Product Design For Engineers 1st edition Shetty Solutions Manual

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Chapter 2 Exercises

2.1. Conduct a complete QFD analysis on a household product of your choice such as a dishwasher, washing machine, or refrigerator. The analysis should include the voice of the customer and the product's ranking compared to that of competitors. Briefly explain your reasoning for the selection.

Product considered: Refrigerator

Voice of the Customer:
A. Energy efficient. Low importance.
B. Aesthetically pleasing. High importance.
C. Easy to clean. High importance.
D. Labor saving. Medium importance.
E. Reliable. High importance.
F. Quiet. High importance.
G. Cost. Medium importance.

Requirements	What	How
Energy efficient	Low electrical consumption	High efficiency compressor
	Low cooling loss when door is open	Temperature barrier
Aesthetically pleasing	Refined handles and exterior details	Design includes ergonomic considerations
	Finish options	Stainless, wide variety of colors
		Built-in cabinet option
Easy to clean	Exterior	Fingerprint resistant
	Interior	Stable shelving
		Spill guards to contain spill on one shelf
Labor saving	Additional options	Ice maker (cube and chip)
		Water dispenser
		Night light
	Convenience	Controls are ergonomically designed and located
Reliable	Long design life	Components with 15 year design life
		Minimize vibration or redesign components to eliminate source
	Warranty	15 year, parts and labor
Low Cost	High Value	Market value for dollar spent versus absolute cost

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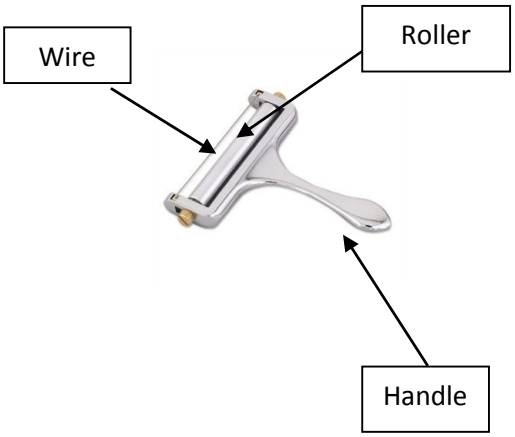
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Quiet	Compressor	High efficiency compressor
		Sound isolation
		Vibration dampers
	Ice Maker	Low noise pump, sound isolation

A QFD chart with detailed market analysis and survey might capture a few more customer requirements.

2.2. Select a simple product of your choice (such as a can opener or umbrella) and identify the parts and objectives.

Product 1: *Hand Held Cheese Slicer*



Parts	Objectives
Handle	Power Input, Control
Roller	Cutting Guide
Wire	Cutting Blade

Product 2: *Electric Kettle*

Parts	Objectives
Base	Main component of kettle for assembly.
Reservoir	Used to boil small quantity of water for domestic use.
Toggle switch	Used for energizing.
Handle Grip	Made of thermoplastic elastomers and facilitates handling of kettle.
Rear Cover and lid	These parts are interlocked with snap-fit with the base.

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2.3. Create a figure that shows the elements of a QFD chart. Explain how a cascade of these charts can be used to cover the total design and development process.

The typical product selected here is: ***Sports Bicycle.***

Before the QFD chart is drawn, the basic customer requirements are identified.
Customer Requirents/Voice of the customer:

- affordable,
- easy to pedal,
- adjustable positions,
- lightweight,
- aesthetically pleasing,
- comfortable seat,
- ability to ride on and off the road

Elements of House of Quality

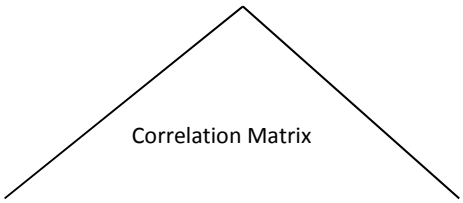
The central body of the house of quality consists of WHATS (Customer needs), HOWS (what we control), and a matrix of relationships between the WHATS and HOWS. *Figure* shows the essential elements of a general house of quality. The customer requirements/needs/wants are listed horizontally and are known as WHATS. The counterpart technical characteristics are listed vertically and are known as HOWS.

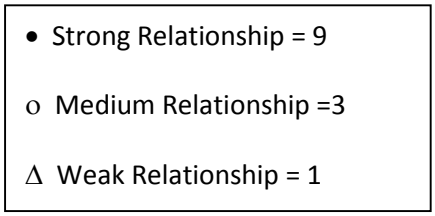
The interrelationship matrix (WHATS against the HOWS) is shown where horizontal and vertical axes meet. The roof of the matrix shows the correlation between the HOWS and HOWS. The bottom of the house of quality gives an indication of the technical characteristics against the technical bench marking (HOWS against the HOW MUCH).

