

Engineering Design Process of Door Handle

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Abstract

The most important piece of hardware that people use on a daily basis is doors. We use doors to give ourselves a sense of security. The most crucial component of the door is the handle, which is required to operate the door. Door handles are used to open and close doors with the least amount of effort. We encounter many different kinds of door handles in our daily lives, including pull, lever, and doorknob handles. We are not aware of any selection criteria for door handles because there are so many different designs available. Depending on how the user responds to the available door handle, various shapes can be designed. It's not just a device used for opening and closing of doors but also for locking purpose. Door handles are divided based on different types of doors, finishes, and shapes.

Keywords: Door Handle, market survey, Product architecture, modular, quality functional deployment, concept generation, aesthetic, ergonomics, design for manufacturing, design for environment, product life cycle.

INTRODUCTION

The only hardware needed to open and close doors is the door handle. Everybody uses doors, and door handles are necessary for doors to function. Doors are used to keep our possessions secure. Doors come in a variety of styles, including closet, dummy, and passage doors. In a similar vein, different door types and functions call for different types of door handles. Doors have door handles installed so that people can easily open and close them with little effort. Door handles occasionally have locks installed for added security and safety. There are also lockless door handles on the market. We have divided door handles into three groups for this project: pull handles, doorknobs, and lever handles [1].

The first step in any design process is to conduct a market survey. The methodical planning, gathering, analyzing, and reporting of information pertinent to a particular marketing scenario that an organization is facing is known as a marketing survey. Research has shown that the absence of marketing information is often linked to new product failure, while the presence of marketing information is positively correlated with new product success. According to their decor and style, the majority of people, I discovered, use Door Handles. Stainless steel door handles are another popular choice [2].

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Received Date: February 24, 2024

Accepted Date: April 13, 2024

Published Date: June 07, 2024

Citation: Sachin S. Chavan, Prashant D. Yadav, Dadaso D. Mohite, Pramod V. Londhe, Lakshit Kumar. Engineering Design Process of Door Handle. Journal of Production Research & Management. 2024; 14(1): 11–20p.

The second phase is called product architecture. The process of drawing a schematic for a product and all of its features is called architecture. The product is expressed geometrically by breaking it down into its fundamental components instead of being represented as a prototype. This improves the expression of the relationships between various features and highlights redundancies. Generally

speaking, there are two types of product architecture: Modularity is the first. Product features and their relationships are the main focus of modular product architecture. While the ways in which these functions interact are explained in detail, these functions are only briefly discussed [3].

The second type of product architecture is integral. Integral architecture is just the opposite: it focuses on the function, purpose, and inner workings of each feature, with brief notes covering the relationships between them. Modular product architecture is widely used nowadays and is cost efficient and gives a lot of variety but if performance is our priority and cost is not a matter then one should go for integral product architecture.

The most crucial stage in connecting functional parameters and customer requirements is Quality Function Deployment. A customer-driven method for processing new product developments to maximize customer satisfaction is called quality function deployment, or QFD. Every aspect of engineering design is optimized for product performance based on the degree of customer satisfaction. In order to compare the performances of various competitors, identify the optimal marketing strategy, and apply the knowledge gained from the current goal to the future ones, an attempt has been made to investigate the applicability of QFD as a strategic decision-making tool in this paper [4].

A set of target specifications and customer needs serve as the starting point for the concept generation process, which produces a number of alternative product concept designs from which a final design will be chosen. This stage calls for a higher level of abstraction in thought than maybe most engineers are accustomed to. Design for ergonomics and aesthetics is a successful design process that entails creating outstanding designs while taking into account human factors and the product's appearance. In order to create successful products, it combines all the components of ergonomics and aesthetics, such as comfort and visual appeal. These days, a lot of designers use ergonomics and aesthetics in their work to create visually appealing products that live up to customer expectations.

During the early stages of the product lifecycle, Design for Manufacturing and Assembly (DFMA) is an engineering methodology that prioritizes the ease of manufacturing the product's parts and the simplified assembly of those parts into the final product. The goal is to reduce time-to-market and total production costs [5]. Reducing carbon footprints and pollution in the environment is the primary goal of design for environment, or DFE. decreasing waste and increasing the use of clean energy in order to create a healthy and environmentally friendly environment.

