Module 4 - 15 % Marks

4 Hours Lecture
Design for “X”; covering quality, reliability, safety, manufacturing/construction, assembly, maintenance, logistics, handling; disassembly; recycling; re-engineering etc. List out the design requirements(x) for designing a rocket etc.

4 Hours Project
Design mineral water bottles that could be packed compactly for transportation.
DESIGN FOR “X”

- Initial design based on *function, appearance & cost*
- Other major objectives than those dealt in initial design
  Design for “X”, Where, X= Design objective
  (other than those dealt during initial stages of design)

- Some of the objectives are:
  Design for Manufacturing/Construction
  Design for Assembly/Fitting
  Design for Safety and Reliability
  Design for Maintenance & Serviceability
  Design for Logistics
  Design for Disassembly and Recycling
DESIGN FOR MANUFACTURING/CONSTRUCTION

DFM is based on: Minimizing Cost of production
Minimizing Time to market while maintaining appropriate level of quality.

- First design team is formed: include engineers, managers, logistics specialists, accountants, marketing & sales professionals.

- Reduction in parts and their costs
- Use of standard parts/subcontracted items.
- Change in materials if possible.
- Use wider tolerances wherever possible.
- Design using Group Technology.
Who Casts the biggest shadow?

- Design: 5%
- Material: 50%
- Labor: 15%
- Overhead: 30%
- Influence: 20%
- Product Cost:
Design for X

X = MANUFACTURING
X = ASSEMBLY
X = RELIABILITY
X = MAINTAINABILITY
X = SERVICEABILITY
X = ENVIRONMENT
X = LIFE CYCLE COST
Design for manufacturability (DFM) is the general engineering art of designing products in such a way that they are easy to manufacture.
Design for Manufacturing (DFM)

- Designing or engineering a product in order to facilitate the manufacturing process
- Reduce manufacturing cost
- Designer should consider the type of raw material and the form of the raw material
- Optimize all the manufacturing functions: fabrication, assembly, test, shipping, delivery, service, and repair
- Assure the best cost, quality, reliability, regulatory compliance, safety, time-to-market, and customer satisfaction.
DFM GUIDELINES

1. Simplify the design and reduce the number of parts

The reduction of the number of parts in a product is probably the best opportunity for reducing manufacturing costs. Less parts implies less purchases, inventory, handling, processing time, development time, equipment, engineering time, assembly difficulty, service inspection, testing, etc.
2. Develop a modular design

The use of modules in product design simplifies manufacturing activities such as inspection, testing, assembly, purchasing, redesign, maintenance, service, and so on.
3. Use of standard components

Standard components are less expensive than custom-made items. The high availability of these components reduces product lead times. Also, their reliability factors are well ascertained. Furthermore, the use of standard components refers to the production pressure to the supplier, relieving in part the manufacture’s concern of meeting production schedules.
3. Design parts to be multi-functional

Multi-functional parts reduce the total number of parts in a design, thus, obtaining the benefits given in rule.

Automobile chassis act as structural member as well as electricity earthing line.

Bike engine casing act as heat dissipater.
4. Design for ease of fabrication

Select the optimum combination between the material and fabrication process to minimize the overall manufacturing cost. In general, final operations such as painting, polishing, finish machining, etc. should be avoided. Excessive tolerance, surface-finish requirement, and so on are commonly found problems that result in higher than necessary production cost.

5. Provide Tolerance

Each manufacturing process has an inherent ability to maintain a certain range of tolerances, and to produce a certain surface roughness (finish). To achieve tolerances outside of the normal range requires special processing that typically results in an exponential increase in the manufacturing cost.
Design for Assembly (DFA)
It is a subset of DFM which involves the minimization of cost of assembly

- **To maximize ease of assembly**
  - Part is inserted from top
  - Part is self aligned
  - Part does not need to be oriented
  - Part requires only one hand for assembly
  - Part require no tool
  - Part is assembled in single linear motion
  - Part is secured immediately upon insertion
Design for uni-directional assembly preferably using gravity. Assembly to a stable base.

Design parts by considering access and visibility for ease of insertion.