Four Phases of QFD

The four phases of QFD are:

- Product planning phase
- Part deployment phase
- Process deployment phase
- Product deployment phase





Customer Requirements

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		Use of light weight material	Standard components	Quick release fastener	Multi-suspension system	Make a Snap Fit
Inexpensive	2	o	•			o
Easy to pedal	5	•	Δ		o	Δ
Adjustable positions	3		Δ	•		o
Lightweight	4	•		Δ	o	
Smooth ride	5	o	Δ		•	o
Target values		X	X	X	X	X

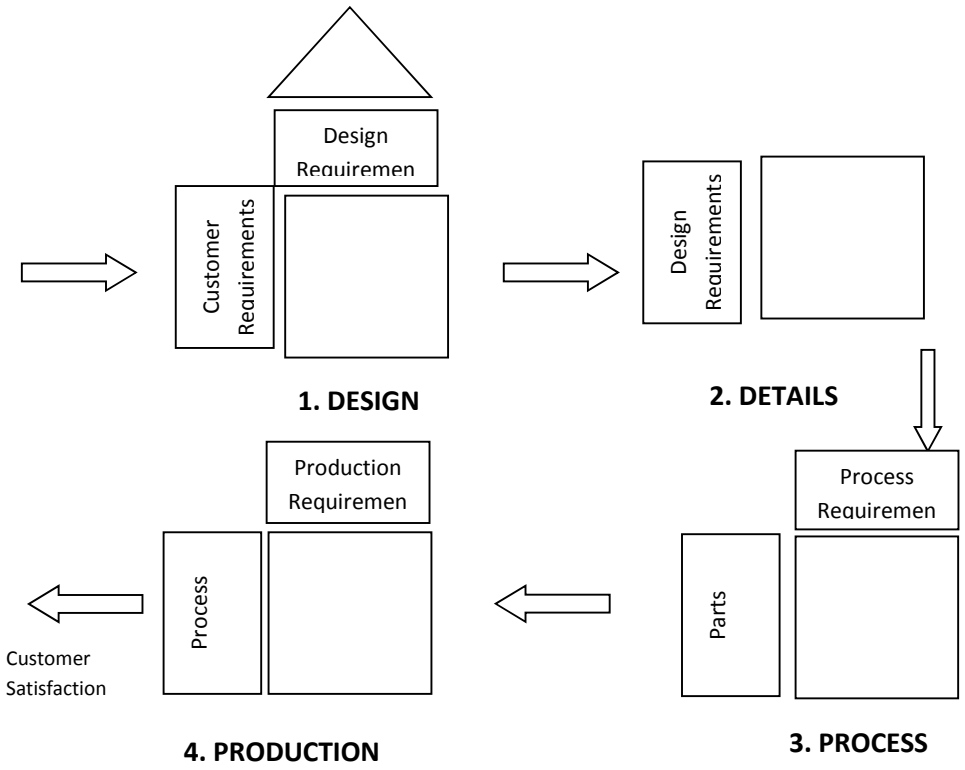
House of Quality

In the *product planning phase*, customer attributes are drawn based on surveys, interviews, observations, field contacts, focus groups, employee feedback, publications, and sales records and are converted into product characteristics. A relationship matrix between the customer requirements and the product characteristics is drawn. This matrix will have data from market evaluation that includes customer expressed importance ratings and data on competitor's products. The matrix will have information on data on current product strengths and weaknesses, measurable targets to be achieved, and selling points. In the *part deployment phase*, the product characteristics are translated into component characteristics. At this stage, the characteristics of the final product are converted into part details at the component level. In the *process deployment phase*, the process plan for the manufacture of the component, sub-assembly, and assembly are identified as well as quality parameters. In the *production deployment phase*, the output from the process deployment charts provides a measure of critical product and process parameters. At this stage production operations for all critical components are identified

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Four Phases of QFD



2.4. Generate a number of concepts for a potato peeler and then create a product design.

The four-step concept generation methodology is used to generate a number of concepts for a potato peeler as follows:

1. ***Clarifying the problem***
   - Understanding the current situation
   - Decompose the system into logical sub-components
   - Examine customer feedback
2. ***Search Externally***
   - Patents
   - Literature
   - Experts
   - Benchmarking

   Search Internally
   - Review historical design data
   - Consultation
   - Brainstorming
3. ***Explore Systematically***
   - Combine and Classify

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4. ***Reflect on the Solutions & Process***
   - Constructive feedback; Focus on each component individually

The four-step concept generation methodology can be applied to the potato peeler as follows:

- *Clarifying the problem*: How to peel potatoes quickly, easily, safely, and cheaply. The problem is broken down into four critical sub-problems.
- *External search*: An external search would consist of obtaining currently available potato peelers and evaluating their performance. Tests will be run to quantify their performance.
- *Internal search* would consist of reviewing the internal knowledge and brainstorming on potato peeler design methods.
- *Explore:* Organize, compile, and analyze the information.
- *Solution:* A design of new potato peeler would be presented. Its performance would be compared with other potato peelers. Feedback from the analysis will be analyzed for further refinement.

