11) Design for Manufacturing

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Design For Manufacturing (DFM)?

Product Development Process

DFM in product development

DFM emphasizes manufacturing issues throughout the development process primarily at system level design and detail design?

Successful DFM results in lower production cost without sacrificing product quality.
What is (DFM)?

What is DFM?
DFM is a process describes techniques for products/assembly/components designs which:
(a) Determine appropriate processes achieving manufacturability and assembly.
(b) Consider factors affect the manufacturability such as the type of processes used, raw material form and type, and dimensional tolerances.
Why (DFM)?

Why DFM?
It is used to ease manufacturing providing:
(a) Shorter processing time to manufacture/assemble.
(b) Reducing Cost of manufacturing and assembly, and
(c) Reproducibility of parts and product
(d) Increase quality
(e) Improve reliability
What are the objectives of (DFMA)?

1) Material and Process selection and understanding their impact on design
2) Process planning avoiding expensive and timely processes
3) Simplification (reducing number of processes of manufacturing and number of parts in an assembly)
4) Cost estimating of manufacturing and assembly
5) Time estimating of manufacturing and assembly
6) Taking into account product maintainability (adequate access and unrestricted vision)
7) Considering product packaging and handling
Example for (DFM)?

Before DFM

After DFM
Examable for (DFM)?

From examples notice that:
- Less complexity, parts to design, document (BOM), parts to receive, inspect, store, handle, revise
- Simpler assembly instructions and faster assembly
- Less cost
- Better quality
- Better position in the marketplace
What are the activities of DFMA?

- Identify parts and assembly needed considering their designs for easing manufacturing, assembly, maintainability, and increasing reliability.
- Define the suitable processes easing manufacturing and assembly, increasing quality.
- Estimate the time and cost required for manufacturing and assembly.
DFMA Guidelines

1) **Simplify design (minimize the number of parts):** this *results* in cheaper product, fewer assemblies, part manufacturing, inspection, inventory, etc.

2) **Use Modular design:** this *leads to* simplifies the manufacturing process, use of standard components, tests of modules operation.
3) **Use Standard components:** it provides less expensive and proven component and no need for development.

4) **Design parts for Multi-functional:** this leads to reduction of parts, manufacturing time, inventory cost.

5) **Design part for Multi use:** the part is used for the same or different operations multiple times in a product. This leads to reduce the number of parts that need to be developed.

6) **Design to allow assembly in open spaces,** this leads to that important components not confined or buried, and easing maintainability
6) **Design Parts indicating orientation for insertion.** Parts should have self-locking features so that the precise alignment during assembly is not required. Or, provide marks (indentation) to make orientation easier.

7) **Integrate design:** integration/combination of parts depends on the need of movement relative to others, use of different materials, need to separate to allow assembly access, or repair and need not tangle or stick to each other.
8) **Differentiate between similar parts:** Distinguish different parts that are shaped similarly by non-geometric means, such as color coding.

9) **Design parts to prevent nesting.** Nesting is when parts are stacked on top of one another clamp to one another, for example, cups and coffee lids.
11) **Maximize the ease of inserting parts:** Design the mating parts for easy insertion. Provide allowance on each part to compensate for variation in part dimensions.

12) **Design for stability.** Design the first part large and wide to be stable and then assemble the smaller parts on top of it sequentially.
**DFMA Guidelines**

10) **Design for alignment/orientation:** Design parts with orienting features to make alignment easier.

13) **Minimize Assembly Directions:**
Optimal assembly of a product occurs in one direction (Preferred direction is from above using gravity to assist in assembly). If you cannot assemble parts from the top down exclusively, then minimize the number of insertion direction. Never require the assembly to be turned over.
14) Avoid Separate Fasteners: design fasteners appropriately. Joining parts can be done with fasteners (screws, nuts and bolts, rivets), snap fits, welds or adhesives.

