Product Development
Design for Manufacturing and Assembly (DFMA)

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Overview

Whey do we develop a product?

To create customer value.
Overview

Quality

Cost

Schedule
Product Development Process

- Research
- Product Characterization
- Concept Design
- Detailed Design
- Prototyping
- Manufacturing
- Product Lifespan
- Product Recycling
Product Manufacturing Cycle

- Product Design
- Manufacturing Review
- Tooling
- Processing
- Assembly
- Quality Control
Knowledge and Learning

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Design for Manufacturing and Assembly (DFMA)

Design for Manufacturing (DFM)

Design for Assembly (DFA)
Design for Manufacturing (DFM)

Design for Manufacturing

Definition: DFM is the method of design for ease of manufacturing of the collection of parts that will form the product after assembly.

‘Optimization of the manufacturing process…’

DFA is a tool used to select the most cost effective material and process to be used in the production in the early stages of product design.

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Design for Assembly (DFA)

**Design for Assembly**

**Definition:** DFA is the method of design of the product for ease of assembly.

‘...Optimization of the part/system assembly’

DFA is a tool used to assist the design teams in the design of products that will transition to productions at a minimum cost, focusing on the number of parts, handling and ease of assembly.

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DFMA Examples

Real-World Applications
Design for Assembly
Reduction in Part Count

Motor-drive assembly

Initial design

Redesign

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, Marcel Dekker, New York 1994
Reduction in Part Count

Pneumatic Piston Assembly

Initial design

Redesign

Reduction in Part Count

Component Elimination
Example: Rollbar Redesign

‘..If more than 1/3 of the components in a product are fasteners, the assembly logic should be questioned.’

- 24 Parts
- 8 different parts
- multiple mfg. & assembly processes necessary

- 2 Parts
- 2 Manufacturing processes
- one assembly step

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Fastener Selection

**Fastener Cost**

- Select the most inexpensive fastening method required.

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Why Reduction in Part Count?

Eliminated Parts are NEVER...

- Designed
- Detailed
- Prototyped
- Produced
- Scrapped
- Tested
- Re-engineered
- Purchased
- Progressed
- Received
- Inspected
- Rejected
- Stocked
- Outdated
- Written-off
- Unreliable
- Recycled
- Late from the supplier!

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Criteria to Eliminate or Integrate a Part

Relative Motion

Different Material

Assembly/Maintenance
Design for Assembly

Alpha and beta rotational symmetries for various parts

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010
Ease of Handling

Handling Difficulty

- size
- slipperiness
- sharpness
- flexibility

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Ease of Handling

Examples of parts that may require tweezers for handling

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010
Ease of Handling

Eliminate Tangling/Nesting

Close up springs to avoid tangling

Design parts so they do not nest or tangle

- Locking angle
- Increase angle
- Change shape
- Decrease angle

These parts tangle easily

This part will not tangle

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Ease of Handling

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010
Ease of Handling

Geometrical features affecting part handling

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010
Ease of Handling

Quantitative criteria

- **Handling Time**: based on assembly process and complexity of parts
  - How many hands are required?
  - Is any grasping assistance needed?
  - What is the effect of part symmetry on assembly?
  - Is the part easy to align/position?

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Ease of Handling

Handling Difficulty

- Size
- Thickness
- Weight
- Fragility
- Flexibility
- Slipperiness
- Stickiness
- Necessity for using 1) two hands, 2) optical magnification, or 3) mechanical assistance

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Insertion

Insertion Issues

- Provide self-aligning & self locating parts

Part can hang up  Part falls into place

part must be released before it is located, making it difficult to align

redesign

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Insertion

Insertion Issues

- Ensure parts do not need to be held in position

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Insertion

**Insertion Issues**

- Parts are easy to insert.
- Provide adequate access & visibility

Avoid small clearances, hang-ups, and large force

Restricted access for assembly of screws

Improved access

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Insertion

Insertion Issues

- Provide adequate access and visibility

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Insertion

Design for ease of insertion-assembly of long stepped bushing into counterbored hole

G. Boothroyd, Assembly Automation and Product Design, CRC Press 2005
Insertion

Provision of air-relief passages to improve insertion into blind holes

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010
Insertion

Quantitative criteria

**Insertion time:** based on difficulty required for each component insertion

- Is the part secured immediately upon insertion?
- Is it necessary to hold down part to maintain location?
- What type of fastening process is used? (mechanical, thermal, other?)
- Is the part easy to align/position?

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Eliminate Secondary Operations

- Re-orientation (assemble in Z axis)
- Screwing, drilling, twisting, riveting, bending, crimping.

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Secondary Operation

Eliminate Secondary Operations

- Welding, soldering, gluing.
- Painting, lubricating, applying liquid or gas.
- Testing, measuring, adjusting.

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DFA Guidelines

In order of importance:

- Reduce part count & types
- Ensure parts cannot be installed incorrectly
- Strive to eliminate adjustments
- Ensure parts self-align & self-locate
- Ensure adequate access & unrestricted vision
- Ensure parts are easily handled from bulk
- Minimize reorientation (assemble in Z axis) & secondary operations during assembly
- Make parts symmetrical or obviously asymmetrical

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Types of Assembly

**Manual**
Simple tools, low volume

**Robot**
Robot arms, medium volume

**Automatic**
Automated machines, high volume
Design for Manufacturing (DFM)
Injection Molding

Guidelines for designing parts for injection molding
Shrinkage

Shrinkage impacts dimensions

Different materials shrink differently (shrinkage factor)
Section Thickness

Don’t

\[ t \geq 4 \text{ mm} \]

Do

Use ribs instead

\[ 0.065'' \leq t \leq 0.5'' \]

Minimize section thickness, cooling time is proportional to the square of the thickness of the part(s), and reducing the cooling time directly reduces costs.

Section Thickness

Thicknes
s Uniformity

Don’t

Stepped thickness transition

Do

Better

3t min

Best

Make all transitions smooth and avoid changes in thickness when possible.

Draft Angle

Corners/Radii

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

Ribs

Don’t

\[ t_{\text{rib}} \equiv t \]

voids

Sink marks

Keep rib thickness less than 60% of the part thickness to prevent voids and sinks.

Do

\[ t_{\text{rib}} = \frac{1}{2t^*} \]

3t min

Bosses

Don’t
Potential sink marks and voids

Do
Attach bosses to walls with ribs
Gusset free standing ribs

Keep section thickness uniform around bosses.

References

G. Boothroyd, P. Dewhurst, W. A. Knight, Product Design for Manufacture and Assembly, CRC Press 2010


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