2.5. Show a simple QFD-matrix relationship identifying three customer requirements and three design features.

In Quality Function Deployment analysis, it is very important that the product features have a strong relationship with the customer requirements. The degree to which the product features satisfy the customer requirements is quantifiable and is useful to the successful application of QFD.

Three customer requirements for the **potato peeler** would be:

1. Maximize the rate of peeling of potatoes.
2. Minimize the risk of injury from using the potato peeler.
3. Minimize the effort (translates into strain) required to peel the potato.

Three design elements of the potato peeler would be:

a. Blade length
b. Guard configuration
c. Swivel configuration

Other customer requirements and design features certainly exist, but looking at the three items above, we can recognize a direct relationship. The relationship in three items can be identified as (*1-a. 2-b, 3-c*). As an example, the blade length affects the rate at which potatoes can be peeled. The guard configuration affects the likelihood that the user will cut their finger. A swivel reduces the operator strain because the blade will follow the contour of the potato, rather than having them bend their wrist to follow the contour.

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2.6. If you are designing a technologically integrated product, identify the key criteria.

Design criteria for smart lamp: *Examples of typical criteria are:*

- Must have modern design
- Adjustable height and flexible gooseneck for precise direction of light
- Must be of suitable size to be used as a desk lamp and must not occupy much space
- Must be low voltage and energy saving
- Must appeal to both a male and female market
- Must be able to move to different locations easily
- Includes modern and traditional features
- Must have an inconspicuous switch

2.7. You are interested in creating a sustainable product. However, the supply chain influences its features. Prepare a survey for the supply chain companies to identify the issues of sustainability.

Survey Questions:
The company developing a product should participate in a survey to see that the customer is satisfied. The survey should contain questions related to the quality of the product.
Some of the typical questions are as follows:

- Does the company track, report, and communicate "costs of poor quality" to everyone in the company on a regular basis?
- Is the information system on quality computer-based or manual?
- Does a company have a formal quality evaluation program?
- Does the company have measurable, time-based quality objectives set on a regular basis by the management of the company?
- Are the product returns due to damage during shipping a problem?
- What performance measures are used to assess quality?
- What is the organizational structure for communication on quality issues and specific improvements?
- Does the company have an up-to-date quality manual that clearly defines the processes, procedures, and resources that assure the quality of products and processes?
- Is the company ISO-9000 certified, and has it passed subsequent audits?
- What role has quality played in product standardization?
- Has standardization increased the throughput and efficiency of the organization?
- Has standardization generated better usage of tools/instruments?
- What difficulties (technical, financial, personnel, production, and quality) were encountered in implementing process standardization?

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- Does the company certify suppliers?
- What role have the suppliers played in the quality function?
- What resources were necessary to effectively use suppliers in the quality function?
- What is the percentage of on-time delivery from major suppliers?
- What quality assurance tasks have been delegated to suppliers?
- Do suppliers participate in product design activities?
- What effect did quality improvements have on supplier process standardization?

2.8. Write the design specification for a smart air-pump station for filling automobile tires. This example requires the design of a new "Smart Air Pump Station" for filling automobile tires to the right pressure. The design features include the exact car manufacturer's recommended tire pressure in an internal database without requiring more input from the customer than a basic knowledge of their car's make, model, and year. There will be little possibility of inflating tires to the wrong pressure even in extreme and temperature conditions.

Design specification for a Smart Air Pump:

- 15 inch LCD (liquid crystal display) touchscreen monitor for easy viewing to display user instructions, fees, and advertisements.
- Computer located inside housing for programming and creating database of recommended tire pressure values.
- Ergonomic features such as "easy grip" for user comfort.
- Automatically inflates or deflates tires to the car-maker's recommended tire pressure.
- Shuts off once the desired pressure is reached.
- Recognizes outside temperature (hot or cold) in order to determine the proper adjusted tire pressure.
- Half inch thickness plywood housing with white color vinyl siding covering and ventilation channels for air compressor and desktop computer fan.
- Protection from weather conditions by providing vinyl siding.
- Retractable air hose.
- Attractive and aesthetic look.
- Audio and visual interactive units.
- All weatherproof enclosures.

