Unit 5: Design for X

A successful design must satisfy requirements other than functionality, appearance and cost. Durability and reliability have been recognized as needed attributes for many years. In term DFX “X” represents the performance measure of design, as in Design for Manufacturing(DFM),Design for Assembly(DFA),Design for Environment(DFE),Design for safety, Design for reliability.

The development of DFX methodologies was accelerated by growing emphasis on concurrent engineering. Concurrent engineering involves cross functional teams, parallel design, vendor partnering. It also emphasis on consideration of all aspects of product life cycle from outset of product design efforts. The ability to do this has been greatly facilitated by creation and use of computer software design tools. These DFX tools sometimes referred as concurrent engineering tools.

Steps in Implementing DFX strategies are:

1)Determine the issues (X) targeted for consideration

2)Determine where to give your focus

3)Identify the methods for measurement of “x” characteristics and techniques may include mathematical and experimental methods, computer modeling.

4)The DFX strategy is implemented by insisting the product development team focus on “x”, and by using parametric measurement and improvement techniques as early in design process as possible.

A)Design for Manufacture(DFM) and Design for Assembly(DFA)

A common failure in product development is making product that work but that are also very difficult to build. Difficulty in manufacturing will make product expensive.

Design for manufacturing entails making piece parts easier to produce from raw stalk. It involves application of part forming models, whether they are basic rules , analytical formulas or complex finite element process simulations.

Design for assembly entails making attachment direction and methods simpler.

DFA guidelines:

1)Minimize part count by incorporating multiple functions in to single part.

2)Modularize multiple part into single subassembly.

3)Assemble in open space and avoid confinement.

4)Make part to identify how to orient them for insertion

5)Standardize and reduce variety.

6)Maximize part summery

7)Design geometric or weight polar properties if non symmetric assembly.

8) Eliminate tangle part

9) Color code parts that are different but shaped similarly

10)Prevent nesting of parts

11) Provide orientation features on non symmetries.

12)Design mating features for assembly installation

13)Provide alignment feature

14)Insert new parts into an assembly from above

15)Never require the assembly to be turned over.

16)Eliminate fastener

17)Place fastener away from obstructions

18)Provide access to fastening tools

19)Providing flats for uniform fastening and fastening ease.

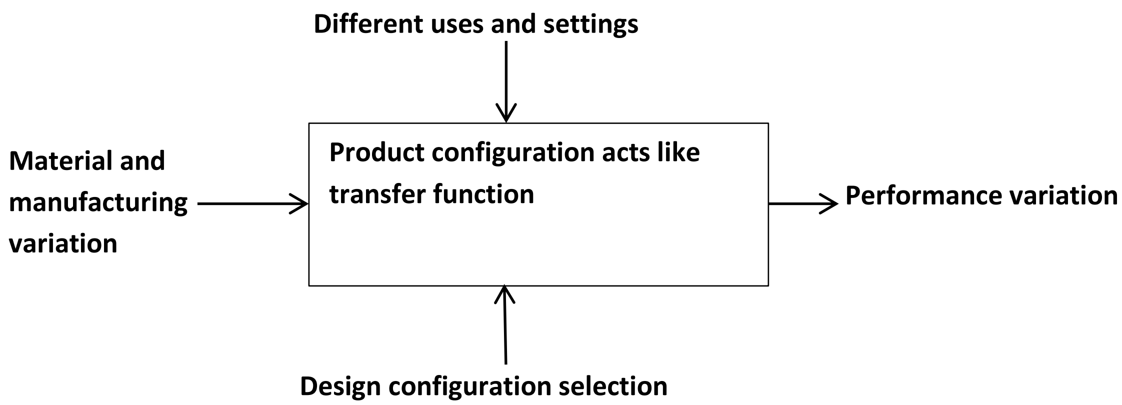
20)Proper spacing ensures allowance for fastening tools.

Application of DFA and DFM guidelines can reduce manufacturing cost and increase quality. However the guidelines does not necessary always do this like if to improve the functionality of part sometimes design of part become unnecessarily complex.

