauser and C., 1996]

Table (2.1): Major benefits of QFD [Shahin, 2008]

Benefits	Resource
Major reduction in development time and costs, shorter design cycles and changes.	Stocker (1991); Stauss (1993); Kathawala and Motwani (1994); Kenny (1988); Markland et al. (1995, 1998); Hales (1995); Bouchereau and Rowlands (1999, 2000a); Lockamy and Curry and Herbert (1998); Zairi (1995); Franceschini and Rossetto (1995); Howell (2000).
Leads to truly satisfied and delighted customers.	Emer and Kniper (1998); Kathawala and Motwani (1994); Kenny (1988); Lim and Tang (2000); Stauss (1993); Howell (2000); Stocker (1991); O'Neal and Lafief (1992); Markland et al. (1995, 1998); Hales (1995); Bouchereau and Rowlands (1999, 2000a); Lockamy and Curry and Herbert (1998); Zairi (1995); Franceschini and Rossetto (1995).
Improved communication within the organization. Brings together multifunctional teams, and encourages teamwork and participation.	Designing for customer satisfaction (1994); Kathawala and Motwani (1994); Stauss (1993); Stocker (1991); Markland et al. (1995, 1998); O'Neal and Lafief (1992); Hales (1995); Bouchereau and Rowlands (1999, 2000a); Lockamy and Zairi (1995).
The quality and productivity of service will become more precise in a continual improvement process.	Designing for customer satisfaction (1994); Kaneko (1991); Ermer and Kniper (1998); Howell (2000); Stocker (1991); Markland et al. (1995,1998); O'Neal and Lafief (1992); Hales (1995); Zairi (1995); Franceschini and Rossetto (1995).
Clarifies customer priorities for competitive advantage. Marketing advantage through increased market acceptability –leading to increased market share and better reaction to marketing opportunities.	Lim and Tang (2000); Stocker (1991); Markland et al. (1995, 1998); Hales (1995); Curry and Herbert (1998); Zairi (1995).
Enables one to focus proactively early in the design stage. Critical items identified for parameter design, and product planning is much easier to carry out. Ensure consistency between the planning and the production process.	Emer and Kniper (1998); Kathawala and Motwani (1994); Stauss (1993); Stauss (1993); O'Neal and Lafief (1992); Zairi (1995).
Brings together large amount of verbal data, organizes data in a logical way, and producing better data for refining the design of future products and services.	Emer and Kniper (1998); Stocker (1991); Markland et al. (1998); Bouchereau and Rowlands (1999, 2000a); Zairi (1995).

2.1.5. Problems and Mistakes During the Use of QFD

QFD is not always easy to implement, and companies have faced problems using QFD, particularly in large, complex systems (Harding et al., 2001). Govers (2001) categorized problems of QFD in three groups as: methodological problems, organizational problems and problems concerning product policy. *Table 2.2* presents some regular problems of QFD (Shahin, 2008).

Table (2.2): Some regular problems of QFD [Shahin, 2008]

Problems	Resource
If all relational matrixes combined into a single deployment, the size of each of the combined relational matrixes would be very large. Completing QFD late does not let the changes be implemented and it takes a long time to develop a QFD chart fully.	Kathawala and Motwani (1994); Prasad (2000); Zairi (1995); Dale et al. (1998); Bouchereau and Rowlands (1999, 2000a); Designing for customer satisfaction (1994).
QFD is a qualitative method, due to the ambiguity in the voice of the customer, many of the answers that customers give are difficult to categorize as demands.	Bouchereau and Rowlands (1999, 2000a); Designing for customer satisfaction (1994).
It can be difficult to determine the connection between customer demands and technical properties, so organizations do not extend the use of QFD past the product planning stage.	Dale et al. (1998); Bouchereau and Rowlands (1999, 2000a).
QFD is not appropriate for all applications. For example, in the automotive industry there are only a limited number of potential customers; the customer identifies their needs and the supplier acts to satisfy them. For a product of limited complexity and a small supplier base, the effort required to complete a thorough QFD analysis might be justified by customers. Setting target values in the HOQ is imprecise. Strengths between relationships are ill-defined.	Dale et al. (1998); Bouchereau and Rowlands (1999, 2000a).

QFD involves the construction of one or more matrices, called “quality tables”, which guide the detailed decisions that must be made throughout the service development process (Cohen, 1995). The first of these “quality tables”, called “The House of Quality HOQ”, is the most commonly used matrix in the QFD methodology. The traditional four-phased, manufacturing QFD methodology (Chan and Wu, 2002) is modified slightly so that it can be applied to the service and industry involves three quality matrices instead of four *figure 2.7* (Stuart and Tax, 1996; Pun *et al.*, 2000; Gonzalez *et al.*, 2004).

2.2. House of Quality Chart

House of Quality HOQ is a diagram, resembling a house, used for defining the relationship between customer desires and the firm/product capabilities. It is a part of QFD and it utilizes a planning matrix to relate what the customer wants to how a firm (that produces the products) is going to meet those needs. It looks like a House with a "correlation matrix" as its roof, customer needs versus product features as the main part, competitor evaluation as the porch etc. It is based on "the belief that products should be designed to reflect customers' needs, desires and tastes". It also is reported to increase cross functional integration within organizations using it, especially between marketing, engineering and manufacturing.

The first chart is normally known as the "house of quality", owing to its shape *figure 2.9 a*. *Figure 2.9 a* shows detailed "house of Quality". The QFD charts help the team to set targets on issues, which are most important to the customer and how these can be achieved technically. The ranking of the competitors' products can also be performed by technical and customer benchmarking. The QFD chart is a multifunctional tool that can be used throughout the organization. For engineers, it is a way to summarize basic data in a usable form. For marketing, it represents the customer's voice and general managers use it to discover new opportunities (Clausing and Pugh, 1991).

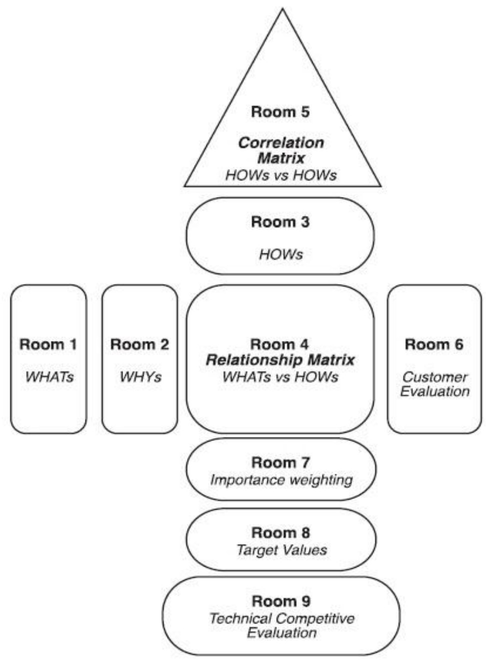


Figure (2.9 a): The chart of house of quality [Bouchereau and Rowlands, 2000]

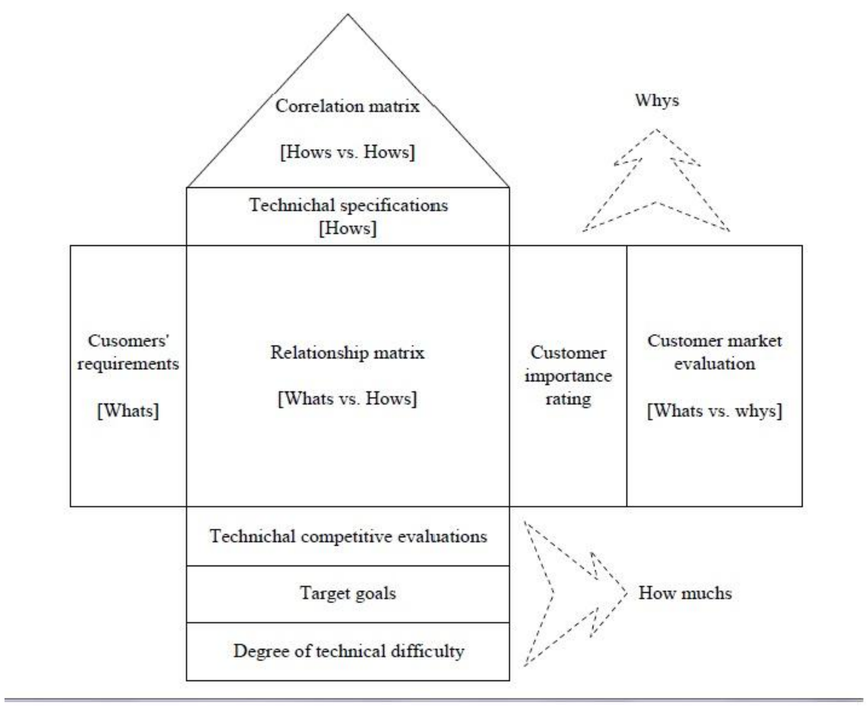
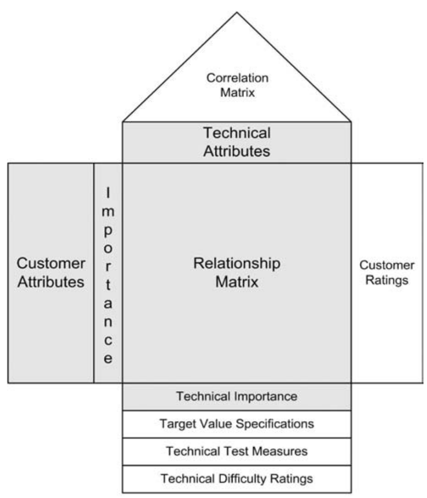


Figure (2.9 b): The chart of house of quality' [Menks et al, 2000]

To support that discussion it is necessary to provide brief background on the mechanics of the HOQ. Besides a conceptual mapping, the HOQ also functions as a model for understanding how attributes in one design node affect attributes in the subsequent design node. Consider *figure 2.10,* which shows a standard HOQ as described by Breyfogle (Breyfogle, 1999). The Customer Attributes CAs represent what the customer wants in the product. CAs are posed in customer language. The Importance section represents the weight the customer assigns to each CA. The Customer Ratings section represents the customer perception of how well a current product performs on each CA. The ratings may also compare competitor products. Technical Attributes TAs represent the product characteristics necessary to meet the CAs. The TAs however, are in engineering design language. The Relationship Matrix is where relationships between CAs and TAs are identified and given a “weak”, “medium” or “strong” relationship value. The technical test measures and technical difficulty ratings sections represent designer evaluations among the TAs. Target Value Specifications represent the target level the designers want each TA to reach. The Technical Importance section contains the calculated importance of each TA, which is a function of the Importance values and the values in the Relationship Matrix. Finally, the Correlation Matrix represents a matrix of the interrelationship among TAs.



Source: Breyfogle (1999)

Figure (2.10): Schematic of a house of quality chart [Menks et al, 2000]

2.2.1. Components of House of Quality

Bouchereau and Rowlands (2000), Menks et al (2000), Biren Prasad, (1998) and Govers (1996) named the components of HOQ as:

The house of quality HOQ consists of nine fundamental areas, all of which are not essential. *Figure 2.9 a* identifies each area, *figure 2.9 b* is a schematic view of an HOQ template. This template has nine rooms, four of which form the basic perimeters of the house. These four are two row-rooms (WHATs and HOW-MUCHes) and two column-rooms (HOWs and WHYs). HOQ also encompasses relationships among these four list vectors, resulting in four relational matrices, as follows:

- HOWs versus HOWs
- WHATs versus HOWs
- HOWs versus HOW-MUCHes
- WHATs versus WHYs

2.2.2. HOQ List Vectors

Figure 2.9 a identifies all rooms in the HOQ by their list vectors and matrices. The four list vectors-- WHATs, HOWs, HOW-MUCHes, and WHYs--are briefly described in the following:

- **WHATs: Customer Requirements CRs**

Customers define the WHATs in a QFD/HOQ. In simple terms, WHATs are a list of customer wants or customer requirements CRs. In most consumer goods manufacturing companies, the voice of the customer VOC is considered the market requirement.

Customers are initially listened to, and a list of customer needs and expectations is created. Some typical WHATs might be: "pleasing to the eyes," "looks well built," "provides good visibility "or" opens and closes easily." The Kano model of quality or features defines three types of WHATs: basic, performance, and excitement.

The Kano model relates customer satisfaction for each WHAT to its degree of achievement. The corresponding WHATs can further be categorized into primary (must have), secondary (maybe), and tertiary (like-to-have) categories. The primary needs set the strategic direction for the product and are called "strategic needs"; secondary needs are called "tactical needs"; and tertiary needs are called "operational needs.

- **HOWs: Quality Characteristics QCs**

Manufacturers define the HOWs in a QFD/HOQ, as represented by the list vector in *figure 2.9 b.* Basically, HOWs are a set of Quality Characteristics QCs through which a set of WHATs can be realized. Manufacturers do not know the magnitude of each of these HOWs. (When considered as a unit) that will be needed to realize as many WHATs as possible. Using this HOW list, a company can measure and control quality to ensure that WHATs are satisfied. Typical entries on the HOWs vector list are parameters for which measurements or a target value can be established. For example, a customer needs for a "good ride" (a WHAT) is achieved through "dampening," "shock isolation," "anti-roll," or "stability requirements" (four HOWs). HOWs determine the set of alternate quality features to satisfy the customer's stated needs and expectations (WHATs). Therefore, HOWs are called quality characteristics. For every WHAT in the Requirements and Constraints RCs list, there is one or more HOWs to describe possible means of achieving customer satisfaction.

- **HOW-MUCHes: Bounds on Quality Characteristics**

HOW-MUCHes comprise a vector list that normally identifies the bounds on the feasibility of HOWs. HOW-MUCHes capture the extremes—the permissible target values for each quality characteristic (see *figure 2.9 b*).In other words, for each HOW (quality characteristic) on the list vector, there is a corresponding value for a HOW-MUCH entry. The idea is to quantify the solution parameters into achievable ranges or specification tables, thereby creating a criterion for assessing success. This information is often obtained through market evaluation and research. A typical HOW-MUCH measures "the importance of HOWs," a "performance of Product X," or a set of "target values." In an optimization formulation discussed in Prasad, a row of HOW-Mooches is used to collect upper and lower bounds for the attributes in the HOWs vector list.

- **WHYs: Weighting Factors on WHATs**

Similar to WHATs and HOWs, a set of WHYs is also a vector list that describes the relative importance of current competitive products, referred to as "world-class" or "best-of-class" products. Best-of-class products contain HOWs that satisfy a set of WHATs in some prioritized manner see *figure 2.9 a*. WHYs are names of competitors, competitive products, market segments, or other items that describe current market conditions. WHYs are also factors for "weighting" the decisions that must be taken into account for a future product. Once these weighting factors are multiplied with the corresponding set of WHATs and then summed over, they provide a single pseudo measurement index for "overall customer satisfaction." A typical WHY might be a vector list of "overall importance" a vector list of "importance to the world purchaser" or a set of "world-class achievable performance of product X."

- **HOQ Relational Matrices**

The four HOQ relational matrices employ either numbers or symbols, depending on the purpose of the QFD and the context in which it is being used (see *figure 2.9 a).* Two possible rationales are traditionally proposed depending on whether a relational matrix is used for calculations or for visual aid. *Quantitative Reasoning:* Numbers are used for specifying magnitudes of HOQ matrices. This facilitates comparing magnitudes of computed vector lists by mathematical means.

Qualitative Reasoning: Symbols are used to represent list vectors or matrices. This provides a better visual communication. Three symbols are often used to indicate the relationship between WHAT and HOW entries. A solid circle (e) implies a strong relationship, an open circle (o) a medium relationship, and a triangle (A) a weak or small relationship.

This process of evaluating expressions in QFD gives concurrent engineering teams a basic method of comparing the strengths, weaknesses, and importance of column vectors

(WHATs, WHYs) or row vectors (HOWs, HOW-MUCHes) and measuring interactions between them. According to Akao, 1 there is no established theory in attaching these numbers to mark the priorities. Literature shows ratings on 1 to 5 or 1 to 9 scales, with the larger number indicating the higher priority. A close analysis reveals that the scale 1 to 5 represents an arithmetic progression, while the 1 to 9 scale represents a geometric progression. This means that the 1 to 9 scale discriminates the weak relationships heavily against the strong relationships, while the 1 to 9 scale discriminates evenly.

- **WHATs vs. HOWs**

To get a relationship between market requirements and quality characteristics, a correlation matrix is created by placing the HOWs list along the column of a matrix and the WHATs list along its rows (see *figure 2.10). The* rectangular area between the rows and the columns depicts the relationships between the WHATs and HOWs. Relationships within this matrix are usually defined using a four-level procedure: strong, moderate, weak, or none. An example is shown in *(figure 2.11).* This matrix may be densely populated (more than one row or column affected); this results from the fact that some of the quality solutions may affect more than one market requirement. For example, what a customer wants in "good ride" and "good handling" (WHATs) are both affected by quality characteristics like "dampening", " anti-roll," or "stability requirements" (HOWs). A diagonal correlation matrix means there is no or very little interaction between the rows and columns.

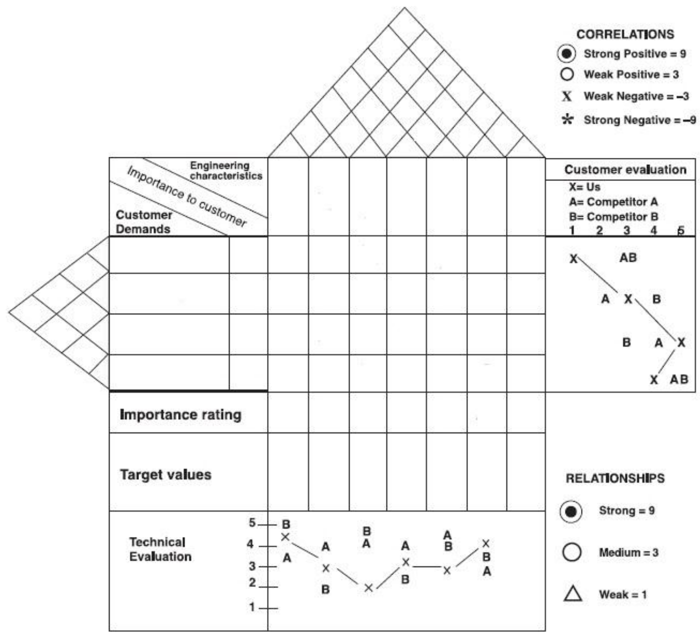


Figure (2.11): The chart of house of quality [Vivianne and Hefin, 2000]

- **WHATs vs. WHYs**

This is a matrix of influence coefficients that prioritizes the WHATs based on criteria for competitiveness. Usually, a list vector in the matrix (say, a column) consists of one or more of the following (see *figure 2.9 b*):

- Marketing information ratings, which identify the relative importance of each of the WHATs.
- Ratings showing how important the different customer groups perceive each of the WHATs. These are often referred to as Customer Importance Ratings CIRs.
- Ratings show how well a competitor's product is perceived as meeting each of the WHATs.
- Ratings showing where the product ranks or is perceived relative to the competition (better or worse).
- Factors that a company would like to consider in its (a product) specification set to be a "world-class quality producer."

The above criteria provide a set of possible options for identifying the stated importance ratings and factoring in how a product is perceived relative to competitors. Most importantly, the above criteria can be used to determine a weighted average of WHATs as a single performance index.