2.9. Write the design specification for creating the next generation of dishwasher.

Design specification of a modern dishwasher:

- Large interior capacity makes room for larger dinnerware
- Energy Efficiency Class

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- Noise level: 44 dB – 48 dB
- Efficient water consumption
- Different cleaning temperatures
- Water management system
- Load sensor with overload protection
- Detergent automation
- Self-cleaning filter system
- Push button top controls
- Attractive display inside
- Acoustic end of cycle indicator
- Real-time clock
- Electronic delay timer: 1-24 hours
- LED rinse aid refill indicator
- Anti-fingerprint surface coating
- Large size baskets
- 6 foldable plate racks in top basket
- 8 foldable plate racks in bottom basket
- 2 cup shelves in bottom basket
- Glass rack in bottom basket and glass care protection system
- Components with life time guarantee
- Childproof door lock
- Servo lock for effortless door closing

2.10. The design team decided to implement a full QFD chart for designing a garden implement such as weed cutter. It can be used in maintaining quality gardens. The requirements include (a) durability, (b) adequate power requirement, (c) light weight, (d) consistent starting, and (e) easy maintenance. Develop customer requirements and engineering parameters. Compare your design to a commercially available product.

Product considered: *Weed Cutter*

The product features can vary depending on the customer views. For some customers the major requirement could be dependability, ergonomic design, and cost as shown below. These requirements can also be broken down as secondary requirements. For example, dependability can be broken down as 1. String trimmer starts every time, and 2. String trimmer lasts 10 years. The importance of these secondary requirements can be shown by ranking them from 1 to 5.

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Voice of the Customer Survey

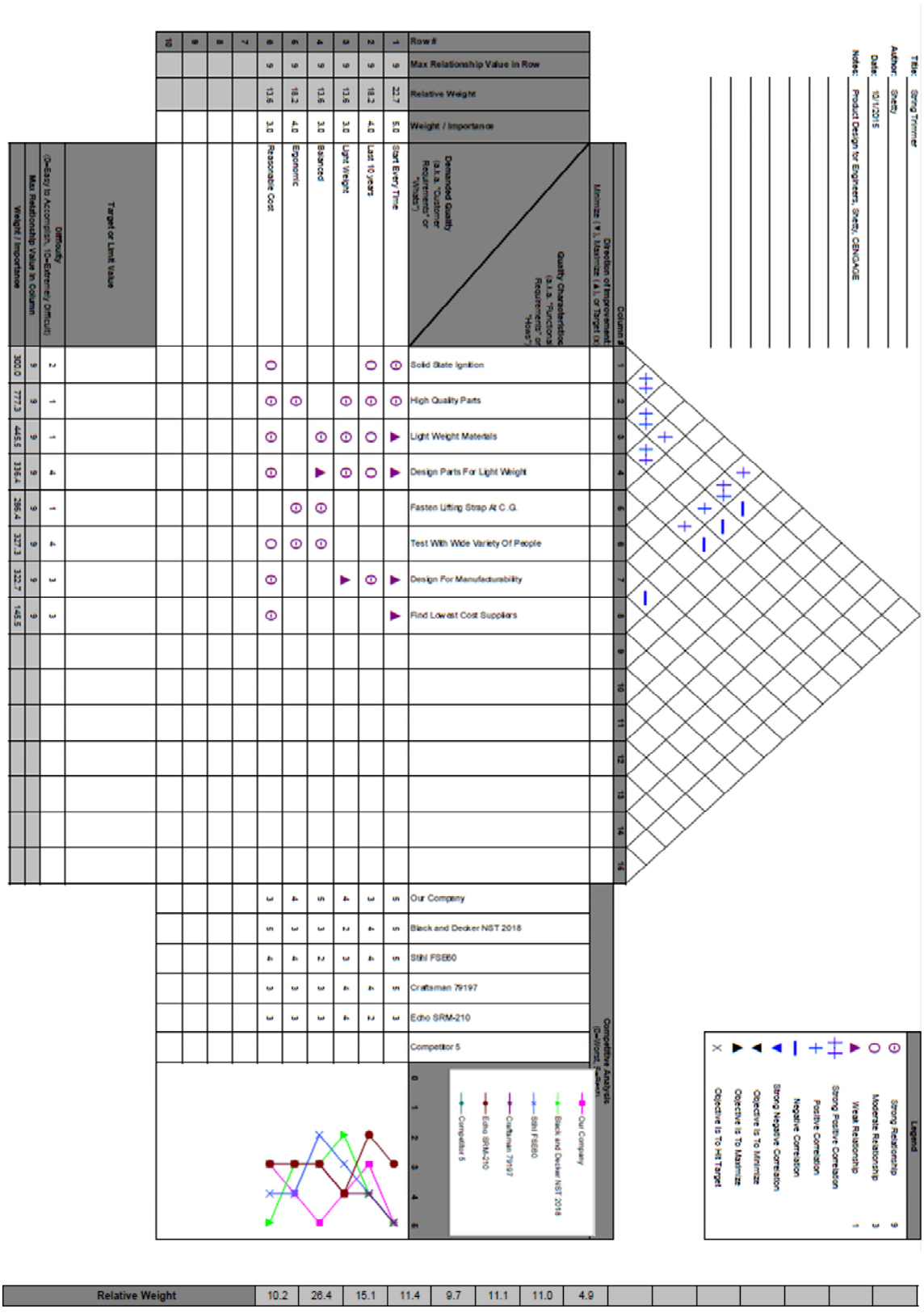
Requirement	What	Rank	How
Dependable	Start Every Time	5	Solid state Ignition
	Last 10 Years	4	High Quality Critical Parts
Ergonomic	Weight	3	Light Weight Materials
			Design Parts for Light Weight
	Balance		Fasten Lifting Strap at C.G.
	Shape	4	Survey different types of customers for best design shape
Cost	Manufacturing process	3	Design For Manufacturability
	Suppliers		Find Lowest Cost Suppliers