The product life cycle is the time from the product concept through its eventual withdrawal from the market. The product life cycle is used for decision-making and strategy development throughout each stage. We need to understand that the difference among the products is in terms of length of life but the basic thing is that all thing born has to die one day [6].

METHODOLOGY

Industrial Design is defined as 'the art or process of designing manufactured products' which has subsequently led to the mass production of all manner of identical products from cars to clothing.

To develop a door handle from the manufacturer's point of view, the following is the process to develop it in an efficient manner that satisfies customer requirements and is capable enough to sustain itself in the market as a strong competitor.

Market Survey

The methodical planning, gathering, analyzing, and reporting of information pertinent to a particular marketing scenario that an organization is facing is known as a marketing survey. Research has shown that the absence of marketing information is often linked to new product failure, while the presence of marketing information is positively correlated with new product success [7]. A type of applied

sociological study known as "marketing research" focuses on comprehending the preferences and behaviors of consumers in market-based economies, both present and potential(fig.1). There were roughly sixteen questions, and fifty-five answers in all were received.

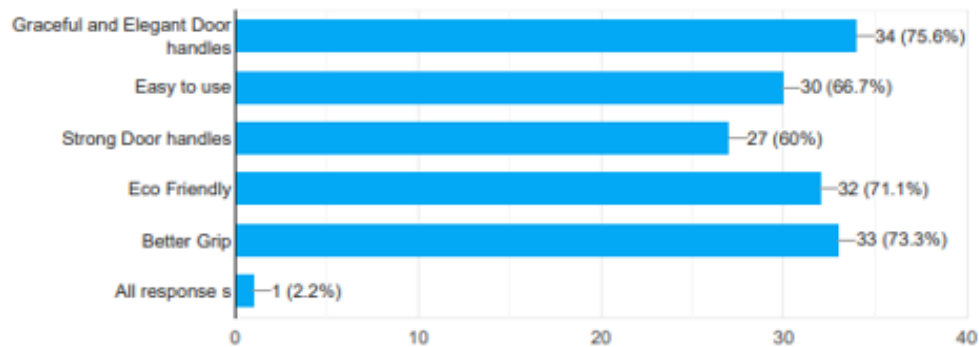


Figure 1. Features required in door handle.

Product Architecture

Product architecture is a product development mapping tool project managers and other professionals can use to understand and outline the features and functions of a product. Professionals can express a product's architecture using schematic diagrams or other visual aids.

It enables people to separate and arrange a product's functional components for later examination and analysis. It is important to remember that product architecture refers to the relationships between the components of a product rather than its physical attributes [8]. Basically, there are two kinds of it: Whole Architecture: Integral product architecture is a useful tool for designing specific product components. Instead of classifying functions into groups, they are examined as a variety of components. Examining the intricacies of each product feature and their interrelationships is the aim of this kind of product architecture.

Modular architecture

This design approach enables the separation of a product into distinct modules with the main objective being the enhancement or optimization of a particular function. The relationships between features and modules are outlined when designing a modular architecture.

Product Architecture on Door Handle

Modular type of product architecture is used in the door handle as the door handle is something which is nowadays a part of the lifestyle and with time, people need changes in their daily usage. Using modular design, one could manufacture a variety of door handles cost-effectively. Consumers will benefit from the variety, and manufacturers will benefit from being able to reach a sizable market with this philosophy [9]. An example of a conceptual map that facilitates inter-functional planning and communication is the house of quality. Individuals with disparate issues and duties can debate design priorities by consulting evidence patterns on the house grid.

Sample Calculations

Importance Calculations

- Material: $10.7*4 + 17.8*4 + 7.14*10 + 14.28*4 + 17.8*10 + 17.8*4 = 491.7$
- Weight: $10.7*10 + 17.8*10 + 17.8*1 = 302.8$
- Shape: $10.7*4 + 17.8*10 + 14.28*4 + 14.28 + 17.8 * 4 = 363.4$
- Dimensions: $10.7*4 + 17.8*10 + 14.28*4 + 17.8 = 295.72$
- Cost: $17.8 *4 + 7.14*10 + 17.8*4 = 213.8$
- Protective Layer Material: $17.8 + 7.14 + 17.8*4 = 96.14$