- **HOWs vs. HOW-MUCHes**

This is a feasibility matrix that lets a team decide how much each HOW can be varied to meet customer requirements. Typically, the data in this matrix (say, a row) consists of one or more of the following *figure 2.9 b.* In this case, a row of matrix "HOW-MUCHes of HOWs" may contain:

- What an organization perceives its product ranks relative to its competitors (technical competitive assessment).
- Ratings that identify the relative importance of each HOW.
- How a competitive product performs relative to each chosen HOW (benchmark data).
- Estimate of realistic upper limits for a chosen HOW.
- Estimate of realistic lower limit for a chosen HOW.
- Estimate of service repair cost data, direction of improvements, legal, safety, and other control items.
- Computed values of the Technical Importance Rating TIR. This is a weighted sum of Quality Characteristics QCs computed with respect to Customer Importance Ratings CIRs.

- **HOWs vs. HOWs**

This relationship is described by means of a sensitivity matrix that forms the roof of the house of quality (see *figure 2.9 b). The* purpose of the roof is to identify the qualitative correlation between the characteristic items (HOWs). This is a very important feature of the house of quality because, at times, the possible solutions could be redundant and may not add much value to customer wants. If two HOWs help each other meet the target values (HOW-MUCHes), they are rated as positive or strong positive. If meeting one HOW target value makes it harder or impossible to meet another target value, those two HOWs are rated as negative or strongly negative (see *figure 2.11).* In actuality, correlation between quality characteristics (solution parameters) could be positive or negative in varying degrees: strong, medium, or none. For example, "fuel economy" and "gross weight" are considered as having a positive correlation because reducing gross weight will increase fuel economy, keeping all other remaining parameters constant.

After the HOQ relationship matrices are developed, the constructs are reviewed. Blank rows or columns call for closer scrutiny. A blank row implies a potential unsatisfied customer and emphasizes the need to develop one or more HOWs for that particular market requirement (WHAT). A blank column implies that the corresponding quality characteristic item does not directly relate to or affect any of the market requirements. **(Biren, 1998)**

2.3. Analytic Hierarchy Process AHP

AHP is one of Multi Criteria Decision Making (MCDM) methods; it was originally developed by Thomas L. Saaty in the mid-1970s. It combines tangible and intangible aspects to obtain the priorities associated with the alternatives of the problem.

AHP is a structural framework that allows decision-makers to model a complex problem in a hierarchical structure by breaking it down into smaller parts, then calling for a simple comparison with respect to pairs of judgments to develop priorities within each level of hierarchy. Finally, results are synthesized to obtain overall weights of the alternatives. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allows some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the Consistency Index CI is derived from the principal Eigen values.

AHP is based on the experience gained by its developer, Thomas L. Saaty, while directing research projects in the late 1960's in the US Arms Control and Disarmament

Agency. Since then, the simplicity and power of the AHP has led to its widespread use across multiple domains in every part of the world. The AHP has found use in business, government, social studies, R&D and other domains involving decisions in which choice, prioritization or forecasting is needed.

Broad areas where AHP has been successfully employed include: selection of one alternative from many; resource allocation; forecasting; TQM; business process re-engineering; quality function deployment, and the balanced scorecard. By scanning the literature different uses of AHP can be found these include: Serkan et al. (2009) used AHP and TOPSIS methods under fuzzy environment for weapon selection, Hambali et al. (2009) applied AHP for composite manufacturing process selection, Steven (2008) used AHP for asset allocation, Agha (2008) used AHP for evaluating and benchmarking non-governmental training programs, Ahmet and Bozbura (2007) used AHP for prioritization of organizational capital measurement indicators, Forman and Gass (2001) constructed AHP model for assessing risk in operating cross-country petroleum pipelines, Babic and Palzibat (1998) used AHP for ranking of enterprises according to the achieved level of business efficiency**,** Berrittella, (2007) used AHP in deciding how best to reduce the impact of global climate change, McCaffrey, (2005) used AHP in quantifying the overall quality of software systems in Microsoft Corporation, Grandzol, (2005) used AHP in selecting university faculty in Bloomsburg University of Pennsylvania, and Dey, (2003) used AHP in assessing risk in operating cross-country petroleum pipelines for American Society of Civil Engineers (Al Afeefy, 2011).

2.3.1. AHP Methodology

AHP is based on the assumption that when faced with a complex decision, the natural human reaction is to cluster the decision elements according to their common characteristics. It involves building a hierarchy of decision elements and then making comparisons between each possible pair in each cluster. This gives a weighting for each element within a cluster and also a Consistency Ratio CR which is useful for checking the consistency of the data. The methodology of the AHP is explained in *figure 2.12*.

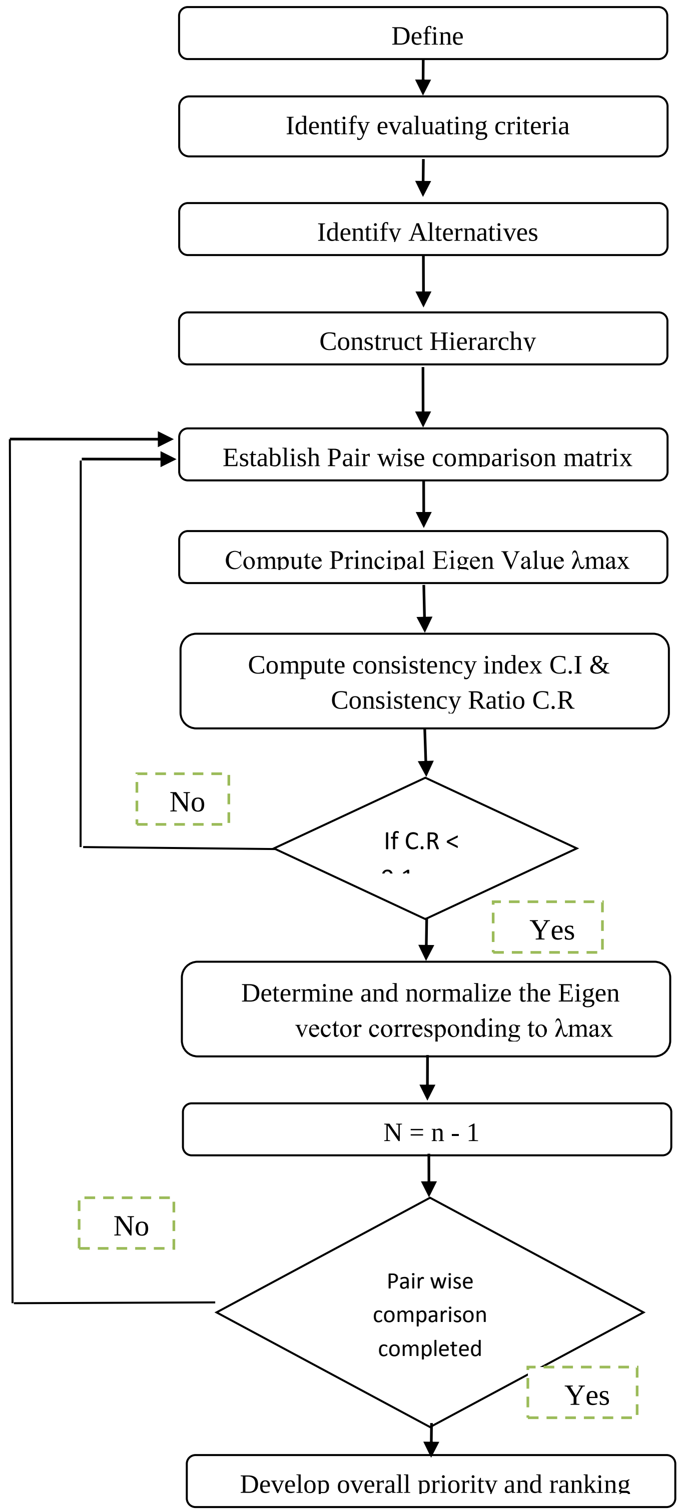


Figure (2.12): AHP methodology [Al Afeefy, 2011]

2.3.2. Performing Pair Wise Comparisons

Once the hierarchy of the problem is defined, the decision-maker performs a series of pair wise comparisons within the same hierarchical level and then between sections at a higher level in the hierarchy structure to have *n*(n-1)/2* comparisons if there are *n* criteria. In comparisons, a ratio scale of *1-9* is used to compare any two elements. *Table 2.3* shows the measurement scale defined by Saaty (1980). The matrix of pair-wise comparisons is:

$$\underline{A} = \begin{bmatrix} w_1/w_1 & w_1/w_2 & w_1/w_3 & \dots & w_{1/}w_n \\ w_2/w_1 & w_2/w_2 & w_2/w_3 & \dots & w_2/w_n \\ w_3/w_1 & w_3/w_2 & w_3/w_3 & \dots & w_3/w_n \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ w_n/w_1 & w_n/w_2 & w_n/w_3 & \dots & w_n/w_n \end{bmatrix}$$

Table (2.3): Saaty's scale of importance intensities [Saaty, 1980]

Intensity of importance	Definition
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate values between the two adjacent judgments

The pair wise comparisons of various criteria are organized into a square matrix as shown in matrix A. The diagonal elements of the matrix are *1*. The criterion in the *ith* row is better than criterion in the *jth* column if the value of element *(i, j)* is more than 1; otherwise the criterion in the *jth* column is better than that in the *ith* row. The *(j, i)* element of the matrix is the reciprocal of the *(i, j)* element.

The pair wise comparisons depend on subjective judgment without any scientific measurements, so it has been verified that a number of these pair wise comparisons taken together forms a sort of average. This average is calculated through a complex mathematical process using Eigen values and Eigen vectors. The principal Eigen value and the corresponding normalized right Eigen vector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalized Eigen vector are termed weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives (Saaty, 1980).

The procedure of pair wise comparison is to evaluate the importance of the criteria and then the preference for the alternatives with respect to each criterion.

The final solution results in the assignment of weights to the alternatives located at the lowest hierarchical level.

2.3.3. Synthesis

Once judgments have been entered for each part of the model, the rating of alternative is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to get global ratings. The AHP produces weight values for each alternative based on the judged importance of one alternative over another with respect to a common criterion. The results are then synthesized to obtain rank of the alternatives in relation to the overall goal.

2.3.4. Consistency Evaluation

Comparisons made are subjective and AHP tolerates inconsistency through the amount of redundancy in the approach. If this Consistency Index (CI) fails to reach a required level, then answers to comparisons may be re-examined. The Eigen value technique enables the computation of a consistency measure which is an approximate mathematical indicator of the inconsistencies or intransitivity in a set of pair wise ratings. This consistency measure is called the *CI* which is calculated as: $CI = (\lambda_{max} - n) / (n-1)$.

Where λmax is the maximum Eigen value of the judgment matrix. This *CI* can be compared with that of Random Consistency Index, (*RI)*. RI can take a value between 0 - *1.49* as shown in *table 2.4*. The ratio derived, *CI/RI*, is termed the CR, Saaty suggests the value of *CR* should be less than 0.1, if it is greater than 0.1 *(or 10%)*, the level of inconsistency in the set of ratings is considered to be unacceptable. In this situation, the evaluation procedure has to be repeated to improve consistency. Sensitivity analysis can be performed to see how well the alternatives performed with respect to each of the objectives as well as how the alternatives are sensitive to changes of the objectives (Saaty, 1980).

Table (2.4): Random consistency index RI [Saaty, 1980]

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

2.3.5. AHP Strengths

The AHP has been combined with a number of quantitative analysis techniques such as LP, goal programming, Data Envelopment Analysis, game theory, conjoint analysis and SWOT analysis.

The benefits of using AHP are as follows: It formalizes and makes systematic what is largely a subjective decision process and thereby facilitates ―accurate judgments, As a by-product of the method, management receives information about the evaluation criteria‘s implicit weights, and the use of computers makes it possible to conduct sensitivity analysis of the results.

2.4. Customer Satisfaction

Satisfaction is used as a common marketing benchmark of an organization’s performance, almost to the exclusion of other issues. A major US market research firm states that customer satisfaction is the key to success and makes the emphatic statement that a satisfied customer is a repeat customer (In-Touch Survey Systems, 2003).

While satisfaction itself is an emotional construct, its antecedents or drivers can be either emotional or cognitive, depending on the situation. Oliver (1989) proposed five models of satisfaction and its antecedents, three of which result from disconfirmation of expectations and can be labeled evaluative-based satisfaction. The remaining two depict satisfaction as an outcome of non-rational processes that can be labeled emotion-driven. (Patterson et al., 1997) summarized previous statement and indicated that satisfaction does not always have disconfirmation antecedents **(**Bennett and Rundle-Thiele, 2004)**.**

Customer satisfaction is the feeling or attitude of a consumer toward a product or service after it has been used (Solomon, 1996; Wells and Prensky, 2002; Metawa and Almossawi, 1998). A satisfied customer will repeat the purchase of the product and convey positive messages about it to others (Dispensa, 1997; Metawa and Almossawi, 1998). Customer satisfaction is an important topic for researchers and managers because it is likely that a high level of customer satisfaction leads to increases in repeat patronage among current customers and aids customer recruitment by enhancing an organization's market reputation **(**Singh and Kaur, 2011).The link between customer satisfaction and company success has historically been a matter of faith, and numerous satisfaction studies have also supported the case. Customer satisfaction has always been considered an essential business goal because it was assumed that satisfied customers would buy more. Customer satisfaction is often defined in the marketing literature as a customer's overall evaluation of his or her purchase and consumption experience of a good or service. In addition, perceived service quality refers to consumer's judgment about the performance of product or service. Customer satisfaction is critically important because it reflects subjective customer evaluations of the attribute performance associated with the consumption experience (Namkung, 2008).

It is important for the service and product providers to know the level of customer expectations so that they can meet and even exceed them to gain maximum customer satisfaction. Hence understanding customer expectations is a prerequisite for delivering superior service. Customers' perception of service quality influences the consumer behavior and intention. Organizations can provide the best services to their utmost capabilities but if the customer does not perceive them to be of quality, all is in vain. Thus it is very essential for the service provider to understand how customers can perceive the service as quality service and carry a euphoric feeling. It is the task of the marketing people to understand the factors affecting customer perception, elements of service quality and satisfaction to have a competitive edge and to create a perceptual difference. If all these are considered and then the service provider targets the customers with a total service experience, the customer perceives the service as quality service and spreads positive word of mouth. Thus perception is one of the factors affecting customer satisfaction. Customers seek organizations that are service loyal i.e. aim to provide consistent and superior quality of service for present and long term and organizations aiming for this are bound to get customers' loyalty (Dutti, 2009).

The market place is demanding more and more, and service leader are moving beyond quality to a level service excellence. Executives are extending their corporate aspirations from "delivering on promise" to "exceeding customer expectations. Service excellence addresses customer delight through face to face interactions and looks for ways to make the customer feel special. This special feeling is created through: pleasant surprises; unique actions or approach to service that competitors are unwilling to duplicate; attention to details and; adjusting service based on cues from customers. The essence of service excellence is to satisfy and delight the customer and exceed his expectations. Service excellence concentrates on listening, empowerment, innovation, and making customers and employee's part of the action (Madsen, 1993).

2.4.1. Techniques for Measuring Customer Satisfaction

Businesses have learned to collect data on a number of dimensions to create external data or customer satisfaction information. Sales figures and the trend are up or down over time are important. Usually strong sales mean customer satisfaction. Sometimes it means that a business has a unique product with little or no competition but typically sales and customer satisfaction are correlated. Customer loyalty or repeat business is another important dimension of customer satisfaction. Brand recognition is another. Outstanding organizations have products that are recognized and respected.

More sophisticated efforts lead to an understanding of customer success with one's own efforts and that of competitors'. A company will purchase a competitor's product or use their service to determine how it compares or benchmarks against their own. Products will be examined in careful detail to determine the durability, cost, and desirability. Businesses will comparison shop to examine a competitor's range of options, price, availability, quality, location, delivery alternatives, service capability, convenience, and product guarantee. Many businesses will also use mystery or phantom shoppers to gauge how well their employees' respond to their own customers (UTA, 2002).

2.5. Customer Needs and Customer's Key Inputs

"Customer needs refer to the benefits and features, of a good or service, that customers want to purchase" (Hitt, 1999). Different customers have different needs from a product or service. Companies must find out how to implement these different needs in order to create or reconstruct a product or a service that brings value to the customer.

Before studying the 'users' and their needs as a source of innovation, it is essential to clarify the terminological distinctions between the terms '*user*', '*consumer*', and '*customer*', which are often used as synonymous for each other.

According to the Product Development Management Association, a '*user*' is "*any person who uses a product or service to solve a problem or obtain a benefit, whether or not they purchase it*" (Rosenau, 1996). In this sense, users may also be the consumer of the product or service, or may not directly consume the product or service, but may interact with it for a certain period. This circumstance can be illustrated with a production tool whose user is the tool operator but consumer is the production organization.

The term '*consumer*' refers to a "*firm's current customers, competitors' customers, or current non-purchasers with similar needs or demographic characteristics*". However, the scope of the term 'consumer' is paradoxical. The term ambiguously covers both customers and target users of the firms' products or services. On the other hand, the 'customer' term is terminologically more lucid. Product Development Management describes the 'consumer' as "*one who purchases or uses a firm's products or services*" (Rosenau, 1996).

The product development literature has identified a number of key success factors, many of which are related to the crucial role of customers and suppliers (Brown and

Eisenhardt, 1995). In particular, authors have highlighted that being able to access rich information and knowledge from key customers provides an understanding of the customers' problems and needs, which again is a critical success factor for the developer (Von, 1986; Gruner and Homburg, 2000).

Customers are considered as the foundation of successful business-level strategies. In order to be successful a company must understand its customers and their needs. A company should focus on determining who its customers are, what the needs of these customers are, and how the company can satisfy the customers' needs by implementing a strategy. A company that has succeeded in satisfying its customer's needs have a high possibility to gain loyal customer and form long-lasting customer relationships (Hitt, 1999).

Instead of trying to serve the needs of an average customer, a company can divide its customers into different groups based on differences in their needs. By studying and listening to customers, managers can maintain valuable information about the customers' needs. Managers can use this information to improve a product or a service, the technology behind it, and make better distribution decisions (Hitt, 1999).

There are just as many, if not more, examples in which firms used various traditional (e.g., customer surveys, focus groups) and nontraditional (e.g., ethnography, contextual inquiry, empathic design) research approaches to gain insight into their customers' needs, and to develop highly successful new products (e.g., Burchill, et al. 1997; Squires and Byrne (2002); Crawford and Di Benedetto 2003; Ulrich and Eppinger 2004). Thus, there is persuasive evidence that it is indeed possible to understand customer needs and that this insight can be used in the innovation process. Rather than ignoring customers, it is more prudent to only ignore customers' specific ideas on how to fulfill their needs—it is the company's job to develop new products.

Conceptually, understanding customer needs leads to products that are *desirable*, *feasible*, and *salable* (to the mass market). Note that "product categories" are often defined by firms and not by customers (e.g., the SLR camera category, the digital camera category, the disposable camera category); thus product categories typically relate to feasible combinations of attributes that are salable (and hopefully desirable).