Ranking: 1 (Lowest Importance) - 5 (Highest Importance)

The QFD chart created for String Trimmer is shown in Figure below.

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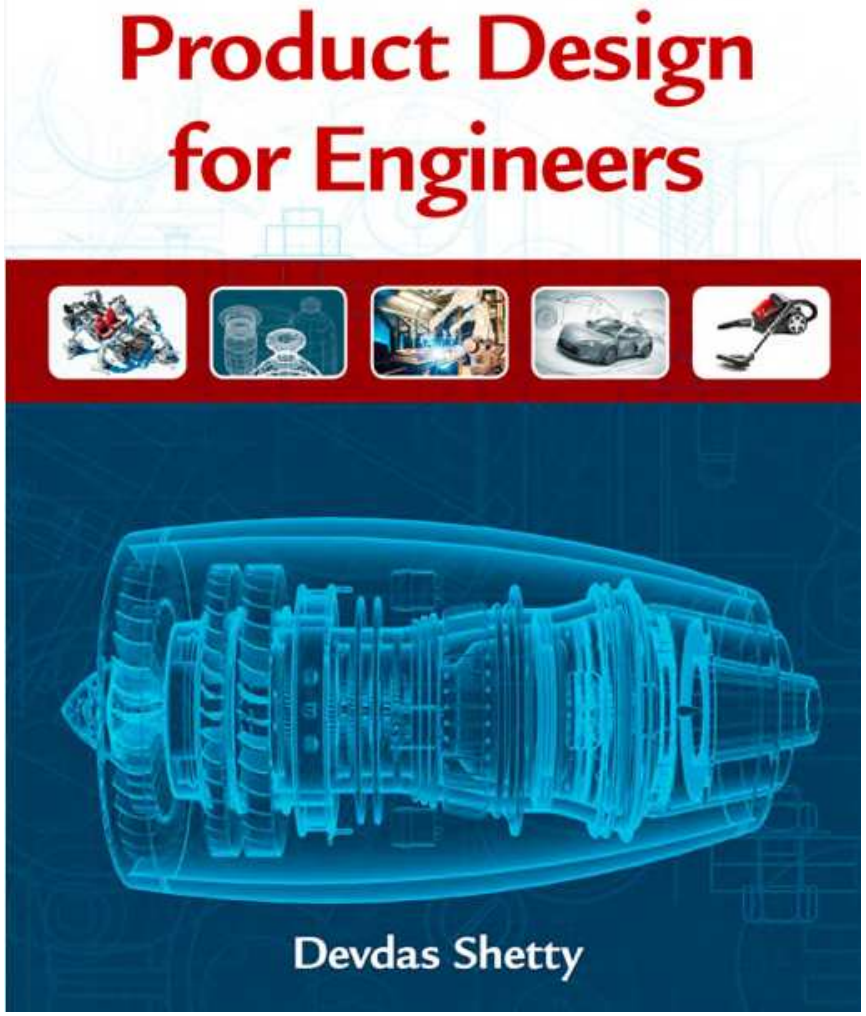
Relative Weight	10.2	26.4	15.1	11.4	9.7	11.1	11.0	4.9							

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Chapter 2

Customer Focus

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Learning Objectives

- Understand the importance of customer focus
- Learn the advantages of quality function development (QFD)
- Understand the four phases of QFD
- Learn how to construct a house of quality
- Identify design constraints