B)Design for Robustness:

There are many inherent causes of variations in process of product manufacturing, under such situation, maintaining product specification such that it satisfies the customer requirements is challenge. To achieve the target specifications consistently, we need to explore causes of deviation from specification. The task of robust design is then to select a best set of nominal configuration parameters that satisfies the performance specification with minimum deviation due to manufacture, material or use of variations. This viewpoint of robust design conforms to the ideas of customer and engineering quality. The product designer must make configuration and parametric choices to specify the product configuration as a complete dimensional, material and manufacturing description. These choices are called as design variables.

The set of variables causing variations is called as noise variables.



The task of robust design is then to construct a product model including performance, design and noise variables and then use the model to improve the design by selecting design configuration that provides low performance deviations when noise variables are free to vary.

The performance, noise and design variables must be identified then the performance variation must be measured as a noise variable. This step must be repeated at different design configurations to determine which design configuration has less performance variation ,this task involves taking a set of performance measurements and reducing them to a single rating for design configuration.

Lastly most robust configuration must be selected based upon robust rating.

C) Design For Environment

Humans can no longer think of technical and industrial society as independent sub entity of a much larger system that can extract materials from and dump waste into environment.

Design for Environment is a product design approach for reducing the impact of products on the environment.

Products can have their adverse impact on the environment during their manufacture through the use of highly polluting process and the consumption of large quantities of raw materials.

They can also have adverse impact through the consumption of large amount of energy and long half lives during their disposal. Because of this entire life cycle of product should be designed with opportunity to recycle, remanufacture and reuse and process waste to reduce environmental impact.

DFE has objectives like protect the biosphere, sustainable use of resources, reduction and disposal of waste, wise use of energy, risk reduction, compensation to environmental damage

Basic DFE methods

1)Design guidelines-These guidelines are effective method to implement which has product structure guidelines and material selection guidelines, Labeling and finishing guidelines

Structural guidelines-

i)Design product to be multifunctional

ii)Minimize number of parts

iii)Design reusable modules

iv)Locate unrecyclable parts and remove them

v)Design parts for stability during disassembly

vi)Lump individual parts with same material

vii)specify remanufactured parts

Material selection guidelines-

i)Avoid regulated and restricted materials

ii) Minimize different type of materials

iii)Use of recyclable materials

iv) High strength to weight ratio materials for moving parts.