According to Holt et al. (1984), at the beginning of the innovation process, need related information is rather unclear, while in the further phases of the process, more exact information is needed. Throughout the process, the need related information might contribute in different phases of the product development process including preparation of the product proposal, evaluation of the product concept, development and testing of the prototype and planning of the marketing and manufacturing operations. Therefore, through different stages of the innovation process, different need related activities could be determined. *Table 2.5* represents the different need related activities that Holt et al. (1984) suggest:

Table (2.5): Different need related activities in the need assessment process (Holt et al., 1984)

Need identification:	A problem or a user need is perceived, often in a vague form. This is usually the initiation of the product innovation process.
Need evaluation:	Based on available information the perceived need is analyzed and evaluated.
Need clarification:	This involves a systematic study of user needs involved. It may be undertaken in connection with a feasibility study in the last part of the idea generation stage.
Need specification:	Based on assessed needs and their relative strength, relevant need requirements are specified.
Need up-dating:	As the project moves ahead, the needs specified are up-dated at intervals in connection with development of the technology and planning of the marketing

2.5.1. Methods for Assessing User Needs

The studies on customer needs have shown that 'need assessment' is the most valuable input for the customer needs process to develop successful products and services (Holt et al., 1984).

In contrast, in today's dynamic environment with enormous changes in user needs and expectations, utmost technological advancements, growing international competition and decreasing product life cycles, the only way for companies to survive is a good coupling of thoroughly understanding user needs with an awareness of technological possibilities (Holt et al., 1984). To understand the real needs of the users, it is needed to apply systematic, well-defined procedures and '*methods'* through the process of collecting need related information.

Studies on customer needs conclude with a number of '*methods'* defined to assess user needs. These methods vary in a couple of factors, such as the industrial sector, targeted degree of novelty in the product or service, and so on. In their study, (Holt et al., 1984) conclude to 27 different methods of assessing need related information. Considering the large number of methods, Holt et al. (1984) classify these methods into three categories:

- ***Utilization of existing knowledge:*** This is relatively cheap way of obtaining information about user needs. The major problems are to locate the most important sources, to train and make those involved need- conscious, and to develop and maintain a practical procedure for systematization, registration, and utilization of relevant data.
- ***Generation of new information:*** This approach requires a relatively great effort and therefore a more expensive way of assessing user needs. One has to plan and implement special activities in order to provide the information. On the other hand, the information acquired in this way is usually more complete and reliable.
- ***Provision of need information by other methods:*** This group includes informal approaches, i.e. information related to user needs obtained by informal contacts with knowledgeable persons, and 'environment-related methods' such as product safety analysis, ecological analysis, and resource analysis (Holt et al., 1984).

Table 2.6 represents a complete list of these methods under the categorization above and brief descriptions of these methods:

Table (2.6): Methods for obtaining need related information (Holt et al., 1984)

Existing Information	
Customer Information	Directly provided from customers through normal business contacts
Staff Information	Acquired and reported in connection with normal business contacts
Government Information	*Provided* by systematic surveillance of current and anticipated legislation
Competitor Information	Systematically collected information concerning products, patents, and activities of competitors
Trade Fairs	User information provided by exhibiting products, by studying products of competitors, and by talking with potential users
Literature	Need information provided through printed material such as books, standards, journals, reports, etc.
Experts	Systematic questioning and/or creative talks with researchers and other knowledgeable persons
Generation of New Information	
User Questioning	Systematic collection of information regarding problems and needs
User Employment	Hiring of people with user experience for a shorter or longer period
User Projects	Purposeful project cooperation with existing and potential users
Multivariate Methods	Graphical and mathematical models based on user perception of product characteristics
Dealer Questioning	Systematic collection of data related to user needs
User Observation	Systematic study of what is unsatisfactory by observing and analyzing the behavior of those involved
Active Need Experience	Working in a relevant environment for a certain period of time
Brainstorming	Creative thinking based on free association, deferred judgment, and cross-fertilization
Progressive Abstraction	Ranking of relevant needs in a hierarchical order
System Analysis	Systematic analysis of problems and needs caused by changes in a system or related subsystems

Other Methods	
Informal Contacts	Information provided through informal talks with people willing to indicate problems, needs and wishes
Product Safety Analysis	Study of product in order to minimize injuries, damages, and losses
Ecological Analysis	Improve environmental consequences of a proposed product
Resource Analysis	Improve resource utilization in a proposed product

Understanding customer needs is a key input into what has become known as the voice of the customer VOC. Originating in the TQM movement, the voice of the customer and quality function deployment QFD enable marketing, design, engineering, R&D, and manufacturing to effectively communicate across functional boundaries.

The Voice of the Customer VOC includes identifying a set of detailed customer needs, as well as summarizing these needs into a hierarchy where each need is prioritized with respect to its customer importance. Prioritizing customer needs is important since it allows the cross-functional development team to make necessary tradeoff decisions when balancing the costs of meeting a customer need with the desirability of that need relative to the entire set of customer needs. The voice of the customer is then translated into requirements and product specs, which in turn are translated into specific product attributes that can be bundled into concepts and prototypes for further testing with customers (e.g., Dahan and Hauser 2002a; Pullman, et al. 2002; Ulrich and Eppinger 2004). Design researchers identify three research platforms (Squires 2002): (1) discovery research (an open-ended exploratory effort to learn about customer culture so as to develop the foundation for “really” new products and services), (2) definition research (which assumes there is already a product concept, and thus define the products by identifying the customer implications associated with specific designs, products, and marketing strategies), and (3) evaluation research (which assumes there is already a working prototype, and thus helps refine and validate prototypes, design usability, market segments, consumer preferences).

The engineering, quality, and operations literatures consider a new product to be a complex assembly of interacting components for which various parametric models are built to optimize performance objectives (Krishnan and Ulrich 2001). According to Michalek, et al. (2005), "engineers generally use intuition when dealing with customer needs, emphasizing the creativeness and functionality of the product concept and working toward technical objectives such are reliability, durability, environmental impact, energy use, heat generation, manufacturability, and cost reduction, among others." Given a set of customer requirements and product specs, as well as related information on priorities, optimal values for key design variables can be determined using various standard techniques. Michalek, et al. (2005) describe how the analytical target cascading method can be used to resolve technical trade-offs by explicitly recognizing designs that are costly and/or impossible to achieve.

By and large, the marketing literature does not directly deal with understanding customer needs; instead, it either implicitly or explicitly focuses on the concept generation and testing stage in the innovation process. To facilitate communication between marketing and engineering, the marketing literature generally considers a new product or service to be a bundle of "actionable" attributes and characteristics (Krishnan and Ulrich 2001). However, as noted by Shocker and Srinivasan (1979) this approach is only "useful for locating 'new' product opportunities which may not be substantially different from current alternatives" (Shocker and Srinivasan 1979). Most of the extensive marketing research dealing with product positioning and conjoint analysis assumes that determinant attributes have already been identified (Shocker and Srinivasan 1979), although novel applications are still possible. Moreover, marketing generally does not completely appreciate the complex interactions and constraints among product specs in developing a fully working product; marketing also usually underestimates the fact that some designs are totally infeasible (Michalek, et al. 2005).

Chapter 3

Methodology

This chapter describes the methodology used in this study, QFD tools, steps of HOQ, and pair wise comparisons AHP.

The procedure used in this study is a QFD matrix. QFD uses a set of matrices, often called the house of quality, to translate customer requirements into a functional design. Building the methodology involves the following steps as shown in (*figure 3.1*).

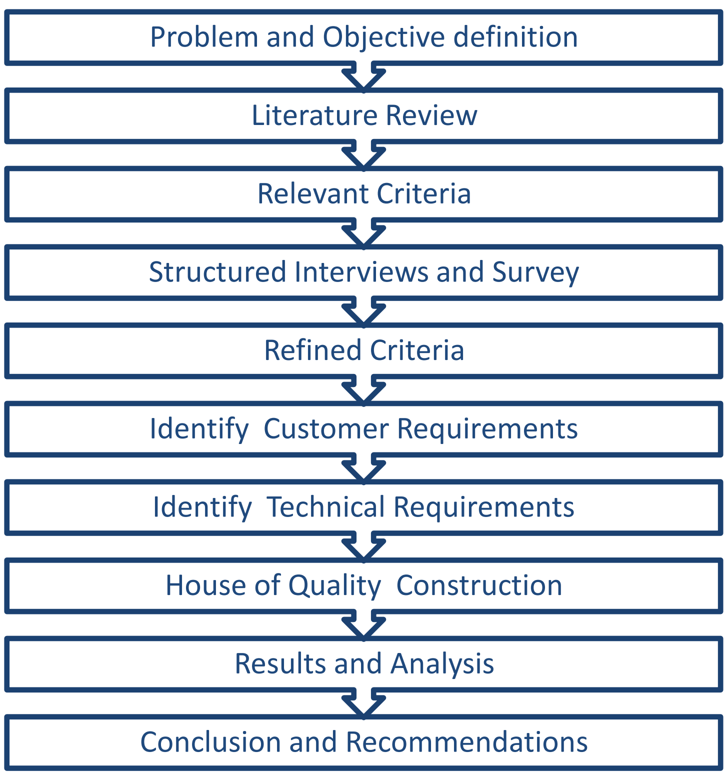


Figure (3.1): The methodology used in the study

3.1. Study Methodology

The study uses the analytical method which describes the applications of QFD in designing a new PET product in *Elredaisi Industrial Company LTD.* where the HOQ and AHP methods are used to compare, explain and evaluate in order to organize meaningful results.

3.1.1. Data Collection

Primary data and secondary data were collected.

The primary data was obtained from survey and interviews that were developed on accordance with the study questions.

The secondary data gathered from scientific journals such as the Knowledge Management, Procedia. Social and Behavioral Sciences, The TQM Magazine, International Journal of Quality & Reliability Management, Journal of International Education in Business, Benchmarking: An International Journal, and others through the electronic data bases such as Emerald. Also the secondary data included thesis, dissertations and text books available on the websites.

3.1.2. Study Tools

The researcher utilized various statistical tools including: Interviews, Focus groups, AHP method, and QFD.

- **Interviews**

More than 30 interviews were conducted with participants in *Yazegy Group for soft drinks*, *Makka Cola Company* and work team in *Elredaisi Industrial Co*mpany who took the time to give the customers' requirements, design, target value of the design requirements and the relationship between the customers' requirements and the design requirements to determine the requirements of designing the new PET preform.

All required data and information were obtained from the work team "see Bibliography/ interviews: pp.106" in both of Elredaisi Industrial Co., Yazegy Group for soft drinks, and Makka Cola Company.

- **Focus Groups**

Thirteen focus groups were conducted with participants in *Yazegy Group for soft drinks*, and *Makka Cola Company* to get the spoken and unspoken customer requirements. The researcher asked a series of internal questions about the customers' requirements, specifications, required service, packaging feature, design, and price of the desired product to the customers. Another ten focus group were conducted with work team in *Elredaisi Industrial Co*mpany to determine the requirements of designing the new PET preform and identify the relationships between technical attributes and correlation matrix of the house of quality.

3.2. QFD Tools

Tools such as affinity diagram and the house of quality HOQ, pair wise comparisons are used to understand the voice of the customer and to forecast the expected success of the end product (Bossert, 1991). These tools are briefly described below:

3.2.1. Affinity Diagram

The affinity diagram was used to organize the data collected from the focus groups (Cohen 1988). The data collected in this study were arranged as a set of unstructured ideas in an overall hierarchical structure (see *figure 4.3*). It was shown in chapter 4 by determining the customer requirements of PET preform as an example of affinity diagrams.

3.2.2. Steps of the House of Quality

Hussain (2011), Chan & Wu (2002), Jagdev at el (1997) and Govers (1996) described the sequence of HOQ steps as following:

3.2.2.1. Customer Requirements - "Voice of the Customer": Also known as voice of the customer, customer attributes, customer requirements or demanded quality. The first step in QFD process is to determine what market segments will be analyzed during the process and to identify who the customers are. Then, gather information on the requirements that the customer want for the product or service. Because the customers do not know all the product or service requirements, the team must document the requirements that the product must adhere to, which are determined by management or regulatory standards. Simple quality tools like affinity diagrams or tree diagrams are used to organize and evaluate customer requirements.

3.2.2.2. Customer Importance Ratings: Also known as design requirements, product features, engineering attributes, engineering characteristics or substitute quality characteristics. They can also be developed using the affinity diagram and tree diagram. Using a scale from 1 - 9, customers then rate the importance of each requirement. This importance rating allows prioritizing the requirements. Typically, the most important requirement assigned a value of 9 and the least important requirement assigned a value of 1, this number will be used later in the relationship matrix.

3.2.2.3. Customer Ratings of the Competition: Understanding how customers rate the competition has a great competitive advantage. In this step of the QFD process, the customers are asked how the product or service is rated in relation to the competition. The comparison results will help the developer position the product on the market as well as find out how the customer is satisfied now. Remodeling can take place in this part of the house of quality. Additional rooms that identify sales opportunities, goals for continuous improvement, customer complaints can be added.

3.2.2.4. Technical Descriptors - "Voice of the Engineer": Also referred as “HOWS”. They are the technical specifications that are to be built into a product with the intention to satisfy customer requirements. In order to complete the HOWS; the steps, actions, goods, and services (called technical descriptors) that are required to ensure that all WHATS met must be determined. The organization may already use some of these technical descriptors to determine product specification, however new measurements are required to ensure that the product meets customer needs. According to American Supplier Institute, good HOWS should be measurable, global, and proactive. In practice, technical measures can usually be generated from current product standards.

3.2.2.5. Direction of Improvement: As the technical descriptors are defined, the direction of movement (either increase or decrease) for each descriptor is determined.

3.2.2.6. Relationship Matrix: The relationship matrix is where the team determines the relationship between customer needs and the organization's ability to meet those needs (technical descriptors). It is the center part of HOQ and must be completed by technical team. The relationships can either be weak, moderate, or strong and may carry a numeric value of 1, 3 or 9 respectively.

3.2.2.7. Organizational Difficulty: Rate the design attributes in terms of organizational difficulty. It is very possible that some of the technical descriptors are in direct conflict. 1 to 5 ratings are used to quantify technical difficulty with 5 being the most difficult and 1 being the easiest.

3.2.2.8. Engineering Competitive Analysis: In this step, engineers conduct a comparison of competitor technical descriptors which helps for better understanding of the competition and to find out if these technical descriptors are better or worse than competitors. Again, 1 to 9 ratings are used with 9 being the fully realized each particular "HOWS" item and 1 being the worst realized.

3.2.2.9. Target Values for Technical Descriptors: At this step, the QFD team establishes target values for each technical descriptor. Target values represent "How Much" for the technical descriptors, and can then act as a base-line to compare against.

3.2.2.10. Correlation Matrix: The term House of Quality comes from this room because it makes the matrix looks like a house with a roof. This part examines how each of the technical descriptors impacts each other's. The team document strong negative relationships between technical descriptors and work to eliminate physical contradictions. This matrix is the least used room in the House of Quality; however, this room is a big help to the design engineers in the next phase of a comprehensive QFD project.

3.2.2.11. Absolute Importance: Finally, the team calculates the absolute importance for each technical descriptor. This numerical calculation is the product of the cell value and the customer importance rating. Numbers are then added up in their respective columns to determine the importance for each technical descriptor. Now the most technical aspects of the product matters to the customer are being known.

3.2.2.12. Pareto Results: Finally, a Pareto chart of the absolute importance for technical descriptors is constructed.

3.2.3. Pair Wise Comparisons (AHP)

The numbers from (1 – 9) are used for showing the preference or the importance in the comparison as shown in *table 3.1* (Saaty, 1980).

Table (3.1): The importance in the pair wise comparison (Saaty, 1980)

Number	Description
1	The criterion (x) is of the same importance of criterion (y)
3	The important of criterion (x) is 3 times the important of criterion (y)
5	The important of criterion (x) is 5 times the important of criterion (y)
7	The important of criterion (x) is 7 times the important of criterion (y)
9	The important of criterion (x) is 9 times the important of criterion (y)
2,4,6,8	The important of criterion (x) is 2, 4, 6, 8 times the important of criterion (y)

3.2.3.1. Illustrative Example

Table (3.2): Illustrative example of pair wise comparison

Specification & Quality	(1.5 – 2 Lt) Bottles	Weight (52 Gram)	High (mm)	Diameter (28 mm) PCO	Color	Strength	Higher performance in both CO2
(1.5 – 2 Lt) Bottles		**3**					
Weight (52 Gram)			**1**				
High (140 mm)							
Diameter (28 mm) PCO						**1/5**	
Color							
Strength							
Higher performance in both CO2 and O2 (5 bar)							

3: Means that the importance of — "Volume of bottle is 3 times the importance of —preform's weight"

1: Means that the importance of —" Preform's weight is the same as the importance of — preform's height"

1/5: means that the importance of —" strength of the preform is 5 times the importance of — Neck's size"

CHAPTER 4

Case Study

This chapter describes the current situation of industry in Gaza Strip, plastic industry in Gaza Strip, types of plastic, study population and sample, QFD team, implementation of QFD in *Elredaisi Industrial Company LTD.*, and the findings and analysis of the study.

4.1. Introduction

Elredaisi Industrial Company LTD. is a manufacturing company specialized in plastic & polystyrene industry, located in Gaza Strip – Palestine. It was established in 1987 on 5000m^2. It started with its polystyrene factory to substitute imported products and to fulfill the local and regional market's needs. Now, it is one of the most important companies in the sector of plastic manufacturing in Gaza Strip, where it has more than 60% of market share of Gaza's local market. It has injection, blow, PET and polystyrene production lines and produces more than 200 different forms of blow molding, PET bottles, thermo isolation boards and injection molding products such as trays and caps.

In the near past, the company's main markets were the West Bank and the Occupied Palestinian Lands (1948). More than 70% of the company's total income was from these two markets. But, it has changed for the last six years. The company has lost all of its market share in both of the West Bank and the occupied Palestinian lands (1948). Therefore, the company must increase its market share in Gaza Strip to compensate the loss. Now, it has more than 60% of market share of Gaza Strip's industry sector.

Currently, the company can completely add new PET Preforms or bottles to its products families, where they are used widely in filling the soft drinks manufacturing sector in Gaza Strip.

When the design process is considered as the most important step in the plastic industry, also customer satisfaction is the main goal of any company when quality of the final product is not everything, and there are many spoken and unspoken customer's requirements that this study will identify.

The economic situation in Gaza Strip has severely deteriorated since the closure imposed on it after mid-June 2007, which has almost completely restricted commercial movement at Gaza's crossing Points. The closure resulted in a negative impact on the local private sector in Gaza Strip, where 98% of Gaza's industrial operations were halted (3800 establishments). The current status of Gaza Strip with closed borders and political instability are summarized as following: No exports, limited imports (Humanitarian needs), difficulty in movement of goods and people, closed businesses, sales to local market only and high unemployment (MNE, 2012).

Elredaisi Industrial Company LTD. Similar to most companies in Gaza Strip, has consequently been facing numerous obstacles to their development, especially: The absence of a law that acknowledges their existence or defines their status, absence of a legal framework for operations, limited benefit and use of Palestinian National Authority's policies intended to enhance investments and support businesses, lack of information regarding competitors, limited financing opportunities, operating in a weak legal environment with inefficient financing opportunities, tight resources for up-scaling, a weak marketing ability and limited access to markets, lack of expertise among workers, lack in all kinds of resources (i.e. Electricity, Fuel, raw materials, …..etc.), consequently weakening their competitive ability, production with lower levels of productivity compared to other enterprises, policies of the Israeli occupation around the area of Gaza Strip have been devastating for all small and large businesses at all, causing hindrances and severe damage to infrastructure and capital, the closure of thousands of businesses and downscaling and therefore, deterioration in the economic situation of large swathes of the population, and finally, the Israeli occupation is severely impeding international trade (Company's owner; MNE, 2012; Palestine Economic Policy Research Institute, 2012).