- Eliminate fasteners.
- Proper spacing insures allowance for a fastening tool.
- Deep channels should be sufficiently wide to provide access to fastening tools. No channel is best.
- Place fasteners away from obstructions.
- Providing flats for uniform fastening and fastening ease.
**DFMA Guidelines**

15) **Maximize compliance:** this leads to reduce Errors in insertion due to positioning and dimensional variability cause damage to parts. Use tapers, chamfers and moderate radii to ease insertion.

16) **Maximize the ease of handling parts:** this results in reducing time and cost of Positioning, orienting, and fixing a part. Use external guiding features to orient the part and Ideally the part should be placed one time.

17) **Design part eliminate unnecessary process steps:** this reduces the number of steps of the production process resulting usually in reduce costs. Use substitution steps, where applicable. Analysis Tool – Process Flow Chart and Value Stream Mapping.
18) **Design and simplify process for ease of manufacturing:** This concerns with design of products ability to be easily manufactured. This differ from process to other. **For examples:**

**a) For injection molding:**

Avoid sharp corners, they produce high stress and obstruct material flow.

Provide adequate draft angle for easier mold removal.

- **Don’t**
  - No draft
  - Add thickness for draft

- **Do**
  - 2° min

Keep section thickness uniform around bosses.

Don’t
- Potential sink marks and voids

Do
- Attach bosses to walls with ribs
- Gusset free standing ribs
18) **Design and simplify process for ease of manufacturing:** This concerns with design of products ability to be easily manufactured. This differ from process to other. **For examples:**

**b) For casting process:**

<table>
<thead>
<tr>
<th>Do</th>
<th>Don’t</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

- Stagger ribs to prevent hot spots.
- Avoid abrupt changes in section thickness.

<table>
<thead>
<tr>
<th>Do</th>
<th>Don’t</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

- Maintain section thickness uniform.
18) **Design and simplify process for ease of manufacturing:** This concerns with design of products ability to be easily manufactured. This differ from process to other. **For examples:**

c) **For sheet metal processing:**

Don’t

On Paper

What will happen

Bulge

Web

Ear

A narrow web will cause bulging. Provide an ear in the blank or include the hole as a notch.

Don’t

Tear

R

Offset bends.

Do

R

R

cutout
18) **Design and simplify process for ease of manufacturing:** This concerns with design of products ability to be easily manufactured. This differ from process to other. *For examples:*

**d) For machining processing:**

- **Don't**
  - Use standard dimensions.
  - Design for reasonable internal pockets radii.
  - Use 1/4 - 1/2 radius for radius smaller than 1/4”.

- **Do**
  - Use 0.627”.
  - Use 0.625”.
  - Do not design impossible to machine hollows or overhangs.
  - Place holes away from corners and edges.
  - Avoid thin walls that break when machining.

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**DFMA Guidelines?**
DFMA Guidelines?

- One assembly direction “tops down”
- No adjustments required
- No hidden features

- Test direction access from top

- Sub-assemblies reduce handling of small hard to grip parts

- Holes large enough (straightness issues if too deep)

- Common datum’s for all fixtures
- One common plane for assembly
- Tabs for robotic lift

- Easy to fabricate parts

- Standard parts (one screw type)

- Parts are self-guiding

- Avoid tangle with use of fixtures

- Symmetry in two axis

- Die cast with minimal amount of holes (debris chip)
- Standard cutters
- Guide features

- Bottom rails for conveyor

Design For Manufacturability (DFM), ppt - Steve Hanssen
San Jose State University - September 15, 2004
Three Methods to Implement DFM

1) Organization: Cross-Functional Teams
2) Design Rules: Specialized by Firm
3) CAD Tools: Boothroyd-Dewhurst Software

1) **Estimate the manufacturing costs.**
2) **Reduce the costs of components.**
3) **Reduce the costs of assembly.**
4) **Reduce the costs of supporting production.**
5) **Consider the impact of DFM decisions on other factors.**