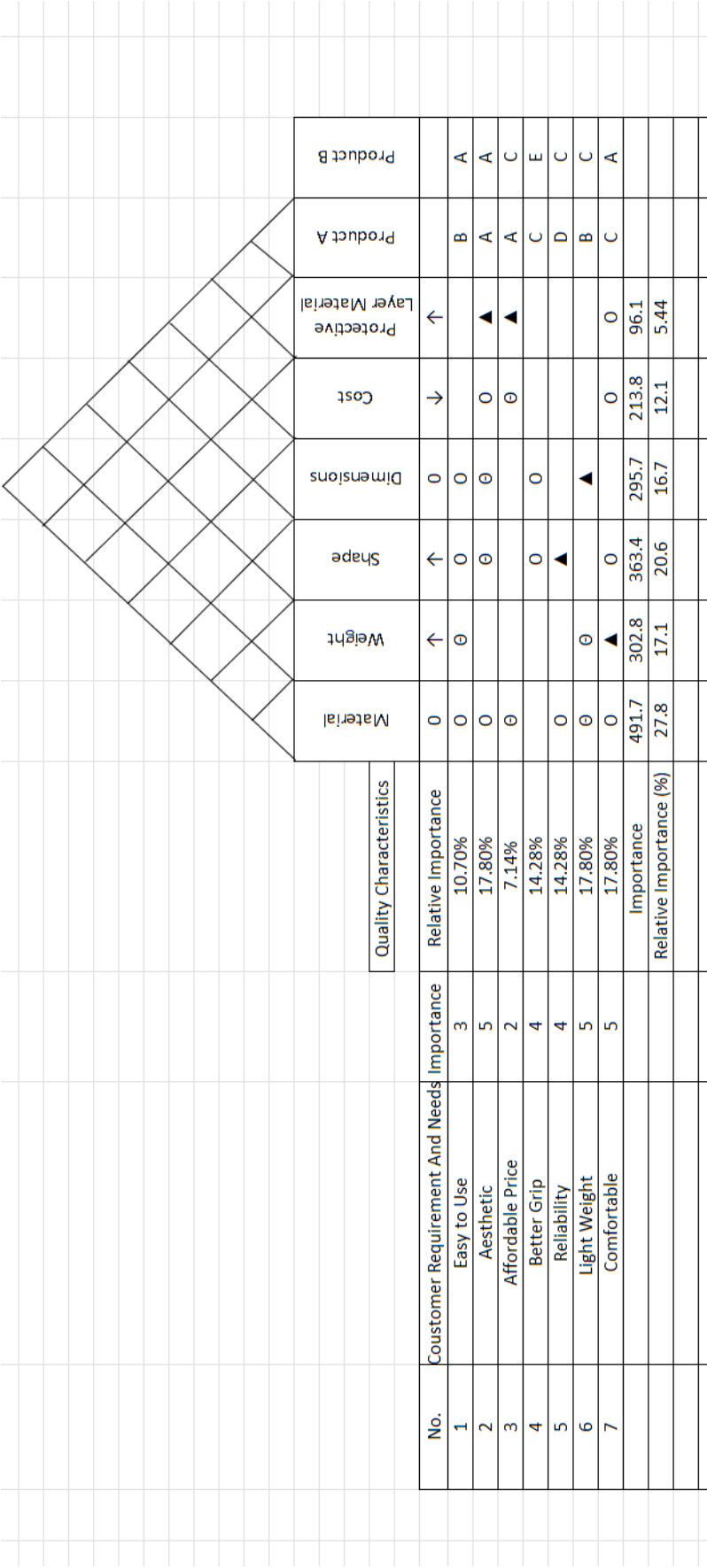


Figure 2. House of quality of door handle.

Relative Importance Calculation

- a. Material: $491.7 / 1763.5 * 100 = 27.8\%$
- b. Weight: $302.8 / 1763.5 * 100 = 17.1\%$
- c. Shape: $363.4 / 1763.5 * 100 = 20.6\%$
- d. Dimensions: $295.72 / 1763.5 * 100 = 16.7\%$
- e. Cost: $213.8 / 1763.5 * 100 = 12.1\%$
- f. Protective Layer Material: $96.14 / 1763.5 * 100 = 5.44\%$

Figure 2 leads us to the following conclusions:

- Material has the highest relative importance (27.8%).
- Dimensions (16.7%), Shape (20.6%), Weight (17.1%), Cost (12.1%), and, lastly, Protective layer material (5.44%)
- QFD ought to be applied since its ultimate goal is total customer satisfaction.
- The entire product/service development and delivery process in the business.
- It facilitates consensus-building among organizations regarding performance standards and measurement schemes that satisfy clients.
- Its goal is to increase a business's strategic competitiveness.
- It also ranks the actions that must be taken by a company to meet the expressed and implicit needs of the client [10–12].