4.2. The Current Situation of Industry in Gaza Strip

Industry in Gaza Strip is still traditional based on micro and small-size firms. Also many of the so-called industrial activities in the West Bank and Gaza are craft works of low productivity. The structure of industry emphasizes this and shows that more than 90% of industrial establishments employ less than 10 persons (MNE, 2011).

Gaza's private sectors have suffered greatly from the strict limitations on imports and almost total banning of exports since June 2007. This has contributed to the closure of 70%-90% of working establishments and lying off 92%-96% of laborers. With the continuation of the closure and the availability of using underground tunnels, few enterprises restarted operations (PalTrade, 2011).

A recent report by the Office of the Quartet Representative (OQR) and Pal Trade, tracking changes in eleven industrial sub-sectors in Gaza between June 2010 and June 2011, concludes that the easing of the Israeli blockade has had an overall positive effect on manufacturing activities. However, the effect of the increased availability of cheaper raw materials with better quality has been partially offset by the strong competition from imported goods. The continued inability to enter the West Bank and Israeli markets has also hindered the further development of Gaza businesses.

Enterprises reported facing the same main challenges to conducting business: reliable supply of electricity, access to export markets, supply of raw materials, access to finance and supply of equipment and spare parts.

High unemployment, low income, closure of the Palestinian areas, Israeli control of the borders, and many obstacles are still facing industry in Gaza Strip. Many firms did not consider the shortage of loans and credit facilities as a real reason for little expansion. The real reason for little expansion is the unstable situation under the Israeli occupation, and the condition of low profitability (PTO, 2012).

4.3. Plastic Industry in Gaza Strip

Plastic industry in Gaza Strip is characterized by smallness, single or family ownership financed, subcontracting with Israeli firms, labor-intensive technique due to the high unemployment and lack of capital, lack of managerial skills, lack of raw materials, inadequate infrastructure, training and unstable political situation (PFI, 2012).

The plastic industry is one of the more developed local industries. According to recent statistics, the total investment in the plastic sector in the Gaza Strip reached 11 million US Dollars. 60% of the local production is marketed in Gaza, 30% in the West

Bank and 10% in Israel. 65% of plastic factories in Gaza market 80-100% of their production in Gaza. 75% of the factories in the West Bank market around 50% of their production in Israel (MNE, 2011).

4.4. Types of Plastic

- **Polyethylene** - most plastic household packaging is made from polyethylene. It is a versatile wax-like thermoplastic in almost a thousand different grades with varying melting temperatures, density and molecular weights.
- **Polypropylene** - was developed in Italy in 1954 from catalysts used to form HDPE. It is very versatile, and makes up about 12 per cent of the plastics used.
- **Polystyrene** - is one of the lower cost plastics to produce and is the easiest to shape. Packaging for a variety of products uses most of the plastic.
- **Vinyls**- are among the most versatile of all thermoplastics, ranging from soft pliable films to rigid structural forms. They are cheap to make because about half the raw material comes from rock salt.
- **Polyethylene Terephthalate** - is one of the more recent plastics, and it is being used for an increasing array of products. One reason for this is a ready supply of raw material (a petroleum by-product) and the only waste from the process is steam (*ACC, 2012*).

4.4.1. Polyethylene Terephthalate PET

PET stands for polyethylene terephthalate, a plastic resin and a form of polyester. Polyethylene terephthalate is a polymer that is formed by combining two monomers: modified ethylene glycol and purified terephthalic acid.

PET plastic bottles are a popular choice for packaging soft drinks due to the numerous benefits they provide both to manufacturers and consumers. This type of plastic labeled with the #1 code on or near the bottom of bottles and containers. 70% of soft drinks (carbonated drinks, fruit juice and bottled water) are now packaged in PET plastic bottles *figure 4.2* (BPF, 2012).

There are two stages to produce PET bottles, the first stage is producing PET preform (see *figure 4.1*) that is moulded on an injection moulding machine, then in the second stage the preform is reheated and blown *(*see *figure 4.2*) on a blow moulding machine.

Figure (4.1): PET preform [first stage]

Figure (4.2): **Reheated and blown PET products [second stage]**

4.4.2. Benefits of Using PET Plastic Bottles

PET quickly gained acceptance among bottlers and consumers. Because it is *Lightweight:* Cost-effective to produce and require less energy to transport, *Safe:* Do not shatter and cause a hazard if broken or damaged, *Convenient:* Because they are safe and lightweight, they are also convenient for on-the-go consumption, *Re-sealable:* Suitable for multi-serve packs, *Recyclable:* Can be recycled so that the PET can be used over and over again, *Sustainable:* Increasing numbers of PET plastic bottles are made from recycled PET, *Distinctive:* Can be moulded into different shapes, enabling brands to use them to build identity and promote drinks and *Flexible:* Manufacturers can switch from one bottle shape or size to another, meaning a high level of efficiency (Hurd, 2010).

4.5. Study Population and Sample

The study population focused on the *Elredaisi Industrial Company LTD.* that has approximately sixty percent (60 %) of the market share of plastic bottles and cans industry in Gaza Strip. Eighty percent (80 %) of the total products of the company are sold to the manufacturing sector and only twenty percent (20 %) are sold to wholesales that distribute in different areas in Gaza Strip (PFI, 2012). In this study, interviews and focus groups are conducted with two manufacturing customers that are specialize in producing and filling water, juice and soft drinks in Gaza Strip. The structured interviews and focus groups were designed to gather data needed to design the desired 52 gram PET preform.

4.6. QFD Team

Effective application of QFD hinges on forming the proper implementation team and employing the QFD tools (Cohen, 1995). In this study, the team consists of the researcher and responsible persons "see Bibliography/ interviews: pp.106". The first task for the QFD implementation team is to identify all customers' needs. Then, the team uses a number of QFD tools to translate the customers' needs to measurable engineering characteristics. Proper deployment of the implementation team encompasses of three phases:

i. Conceptualizing the subject issue by focusing on developing a comprehensive definition of the purpose of the study which is a design of a new PET preform by using QFD.

ii. Collecting the necessary data by:

- Selection of the focus groups' participants which consist of the professionals in plastic industry, production and mechanic engineering, and the customers.
- Conduction of the focus groups' participants to collect accurate data using interviews and the observations.

iii. Analyzing and reporting the results of the data gathered using the HOQ to record, prioritize, analyze, and translate the data collected from the focus groups' to measurable design parameters that ensure customer satisfaction.

4.7. Implementation of QFD in Elredaisi Industrial Company LTD.

This study is about designing a new (52 gram) PET preform which is used in producing and forming different forms of 2 liters bottles that are used in filling and keeping carbonated soft drinks such as Coca Cola, Pepsi Cola and 7UP. The main reason of why the researcher has chosen this topic is to use the pre-analyzed technical requirements. The customer studies and interviews are applied to 11 persons (see Bibliography/ interviews: pp.106) and two '52 gram" PET preform models from different brands are selected as competitive products.

The methodology used in this study has been used to link manufacturing techniques and market demand from the consumer's perspective. Using QFD, the researcher systematically transforms customer requirements and expectations into measurable product and design parameters for designing a new (52 gram) PET preform. The approach helps the company to focus on what customers perceive as important and certifies that these requirements exist in the final product or service. By extracting customer data from QFD matrix, the challenges facing the company and the changes needed to deliver best quality product and service attributes will be derive. It is also a means to achieve effective communication among business units, so that the company can generate an effective and efficient product or service development process. Consequently, QFD assures with high degree of confidence that the company will design and develop its new (52 gram) PET preform in the way that satisfies its customers in Gaza Strip.

The researcher developed the HOQ product-planning matrix for a new (52 gram) PET preform to translate the important customer requirements into key end-product control characteristics. The design of a HOQ contains four basic elements: The quality and attributes of the product and services as demanded by the customer, the technical characteristics of satisfying the desired attributes by the company, including the exact specifications to achieve, correlation matrix: an evaluation of the positive and negative relationships among the company's technical capabilities of meeting customer requirements and relationship matrix: an evaluation of the relationships between the attributes and the means of satisfying the new (52 gram) PET preform. HOQ identified the best ways to satisfy the customer and generates a ranking that is used as a guide throughout the development process.

- **Step1: Customer Requirements**

After reviewing the results of interviews and focus groups with both customers and the engineers of the company, the features of required (52 gram) PET preform were derived. The identifications were derived from customers comments (see *table 4.1*) through interviews with them.

Table (4.1): List of the customers who determined the required data and information

Name	Company	Title
Mr. Ahed Fuad Mahdy	Makka Cola Co.	Director of purchasing department
Mr. Mahir Ramadan Abu Nahil	Makka Cola Co.	Director of marketing department
Eng. Musa Jabir Siyam	Makka Cola Co.	Director of production department
Eng. Rajab El Ghazaly	Yazegy Group	Director of production department

Table 4.2 shows the detailed customer requirements for the required (52 gram) PET preform that are used in blowing (1.5 – 2.0 lt.) plastic bottles, and have the characteristics of: 52 gram weight or less, 140 mm height, 28 mm PCO neck type, color (colorless 75%, green 25%), easy to be handle in the manufacturing process, commitment of the required

quantities, delivering the required amounts on time, delivery in Gaza to avoid the risk during transport to Gaza, using safe raw materials for keeping food, using not too hard raw material in producing the required preform, delivering clean and hygiene preform with the specification of clarity and antistatic protection, having higher performance in both CO_2 and O_2 (5 bar), having good clearness and transparency, and introducing a competitive price.

Table (4.2): Detailed customer requirements for 52 gram PET Preform

Detailed Customer Requirements
(1.5 – 2 Lt) Bottles
Weight (52 gram)
Height (140 mm)
Diameter (28 mm) PCO
Color (Colorless 75%, Green 25%)
Strength
Higher performance in both CO_2 and O_2 (5 bar)
Easy to carry
Easy to transport
Commitment of quantity
Delivering in time
Delivery in Gaza
Hygiene
Safety for keeping food
Not too hard
Clarity and Antistatic protection
Higher performance in both CO_2 and O_2 (5 bar)
Clearness & transparency
Cold filling
Competitive price

Figure 4.3 shows the affinity diagram of the main customer requirements, and *table 4.3* shows the relationship between affinity diagram and detailed customer requirements.

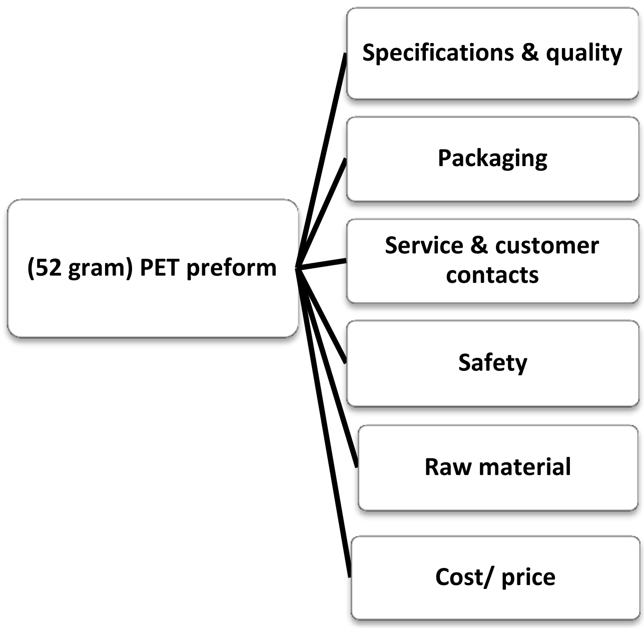


Figure (4.3): Affinity diagram of the main customer requirements of (52 gram) PET preform

Table (4.3): The relationship between affinity diagram and detailed customer requirements

Customer requirement	Detailed customer requirements
Specifications & quality	(1.5 – 2 Lt) Bottles
	Weight (52 gram)
	Height (140 mm)
	Diameter (28 mm) PCO
	Color (Colorless 75%, Green 25%)
	Strength
	Higher performance in both CO_2 and O_2 (5 bar)
Packaging	Easy to carry
	Easy to transport
Service & customer contacts	Commitment of quantity
	Delivering in time
	Delivery in Gaza
Safety	Hygiene
	Safe for keeping food
Raw material	Not too hard
	Clarity and antistatic protection
	Higher performance in both CO_2 and O_2 (5 bar)
	Clearness & transparency
	Cold filling
Cost/ Price	Competitive price

- **Step 2: Customer Importance Ratings**

Work team of Makka Cola and Yazegy Group soft drinks producers were asked to specify the importance of their requirements as "very unimportant", "unimportant", "moderately important", "important", and "very important". Where "very unimportant" has 1 as a score, while "very important" has 9 as a score.

The relative importance of the customer requirements were obtained using AHP. *Table A.1* (appendix A) shows Customer importance rating of 52 gram PET preform from the viewpoint of determined customers.

Main Criteria Pair Wise Comparison

After identifying the main customer requirements, constructing the general model, and entering the experts' judgments of main criteria pair wise comparison to the EC, the results shown in *table A.1* (appendix A) are obtained.

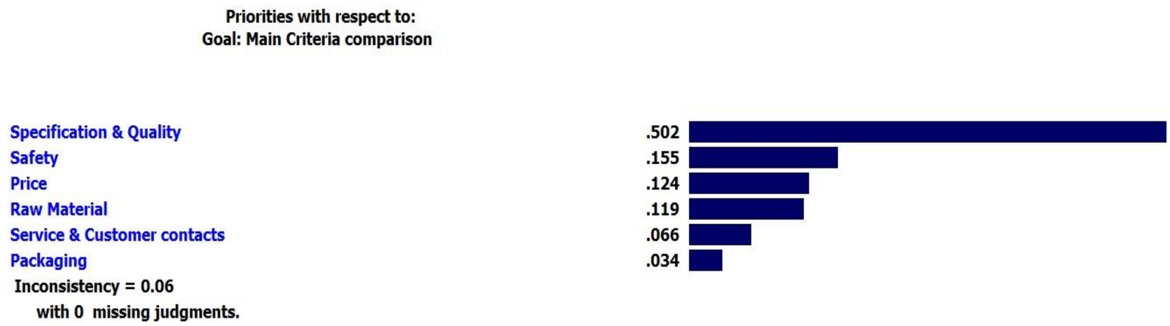


Figure (4.4): EC results of main criteria pair wise comparisons

As it was shown in *figure 4.4*, the specification and quality criteria has the highest priority with respect to the goal with a percentage of 50.2%, this reflexes the importance degree of the required technical specifications and quality of the product. The safety criteria which involve the aspects of hygiene and safe raw material for keeping food, is the 2nd one in priority with a percentage of 15.5%, where it is very important for the customers to receive products in accordance to foods standards. The price criteria which are the 3rd one in priority with a percentage of 12.4%, where it is very important to add a competitive aspect and reduce the manufacturing cost. The raw material criteria which is the 4th one in priority with a percentage of 11.9%, and has approximately the same importance with the price and safety criteria of the product, where it is affects directly on the quality and cost of the final products. The service and customer contact which is the 5th one in priority with a percentage of 6.6% is very important for the customers. The packaging of the product which is the last one in priority with a percentage of 3.4%, where it is very important for customers to handle the product in easy and good packaging way. (These results ensure the experts' opinions that the main customer requirements prioritized should be classified as it shown in *figure 4.4*).

Sub Criteria Pair Wise Comparison

1. Specifications and Quality Sub Criteria Pair Wise Comparison

The experts' judgments of specification and quality sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.2* (appendix A) and *figure 4.5.*

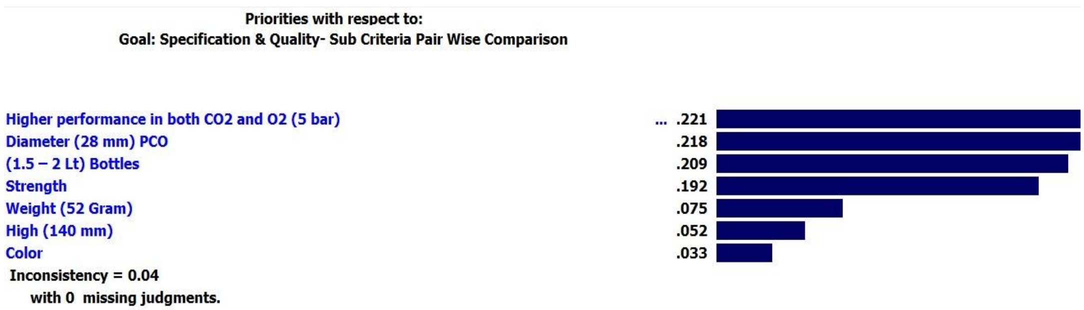


Figure (4.5): EC results of specification and quality criteria pair wise comparisons

As it was shown in *figure 4.5,* the higher performance in both CO_2 and O_2 (5 bar) criteria has the highest priority with respect to the goal with a percentage of 22.1%, this is to get strong product and to avoid the destroy of it after filling. Not far away from it; the diameter (28 mm) PCO criteria which is the 2nd one in priority with a percentage of 21.8%, where it is an international scale standard. The suitability to be blown till 2 liters bottles criteria which is the 3rd one in priority with a percentage of 20.9%, where it is the main goal of the customer. The strength criteria which is the 4th one in priority with a percentage of 19.2%, where affect directly on the quality level of the product. The weight (52 Gram) criteria which is the 5th one in priority with a percentage of 7.5%, where it may less than 52 gram, if it is strong enough to blown on 2 liters. The height (140 mm) criteria with a percentage of 5.2%, to reduce the defects during blowing. The color criteria which is the last one in priority with a percentage of 3.3%, where the required colors are clear and green. (These results ensure the experts' opinions that the specification and quality criteria prioritized should be classified as it shown in *figure 4.5*).

2. Packaging Sub Criteria Pair Wise Comparison

The experts' judgments of packaging sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.3* (appendix A) and *figure 4.6.*

Figure (4.6): EC results of packaging criteria pair wise comparisons

As it was shown in *figure 4.6*, the aspect easy to carry criteria has the highest priority with respect to the goal with a percentage of 66.7%, where the competitor products have difficulties on handling as a reason of packaging in too big bags. The aspect of easy to transport criteria which is the last one in priority with a percentage of 33.3%, where the customers have a lot of troubles during transport and loading the competitive products. (These results ensure the experts' opinions that the packaging criteria prioritized should be classified as it shown in *figure 4.6).*

3. Service & Customer Contacts Sub Criteria Pair Wise Comparison

The experts' judgments of service & customer contacts sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.4* (appendix A) and *figure 4.7*.

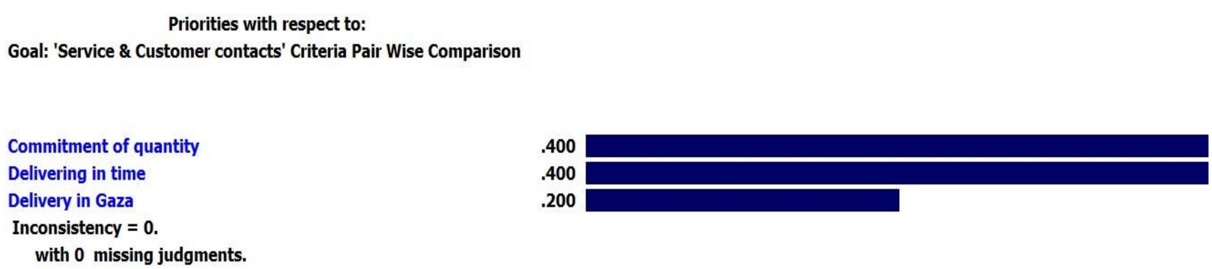


Figure (4.7): EC results of service and customer contacts criteria pair wise comparisons

As it was shown in *figure 4.7*, the aspect commitment of the required quantity criteria has the highest priority with respect to the goal with a percentage of 40%. Same of it; delivering the required orders in time criteria which has the same priority with a percentage of 40% too. That is because the customers need to avoid the lack in quantities during the siege composed around Gaza Strip. The delivery of required orders in Gaza criteria which is the last one in priority with a percentage of 20%, to reduce the risk of crashing and pollution during transport to Gaza from Egypt. (These results ensure the experts' opinions that the service and customer contacts criteria prioritized should be classified as it shown in *figure 4.7*).

