INLAND METALS

Design for Manufacturing and Assembly

General Guidelines
Design for Manufacturing (DFM) refers to design activity that is based on minimizing the cost of production and/or time to market for a product, while maintaining an appropriate level of quality. A primary strategy in DFM involves minimizing the number of parts in a product.

Design for Assembly (DFA) involves making directions and methods for attaching and joining the parts of a product simpler.

DFMA refers to working with both of these concepts together.
Benefits of DFM and DFA

-Reduces part count, thereby reducing cost…
If a design is easier to produce and assemble, it can be done in less time, so it will be less expensive. Design for manufacturing and assembly should be used for that reason if no other.

-Increases reliability…
If the production process is simplified, there is less opportunity for errors.

-Generally increases the quality of the product…
For the same reason it increases reliability.
DFM and DFA start with the formation of a design Team which must be multi-disciplinary, including: engineers, manufacturing managers, estimating and Marketing and sales professionals.

The most basic simplest approach to design for Manufacturing and assembly is to apply a set of design guidelines.

You should use design guidelines with an Understanding of explicit design goals. Make sure That the application of each guideline improves the design concept with respect to those goals.
DFM and DFA Design Guidelines

- Minimize part count by incorporating multiple functions into single parts.
- Several parts could be fabricated by using different manufacturing Processes (sheet metal forming, injection molding).
- Ask yourself if a part function can be performed by a neighboring part.

Minimize part count by incorporating multiple functions into single parts.

Modularize multiple parts into single sub-assemblies.
DFA

Parts should easily indicate orientation for insertion

Don't

Do

Design open enclosures to permit assembly in open space, not in confined spaces. Never bury important components.

Parts should easily indicate orientation for insertion.
Use standardized products and standardized parts to reduce variety of operations, choices and inventory burden.

Example: having similar looking screws that are different sizes is confusing.
Design parts so they do not tangle or stick to each other.

Distinguish different parts that are shaped similarly, or hard to distinguish by non-geometric means, such as color coding.

- Eliminate tangly parts.
- Color code parts that are different but shaped similarly.
Design parts to prevent nesting. Nesting is when parts that are Stacked on top of one another clamp or stick together.

Design parts with orienting features to make alignment easier.
Provide alignment features on the assembly so parts are easily orientated.

Design the mating parts for easy insertion or attachment.

Provide allowance (tolerance) on each part to compensate for variation in part dimensions.
Design the first part large and wide for stability, then assemble smaller parts on top of it sequentially.

If you cannot assemble the parts from the top down exclusively, then minimize the number of insertion directions. Never require the assembly to be turned over.
Joining options: parts can be joined using (screws, nuts and bolts or rivets, snap fits, welds or adhesives. Design to eliminate Fasteners and to place them away from obstructions.
DFM and DFA DESIGN EXAMPLES...

Don’t

Proper spacing insures allowance for a fastening tool.

Do

Providing flats for uniform fastening and fastening ease.

Don’t

Deep channels should be sufficiently wide to provide access to fastening tools. No channel is best.

Do
Combining to minimize the number of parts

To determine whether it is possible to combine neighboring parts, ask the following questions:

- Must the parts move relative to each other?
- Must the parts be electrically or thermally insulated?
- Must the parts be made of different material?
- Does combining the parts interfere with assembly or other parts?
- Will servicing be adversely affected?

If the answer to all questions is “NO”, you should find a Way to combine parts.
Minimizing the number of parts

Another approach

The concept of the *theoretical minimum number of parts* was originally proposed by Boothroyd (1982). Generally, during the assembly of the product, a part is required only when:

1. Kinematic motion of the part is required
2. A different material is required.
3. Assembly of other parts would otherwise be prevented.

If none of these statements are true, then the parts do not need to be separate entities and may be combined.

Follow the KISS principal

“KISS” – Keep it simple stupid
DFM Design Guidelines
Sheet-metal Forming

Design for ease of blanking:
- $W = 0.040''$ min for materials thinner than $0.047''$ – wider if possible.
- $W_1 \geq$ material thickness; wider if possible.
- $L = 5W$ maximum depth; less if possible.
- $L_1 = 5W$ maximum length; less if possible.