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Customer Focus

Worldwide competitiveness has brought increased focus on customers' needs and opinions

Quality Function Deployment (QFD) – a methodology that provides a framework for product or program design

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Quality for Product Success

Advantages of using QFD

- Reduction of product design time
- Cost reduction
- Early exposure of design trade-offs
- Written documentation of design decisions
- Reduction in errors and corrections
- Clarity for decisions
- Incorporation of a collective experience of a multicultural team capable of guiding sound decisions

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Phases of QFD

Product planning phase – customers' preferred attributes are identified

Part deployment phase – product characteristics are translated into a component's characteristics

Process deployment phase – process plan for the manufacture of the component, sub-assembly, and assembly are identified as well as quality parameters

Product deployment phase – output from the process deployment charts provides a measure of critical product and process parameters

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Phases of QFD

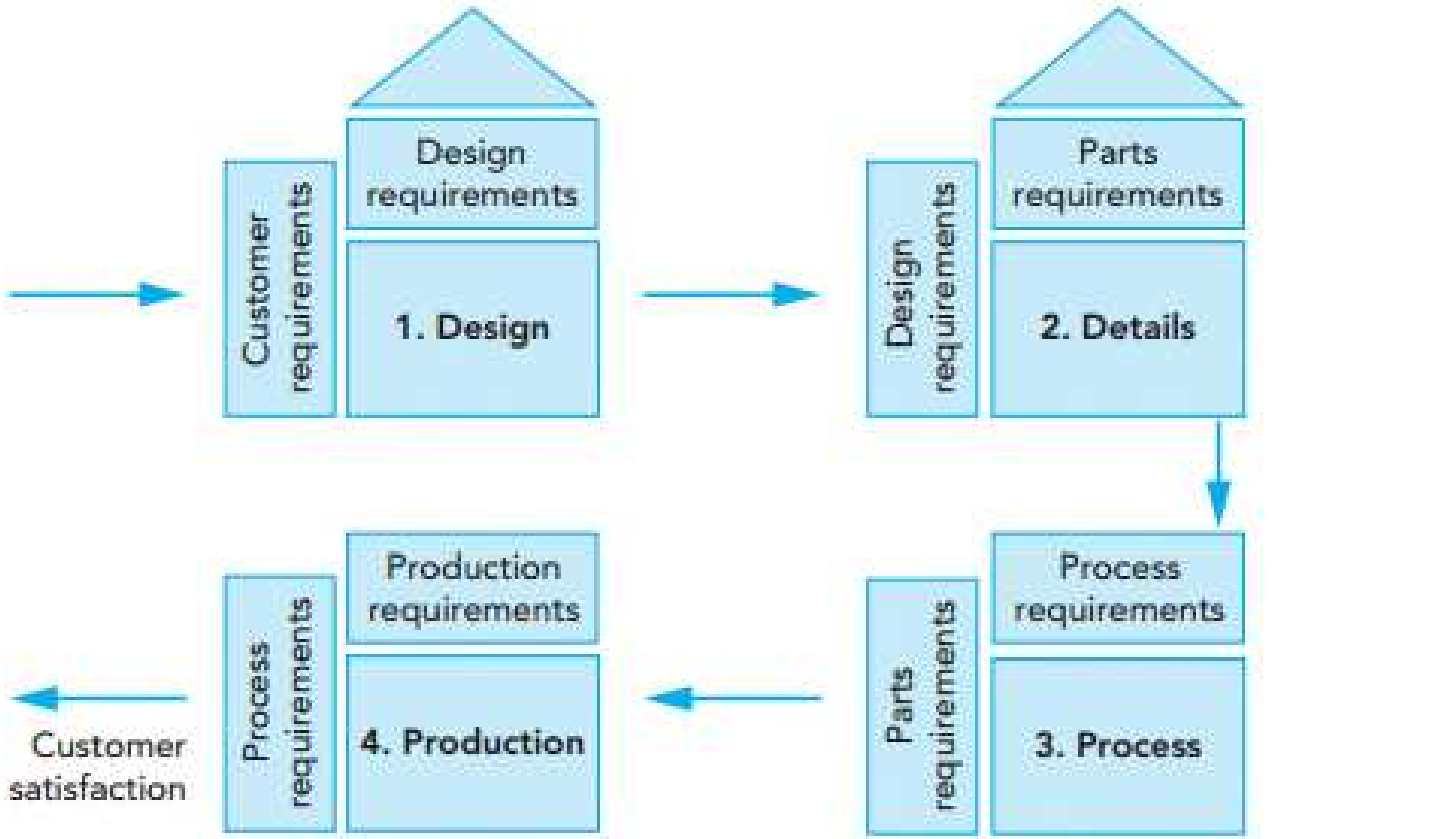


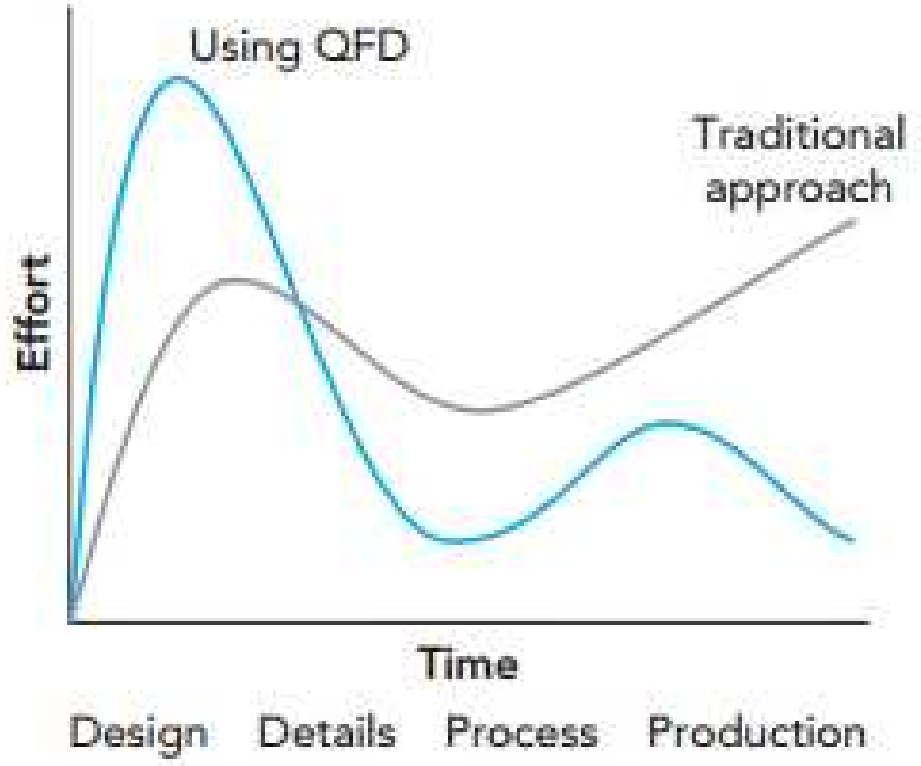
FIGURE 2.2 Four Phases of QFD

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Effort vs. Time



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House of Quality Features

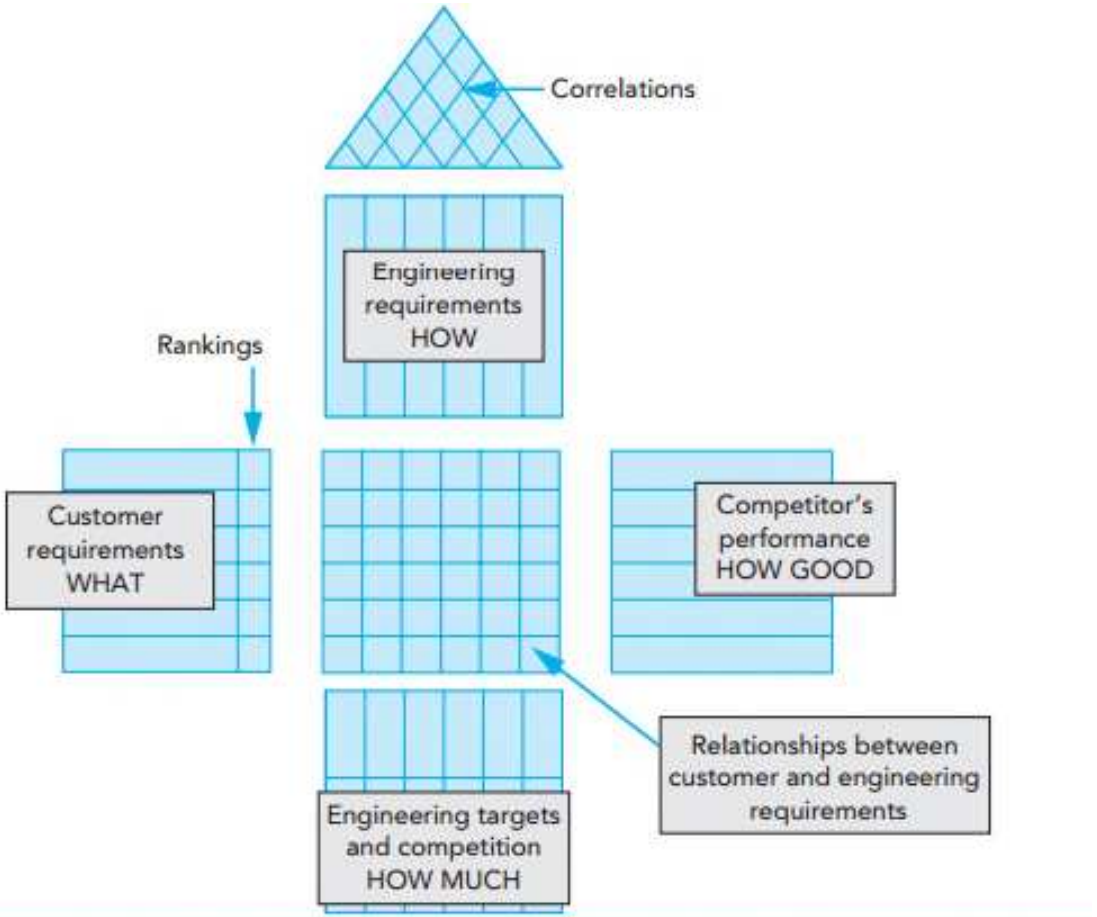


FIGURE 2.3 Typical QFD Matrix for Product Design

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House of Quality - Components

- Voice of the customer (VOC)
- Importance ratings
- Assessment of competitor products
- Target goals
- Correlation matrix
- Technical assessment
- Probability factors
- Relationship matrix
- Absolute score
- Relative score

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House of Quality Features

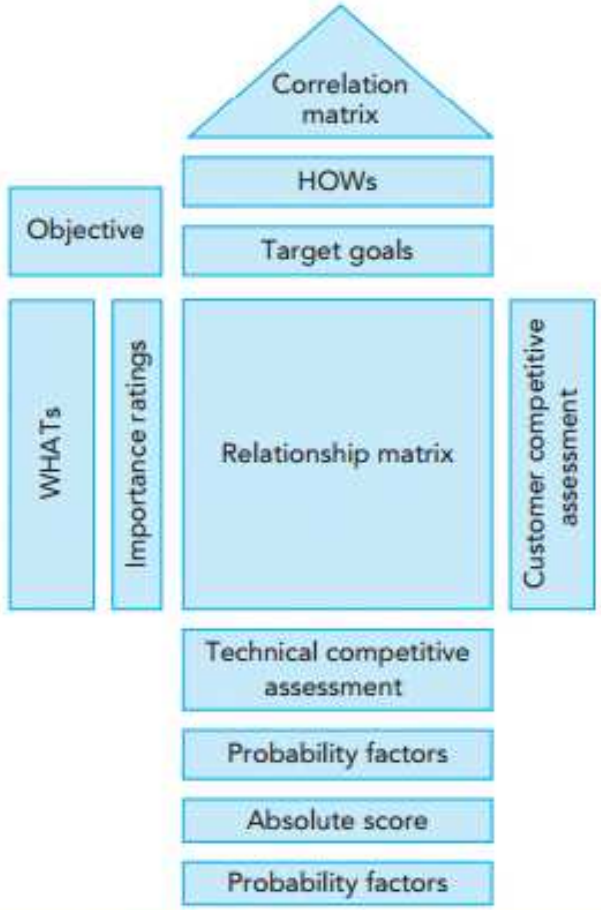


FIGURE 2.4 Components of a QFD Model

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House of Quality – Step by Step

1. Voice of the customer
2. Customer requirements and rating
3. Planning matrix for assessment of competitor product
4. Fill out the correlation matrix to determine how factors relate to target
5. Complete the relationship matrix (correlation) and important rating values
6. Evaluate customer importance and technical assessment

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House of Quality – Step by Step

7. Control the characteristics competitive evaluation
8. Evaluate the chart
9. Develop new target values
10. Technical difficulty and probability factors
11. Deployment selection
12. Deployment matrices
13. Design and test

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Design Constraints and Product Specification

Problem: Design an inexpensive front bumper so that the car withstands 5mph head-on collision with concrete wall without significantly damaging the bumper or other car parts, and must be easily recyclable.

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Design Constraints and Product Specification

Equality constraints examples:

- Government requires all bumpers be installed 18” above ground level
- Weight of bumpers cannot exceed 50 lb
- Mounting brackets on bumpers must be between 8” and 12” from the center

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Conclusion

- Global competitiveness has brought greater focus on customers' views
- Information is gathered from customers by collecting data and interpreting customer needs, allowing for formulation of specifications, generating concepts for detailed design

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