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**DFM Method**

1. **Proposed Design**
   - **Estimate the Manufacturing Costs**
     - **Reduce the Costs of Components**
     - **Reduce the Costs of Assembly**
     - **Reduce the Costs of Supporting Production**
   - **Consider the Impact of DFM Decisions on Other Factors**
     - **Recompute the Manufacturing Costs**
   - **Good Enough?**
     - **N**
       - **Not Acceptable Design**
     - **Y**
       - **Acceptable Design**
1- Estimate the Manufacturing Costs

- Equipment
- Information
- Tooling
- Raw Materials
- Labor
- Purchased Components
- Energy
- Supplies
- Services
- Waste
- Finished Goods
1- Estimate Manufacturing Costs

Manufacturing Cost = Sum of all the expenditures for the inputs of the system (i.e. purchased components, energy, raw materials, etc.) and for disposal of the wastes produced by the system
1- Estimate Manufacturing Costs

Manufacturing Cost can be divided to (Fixed costs + Variable costs)

- Fixed Costs: it is the cost incurred in a predetermined amount, regardless of number of units produced (i.e. setting up the factory work area or cost of an injection mold)
- Variable Costs: it is incurred in direct proportion to the number of units produced (i.e. cost of raw materials, labor cost)

Cost estimating is based on of use the bill of material added to it cost information for each component

For standard component; cost estimates from comparing part purchased or produced

For custom component; fixed and variable cost are estimated.
**Example:**

**Manufacturing Cost**

From nook: product design and development, by Karl Ulrich and Steven Eppinger, McGraw-Hill.
2- Reduce the Cost of Components

- By Understanding the Process Constraints and Cost Drivers
  - Redesign costly parts with the same performance while avoiding high manufacturing costs.
  - Work closely with design engineers—raise awareness of difficult operations and high costs.

- By Redesigning Components Eliminate Processing Steps

- By Choosing the Appropriate Economic Scale for the Part Process
  - The unit cost of a component decreases as the production volume increases.
2- Reduce the Cost of Components

- By Standardizing Components and Processes
  - This leads to be common to more than one product. Use analysis tools, such as group technology and mass customization.

- By Adhering to “Black Box” Component Procurement
  - Successful black box design requires clear definitions of the functions, interfaces, and interactions of each component based on the description of what the component has to do, not how to achieve it.
3- Reduce the Costs of Assembly

- By Design for Assembly (DFA) index
  - Compute Assembly Time; = Handling Time + Insertion Time
  - DFA index = (Theoretical minimum number of parts) x(3 seconds)/ (Estimated total assembly time)
  - The Theoretical minimum number of parts is determined based on part need to move relative to the rest of the assembly, made of a different material from the rest of the assembly for fundamental physical reasons, and has to be separated from the assembly for assembly access, replacement, or repair.

- By Integrated Parts (Advantages and Disadvantages)
  - This results in no assembly is required; less expensive to fabricate; allowing control of critical geometric features to be controlled by the part fabrication process versus a similar assembly process.
  - However, it may Conflicts with other sound approaches to minimize costs and not always a wise strategy
3- Reduce the Costs of Assembly

- By Maximizing Ease of Assembly
  - Insert part from the top of the assembly
  - Assemble the part in a single, linear motion
  - Self-aligning part
  - Securing the part immediately upon insertion
  - Part does not need to be oriented
  - Part requires only one hand for assembly
  - Part requires no tools

- By Considering Customer Assembly
  - Customers accept some assembly
  - Design product so that customers can easily assemble parts correctly
  - Customers will likely ignore directions
4- Reduce the Costs of Supporting Production

- Minimize Systemic Complexity (inputs, outputs, and transforming processes)
  - Use smart design decisions

- Error Proofing
  - Anticipate possible failure modes
  - Take appropriate corrective actions in the early stages
  - Use color coding to easily identify similar looking, but different parts
5- Consider the Impact of DFM Decisions on Other Factors

- Impact of DFM on Development Time
- Impact of DFM on Development Cost
- Impact of DFM on Product Quality
- Impact of DFM on External Factors
  - Component reuse
  - Life cycle costs
DFM Strategy is Contingent

Corporate Strategy

Production Strategy

Product Strategy

DFM Strategy