4. Safety Sub Criteria Pair Wise Comparison

The experts' judgments of safety sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.5* (appendix A) and *figure 4.8*.

Figure (4.8): EC results of safety criteria pair wise comparisons

As it was shown in *figure 4.8*, the criteria of hygiene and safety for keeping food have the same priority with respect to the goal with a percentage of 50%, where it is very important for the customers to receive products in accordance to foods standards. These results ensure the experts' opinions that the safety sub criteria prioritized should be classified as it shown in *figure 4.8*.

5. Raw Material Sub Criteria Pair Wise Comparison

The experts' judgments of raw material sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.6* (appendix A) and *figure 4.9*.

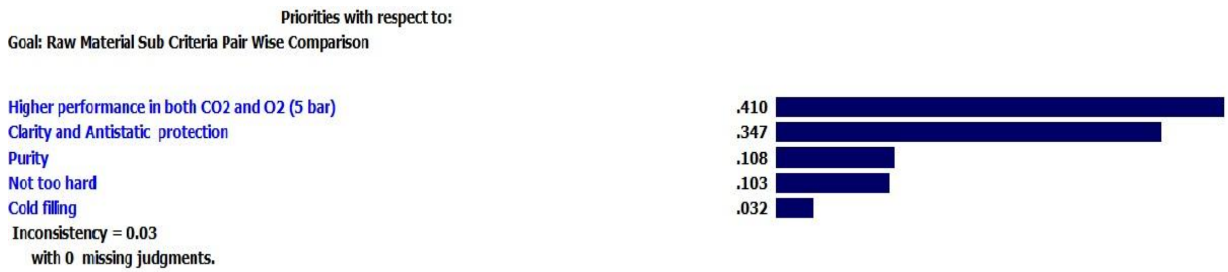


Figure (4.9): EC results of raw material criteria pair wise comparisons

As it was shown in *figure 4.9*, the aspect of higher performance in both CO2 and O2 (5 bar) criteria has the highest priority with respect to the goal with a percentage of 40.1%, where it is the most important technical aspect for customers to get strong product and to avoid the destroy of it after blowing and filling. The Clarity and antistatic protection criteria which is the 2nd one in priority with a percentage of 34.7%, where it is very important for the customers to receive products in accordance to foods standards. Purity criteria which is the 3rd one in priority with a percentage of 10.8%, where it is very important to increase the quality value of the product. Not far away from it; the required raw material should not be too hard, which is the 4th one in priority with a percentage of 10.3%, where it is very important to reduce the scale of defects during manufacturing. Cold filling criteria which is the last one in priority with a percentage of 3.2%. (These results ensure the experts‘ opinions that the specification and quality criteria prioritized should be classified as it shown in *figure 4.9*).

6. Price Sub Criteria Pair Wise Comparison

The experts' judgments of price sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.7* (appendix) and *figure 4.10*.

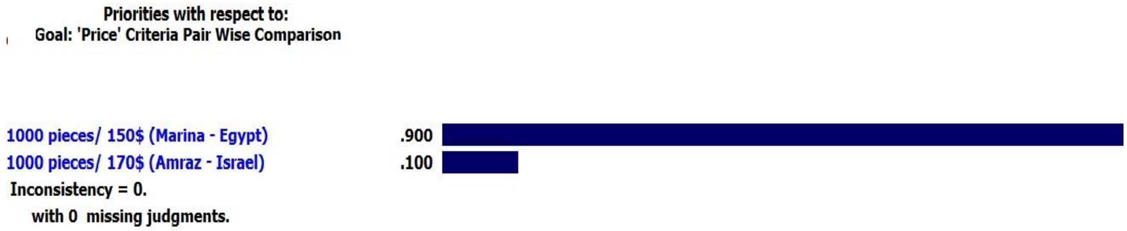


Figure (4.10): EC results of price criteria pair wise comparisons

As it was shown in *figure 4.10*, the introduced price from (New Marina Company - Egypt) criteria has the highest priority with respect to the goal with a percentage of 90%. The introduced price from (Amraz company – occupied Palestinian lands 1948) criteria which is the last one in priority with a percentage of 10%, where it is very important for customers to contract with the competitive price. (These results ensure the experts' opinions that the price criteria prioritized should be classified as it shown in *figure 4.10*). It means that, the customers looking for the lowest prices.

All Customers Requirements Sub Criteria Pair Wise Comparisons

To get more meaningful results that may help the researcher in this study. The experts' judgments of all customers' requirements sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *figure 4.11*.

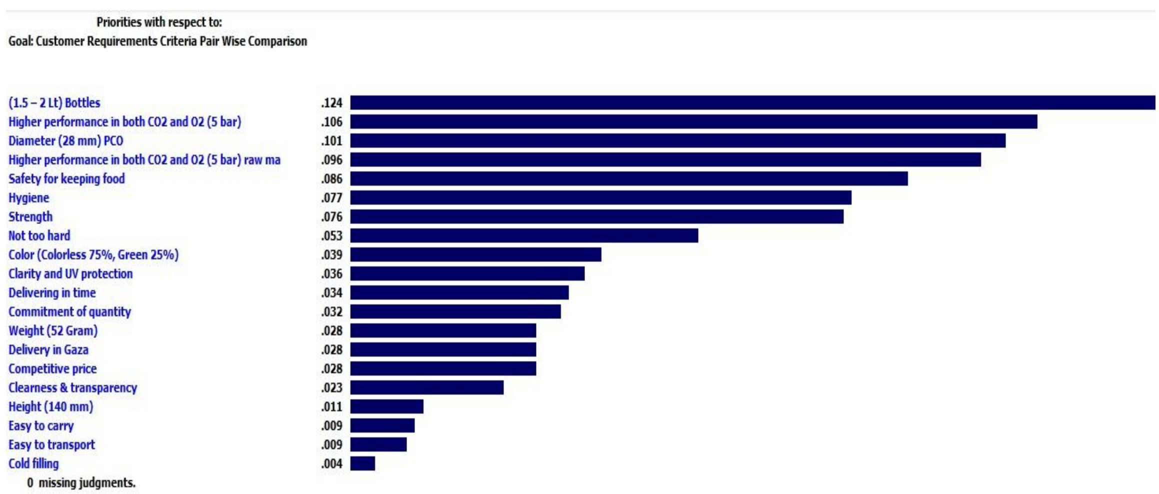


Figure (4.11): EC results of all customer requirements sub criteria pair wise comparisons

- **Step 3: Customer Ratings of the Competition**

In this step of the QFD process, it was a good idea to ask customers how the product of (52 gram) PET preform affected on rates in relation to the competition. The competitive products analyzed (*see table 4.5*) with the same product of both New Marina Co. (Egypt) and Amraz Co. (Occupied Palestinian Lands 1948) models (*see table 4.4*). The main reasons for selecting the researcher these two competitors were high quality, availability in the Gaza's market, and the competitive price.

Table (4.4): The sample companies of the study

Customer rating of the competition		
A	B	C
New Marina Co. (Egypt)	Amraz Co. (Occupied Palestinian Lands 1948)	The new product of Elredaisi Industrial Company LTD.

Table (4.5): Customer rating of competition

Detailed technical attributes	Customer rating of the competition		
	A	B	C
(1.5 – 2 Lt) Bottles	9	9	9
Weight (52 gram)	9	9	9
Height (140 mm)	9	9	9
Diameter (28 mm) PCO	9	9	9
Color (Colorless 75%, Green 25%)	9	9	9
Strength	6	7	8
Higher performance in both CO2 and O2 (5 bar)	8	8	8
Easy to carry	1	9	9
Easy to transport	1	9	9
Commitment of quantity	4	4	6
Delivering on time	4	4	6
Delivery in Gaza	1	1	9
Hygiene	7	7	9
Safety for keeping food	8	8	9
Not too hard	8	8	8
Clarity and Antistatic protection	8	8	8
Higher performance in both CO^2 and O^2 (5 bar)	8	8	8
Transparency	7	7	8
Cold filling	9	9	9
Competitive price	4	7	6

- **Step 4: Technical Descriptors - "Voice of the Engineer"**

The work team of engineers in *Elredaisi Industrial Company LTD.* (see *table 4.6*) were asked to determine the technical attributes (*see table 4.7*) that match customers' requirements and specify the importance of each one as "very unimportant", "unimportant", "moderately important", "important", and "very important". That "very unimportant" has 1 as a score, while "very important" has 9 as a score.

Table (4.6): List of the work team in Elredaisi Industrial Co. LTD

Name	Company	Title
Eng. Badreddin El Redaisi	Elredaisi Industrial Co.	Head manager
Eng. Raed Abu Shahla	Elredaisi Industrial Co.	Director of QA department
Mr. Refat Nabil El Redaisi	Elredaisi Industrial Co.	Director of sale & marketing department
Mr. Zuher Zaid	Elredaisi Industrial Co.	Director of production department
Mr. Jamil Gabayin	Elredaisi Industrial Co.	Maintenance responsible
Mr. Favzi Salem	Elredaisi Industrial Co.	Production responsible

As it was shown in *table 4.6*, the engineers in *Elredaisi Industrial Company LTD.* determined the detailed technical attributes for the desired (52 gram) PET preform that will be used in blowing (1.5 – 2.0 lt.) plastic bottles, and have the characteristics of: 52 gram weight or less, 140 mm height, 28 mm PCO neck type, color (colorless 75%, green 25%), blowing strong bottles, have higher resistance performance in both CO_2 and O_2 (5 bar), produced by using 48 cavity mould, producing by using 3.5 kg. injection machine, covering by "56*44*41cm" plastic boxes to aim to reduce the packaging cost instead of carton boxes that are more expansive and can't be reused, putting 500 Pieces/ box, 30 boxes/ Pallet covered by gelatin to be easy to handling in the manufacturing process, introducing good personality by the qualified sale and marketing employees, giving the ability for customers to resell the defect preform to the company by a known price, commitment of the required quantities by delivering it on the time and in Gaza to avoid the risk of crashing and pollution during transport to Gaza, introducing good offer of easy payments, introducing a product with high quality level, with record batch numbers in accordance to ISO 9001/2008 standards, using safety raw material for keeping food in accordance of food standards, receiving clean and hygiene preform, using not too hard raw material in producing the required preform, introducing clarity and antistatic protection preform, good clearness and transparency, and introducing a competitive price (more cheaper than Amrazs' price and more expansive than Marinas' price).

Table (4.7): Detailed technical attributes for 52 gram PET Preform

Detailed technical attributes
Suitable for blowing (1.5 – 2 Lt) bottles
Weight (52 gram)
Height (140 mm)
Diameter (28 mm) PCO
Color (Colorless 75%, Green 25%)
Strength
Higher performance in both CO_2 and O_2 (5 bar)
48 Cavity mould
3.5 Kg. injection machine
"56*44*41cm" plastic box
500 Pieces/ box
30 boxes/ Pallet covered by gelatin
Good personality
Reselling the defects
Commitment of quantity
Commitment of time
Delivery in Gaza
Easy payments
High quality level
Batch records
Hygiene
Safety for keeping food
Not too hard
Clarity and antistatic protection
Higher performance in both CO_2 and O_2 (5 bar)
Purity
Cold filling
(Marina – Egypt) price < company price < (Amraz – Israel) price

Figure (4.12): shows the affinity diagram of the main engineers' requirements and *table 4.8* shows the relationship between affinity diagram and detailed technical attributes.

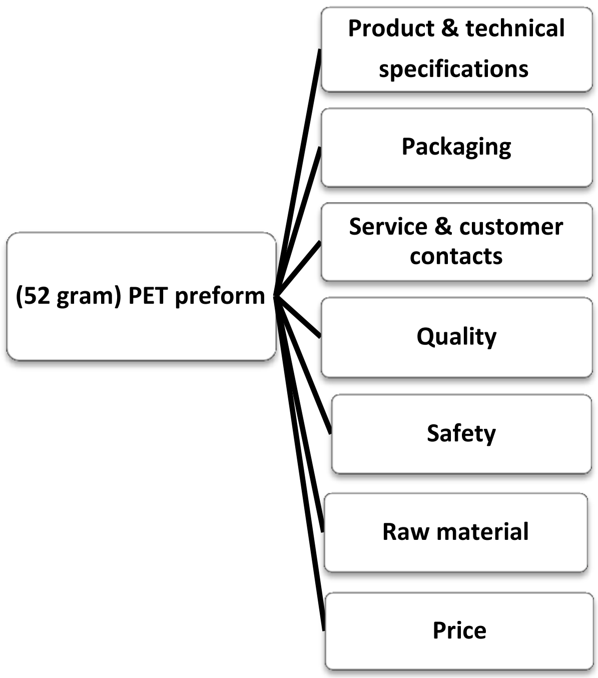


Figure 4.12: Affinity diagram of the main engineers' technical requirements of (52 gram) PET preform

Table (4.8): The relationship between affinity diagram and detailed engineer attributes

Engineers' requirement	Detailed technical attributes
Product & technical specification	Suitable for blowing (1.5 – 2 Lt) bottles
	Weight (52 Gram)
	Height (140 mm)
	Diameter (28 mm) PCO
	Color (Colorless 75%, Green 25%)
	Strength
	Higher performance in both CO_2 and O_2 (5 bar)
	48 Cavity mould
	3.5 Kg. injection machine
Packaging	56*44*41 Plastic box
	500 Pieces/ box
	30 boxes/ Pallet covered by gelatin
Service & customer contacts	Good personality
	Reselling the defects
	Commitment of quantity
	Commitment of time
	Delivery in Gaza
	Easy payments
Quality	High quality level
	Batch records
Safety	Hygiene
	Safety for keeping food
Raw material	Not too hard
	Clarity and antistatic protection
	Higher performance in both CO_2 and O_2 (5 bar)
	Purity
	Cold filling
Cost/ price	(Marina – Egypt) price < company price < (Amraz – Israel) price

Main Technical Attributes Criteria Pair Wise Comparison

After identifying the main engineer attributes, constructing the general model, and entering the experts' judgments of engineers' requirements pair wise comparison to the EC, the results shown in *Table A.8* (appendix A) and *figure 4.13* are obtained.

The relative importance and the relative importance indexes of the technical attributes were obtained using AHP. *Table A.8* (appendix A) shows main technical attributes importance rating of (52 gram) PET preform from the viewpoint of determined engineers (see *table 4.6*).

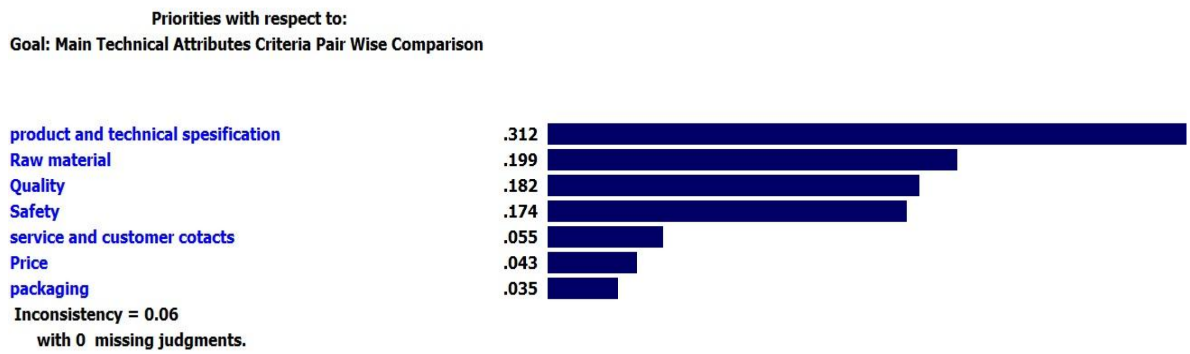


Figure (4.13): EC results of main technical attributes criteria pair wise comparisons

As it was shown in *figure 4.13,* the product and technical specification criteria have the highest priority with respect to the goal with a percentage of 31.2%, where it is a normal result in accordance to customer requirements (see *figure 4.4*). The raw material criteria which is the 2^{nd} one in priority with a percentage of 19.9%, that it affects directly on the quality and specification of the desired product. The quality criteria which is the 3^{rd} one in priority with a percentage of 18.2%, where it is very important to ensure reaching the desired specifications of the product in all manufacturing processes. The safety criteria which is the 4^{th} one in priority with a percentage of 17.4%, where it is very important for the producer to deliver a product in accordance to foods standards. The service and customer contacts criteria which is the 5^{th} one in priority with a percentage of 5.5%,where it is one of unconscious needs (see *figure 2.6*) that beyond customers’ expectations and aims to increase customers’ satisfaction that enhance the company's competitive benefit and loyalty of the customers. The price criteria with a percentage of 4.3 %, where it is very important for both customers and suppliers that enhance the competitive benefits for them. The packaging criteria which is the last one in priority with a percentage of 3.5%, where it is very important for the engineers to find new meaning ideas to avoid the troubles that face the customers during importing the competitive products. (These results ensure the experts' opinions that the main technical attributes criteria prioritized should be classified as it shown in *figure 4.13).*

Sub Criteria Pair Wise Comparison

1. Product & Technical Specification Sub Criteria Pair Wise Comparison

The experts' judgments of product and technical specification sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.9* (appendix A) and *figure 4.14.*

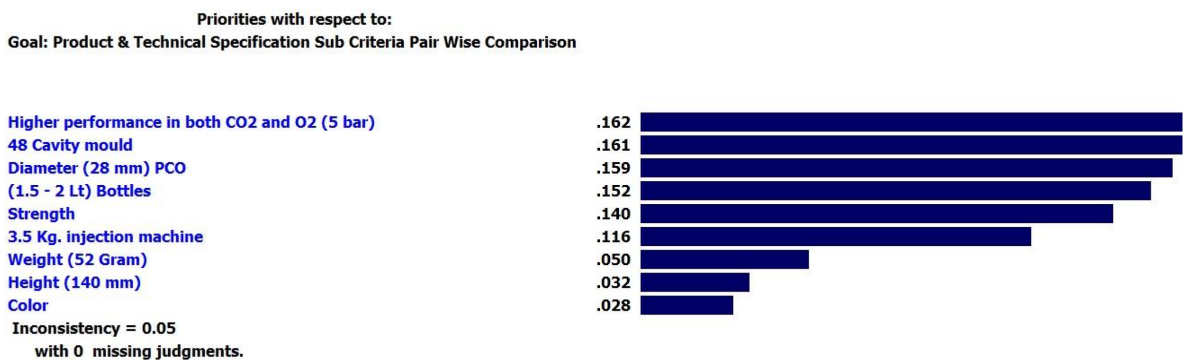


Figure (4.14): EC results of product & technical specification sub criteria pair wise comparisons