Concept Creation of Door Handles

Recognizing issues

Every subsequent step is built upon the first one. If we can't get this one right, the entire development process will be in vain. As per Wikipedia, the dirtiest surface in homes and offices is the door handle. It was necessary to make some adjustments to the current door handles because cleaning it on a daily basis is insufficient to solve this issue.

Searching for solution externally

Many details were obtained from the market survey, including recommendations for data-driven solutions that could be applied to the market's current door handle models. Research papers were consulted in order to determine that sensors and the internet of things could be used to create door handles that would clean themselves. Furthermore, it was determined through research papers and the appropriate advice of some experts that using the right anti-bacterial fluid can minimize a number of issues, particularly those pertaining to unpleasant odors [13].

Searching of solution internally

Many new things also entered the picture after having conversations with people of various ages and professions; with each new perspective, something new was about to happen. The cost of door handles may also increase with the use of sensors; however, a more affordable option would be to use an antimicrobial solution that lasts longer. Various ideas and solutions to many problems are provided by brainstorming this topic.

Select the victor and get to work on it: It's time to get the product development process underway. Particular design selection comes next. Additionally, you can use generative design and other potent CAD software features there to help with the process of creating highly optimized designs [14].

Aesthetics and Ergonomics

Aesthetics

Aesthetics is a core design principle that defines a design's pleasing qualities. In visual terms, aesthetics includes factors such as balance, color, movement, pattern, scale, shape and visual weight.

Aesthetics consideration for door handle:

- *Shape:* A product's perception is channeled by its shape design. It is possible to gain an advantage by making geometrically more complex shapes appear larger than geometrically simpler ones of equal height and size.
- *Design:* Every product has been created with the intention of providing safety, comfort, and benefits to each and every user. Thus, it will lead to user-product interactions, which are typically focused on whether the products feel secure, cozy, simple to use, offer advantages, have a positive emotional impact on the user's problem, and so on [15].
- *Visual Weight:* The concept of visual weight is based on the notion that different design elements are heavier or lighter than one another. There are situations when visual weight is evident, like when bigger objects seem heavier than smaller ones simply because they occupy more space.
- *Touch:* Touch and feel is a universal and strong urge, but in consumer product design, as well as in the products themselves, there has been a conspicuous lack of scientific attention paid to comprehending and improving the aesthetic component of a product's overall "feel" in order to increase user satisfaction.
- *Finishing:* One of the most in-demand finishes at the moment is one that should complement our overall design concept. Polished Finish: The reflection of light created by polished treated steel gives the impression of larger, brighter living areas.
- *Color:* Colors are used by designers to create complements and contrasts. In this instance, it is possible for the door handle to contrast with the color of the door. Your handle will be noticeable as a consequence. Prospective customers are likely to notice your branding on your door handle because of the striking contrast in color [16].

Ergonomics

Ergonomics can roughly be defined as the study of people in their working environment. More specifically, an ergonomist (pronounced like economist) designs or modifies the work to fit the worker, not the other way around. Eliminating discomfort and the chance of work-related injuries is the aim. Put another way, when we examine a workstation, the employee comes first. Considering the ergonomics of door handles.

- *Weight:* Light doors open with a light touch or push, whereas heavyweight doors require greater leverage to open. The handle on an external door should be carefully chosen for ease of opening and closing because exterior doors are typically heavy in order to be safe and protected.
- *Simple to Use:* Modern door handles only require a pull to open and close; in contrast, doorknobs can be a little tricky to operate in this situation. This makes door handles extremely user-friendly.
- *Proper Grip:* Proper grip is an essential consideration when designing door handles. Sometimes users find it difficult to hold door handles under certain circumstances.
- *Dimensions:* There are several different parts of doors that should be measured, prior to the installation of new or replacement door handles. It'll be very useful for you to know these so that you can continue to update your home's interiors in the future.
- *Lock Friendly:* Door handles are easy to use but difficult when it comes to the lock system. They do not have separate locks with them, and you need to arrange a lock system separately for your door. The wooden door handles can be made using good quality wood but still needs protection for sustainable usage. Every doorknob has a lock in the center, so you don't need to install a lock on your door separately. This adds to the attractive appearance of your doors and makes them stand out more in your home.
- *Display:* It's important to remember that door knobs should complement our color palette and interior design. Because both are used and the quantity of people who use them, interior door handles have a different function than exterior door handles. For the handles to be safe, they also require improved hardware [17].