v)Avoid use of composite and high alloy materials

Labeling and finishing process-

i)Eliminate incompatible painted parts

ii)Use electronic part documentation instead of papers

Fastening guidelines

i)Minimize number of and easy to remove fasteners

ii)eliminate adhesives unless compatible with both parts joined

iii)Minimize number of interconnecting wires and cables

iv)If two parts are not compatible, make them easy to separate

Design for Recycling

1)Use of commonly recyclable material

2)Design system to accommodate recycled products

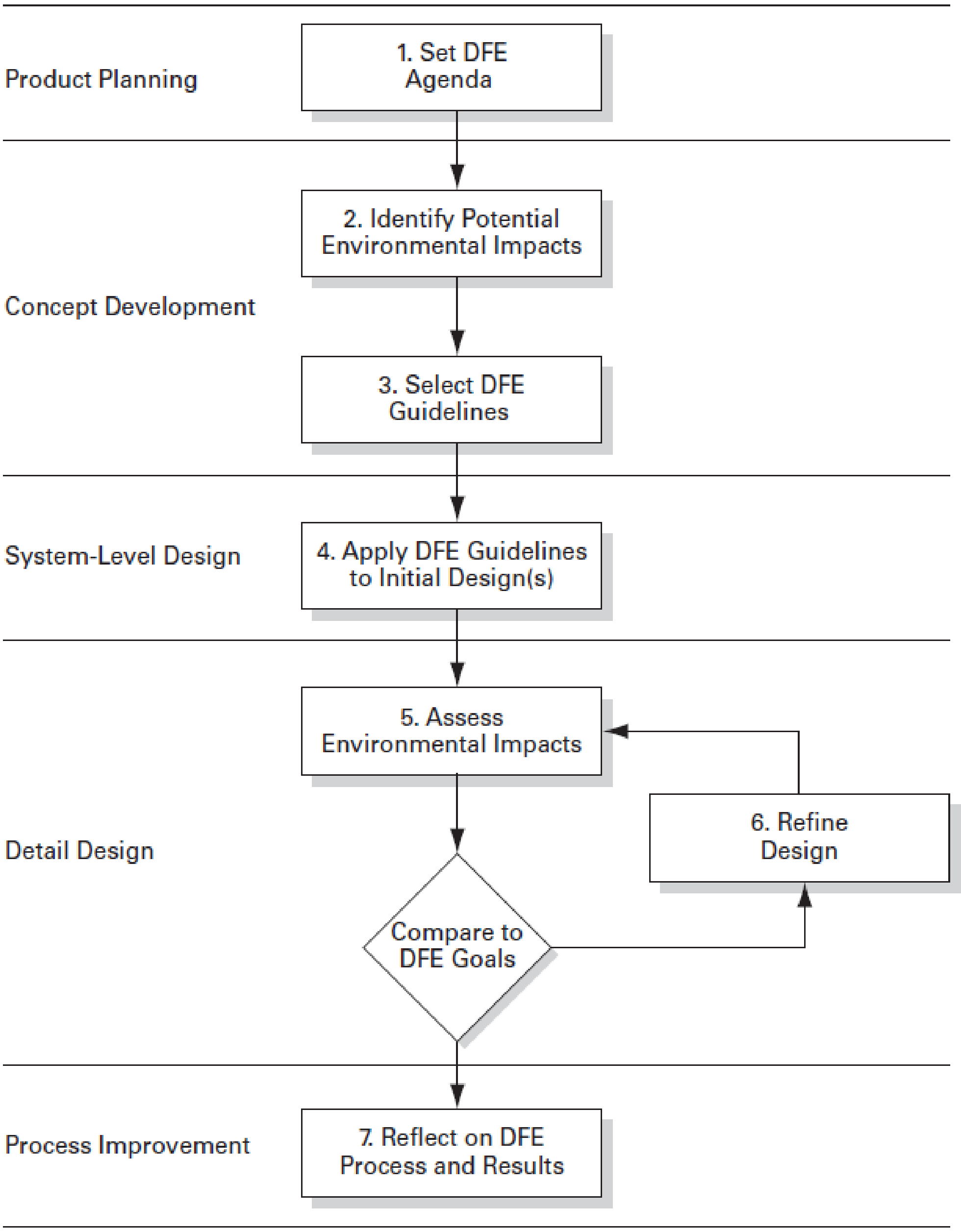
3)Avoid using materials which has high impact on environment

Enforcement of environmental law as and energy efficient standards:

International Organization for Standardization(ISO) has developed ISO14000 standards on environmental Impact management. A company certifies under ISO 14000 must establish and maintain procedure to identify and access all environmental regulations. Regular Audit procedures should be enforced for compliance.

Home appliances having BEE ratings in India are designed for low energy consumption.

Some voluntary actions like Green lighting,, Using energy efficient heating and air conditioning systems(HVAC) ,waste water treatment and recycling water material during construction of residential building or manufacturing plants are desired.



Design for Environment Process

Local, Global and Regional issues while designing:

While designing a product, many environmental issues occur at local level

Local issues like availability of resources, skilled labor, demography of customers and culture around the manufacturing environment affects quality and profitability of organization.

Regional issues like balance of ecological system around the plant area, air, water, soil and noise pollutions because of manufacturing process are key issues to be addressed in design stage itself.

Global issues like Climate change, depletion of ozone layer and minimizing biodiversity loss need to be considered while designing. These issue are being taken care by Paris agreement.

Paris Agreement: is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016. The agreement's language was negotiated by representatives of 196 countries at the 21st Conference of the Parties of the UNFCCC in Le Bourget, near Paris, France, and adopted by consensus on 12 December 2015.

Under the Paris Agreement, each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. a country to set a specific emissions target by a specific date, but each target should go beyond previously set targets. In June 2017.It has target of restricting increase in global warming below 2 degree Celsius.