As it was shown in *figure 4.14*, the aspect higher performance in both CO_2 and O_2 (5 bar) sub criteria has the highest priority with respect to the goal with a percentage of 16.2%. Not far away from it; the aspect size of mould (48 Cavity mould) sub criteria which is the 2nd one in priority with a percentage of 16.1%. The aspect cap type (28 PCO) sub criteria which is the 3rd one in priority with a percentage of 15.9%. The aspect suitable for (1.5 – 2 Lt) bottles sub criteria which is the 4th one in priority with a percentage of 15.2%. The aspect strength sub criteria which is the 5th one in priority with a percentage of 14.0%. The aspect volume of the machine (3.5 Kg. injection machine) sub criteria which is the 6th one in priority with a percentage of 11.6 %. The aspect required weight of the product (52

Gram) sub criteria which is in 7th priority with a percentage of 5.0%. The aspect required height of the product (140 mm) sub criteria which is the 8th one in priority with a percentage of 3.2%, and the aspect estimated price sub criteria is the last one which is in the 9th priority with a percentage of 2.8 %. All of the previous technical requirements are classified as implied and stated needs (see *figure 2.6*). These needs are so obvious that the customer doesn't mention them. (These results ensure the experts' opinions that the main technical attributes criteria prioritized should be classified as it shown in *figure 4.14).*

2. Packaging Sub Criteria Pair Wise Comparison

The experts' judgments of Packaging sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.10* (appendix A) and *figure 4.15.*

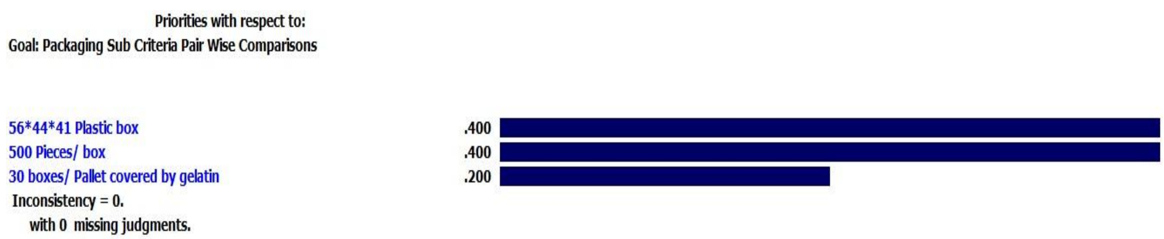


Figure (4.15): EC results of packaging sub criteria pair wise comparisons

As it was shown in *figure 4.15*, the aspect using the plastic box with dimension "56*44*41cm" (see *figure 4.15 a*) criteria has the highest priority with respect to the goal with a percentage of 40%. Same of it; the aspect filling 500 pieces / box criteria which has the same priority with a percentage of 40% too. That is because, the producer aims to reduce the packaging cost by using the un consumption plastic boxes, and to add value to the aspect of packaging by using plastic boxes instead of carton boxes to avoid damage during transportation or production. The aspect covering 30 box/ Pallet criteria which is the last one in priority with a percentage of 20%, to make the handling and transportation of the product more easy than the competitive products, and to avoid crashing and pollution during transport. These results ensure the experts' opinions that the service and customer contacts criteria prioritized should be classified as it shown in *figure 4.15*.

Figure (4.15) a: The desired plastic box of packaging the preform

3. Service & Customer Contacts Sub Criteria Pair Wise Comparison

The experts' judgments of Service & Customer Contacts sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.11* (appendix) and *figure 4.16*.

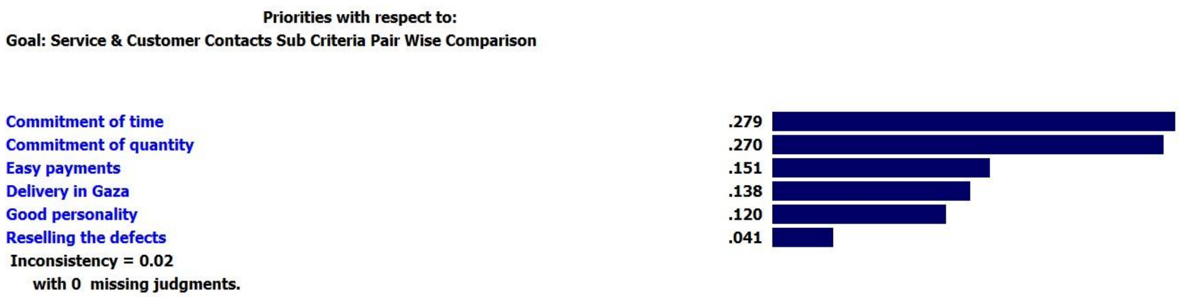


Figure (4.16): EC results of service & customer contacts sub criteria pair wise comparisons

As it was shown *in figure 4.16*, the aspect commitment of time sub criteria has the highest priority with respect to the goal with a percentage of 27.9%, not far away from it; the commitment of quantity sub criteria which is the 2nd one in priority with a percentage of 27.0%, where it is going parallel with the EC results of service and customer contacts criteria pair wise comparisons (see *figure 4.7*), and reflex the importance degree of the customers in this criteria. The aspect easy payments sub criteria which is the 3rd one in priority with a percentage of 15.1%, where it was a suggestion idea from the engineers work team in Elredaisi Industrial Company LTD. to introduce a competitive offer to its customers in this field. The aspect delivery in Gaza city sub criteria which is the 4th one in priority with a percentage of 13.8%, that aims to decrease and minimize risk of crashing and pollution during transport to Gaza from Egypt. The aspect good personality sub criteria which is the 5th one in priority with a percentage of 12.0 %, and the aspect re-buying the defect preforms from customers sub criteria is the last one which is in the 6th priority with a percentage of 4.1 %. These results ensure the experts' opinions that the service & customer contacts criteria prioritized should be classified as it shown in *figure 4.16*.

4. Quality Sub Criteria Pair Wise Comparison

The experts' judgments of Quality sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.12* (appendix A) and *figure 4.17*.

Figure (4.17): EC results of quality sub criteria pair wise comparisons

As it was shown in *figure 4.17*, the aspect high quality level sub criteria has the highest priority with respect to the goal with a percentage of 80.0%, where it shows the importance of quality level of the product during all production stages, where it refers to importance of applying all quality procedures, specification, and standards to reach customer satisfaction. The aspect batch records sub criteria which is the last one which is in the 2nd one in priority with a percentage of 20.0%, where it is classified as a unconscious needs of the customers (see *figure 2.6*), where by fulfilling customers' unconscious needs the company can gain a competitive benefit and more loyal customers, and if the company succeeds in fulfilling customers' unconscious needs it can increase customer satisfaction. If the company does not fulfill its customers' unconscious needs it does not result in customer dissatisfaction, because the customers do not expect fulfillment of these needs. These results ensure the experts' opinions that the quality criteria prioritized should be classified as it shown in *figure 4.17*.

5. Safety Sub Criteria Pair Wise Comparison

The experts' judgments of Safety sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.13* (appendix A) and *figure 4.18*.

Figure (4.18): EC results of safety sub criteria pair wise comparisons

As it was shown in *figure 4.18*, the aspect sub criteria of hygiene and safety for keeping food have the same priority with respect to the goal with a percentage of 50%, where it reflexes the importance of both to ensure introduce the products in accordance to food standards. These results ensure the experts' opinions that the safety criteria prioritized should be classified as it shown in *figure 4.18*.

6. Raw Material Sub Criteria Pair Wise Comparison

The experts' judgments of raw material sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.14* (appendix A) and *figure 4.19*.

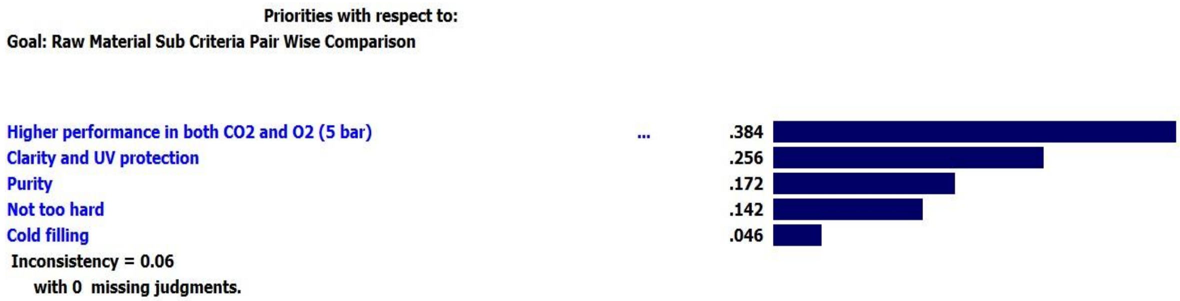


Figure (4.19): EC results of raw material sub criteria pair wise comparisons

As it was shown in *figure 4.19*, the aspect sub criteria of higher performance in both CO_2 and O_2 (5 bar) has the highest priority with respect to the goal with a percentage of 38.4%, where it is the most important technical aspect for customers to get strong product and to avoid the destroy of it after blowing and filling. The aspect sub criteria of clarity and antistatic protection which is the 2nd one in priority with a percentage of 25.6%, where it is one of the most important technical aspects for adding value to the final image of the product and to ensure keeping it to food standards. The aspect sub criteria of purity which is the 3rd one in priority with a percentage of 17.2%, where it is one of the most important technical aspects for adding value to the final image of the product. The aspect sub criteria of the kind of raw material "not too hard" which is the 4th one in priority with a percentage of 14.2%, where it is one important for the customer to reduce the defect products during the production. And the aspect sub criteria of cold filling is the last one which is in the 5th priority with a percentage of 4.6 %. (These results ensure the experts' opinions that the raw material criteria prioritized should be classified as it shown in *figure 4.19*).

7. Price Sub Criteria Pair Wise Comparison

As it was shown in *figure 4.10*, the introduced price from (New Marina Company - Egypt) criteria has the highest priority with respect to the goal with a percentage of 90%. The introduced price from (Amraz company – Occupied Palestinian Lands 1948) criteria which is the last one in priority with a percentage of 10%, where it is very important for customers to contract with the competitive price. Elredaisi Industrial Company LTD. can introduce its product with an estimated price formula "Marina – Egypt) price < company price < (Amraz – Israel) price".

All Technical Attributes Sub Criteria Pair Wise Comparisons

To get more effective and meaningful results that may help the researcher making the customer satisfied. The experts' judgments of all customers' requirements sub criteria pair wise comparison which were entered to the EC resulted in the priorities of each sub criteria with respect to the goal as shown in *table A.16* (appendix A) and *figure 4.20*.

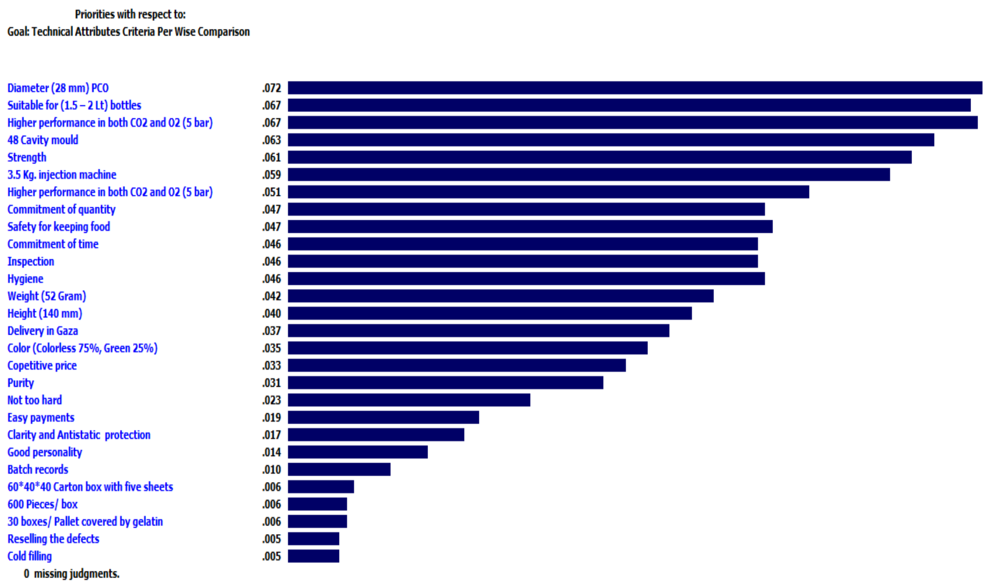


Figure (4.20): EC results of all customer requirements sub criteria pair wise comparisons

The results of steps "5, 6, 7, 8, 9, 10, 11, and 12" that applied in HOQ method were shown clearly in the final model of HOQ (see *figure 4.21*), where showed and reflected the desires and expectations of work team of OFD and customers in accordance of relationships of customer requirements, direction of all technical improvement, engineering competitive analysis, target values for technical descriptors, correlation matrix, absolute importance, and finally the absolute importance.

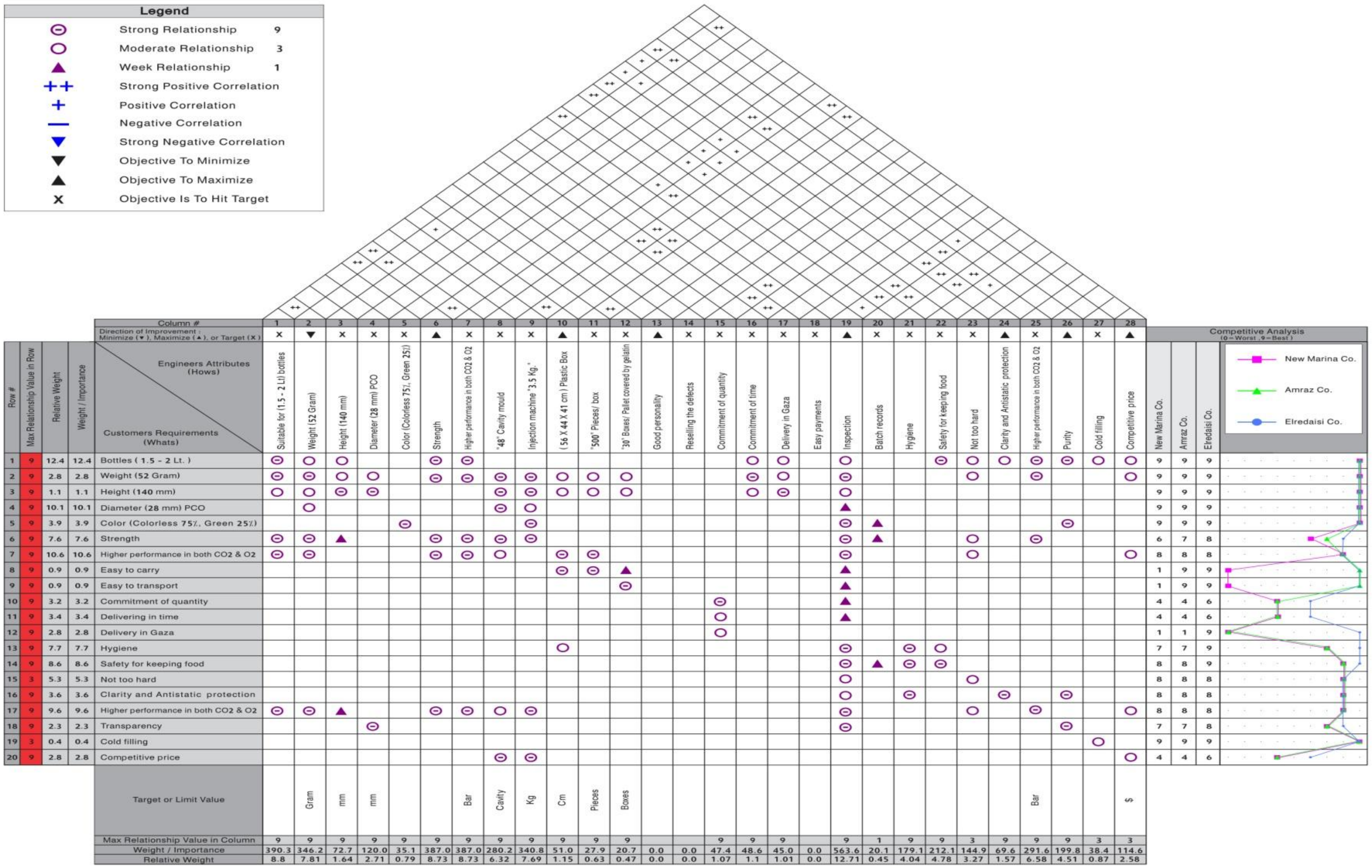


Figure (4.21): The final model of House of Quality HOQ

4.8. Findings and Analysis

The set of key inputs influencing the applications of QFD (customer requirements and technical attributes) were determined to satisfy the customers, and detailed technical attributes determined by engineers to reach this goal. The most important design requirements (criteria) of 52 gram PET preform were shown in *table A.17* (Appendix A).

As a summary comparing results between detailed technical attributes analysis using AHP methodology and HOQ results:

- Inspection of the desired product including all phases and stages of QFD occupied the first priority to insure that it will achieve customer's satisfaction with a relative weight of (0.127) as a result of HOQ, and a rate index of (0.046) using AHP methodology,
- Ensuring that the desired PET preform is suitable to blow different forms of 2 liters PET bottle occupied the second priority with a relative weight of (0.089), and a rate index of (0.067) using AHP methodology,
- Appropriateness of the desired 52 gram PET preform to blow different forms of 2 liters PET bottle with the specification of higher performance in both CO_2 and O_2 occupied the third priority with a relative weight of (0.087),and a rate index of (0.067) using AHP methodology,
- The strength of the desired PET preform had the same priority with criteria of higher performance in both CO_2 and O_2 with a relative weight of (0.087), where this criteria plays a big role in reducing the defects during and after production, and a rate index of (0.061) using AHP methodology,
- Ensuring that the weight of the desired PET preform is 52 gram (see *figure 4.23*) occupied the fourth priority with a relative weight of (0.078), where this is the known standard weight known around the world, and the experts in this field work hard and try to reduce this weight to reduce the cost, and a rate index of (0.042) using AHP methodology,
- The size of the required injection machine that will be used in the process of producing the 52 gram PET preform is 800 Tons with capacity of 3.5 kg. in the shot, came in the fifth priority to ensure the differentiation in using multiple forms of products in the aim

to reduce cost as soon as possible with a relative weight of (0.077),and a rate index of (0.059) using AHP methodology,

- Appropriateness of the desired 52 gram PET preform to the international standards of filling and keeping soft drinks such as Coca Cola, Pepsi Cola and 7UP with the specification of higher performance in both CO_2 and O_2 occupied the sixth priority with a relative weight of (0.066),and a rate index of (0.051) using AHP methodology,
- Using a 48 cavity PET injection mold (see *figure 4.22*) to ensure the commitment of required quantities and commitment of delivery in time occupied the seventh priority with a relative weight of (0.063), and a rate index of (0.063) using AHP methodology,
- Appropriateness of used raw material for safety for keeping food occupied the eighth priority with a relative weight of (0.048),and a rate index of (0.047) using AHP methodology,
- The purity and clearness of desired 52 PET preform occupied the ninth priority with a relative weight of (0.045), and a rate index of (0.031) using AHP methodology,
- Holding the desired PET preform in high level of hygiene in all stages of production occupied the tenth priority with a relative weight of (0.040), especially when the competitive products have some troubles in this aspect, and a rate index of (0.046) using AHP methodology,
- The customers prefer the quite hard preform to reduce the reject during the production with a relative weight of (0.033), and this depends on the type of used raw material, and a rate index of (0.023) using AHP methodology,
- The type of desired neck of the PET preform is (28 mm PCO), in accordance to international standards with a relative weight of (0.027), and a rate index of (0.072) using AHP methodology,
- The criteria of required price of the desired PET preform with a relative weight of (0.026), where the price of the required PET preform is not the most important criteria to both the customer and producer, and a rate index of (0.033) using AHP methodology,
- The preferred height of the desired PET preform is (140 mm) with a relative weight of (0.016), where the available height of some competitive in the market is (120 mm).

