Session 2

General Design Principles for Manufacturability

Lecture delivered by

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Session Objectives

At the end of this session the delegate would have understood the general design principles for manufacturability -

- Simplicity of design
- Use of most processable and available materials, standard components and assemblies
- Specifying liberal tolerances appropriate with the manufacturing process and avoiding additional operations
- Design for expected production quantities
- Teamwork across the organisation
- Use of appropriate software tools for Design and PDM
Session Topics

- Simplicity of Design
- Standard Materials and Components
- Standardised Product Design
- Liberal Tolerances
- Use of the most processable materials
Session Topics

• Teamwork across the Organisation
• Avoidance of Secondary operations
• Design for the expected production Quantities
• Utilising Special process Characteristics
• Taking care of process requirements
• Use of appropriate software tools for product design, tool design, and PDM
Simplicity of Design

Other factors being equal, the product with
• The fewest parts
• The least intricate shape
• The fewest intricate adjustments
• The shortest manufacturing sequence
will be the least costly to produce
It will also be the most reliable
and easiest to service
Simplicity of Design-Examples

• Televisions - cabinet and back cover design, PCB fixing, touch button, power knob, rear connectors
• ECG recorder - paper loading, motor assembly, main PCB assembly, key PCB assembly and decal
• ECG recorder – redesign of existing model using existing circuit and printer module design
• Defibrillator - Printer module based on ECG design, HV connector
• Defibrillator - new design with reduced features, using existing PCBs
Television Receiver
ECG Recorder
Defibrillator
Defibrillator
Standard Materials and Components

Use of widely available and standard materials enables

• Cost benefits of mass production even at low quantity production
• Speeds manufacturing cycle
• Simplifies inventory management
• Eases purchase
• Avoids tooling investments
• Avoids equipment investment
• Reduces processing costs
• Reduces inspection costs
Standard Materials and Components
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Standard Materials and Components
Standardised Product Design

When several similar products are to be produced, specify
• Same materials
• Same parts
• Same sub assemblies
  as far as possible
This approach will
• Provide economies of scale for component production
• Simplify process control
• Simplify operator training
• Reduce investment on tooling and equipment
Standardised Product Design
Standardised Product Design
Standardised Product Design
Liberal Tolerances

Closer tolerances leads to higher cost owing to

• Extra operations after primary process/ operation
• Higher tooling costs
• Higher tool maintenance costs as the tools wear
• Longer operating cycles
• Higher scrap and rework costs
• Need for more skilled and highly trained workers
• Higher material costs
• More investments for precision equipment
Tolerances in Sheet Metal Parts
Tolerances in Casting and Machining
Tolerances In Injection Moulding
Use of the most processible materials

Advantages are

• Reduced cycle time
• Optimum cutting speed
• Flowability
• Increased tool life

Examples are free cutting steels, appropriate draw quality sheets, moulding resins with good melt flow index

The most economical material in the long run is decided by the total cost of material, processing, warranty and service charges over the designed life of the product
Free Cutting Steels
Drawing Quality Sheets
Plastic Resins with Good Melt Flow Index
Teamwork across the Organisation

• The most producible designs are provided when the Design team works closely with manufacturing, service, marketing and procurement teams from the early stages.
• Design reviews are held at different stages of the product development cycle.
• This concurrent engineering approach may increase the design time, but reduces the product development time and reduces modifications after production release.
# Product Development Stages

<table>
<thead>
<tr>
<th>Phase 0</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept evaluation</td>
<td>Planning &amp; specification</td>
<td>Development</td>
<td>Test &amp; evaluation</td>
<td>Product release</td>
</tr>
</tbody>
</table>

- **Phase 0 (Concept Evaluation)**: Evaluation of initial ideas and feasibility studies.
- **Phase 1 (Planning & Specification)**: Detailed planning and specification of the product.
- **Phase 2 (Development)**: Development of the product.
- **Phase 3 (Test & Evaluation)**: Testing and evaluation to ensure quality.
- **Phase 4 (Product Release)**: Release of the product to the market.

**Stability in volume manufacturing**

- Redirect: Decision to go back to previous phase.
- Go: Decision to proceed to next phase.
- No: Decision to stop and abandon the project.
Concurrent Engineering
Avoidance of Secondary operations

• Design should aim at eliminating or simplifying secondary operations, which may prove as expensive as the primary operation.

• Examples are additional machining operations, deburring, inspection, plating or painting, heat treatment, material handling.

• Material selection, process selection and shape provided by design to be done suitably.
Manual Deburring
Vibratory Deburring
Chemical Deburring
In Process Inspection
Design for the expected production Quantities

• Design dictates tooling and production costs
• For low production quantities, tooling costs should be low, hence the design should be done accordingly- example sand castings, thermoformed parts, sheet metal parts made on turret punch press and press brake
• For high production quantities, tooling costs can be higher and the design should be done accordingly- example die castings, injection moulded parts, sintered parts, sheet metal pressed parts made from press tools. Production cost per piece with mass production tooling will be less than that with low cost tooling
• In all cases, the product cost including amortised tooling cost should be optimised
Design for Low Volume production
Design for Low Volume production
Design for Low Volume production
Design for High Volume Production
Design for High Volume Production
Design for High Volume Production
Design for High Volume Production
Utilising Special process Characteristics

Designers should take advantage of special process characteristics

• Injection moulded parts can have colour, texture, flame retardant properties and EMI shielding incorporated in them

• Some plastic materials can provide living hinges

• Powder metal parts provide self lubrication

• CNC machines can generate complicated profiles for small quantity production without investment on tooling

• Non conventional processes can machine thin, hard or fragile parts

• Non conventional processes can produce burr free parts or deburr parts made by conventional machining
Colour and Texture of Injection Moulded Parts
Colour and Texture of Injection Moulded Parts
Living Hinges
Living Hinges
Self Lubricating Parts
CNC machined Parts
Photochemical machining
Laser machining
Taking care of process requirements

• Designers should specify final characteristics in their drawings

• Manufacturing engineers should be consulted in deciding process characteristics like draft angles, rib thickness, surface texture

• Gate positions in injection moulded parts can be covered with a decal

• Design can be made to avoid side core construction

• Design tools for use on available equipment with quick loading and unloading (SMED) eg – collets, cutting tools, punches and dies, press tools, moulds
Gating Design, Ribs and Draft
SMED

Five Step Approach

1. Preliminary Stage
2. Analysis Phase
3. Identify Internal and External Elements
4. Convert Internal to External Where Possible
5. Reduce Internal and External Times
Use of appropriate software tools for product design, tool design, and PDM

- Use of CAD systems enables top down design, use of standard and library parts, modularity, and faster design of platform products
- Use of CAM systems enables faster creation of tool designs and CNC machine programmes for component and tooling, and also for modifications or manufacture of similar components or tooling at a later date
- Use of PDM tools enables design control and part/assembly modification control across the organisation for production, service and vendors
CAD Software
PDM Software
Summary

The general design principles for manufacturability are critical for development of effective designs in terms of cost, quality, serviceability and time to market

• Simplicity of design
• Use of standard materials, components and assemblies
• Specifying liberal tolerances appropriate with manufacturing process
• Design for expected production volumes
• Teamwork across the organisation
• Use of software tools for Design and PDM