Shear and form operations should have a minimum height ($h$) of $2\ 1/2$ the blank thickness.
DFM Design Guidelines
Sheet-metal Forming

Position openings away from bends.

Position holes away from bends.

Don’t

Do

Avoid sharp corners, or the material will tear.
DFM Design Guidelines
Sheet-metal Forming

Don’t
On Paper
What will happen
Web
Bulge
Ear

Don’t
Tear

Do
R

Offset bends.

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

If $D \geq 2t$, a cutout is needed to bend flange.
DFM Design Guidelines - Casting

Casting, one of the oldest manufacturing processes, dates back to 4000 B.C. when copper arrowheads were made.

- Casting processes basically involve the introduction of a molten metal into a mold cavity, where upon solidification, the metal takes on the shape of the mold cavity.
- Simple and complicated shapes can be made from any metal that can be melted.
- Example of cast parts: frames, structural parts, machine components, engine blocks, valves, pipes, statues, ornamental artifacts.....
- Casting sizes range form few mm (teeth of a zipper) to 10 m (propellers of ocean liners).
Casting Processes

1. Preparing a mold cavity of the desired shape with proper allowance for shrinkage.
2. Melting the metal with acceptable quality and temp.
3. Pouring the metal into the cavity and providing means for the escape of air or gases.
4. Solidification process, must be properly designed and controlled to avoid defects.
5. Mold removal.
6. Finishing, cleaning and inspection operations.
Sand Casting Terminology

Pouring cup
Sprue
Riser
Draft
Core
Mold cavity
Core print
Gating system
Flask
Parting line
COPE
DRAG
Core box
Parting line
Pattern
Core
Casting
Casting Defects

Hot spots – thick sections cool slower than other sections causing abnormal shrinkage. Defects such as voids, cracks and porosity are created.
Casting Defects and Design Consideration

- Poor
- Poor
- Poor
- Poor

- Good
- Good
- Good
- Good
**DFM Design Guidelines - Casting**

![Diagram showing design guidelines for casting, including radius (r = D/3) and slope considerations.](image)

**TABLE 13.2** Recommended Minimum Section Thicknesses for Various Engineering Metals and Casting Processes

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum</th>
<th>Desirable</th>
<th>Casting Process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>Steel</td>
<td>4.76</td>
<td>⅛</td>
<td>6.35</td>
</tr>
<tr>
<td>Gray iron</td>
<td>3.18</td>
<td>⅛</td>
<td>4.76</td>
</tr>
<tr>
<td>Malleable iron</td>
<td>3.18</td>
<td>⅛</td>
<td>4.76</td>
</tr>
<tr>
<td>Aluminum</td>
<td>3.18</td>
<td>⅛</td>
<td>4.76</td>
</tr>
<tr>
<td>Magnesium</td>
<td>4.76</td>
<td>⅛</td>
<td>6.35</td>
</tr>
<tr>
<td>Zinc alloys</td>
<td>0.51</td>
<td>0.020</td>
<td>0.76</td>
</tr>
<tr>
<td>Aluminum alloys</td>
<td>1.27</td>
<td>0.050</td>
<td>1.52</td>
</tr>
<tr>
<td>Magnesium alloys</td>
<td>1.27</td>
<td>0.050</td>
<td>1.52</td>
</tr>
</tbody>
</table>
DFM Design Guidelines - Casting

Don’t  Do

Stagger ribs to prevent hot spots.

Don’t  Do

Avoid abrupt changes in section thickness.

Don’t  Do

Maintain section thickness uniform.
DFM Design Guidelines – Machining

Don’t

D = 0.627"  

Do

D = 0.625"  

Use standard dimensions.

Don’t

Do not design impossible to machine hollows or overhangs.

Don’t

Impossible  
Radius smaller than 1/4"  

Design for reasonable internal pockets radii.

Do

Use 1/4 + 1/2 radius  

Avoid thin walls that break when machining.

Don’t

Thin wall

Do

Place holes away from corners and edges.
END…

Design for Manufacturing and Assembly