Design for Manufacturing and Assembly (DFMA)

Design for Manufacture and Assembly (DFMA) is a design approach that focuses on ease of manufacture and efficiency of assembly. A product can be manufactured and assembled more quickly, more cheaply, and more efficiently by simplifying its design.

Mask Assembly and Manufacturing Design

Material

The two most common raw materials used to make handle hardware are brass and aluminum. This is due to the fact that handles made of brass or aluminum are more easily fashioned using molds or, in the case of aluminum, die casting. Brass is a very dependable and durable metal that naturally resists corrosion, but aluminum is much lighter than other metals, making it more practical to use. Thus, I'll go with brass instead of aluminum.

Aluminum

- Advantages: Strength, stability, weatherproof qualities
- Disadvantages: Quick oxidation, easily water stained

Brass

- Advantages: Brass handles are durable and have great strength and provide artistic and elegant appearance
- Disadvantages: can be scratched or dented which gives bad look and suitable for only interiors as they fade away in harsh weather conditions.

Protective Layer material

Coatings, whether organic or inorganic, are applied using various techniques. Epoxies, acrylics, and polyurethanes are examples of organic coatings. Manufacturers are switching to inorganic coatings based on inert metals because the solvents used in organic coatings can produce hazardous materials and quality issues. Physical vapor deposition (PVD) or electroplating are the methods used to apply these.

Manufacturing Process

- *Cutting:* A brass billet with the appropriate diameter is cut from brass stock. Brass is a naturally corrosion-resistant metal that is very dependable and durable. Compared to aluminum or plated steel hardware, it is smoother, heavier, and stronger.
- *Forging:* Using a time-honored method called heat forging, which involves pounding hot metal into a specially made die, skilled artisans turn raw brass into exquisite hardware. Heat forging, which yields stronger, heavier products, is more labor-intensive and meticulously detailed than casting, a simpler forging technique. Depending on the use, a hot forging machine may cost up to 3.8 lakhs.
- *Trimming:* The hardware is trimmed before it is completed. The stamping press, which trims the excess metal left by the forge, is operated by skilled workers. The smooth metal is then exposed after the forge-induced oxidation is removed by another machine grinding the surface.
- *Finishing Touch:* A variety of finishes are available, including satin nickel, venetian bronze, satin black, lifetime polished brass, and many more. Whether you want the hardware to look well-worn and vintage or clean and minimalistic, a completely different process will be involved.
- *Polishing:* In the final step of production, hardware goes through two stages of polishing the first to thoroughly remove any imperfections such as scratches or nicks and the second to buff the hardware to a flawless shine. In the first stage, fast spinning wheels wipe away potential scratches left by the forge. Then jeweler's rouge is used to carefully buff the metal.

Labour Cost

- *Skilled Labor:* The costing includes skilled labor, which includes designers, material selectors, CAD model designers, architects, and so on. In total, we must pay them for one eye frame, or about \$800 for the door handle.

- *Semi-Skilled Labor*: The average cost of this labor is between \$500 and \$600. Examples of this type of labor include fabrication, machine operators, forgers, etc.
- *Unskilled Labor*: This costing pertains to laborers without specialized training, such as porters, painters, and advertisers. The price range is roughly 300–400. Therefore, from start to finish, the cost of a single door handle ranged from Rs 300 to Rs 4000, depending on customization and additional durability.

Design for Environment

The goal of design for the environment is to create high-quality products that are reasonably priced and do not negatively impact the environment. Global warming is the world's most pressing issue right now. As we design products in the lab, we should put certain strategies or approaches into practice to address this issue.

Environmentally Friendly door Handle Design

Steel is the most recycled material in the world (not just metal); globally, it is recycled at a rate higher than that of aluminum, glass, and paper combined. Every year, more than 100 million tons of steel are recycled. Steel is among the most environmentally friendly materials since it can be recycled virtually endlessly without losing its strength.