The highest one makes the production process more easy, and a rate index of (0.04) using AHP methodology,

- The criteria of clarity and antistatic of the used raw material with a relative weight of (0.016), and a rate index of (0.017) using AHP methodology,
- The type of packaging criteria had the relative weight of (0.012), and a rate index of (0.006) using AHP methodology,
- The commitment of delivering on time had the relative weight of (0.011), and a rate index of (0.046) using AHP methodology,
- The commitment of delivering the required quantity had the relative weight of (0.01), and a rate index of (0.047) using AHP methodology,
- The commitment of delivering in Gaza had the relative weight of (0.01), and a rate index of (0.037) using AHP methodology,
- The criteria of the ability to fill the blown bottles in cold system had a relative weight of (0.009), and a rate index of (0.005) using AHP methodology,
- The number of items in the box (500 pieces) had the relative weight of (0.006), and the number of boxes on the pallet (36 boxes/pallet) had the relative weight of (0.005), and a rate index of (0.006) using AHP methodology,
- Record the information about the batch number of the product that help on follow the production steps by details had the relative weight of (0.005), and a rate index of (0.01) using AHP methodology,
- Both of the introduced good personality, giving the ability of reselling the defect product to the producer, and makes the aspect of easy payments have the same relative weight of (zero). And a rate index of (0.001) and (0.005) using AHP methodology**.**

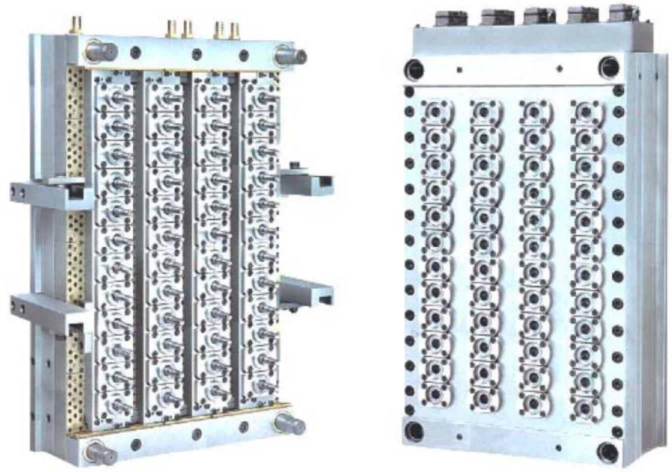


Figure (4.22): Estimated (52 gram) PET perform 48 cavity mold

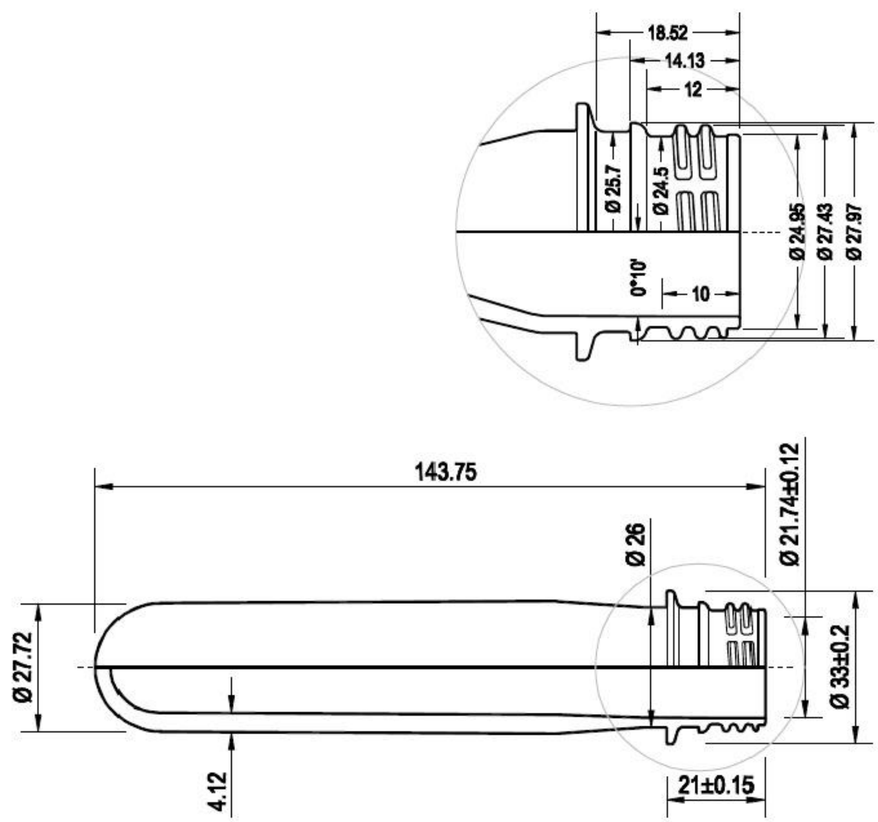


Figure (4.23): Technical drawing of the estimated (52 gram) PET preform

CHAPTER 5

Conclusions and Recommendations

This chapter contains information about the conclusions and the practical recommendations that help in designing a new (52 gram) PET preform which is used in producing and forming different forms of 2 liters plastic bottles, and used in filling and keeping carbonated soft drinks such as Makka Cola, Pepsi Cola and 7UP.

5.1. Conclusions

The findings of this study revealed the importance of QFD implementation, where it used clear indicates of QFD approach to introduce a high quality level products and services during and after process. Bearing in mind that *Elredaisi Industrial co. LTD.* is the first manufacturing company that used the QFD applications in designing a new product in Gaza Strip, it is important that the company listen to the voice of the customers and the findings of the applications to reduce the gap between the actual or perceived customer requirements and the product attributes identified by the affinity diagram show that they are both equally important in order to make the company more competitive.

To ensure reaching the main goal of the study, the use of QFD approach must be integrated with all stages of producing the desired PET preform, starting by design process and ending by using it by the customers. For instance, the QFD implementation identifies the customer requirements, competition factors, the challenges and obstacles that face the company, and the relationships between all factors and key inputs.

This study shows that design techniques and tools alone however cannot provide results by themselves. They must be developed to reflect the voice of the customers, companies' culture and management vision.

5.2. Recommendations

Considering the results of the study that has been made for potential customers and work team of the company, the previous ranking of criteria (see *table A.17* "appendix A") don't mean, neglecting any of these criteria or customers desires or reducing the importance of any of them.

To implement QFD successfully, it will be better if the company was able to control the production processes at a level of obtaining an ISO certificate (process orientation), because, QFD is represented as part of a larger set of tools and strategies under the TQM umbrella, QA and continuous quality improvement activities focus on results, where the ranking of the inspection criteria had the highest relative weight in the results of HOQ.

To ensure meeting the estimated quantities in estimated required time by the company, they should add a new big injection machine to their production line with special technical attributes determined by *table A.18* (appendix A), and design a new PET preform mould with 48 cavity (see *figure 4.23).*

To ensure delivering the estimated product within the determined requests of packaging, the QFD work team recommends to package the preform by reusable plastic box (see *figure 4.15 a*) to reduce the cost of packaging when the Egyptian product covered by carton boxes that used for only one time, and the other competitor product covered by big plastic bags that make it is very difficult to carry and transport in addition to its high price.

The study provides good information about QFD applications for new researchers in Gaza Strip, and can be used as a good reference for Gaza's libraries about developing not only the plastic manufacturing sector but all manufacturing sectors.

The research has been made in this study with customers who mostly use the preforms in blowing 2 liters PET bottles, but it will be better for the company if it applied the method of QFD in designing all of its' new products.

Bibliography

1. Abd Rahman A. and Mohd. Shariff (2003), "Application of Quality Function Deployment QFD Method for Pultrusion Machine Design Planning", Industrial Management & Data Systems, Vol. 103, No. 6, pp.373-387.
2. Agha, S. (2008), "Evaluating and Benchmarking Non-Governmental Training Programs: An Analytic Hierarchy Approach", Jordan Journal of Mechanical and Industrial Engineering, Vol. 2, No. 2, pp 77-84.
3. Akao, Y. (1990), "Quality Function Deployment (QFD) – Integrating Customers' Requirements into Product Design", English Translation Copyright, Productivity Press, USA.
4. Akao, Y., (1990), Quality function deployment: Integrating customer requirements into product design. Journal of Productivity Press, Cambridge, MA.
5. Akao, Y., (1997), QFD: Past, Present, and Future, Proceedings of the International Symposium on QFD, Linkping
6. Akao, Y., et al. (1983), "Quality Deployment Including Cost, Reliability, and Technology", Quality, Vol.13, No.3, pp. 61-77.
7. Al Afeefy A. (2011), "Compensating Fund Allocation for Industrial Sectors in Gaza Strip Using AHP and Goal Programming".
8. Biren Prasad (1998), "Review of QFD and Related Deployment Techniques", Journal of Manufacturing Systems, Vol. 17, No. 3, pp. 221-234.
9. Bode, J. and Fung, R.Y.K. (1998), "Cost Engineering with Quality Function Deployment", Computers and Industrial Engineering, Vol.35, No. 3/4, pp. 587-590.
10. Brown and Eisenhardt (1995), "Product development: past research, present findings and future decisions", Academy of Management Review, Vol. 20, No. 2, pp. 343-78.
11. C.C. Usama-Alvarez et al., (2010). "Identification of design requirements for rugby wheelchairs using the QFD", Procedia Engineering, Vol. 2.
12. Bouchereau, V. and Rowlands, H. (1999), "Analytical Approaches to QFD", Manufacturing Engineer, Vol.78, No.6, pp. 249-254.
13. Bouchereau, V. and Rowlands, H. (2000a), "Methods and Techniques to Help Quality Function Deployment (QFD)", Benchmarking: An International Journal, Vol.7, No.1, pp. 8-19.
14. Burchill, G. and Fine, C.H. (1997), "Time Versus Market Orientation in Product Concept Development: Empirically-Based Theory Generation", Management Science, Vol.43, No.4, pp. 465-478.
15. C.P.M. Govers (1996), "What and How about Quality Function Deployment QFD", International Journal of Production Economics, Vol. 46, pp. 575-585.
16. Chan, L.K. and Wu, M.L. (2002), "Quality Function Deployment: A Literature Review", European Journal of Operational Research, Article In Press, Uncorrected Proof, Available online 1 April, pp. 1-35.
17. Chow-Chua, C. and Komaran, Raj (2002), "Managing Service Quality by Combining Voice of the Service".
18. Clausing, D. and Pugh, S. (1991), "Enhanced Quality Function Deployment", Proceedings of The Design and Productivity International Conference, February 6-8, Honolulu, HI.

19. Cohen, L. (1995), "Quality Function Deployment – How to Make QFD Work for You", Addison Wesley Longman Inc., USA.
20. Cor P.M. Govers (2001), " QFD not Just a Tool but a Way of Quality Management", International Journal of Production Economics, Vol. 69, pp. 151-159.
21. Crawford, M. and A. Di Benedetto (2003), *New Products Management*, New York: McGraw-Hill/Irwin.
22. Cristiano, J.J., Liker, J.K., and White, Ch.C. (2000), "Customer-Driven Product Development Through Quality Function Deployment in the U.S. and Japan", Journal of Production Innovation Management, Vol. 17, No.4, pp. 286-308.
23. Curry, A. and Herbert, D. (1998), "Continuous Improvement in Public Services: a Way Forward", Managing Service Quality, Vol.8, No.5, pp.339-349.
24. Dale, B., Boaden, R., Wilcox, M., and McQuarter, R. (1998), "Use of Quality Management Techniques and Tools: An Examination of Some Key Issues", International Journal of Technology Management, Vol.16, No.4-6, pp. 305-325.
25. Dube, L., Johnson, M.D. and Renaghan, L.M. (1999), "Adapting the QFD Approach to Extended Service Transactions", Production and Operations Management, Vol.8, No.3, pp. 301-317.
26. Ermer, D.S. and Kniper, M.K. (1998), "Delighting the Customer: Quality Function Deployment for Quality Service Design", Total Quality Management, Vol.9, No.4/5, S86-S91.
27. Franceschini, F. and Rossetto, S. (1995), "QFD: the Problem of Comparing Technical/Engineering Design Requirements", Research in Engineering Design, Vol.7, pp. 270-278.
28. Fung, et al. (1998) "An intelligent hybrid system for customer requirements analysis and product attribute targets determination", Int. J. Prod. Res. Vol.36, pp. 13–34.
29. Gerst, Robert M. (2004), "QFD in Large-Scale Social System Redesign", International Journal of Quality & Reliability Management, Vol. 21, No. 9, pp. 959-972.
30. Govers, C.P.M. (2001), "QFD not Just a Tool but a Way of Quality Management", International Journal of Production Economics, Vol.69, No.1, pp. 151-159.
31. Gruner and Homburg (2000), "Does customer interaction enhance new product success?" ,Journal of Business Research, Vol. 49, No. 1, pp. 171-87.
32. H. Jagdev et al. (1997), "A QFD Based Performance Measurement Tool", Computers in Industry, Vol. 33, pp. 357-366.
33. Hales, R. (1993), "QFD for Invisible Products, ProAction Development", Inc., Milford, OH, Available at: http://www.proactdev.com/pages/invisqfd.htm.
34. Hales, R. (1995), "Adapting Quality Function Deployment to the U.S. Culture", IIE Solutions, pp. 15-18.
35. Hales, R. and Staley, D. (1995), "Mix Target Costing, QFD for Successful New Products", Marketing News, Vol.29, No.1, p. 18.
36. Hales, R., Lyman, D. and Norman, R. (1994), "QFD and the Expanded House of Quality", Quality Digest, Available at: http://www.proactdev.com/pages/ehoq.htm.
37. Harding, et al. (2001), "An Intelligent Information Framework Relating Customer Requirements and Product Characteristics", Computers in Industry, Vol.44, pp. 51-65.

38. Hauser, J.R. and Clausing, D. (1996), "The House of Quality", IEEE Engineering Management Review, Vol.24, No.1, spring, pp. 24-32.
39. Hitt (1999), "Strategic Management: Competitiveness and Globalization: concepts and cases", third edition, South-Western College Publishing.
40. Holt et al. (1984), "Need assessment: a key to user-oriented product innovation".
41. Hurd (2010), "Best Practices and Industry Standards in PET Plastic Recycling".
42. Howell, D. (2000), "Making Wishes Come True", Professional Engineering, p. 39.
43. Ictenbas and Eryilmaz, (2011), "Linking Employers' Expectations with Teaching Methods: Quality Function Deployment Approach", Procedia- Social and Behavioral Sciences, Vol. 28, pp. 568-572.
44. J.A. Harding et al. (1999), "Applications of QFD within a concurrent engineering Environment", International Journal of Agile Management Systems, Vol. 1/2, pp. 88-98. Cheng Lim, P., et al. (1999), "An innovative framework for health care performance measurement", Managing Service Quality, Vol.9, No.6, pp. 423-433.
45. Jagdev, H., Bradley, P., and Molloy, O. (1997), "A QFD Based Performance Measurement Tool", Computers in Industry, Vol.33, pp. 357-366.
46. Jannat Allahham (2010), "Vocational Educational Facility Design: A Fuzzy QFD Approach"
47. K. Chan et al. (2002), "Applying QFD in the Clothing Manufacturing Sector: A Case Study in Improving a Distance-Learning Program in Hong Kong", Managerial Auditing Journal, Vol. 17, No. 1/2, pp. 86-91.
48. Kaneko, N. (1991), "QFD Implementation in the Service Industry", ASQC Quality Congress Transactions, Milwaukee, pp. 808-813.
49. Kenny, A.A. (1988), "A New Paradigm for Quality Assurance", Quality Progress, June, pp. 30-32.
50. Kerala State Industrial Development Corporation Ltd (2012), "Project Profile on Manufacturing of PET Preforms".
51. Krishnan, and K. Ulrich (2001), "Product Development Decisions: A Review of the Literature," Management Science, Vol.47, No.1, pp 1-21.
52. Leo Lo, T.; Kolence, Kenneth W. (1994), "House of Quality and Service Management", CMG Proceedings, Vol.1, pp. 521-532.
53. Lim, P.Ch. and Tang, N.K.H. (1999), "The Development of a Model for Total Quality Health Care", Managing Service Quality, Vol.10, No.2, pp. 103-111.
54. Lockamy III, A. and Khurana, A. (1995), "Quality Function Deployment: Total Quality Management for New Product Design", International Journal of Quality & Reliability Management, Vol.12, No.6, pp. 73-84.
55. Mark Hartley (2007), "Designing a Supply Chain Management Academic Curriculum Using QFD and Benchmarking"
56. Markland, et al. (1998), "Operations Management –Concepts in Manufacturing and Services, South-Western College Publishing", Second edition, USA, pp.179.
57. Markland, R.E., Vickery, Sh. K., and Davis, R.A. (1995), "Operations Management – Concepts in Manufacturing and Services", West Publishing Company, USA, pp. 164-171.
58. Martins, A. and Aspinwall (2001), "Quality Function Deployment: an Empirical Study in the UK", Total Quality Management, Vol.12, No.5, pp. 575-588.

59. Marvin E. Gonzalez et al. (2004), " Customer satisfaction using QFD: an e-banking case", Managing Service Quality, Vol. 14, No. 4, pp. 317–330.
60. Marvin E. Gonzalez et al. (2007), "Designing a Supply Chain Management Academic Curriculum Using QFD and Benchmarking", Quality Assurance in Education, Vol. 16, No. 1, pp. 36-60.
61. Matzler, K. and Hinterhuber (1998), "How to Make Product Development Projects more Successful by Integrating Kano's Model of Customer Satisfaction into Quality Function Deployment", Technovation, Vol.18, No.1, pp. 25-38.
62. Mazur, G.H. (1993), "QFD for Service Industries, from Voice of Customer to Task Deployment", The Fifth Symposium on Quality Function Deployment, Novi, Michigan, Japan Business Consultants, Ltd., pp. 485-503.
63. Menks, D., et al.(2000), "Quality Function Deployment", SENG 613 Team Work, Software Engineering Research Network, University of Galgary, Fourth of December, Available at: http://sern.ucalgary.ca/~kjfu/courses/SENG613/teamwork.html.
64. Michalek, J., F. Feinberg, and P. Papalambros (2005), "Linking Marketing and Engineering Product Design Decisions via Analytical Target Cascading," Journal of Product Innovation Management, Vol.22, No.1, pp. 42-62.
65. Miguel, (2007). "Innovative new product development: a study of selected QFD case studies", The TQM Magazine, Vol. 19, No. 6, pp. 617-625
66. Ming-Li Shiu et al. (2007), "Reconstruct QFD for Integrated Product and Process Development Management", the TQM Magazine, Vol. 19, No. 5, pp. 403-418.
67. Ministry of National Economy (2011), "Gaza Economic Strategy".
68. Mueller (2011), "International Business Curriculum Design: Identifying the Voice of the Customer VOC using QFD"
69. Oakbrook, (1999). "Joint Commission on Accreditation of health-care Organizations", Journal on Quality Improvement III.
70. O'Neal, Ch.R. and Lafief, W.C. (1992), "Marketing's Lead Role in total quality", Industrial Marketing Management", Vol.21, No.2, pp. 133-143.
71. Palestinian Central Bureau of Statistics (2012), "Survey of the Perceptions of Owners/ Managers of Industrial Enterprises Regarding the Economic Situation".
72. Palestinian Federation (2012), "The Current Status of Industrial Sector in Palestine".
73. Paulo A. Cauchick Miguel (2009), "Combining ISO 9001 quality system and quality function deployment QFD"
74. Prasad, B. (1998a), "Review of QFD and Related Deployment Techniques", Journal of Manufacturing Systems, Vol.17, No.3, pp. 221-234.
75. Prasad, B. (2000), "A concurrent Function Deployment Technique for a Workgroup Based Engineering Design Process", Journal of Engineering Design, Vol.11, No.2, pp. 103-119.
76. Pun, K.F., Chin, K.S., and Lau, H. (2000), "A QFD/hoshin Approach for Service Quality Deployment: A Case Study", Managing Service Quality, Vol.10, No.3, pp. 156-169.
77. Rosenau (1996), "The PDMA Handbook of New Product Development", New York: John Wiley & Sons, 153-166.