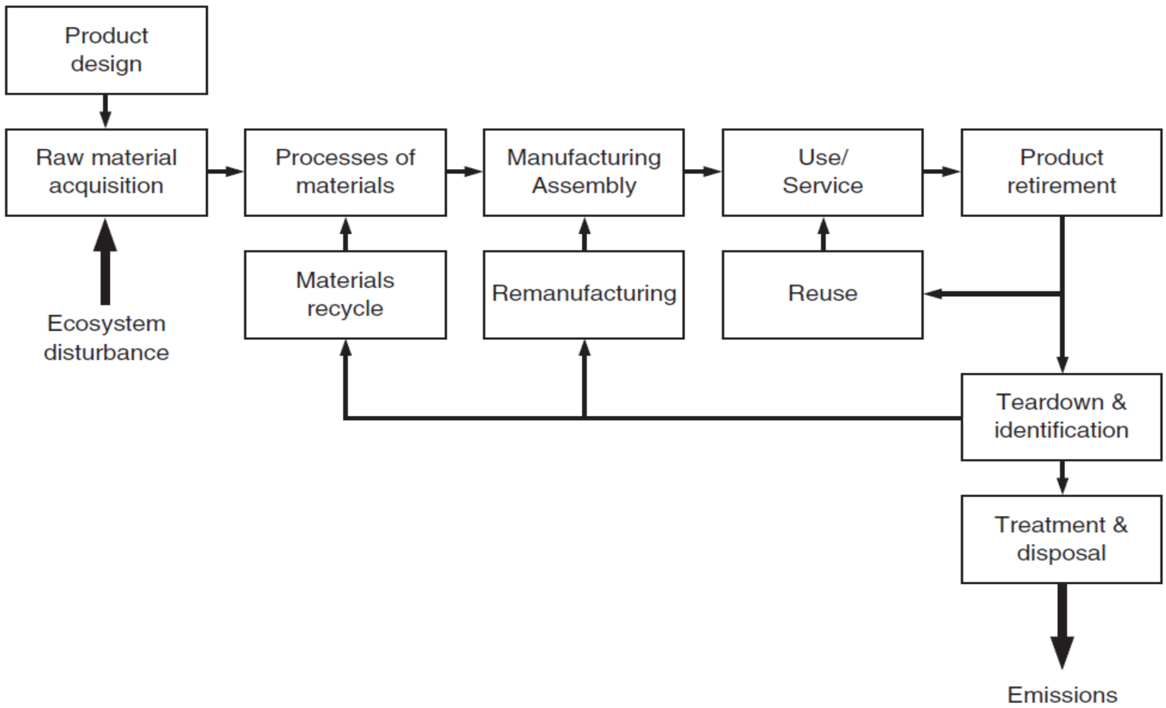
Basic lifecycle assessment-

Greater concern for environment places emphasis on life-cycle design in the product development process. Life cycle design emphasizes giving attention in embodiment design to those issues that impact a long , useful service life to the product. It means designing for long service, and eventually replacement or disposal.

Design strategies for extending life of product are as follows.

1)Design for durability 2)Design for reliability 3)Create an adaptive design

4)Repair 5)Remanufacture 6)Reuse 7)Recycling 8)Disposal



Life cycle assessment has three stages-

1) Inventory analysis-The flows of energy and materials to and from product during its life are determined quantitatively.

2) Impact analysis-Consideration of all potential environmental consequences of the flows determined in above stages

3) Improvement analysis-Result of above two steps are translated into specific actions that reduce the impact of product or process on environment.