Self Aligned Parts

Uni-directional insertion

Avoid separate fasteners: design the fastening functions into the parts.
Use hustle free joining methods

Snap Joints
MISTAKE PROOFING ISSUES (POKA-YOKE)

- Cannot assemble wrong part
- Cannot omit part
- Cannot assemble part wrong way around.
Annular Snap-Fits

A pen utilizes an annular snap fit to retain the cap.

A ball and socket joint is a kind of annular snap fit.

Bottle cap uses an annular snap fit.
Three solutions to the same design issue.

Comments?
Which do you prefer?
Why?
Design for Reliability

**Reliability** is defined as the probability that a component, equipment or system will satisfactorily perform its intended function under given circumstances.

**Improving Reliability**

- Making failures less likely to happen in the first place  
  (e.g. By maintaining the equipment properly or fitting more reliable equipment)
- Making changes such that the overall system continues to function satisfactorily even when a failure occurs  
  (e.g. By fitting standby equipment)
Reliability Network

Series Connection

Parallel Connection

Series-Parallel Network
DESIGN FOR SAFETY & RELIABILITY

- Product safety is to be ensured in design.
- This covers the materials used, design aspects on safety in operation, fool proofing, warning systems etc.
- They prepare test plans and go accordingly.

..\Innovative designs\Video 17 Crash Test New Mercedes SLS AMG 2010.mp4

..\Innovative designs\Video 18 Turbine engine explodes.mp4

Providing ordnance in space vehicles as ultimate safety tool.

In order to improve the reliability redundant systems are used in specific designs.
The objective of Design for Maintainability is to assure that the design will perform satisfactorily throughout its intended life with a minimum expenditure of budget and effort. Design for maintainability (DFM), Design for Serviceability (DFS), and Design for Reliability (DFR) are related because minimizing maintenance and facilitating service can be achieved by improving reliability.

An effective DFM minimizes
1. The downtime for maintenance,
2. user and technician maintenance time,
3. personnel injury resulting from maintenance tasks,
4. cost resulting from maintainability features, and
5. logistics requirements for replacement parts, backup units, and personnel
Types of Maintenance
Improving Maintainability

- Minimize the number of serviceable design parameters (DPs) with simple procedures and skills.
- Provide easy access to the serviceable DPs by placing them in serviceable locations. This will also enhance the visual inspection process for failure identification.
- Use common fasteners and attachment methods.
- Design for minimum hand tools.
- Provide for safety devices (guards, covers, switches, etc.)
- Design for minimum adjustment and make adjustable DPs accessible.
Placing projector bulb at accessible location reduces maintenance.

Use standard fasteners.

Providing protective casing is DSM.

Easy access to Watch battery is a Maintainability consideration.
Design for Environment

Design for the Environment (DFE) is a design approach to reduce the overall human health and environmental impact of a product, process or service, where impacts are considered across its life cycle.

- Design for environmental processing and manufacturing
- Design for environmental packaging
- Design for disposal or reuse
- Design for energy efficiency
DESIGN FOR LOGISTICS

- Design for packaging, handling, transportation and storage.
- Design for seamless transportation.
- Optimal packaging to save space and damage.
- Provision for product handling with safety.
Design for Life cycle cost

1 | PRODUCT CONCEPT
Function
Cost
Use Issues
Industry Problems

2 | ENVIRONMENTAL ISSUES
Environment of Use
Material Footprint
Manufacturing Footprint
Longevity

3 | END-OF-LIFE ISSUES
Disposal vs Recycling
Material Dispersal
Closing the Loop

4 | DESIGN
Design for Use
Material Choice
Manufacturing Method

5 | FINAL REVIEW
Product Concept
Environmental Issues
End-of-Life Issues
Packaging

6 | MANUFACTURING
Sourcing
Certification
Scheduling
Prototypes

7 | END-OF-LIFE
Store/Consumer Recycling
Leasing options
Waste Stream

8 | REUSE
Recycled Municipally
Recycled by GHG
Design for Disassembly & Recycling

Design for disassembly is the strategy that considering the future need of a product that to be disassembled for repair, refurbish or recycle.
How Many Lifetimes?
Mixed Materials
Separating Materials
Disassembly Allows…

- Repair
- Upgrade
Race Against Time
Disassembly Strategies
Redesign for Disassembly
Biodegrading
Recycling/Reuse
Recyclability Strategies
Downcycling/Recycling/Upcycling
Redesign for Recycling
Take back Programs