Recycling one ton of steel saves:

- 2.5 tons of iron ore,
- 1 ton of coal
- 120 pounds of limestone
- More than 80% of the carbon dioxide emissions produced by smelting iron ore.
- The most well-known families of copper-base alloys are probably bronzes and bronzes, which are probably used in more doorknobs and door handles than any other metal.
- A variety of techniques are used to apply an organic or inorganic coating. Over 75% of the metal used by foundries, copper and brass mills, ingot makers, and other industries comes from recycled material. Epoxies, acrylics, and polyurethanes are examples of organic coatings. Manufacturers are switching to inorganic coatings based on inert metals because the solvents used in organic coatings can produce hazardous materials and quality issues. Physical vapor deposition (PVD) or electroplating are the methods used to apply these.
- Carbon Footprint of Products (CFP) is defined as Greenhouse Gas emissions (GHG) of a product through its life cycle stages, including material acquisition, production process, distribution, usage and waste management at its end of life as well as relevant transportation in each stage of the product. As car roof rack manufacturing is not complicated process it is typical forging and welding process. So forging process and welding process is having 10-20% carbon emission of manufactured part.

Product Life Cycle

A product experiences cycles and has a life of its own. While there are differences in the life cycles of various products, most products follow a traditional life cycle. The product life cycle has the following primary stages:

The Life Cycle of a Door Handle Product

Introduction (Offer) Since it's the first time the product and market have met, significant funds for promotion must be set aside at that level. Therefore, even with a product this qualified, word-of-mouth marketing is not feasible. The length of the product life cycle is influenced by the budget's size. Because of the expenses associated with promotion and supply, the new product is not profitable.

Growth Stage

A successful new product typically has a sales curve that gradually rises during the market development stage. Sales start to soar at this point in the rise due to a noticeable surge in customer

demand. The boom has begun. The second stage, which is the market growth stage, has begun. Potential rivals who have been following the action during Stage I now enter the fray. Some people bring carbon copies of the original product onto the market. Others enhance the design and functionality. And this is when the development of product and brand differentiation starts.

Data management

In this, we'll perform thorough analysis and upkeep of data related to a door handle, including component features, project structure, and material billing.

Supply Chain Management

During this phase, we will oversee the various groups, individuals, tasks, data, and assets needed to transfer goods or services from a supplier to a client. Since there are many imitation products on the market, we must take care of everything from production to customer service, making sure the customer receives an authentic door handle. Therefore, choosing a reliable seller is crucial. Transportation is crucial, and since truck owners have been stealing a lot of goods, we need to be careful.

Transaction Cost Analysis

It is a method based on financial models, transaction cost analysis (TCA) essentially looks at prices to determine whether or not goods were bought at a low price and sold at a high price. This analysis is generally performed over a specific period.

Maturity Stage

The market has matured to this new stage. Evidence of market saturation is the first indication that it has arrived. This implies that the product will be owned or used by the majority of consumer companies or households that are potential customers. Today, sales increase roughly in line with population growth. There is no need to fill any more distribution pipelines. To achieve product maturity in the market, we must continuously improve the product, conduct research on it, and make changes to it. We must develop effective marketing plans for our door handle products. When a product reaches maturity, sales meet expectations and then start to decline.

Decline Stage

When market maturity tapers off and consequently comes to an end, the product enters Stage 4—market decline. In all cases of maturity and decline the industry is transformed. Few companies can weather the competitive storm. As demand declines, the overcapacity that was already apparent during the period of maturity now becomes endemic. Even though some producers can clearly see the writing on the wall, they believe that with the right strategy and shrewd management, they will survive the industry-wide catastrophe they so vividly predict. In the event that the product enters a declining stage, we must exercise caution. With regard to product facility and application purpose, we need to gather expert opinion and customer survey data. If we want to keep the product at the mature stage in the market, we have to keep improving research and development and upgrading the door handle. Possibility of Failure: As previously mentioned, the complexity, degree of novelty, fit into customer needs, and existence of competitive substitutes all affect how long and how steeply the market development stage goes.

CONCLUSION

Market research is necessary for any product's design. Knowing the various types of doors that are available and their purposes is necessary when designing a door handle. The aforementioned process will not only assist in getting any product established in the market, but it also solves many issues and distinguishes our offering. It would be less expensive, more sustainable, and environmentally friendly to use easily recyclable materials like aluminum for recycling and inorganic materials for protection. Establishing an appropriate supply chain management system is crucial for a product's life cycle. In short whilst making product we should think of our profit but with that also think about the environment and future generation.

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