Framework for developing lifecycle analysis

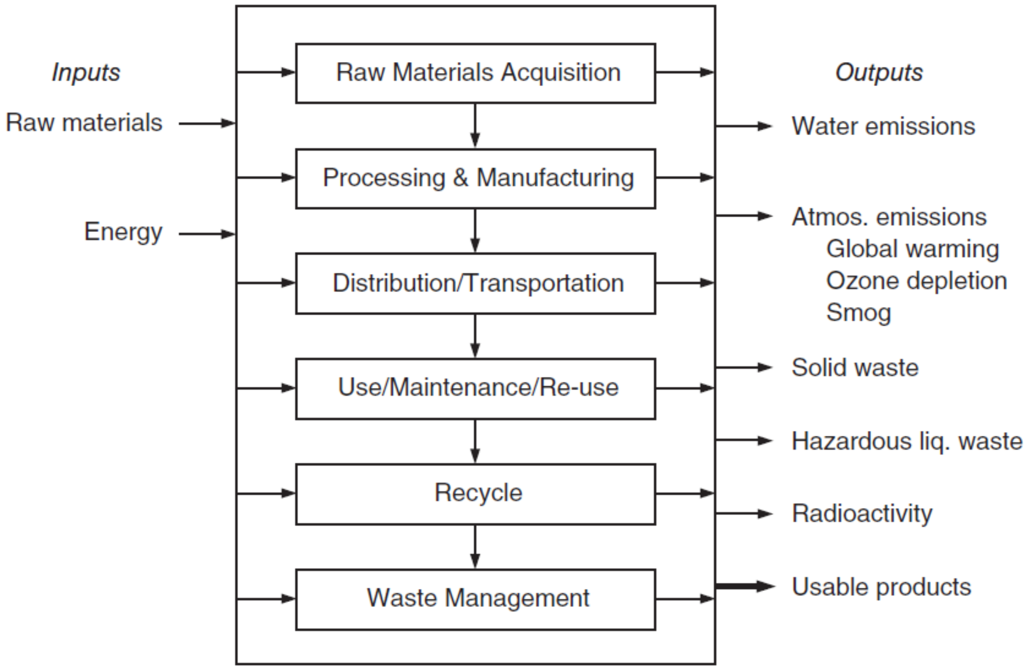


FIGURE 8.32
Framework for developing a life-cycle analysis.

D)Design for safety:

If users suffer from an accident during the normal usage of product, he would expect a compensation from manufacturer. Engineers and designers are always concern with legal aspects of safety.

Products are required to function in real life situations allowing for human errors as permitted by ergonomic factors.

Real life situations may include ignorance, negligence, and abuse. Wherever possible, safety warnings should be placed on product and emphasis fool proof designs .

If possible safety standards or guidelines must be formed for individual part and assembly system functioning as like in case of automobile.

Some common examples for design for safety are.

i)Automobile windshields are engineered to prevent shattering

ii)Keys for a car with an automatic transmission can not be removed unless the shift is in park position

iii)Automatic tripping of electrical devices to get protected from voltage surge

Workplace Environmental safety Laws or Occupational Health and safety Administration (OSHA) –

Material safety and datasheet (MSDS) for hazardous material should be maintained by manufacturer by which work safety is ensured and all associated employees of manufacturer must be trained for case of emergency.

E)Design for Reliability-

Reliability is the probability that a system , component or device will perform without failure for specific period of time under specified operating conditions.

Provision for reliability must be established during design concept stage, carried through detail design development and maintained during many steps in manufacturing.

Once the system becomes operational, it is imperative that provision be made for its continued maintenance during its service period.

Causes of unreliability in engineering systems are

1) Design mistakes

2) Manufacturing defects

3) Neglecting maintenance aspect

4) Exceed design limits

5) Environmental factors

The design strategy used to ensure reliability can fall between two broad extremes

1) Fail-safe design Approach

2) Absolute worst Approach

1)Fail safe design approach-It is weak spot in a system is identifies and monitored. The object is to design all components to have equal life so the system will fail apart at end of useful time.

e.g- fail safe is the attribute of the structure that permits it to retain its required residual strength for a period of unrepaired use after the failure or partial failure of a principal structural element like wings of airplane

2) Absolute worst case approach-Worst combination of parameters is identifies and the design is based on the premise that all can go wrong at same time .This is very conservative approach and often lead to overdesign.

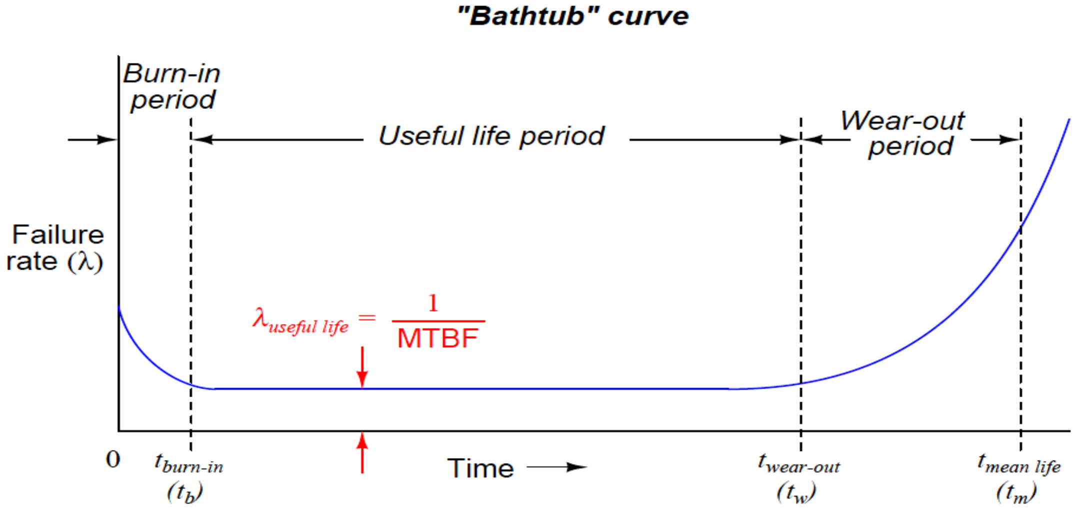
e.g- the worst-case scenario is a useful device when low probability events may result in a catastrophe that must be avoided even at great cost like design of dams.