78. S. Burce Han et al., (2001), "A conceptual QFD planning model", International Journal of Quality and Reliability Management, Vol.18, No.8, pp. 796-812.
79. Saaty, T., Peniwati, K. and Shang, J. (2007), "The analytic hierarchy process and human resource allocation: Half the story", Mathematical and Computer Modelling, Vol. 46, pp 1041–1053.
80. Scheurell, D.M. (1994), "Concurrent Engineering and the Entire QFD Process: one Year after Start-up of a New Mill", Transactions of the Fifth Symposium on Quality Function Deployment, Novi, MI: QFD Institute.
81. Shahin (2008), " Quality Function Deployment: A Comprehensive Review".
82. Shamsuddin Ahmed (2010), "Application of QFD in Product Development of A Glass Manufacturing Company in Kazakhstan", Benchmarking: An International Journal, Vol. 17, No. 2, pp. 195-213.
83. Shocker, A. and S. Srinivasan (1979), “Multiattribute Approaches for Product Concept Evaluation and Generation: A Critical Review,” *Journal of Marketing Research*, Vol.16, pp. 159-180.
84. Smith, J.A. and Angeli, I.I. (1995), "The Use of Quality Function Deployment to Help Adopt a Total Quality Strategy", Total Quality Management, Vol.6, No.1, pp. 35-44.
85. Squires, S. and B. Byrne (eds.) (2002), Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry, Westport, CT: Bergin and Garvey.
86. Stauss, B. (1993), "Service Problem Deployment: Transformation of Problem Information into Problem Prevention Activities", International Journal of Service Industry Management, Vol.4, No.2, pp. 41-62.
87. Stocker, G.D. (1991), "Quality Function Deployment: Listening to the Voice of the Customer", American Production and Inventory Control Society – The Performance Advantage 1, pp. 44-48.
88. Stuart, F.I. and Tax, S.S. (1996), "Planning for Service Quality: an Integrative Approach", International Journal of Service Industry Management, Vol.7, No.4, pp. 58-77.
89. Trappey, el at. (1996), "A computerized Quality Function Deployment Approach for Retail Services", Computers and Industrial Engineering, Vol.30, No.4, pp. 611-622.
90. Vivianne Bouchereau and Hefin Rowlands (2000), "Methods and Techniques to Help Quality Function Deployment QFD", Benchmarking: An International Journal, Vol. 7, No. 1, pp. 8-19.
91. Von (1986), “Lead users: a source of novel product concepts”, Management Science, Vol. 32, No. 7, pp. 701-805.
92. Ulrich, K. and S. Eppinger (2004), *Product Design and Development*, New York: McGraw-Hill/Irwin.
93. Xie, Shen, and Tan (2004), "Benchmarking in QFD for Quality Improvement", Benchmarking: An International Journal, Vol. 7, No. 4, pp. 282-291.
94. Yoji Akao and Glenn H. Mazur (2003), "The Leading Edge in QFD: Past, Present and Future", International Journal of Quality & Reliability Management, Vol. 20, No. 1, pp. 20-35.
95. Zairi, M. (1995), "Quality Function Deployment - A Main Pillar for Successful Total Quality Management and Product Development", International Journal of Quality and Reliability Management, Vol.12, No.6, pp. 9-23.

Interviews

List of the participants in both of Elredaisi Industrial Co., Yazegy Group for soft drinks, and Makka Cola Company

Name	Company	Title
Mr. Ahed Mahdy	Makka Cola Co.	Director of purchasing department
Mr. Mahir Abu Nahil	Makka Cola Co.	Director of marketing department
Eng. Musa Siyam	Makka Cola Co.	Director of production department
Eng. Rajab El Ghazaly	Yazegy Group	Director of production department
Eng. Badreddin El Redaisi	Elredaisi Industrial Co.	Head manager
Eng. Raed Abu Shahla	Elredaisi Industrial Co.	Director of QA department
Mr. Refat El Redaisi	Elredaisi Industrial Co.	Director of QA department
Mr. ZuherZaid	Elredaisi Industrial Co.	Director of production department
Mr. Jamil Gabayin	Elredaisi Industrial Co.	Maintenance responsible
Mr. Favzi Salem	Elredaisi Industrial Co.	Production responsible
Mr. Ahmed Elnamarah	Elredaisi Industrial Co.	Production responsible

Websites

1. *General information on "PET industry"*. Retrieved 2012, From RESILUX in Belgium: http://www.resilux.com.
2. *General information on "Industrial plastic boxes"*. Retrieved 2012. From Solent Plastic in United Kingdom: http://www.solentplastics.co.uk.

3. *General information on "Industrial plastic boxes"*. Retrieved 2012, From Go Plastic Boxes in United Kingdom: http://www.goplasticboxes.com/.
4. *Technical information on "PET perform library"*. Retrieved 2012, From KenPlas in China: http://www.kenplas.com/pp/petpreform.
5. *Technical information on "PET perform molds"*. Retrieved 2012, From KenPlas in China: http://www.kenplas.com/mold/preformmold/.
6. *General information on "Plastic industry"*. Retrieved 2012, From the Plastics Industry Trade Association in the United States: plasticsindustry.org.
7. *General information on "PET industry and recycling"*. Retrieved 2012, From National Association for PET Container Resources NAPCOR in the United States and Canada: http:www.Napcor.com.
8. *General information* from "the library of the *Islamic University of Gaza"*. *The Islamic University of Gaza*. Retrieved 2012, from The Islamic University of Gaza: http://library.iugaza.edu.ps/fulltext.aspx.
9. *General information on "Injection moulding machines"*. Retrieved 2013, From Chuan Lih Fa Machinary -Taiwan: http://www.clf.com.tw/en/products_i_PET-Series-PET-Preform-Series-Injection-Molding-Machine.html#tab3.

Appendix A

The aim of these tables is to identify the importance of main and sub-criteria of customer requirements and technical attributes using the Analytic Hierarchy Process AHP.

Table (A.1): EC results of main criteria pair wise comparisons

Main criteria	Specification & quality	Packaging	Service & customer contacts	Safety	Raw material	Price	Rate index
Specification & quality		9	9	4.5	3	6	0.502
Packaging			1/3	1/3	1/6	1/4	0.034
Service & customer contacts				1/2	1/2	1/2	0.066
Safety					2	2	0.155
Raw material						2	0.119
Cost/ price							0.124

Table (A.2): EC results of specification & quality criteria pair wise comparisons

Specification & quality	(1.5 – 2 Lt) Bottles	Weight (52 Gram)	Height (140 mm)	Diameter (28 mm) PCO	Color	Strength	Higher performance in both CO_2 and O_2 (5 bar)	Rate index
(1.5 – 2 Lt) Bottles		4.5	4.5	1	7	1	1/2	0.209
Weight (52 gram)			2	1/4	4	1/3	1/3	0.075
Height (140 mm)				1/5	3	1/4	1/4	0.052
Diameter (28 mm) PCO					6	1	1	0.218
Color						1/4	1/4	0.033
Strength							1	0.192
Higher performance in both CO_2 and O_2 (5 bar)								0.221

Table (A.3): EC results of packaging criteria pair wise comparisons

Packaging	Easy to carry	Easy to transport	Rate index
Easy to carry		4	0.667
Easy to transport			0.333

Table (A.4): EC results of service and customer contacts criteria pair wise comparisons

Service & Customer Contacts	Commitment of quantity	Delivering in time	Delivery in Gaza	Rate index
Commitment of quantity		1/3	2	0.400
Delivering in time			4	0.400
Delivery in Gaza				0.200

Table (A.5): EC results of safety criteria pair wise comparisons

Safety	Hygiene	Safety for keeping food	Rate Index
Hygiene		1	0.500
Safety for keeping food			0.500

Table (A.6): EC results of raw material criteria pair wise comparisons

Raw Material	Not too hard	Clarity and antistatic protection	Higher performance in both CO_2 and O_2 (5 bar)	Purity	Cold filling	Rating index
Not too hard		1/4	1/4	1	4	0.103
Clarity and antistatic protection			1	3	9	0.347
Higher performance in both CO_2 and O_2 (5 bar)				6	9	0.410
Purity					5	0.108
Cold filling						0.032

Table (A.7): EC results of Price criteria pair wise comparisons

Price	1000 pieces/ 150$ (Marina - Egypt)	1000 pieces/ 170$ (Amraz - Israel)	Rating Index
1000 pieces/ 150$ (Marina - Egypt)		9	0.900
1000 pieces/ 170$ (Amraz - Israel)			0.100

Table (A.8): EC results of main technical attributes criteria pair wise comparisons

Main Criteria	Product & technical specification	Packaging	Service & customer contacts	Quality	Safety	Raw material	Price	Rate index
Product & technical specification		7.5	6.5	1	3	2	7	0.312
Packaging			1/3	1/7	1/6	1/7	2	0.035
Service & customer contacts				1/3	1/3	1/5	1	0.055
Quality					1/2	1	4	0.182
Safety						1	2	0.174
Raw material							6	0.199
Cost/ price								0.043

Table (A.9): EC results of product and technical specification sub criteria pair wise comparisons

Product & technical specification	(1.5 – 2 Lt) Bottles	Weight (52 gram)	Height (140 mm)	Diameter (28 mm) PCO	Color	Strength	Higher performance in both CO_2 and O_2 (5 bar)	48 Cavity mould	3.5 Kg. Injection machine	Rate index
(1.5 – 2 Lt) Bottles		7	6	1	6.5	1/2	1/2	1/3	2	0.152
Weight (52 gram)			2	1/4	4	1/3	1/5	1/3	1/2	0.050
Height (140 mm)				1/6	1	1/4	1/4	1/3	1/3	0.032
Diameter (28 mm) PCO					4	2	1	1	1	0.159
Color						1/4	1/5	1/5	1/4	0.028
Strength							1	1	1	0.140
Higher performance in both CO_2 and O_2 (5 bar)								1	1	0.162
48 Cavity mould									1	0.161
3.5 Kg. Injection machine										0.116

Table (A.10): EC results of packaging sub criteria pair wise comparisons

Packaging	56*44*41 Plastic box	500 Pieces/ box	30 Boxes/ pallet covered by gelatin	Rate index
56*44*41 Plastic box		1	2	0.400
500 Pieces/ box			2	0.400
30 Boxes/ pallet covered by gelatin				0.200

Table (A.11): EC results of service & customer contacts sub criteria pair wise comparisons

Service & Customer Contacts	Good personality	Reselling the defects	Commitment of quantity	Commitment of time	Delivery in Gaza	Easy payments	Rate index
Good personality		3	1/2	1/2	1	1/2	0.120
Reselling the defects			1/7	1/5	1/5	1/3	0.041
Commitment of quantity				1	2	2	0.270
Commitment of time					3	2	0.279
Delivery in Gaza						1	0.138
Easy payments							0.151

Table (A.12): EC results of quality sub criteria pair wise comparisons

Safety	High quality level	Batch records	Rate index
High quality level		4	0.800
Batch records			0.200

Table (A.13): EC results of safety sub criteria pair wise comparisons

Safety	Hygiene	Safety for keeping food	Rate index
Hygiene		1	0.500
Safety for keeping food			0.500

Table (A.14): EC results of raw material sub criteria pair wise comparisons

Raw Material	Not too hard	Clarity and antistatic protection	Higher performance in both CO_2 and O_2 (5 bar)	Purity	Cold filling	Rating index
Not too hard		1	1/3	1/2	3	0.142
Clarity and antistatic protection			1	2	5	0.256
Higher performance in both CO_2 and O_2 (5 bar)				4	6	0.384
Purity					5	0.172
Cold filling						0.046

Table (A.15): Detailed technical attributes for 52 gram PET Preform

Main criteria	#	Detailed technical attributes
Product & technical specification	1	Suitable for (1.5 – 2 Lt) bottles
	2	Weight (52 Gram)
	3	Height (140 mm)
	4	Diameter (28 mm) PCO
	5	Color (Colorless 75%, Green 25%)
	6	Strength
	7	Higher performance in both CO_2 and O_2 (5 bar)
	8	48 Cavity mould
	9	3.5 Kg. injection machine
Packaging	10	"56*44*41 cm" Plastic box
	11	500 Pieces/ box
	12	30 boxes/ Pallet covered by gelatin
Service & customer contacts	13	Good personality
	14	Reselling the defects
	15	Commitment of quantity
	16	Commitment of time
	17	Delivery in Gaza
	18	Easy payments
Quality	19	Inspection
	20	Batch records
Safety	21	Hygiene
	22	Safety for keeping food
Raw material	23	Not too hard
	24	Clarity and Antistatic protection
	25	Higher performance in both CO_2 and O_2 (5 bar)
	26	Purity
	27	Cold filling
Cost/ price	28	(Marina – Egypt) price < company price < (Amraz – Israel) price

Table (A.16): EC results of product & technical specification sub criteria pair wise comparisons

Main Criteria	#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Rate Index
											Packaging			Service & customer contacts						Quality		Safety		Raw Material					Pric	
Product & technical specification	1		9	6	1	6.5	1/2	1/2	1/3	2	8	8	8	6.5	8	1	1	1	3.5	1	6	1	1	2	3	1	1	8	1	0.067
	2			2	1/4	4	1/3	1/5	1/3	1/2	8	8	8	6	6	1	1	1	2	1	4	1	1	3	3	1	1	7	3	0.042
	3				1/6	1	1/4	1/4	1/3	1/3	9	9	9	4.5	7	1	1	1	2	1	5	1	1	3	3.5	1	1	6	6	0.040
	4					4	2	1	1	1	9	9	9	6	9	1	1	1	5	1	4	1	1	5	6	1	2	7	6	0.072
	5						1/4	1/5	1/4	1/4	8	8	8	5	6.5	1	1	1	3.5	1	5	1	1	3	4	1	1	5	2	0.035
	6							1	1	1	9	9	9	5	7	1	1	1	3.5	1	5	1	1	5	5	1	2	6	2	0.061
	7								1	1	9	9	9	5	9	1	1	1	4	1	5	1	1	4	6	1	2	8	3	0.067
	8									1	9	9	9	6	9	1	1	1	5	1	6.5	1	1	3.5	5	1	2	7	1	0.063
	9										9	9	9	7	9	1	1	1	4	1	8	1	1	3	6	1	4	8	1	0.059
Packaging	10											2	2	1/4	4.5	1/7	1/7	1/7	1/3	1/9	1/2	1/9	1/9	1/3	1/3	1/9	1/8	2.5	1/5	0.006
	11												2	1/5	3	1/8	1/8	1/8	1/3	1/8	1/2	1/8	1/8	1/5	1/5	1/9	1/6	4	1/6	0.006
	12													1/5	3	1/8	1/8	1/8	1/3	1/8	1/2	1/8	1/8	1/5	1/5	1/9	1/6	4	1/6	0.006
Service & customer contacts	13														3	1/2	1/2	1	1/2	1/4	3	1/5	1/5	1/3	1	1/8	1/6	5	1/3	0.014
	14															1/7	1/5	1/5	1/2	1/8	1/6	1/9	1/9	1/8	1/8	1/9	1/8	1	1/9	0.005
	15																1	2	2	1	8	1	1	1	7	1	2	9	1	0.047
	16																	3	2	1	7	1	1	1	5	1	2	8	1	0.046
	17																		1	1	4	1/3	1/2	1	2	1	3	8	1	0.037
	18																			1/5	3	1/4	1/4	1	1	1/6	1	7	2	0.019
Quality	19																				4	1	1	1	3	1	3	7	1	0.046
	20																					1/5	1/5	1/5	1	1/7	1/6	3	1	0.010
Safety	21																						1	1	2	1	1	9	1	0.046
	22																							3	3	1	1	9	1	0.047
Raw material	23																								1	1/3	1/2	3	1	0.023
	24																									1	2	5	1/5	0.017
	25																										4	6	1	0.051
	26																											5	1	0.031
	27																												1/8	0.005
Cost	28																													0.033

Table (A.17): Comparing between technical attributes analysis using AHP methodology and HOQ

Criteria	Relative weight QFD	Rate index AHP
Suitable for (1.5 – 2 Lt) bottles	0.0880	0.067
Weight (52 gram)	0.0781	0.042
Height (140 mm)	0.0164	0.040
Diameter (28 mm) PCO	0.0271	0.072
Color (Colorless 75%, Green 25%)	0.0079	0.035
Strength	0.0873	0.061
Higher performance in both CO_2 and O_2 (5 bar)	0.0873	0.067
48 Cavity mould	0.0632	0.063
3.5 Kg. injection machine	0.0769	0.059
"56*44*41 cm" Plastic box	0.0115	0.006
500 Pieces/ box	0.0063	0.006
30 boxes/ Pallet covered by gelatin	0.0047	0.006
Good personality	0.0000	0.014
Reselling the defects	0.0000	0.005
Commitment of quantity	0.0107	0.047
Commitment of time	0.0110	0.046
Delivery in Gaza	0.0101	0.037

Criteria	Relative weight QFD	Rate index AHP
Easy payments	0.0000	0.019
Inspection	0.1271	0.046
Batch records	0.0045	0.010
Hygiene	0.0404	0.046
Safety for keeping food	0.0478	0.047
Not too hard	0.0327	0.023
Clarity and Antistatic protection	0.0157	0.017
Higher performance in both CO_2 and O_2 (5 bar)	0.0658	0.051
Purity	0.0451	0.031
Cold filling	0.0087	0.005
Cost/ price	0.0258	0.033

Table (A.18): Technical specification of the desired injection moulding machine (Chuan Lih Fa Machinary, 2013)

Injection unit	Unit	6630
Screw diameter	mm	95
Theoretical inj. volume	cm3	3542
Max. injection pressure	kg/cm2	1872
Max. injection speed	mm/sec.	104
Max. injection rate	cm3/sec.	742
PET max. shot weight	gram	3701
PET plasticizing rate	Hg/Hr.	249
Screw rotation speed	PRM	98.5
Nozzle radius / hole	mm/mm	25 / 30
Heating zones	zone	10
Heating capacity	kw	49.8
Clamping unit		
Distance between tie bars	mm	810 x 810
Dimension of platen	mm	1260 x 1260
Mold height	mm	300 - 900
Mold opening stroke	mm	1000
Clamping force	Ton	500
Dia. of centering ring	mm	200
Ejector stroke	mm	200
Ejecting force	Ton	11
General data		
Pump driving motor	HP	150
Capacity of oil reservoir	Liter	2000
Machine dimension (L x W x H)	m	9.4 x 1.95 x 2.5
Net weight	Ton	30