Reliability is ensured in different design stages through different design activities as follows

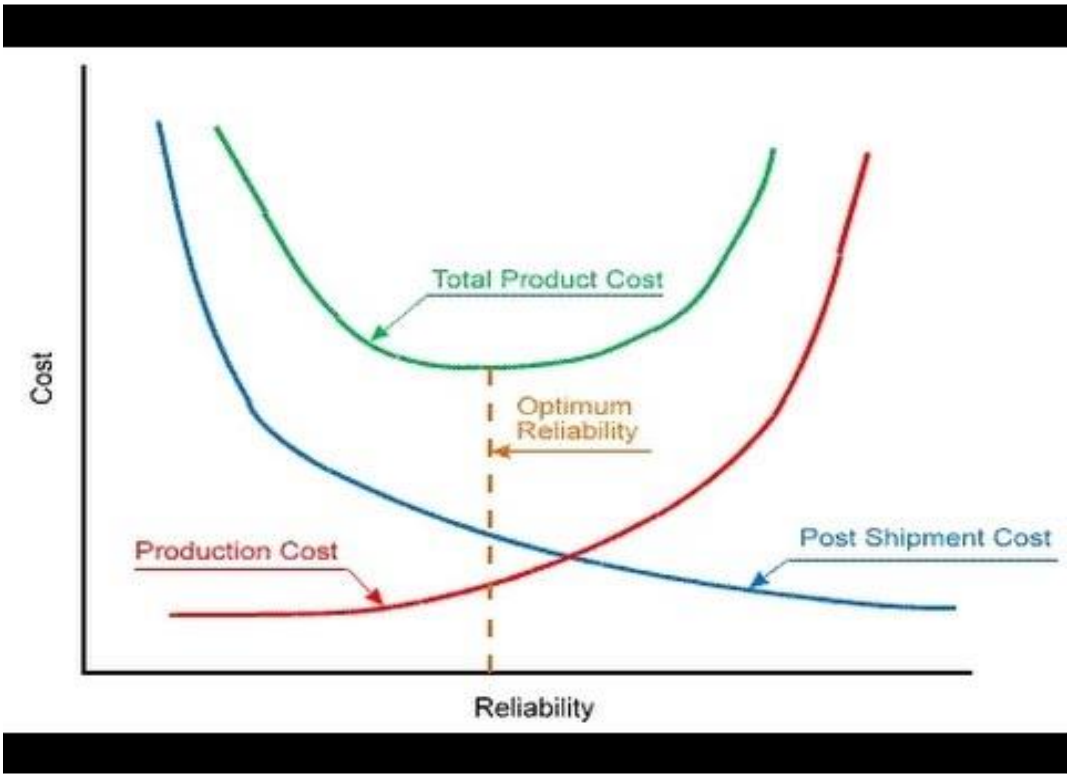
Design stage	**Design Activity**
Conceptual Design	Problem definition: 1)Estimate reliability requirements 2)Determine likely service environments
Embodiment Design	Configuration Design 1)Investigating redundancies 2)Provide accessibility for maintenance Parametric Design 1)Select highly reliable components 2)Build and test physical components 3)Full environmental test 4)Establish Failure modes/FMEA 5)Establish MTBF(Mean time Between Failures) 6)Use trails and modifications
Detail design	1)Produce and test production prototype 2)Final estimate of reliability.

Influence of reliability on product cost:

Below curve shows relation of failure rate with service period for electronic component



Below curve shows impact of reliability on product cost.

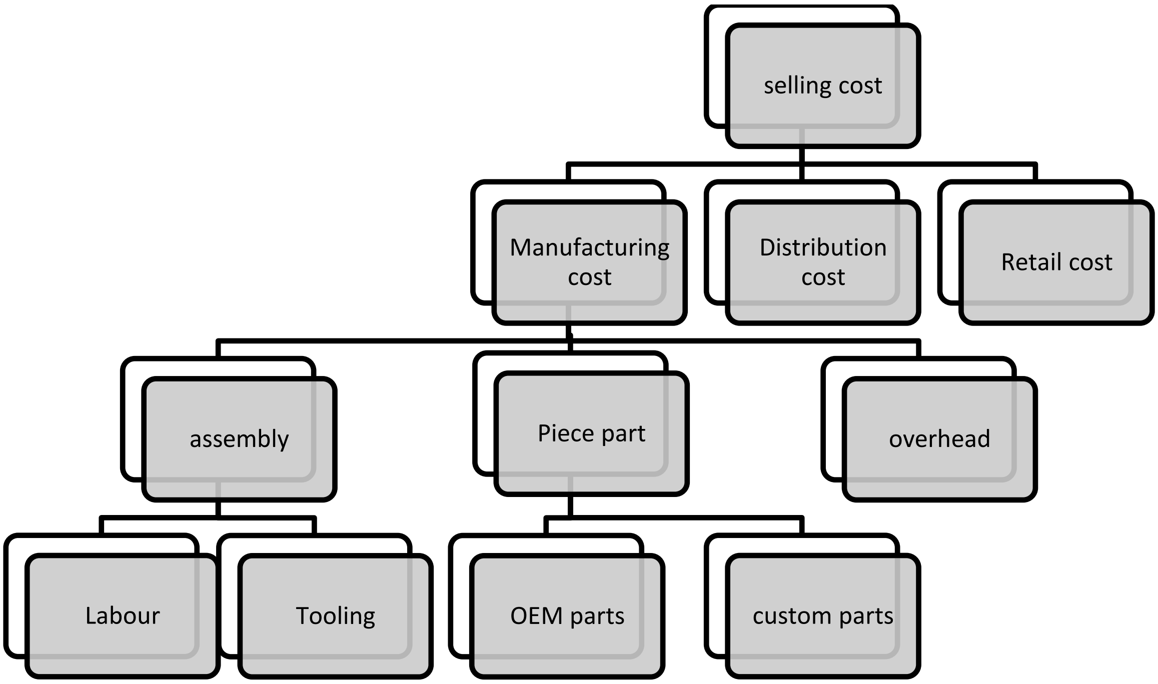


Manufacturing cost Analysis:

Understanding the cost structure designed into product is important for deciding what portion of design is more appropriate for detailed cost reducing activity and for comparing different design concepts.

80% cost reduction can occur in top 20% of relatively high cost components by using techniques of assembly simplification.

Production cost analysis breakdown shown in figure



To simplify cost estimation, normal ratios are established between example:

Material cost: Direct cost: Selling cost=1:3:9

Direct cost includes power, labor, equipment, packaging, machine maintenance, material cost

Indirect cost includes Administrative cost, sales cost, commissioning cost, rent utilities, employee benefits, Research and development cost, warranty, patent and royalty, interest paid on borrowed capital

Total cost=variable cost*Quantity+ Fixed cost

Unit cost=variable cost+ (Fixed cost/quantity)

Some aspects which will lower the cost of manufacturing, if they are considered during stage of design are

1) Standardization 2)Modular design 3)Group Technology 4)Automation

5)Assembly line 6)Specification & tolerance 7)Compact design 8)Foldable or telescopic design 9)Complementary product planning 10)Use of available stock

Design Failure mode Effect Analysis-(DFMEA)

References:

1)Product design book by Kevin Otto and Kristin woods

2)Engineering Design by George E Dieter

3)Product Design and development by Karl T Ulrich and Steven Eppinger

4) Various Web sources

Note-These notes are prepared for subject of Product Design Development (PDD) as per syllabus of University of Pune .
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