

Design for Assembly

Instructor: Amy Smith

Background

When assembly is taken into account during the design process, several good things should happen. Quality and reliability are improved because there are fewer parts, and the device is simpler to put together.

In the U.S., one often tries to limit number of jobs required. This goal does not necessarily fit in developing countries. Scale may be different because transportation challenges lead you to a more decentralized manufacturing model. Finally, hand workmanship means less strict standardization (less repeatability).

Assembly methods include

- Manual assembly
- Fixed automatic assembly
- Flexible automatic assembly

What considerations affect the choice of methods? For manual assembly, the cost is fixed per unit regardless of the production volume. Fixed automatic assembly (i.e. injection molded part), the more units produced, the closer you get to just the cost of the materials (spreading fixed tooling costs and capital). Robotic or flexible assembly allows capital costs to spread across multiple uses, making cost per unit non-linear at lower volumes.

Hands-on Assembly Exercise

Groups of two students disassemble and then reassemble two items – a small keychain flashlight and a container of dental floss. How long does it take to take all the pieces apart? What's the part count? What do you notice about the way the parts fit together?

The flashlight had 18 pieces. Takes 1-5 minutes to take apart, and 6 minutes to "infinite" (i.e. parts broke during disassembly) to put back together. Note in particular the challenges posed by six very small screws.

Design for Assembly

"a process for improving product design for easy and low-cost assembly, focusing on functionality and on assemblability concurrently."

--Vincent Chan & Filippo A. Salustri

Design for Assembly

- Reduce cost of assembly
- Improve quality and reliability
- Reduce part inventory
- Reduce production equipment

Special Considerations for Developing Countries

- Job Creation
- Resource Availability
- Scale
- Scope
- Repeatability

Floss container took just a few seconds to disassemble, only 3 or 4 parts. The case has several segments, hinged, making assembly much easier. No tools needed.

What does this say about principles of good Design for Assembly:

- Connected pieces or segments
- Small parts are harder to work with
- The fewer tools required, the better
- Any clues to alignment are helpful
- Deformable parts are a problem
- Snap-fit assembly (vs. screws) reduces part count, simplifies assembly.

Design Guidelines for Manual Assembly.

Try to make it so there's only "one way" – e.g. one sequence or one orientation for things to happen. Don't hide important parts. Try to make everything self-aligning.

Jigs and fixtures for manufacturing are quite helpful. If you take care with the jig, then each manufactured part is easily made, as it inherits the quality of the jig. (Photos courtesy of DISACARE. Used with permission.)

Continuing...imagine what a pain it would be if 3 of six screws were Philips head, and 3 were slot head screws.

Loose wires are particularly prone to getting tangled during assembly.

Design Guidelines for Automated Assembly

Reduced part count: floss container used to have a separate "lid" snapped in, but that's not needed. Instead, the entire package can be made from a single hinged piece of plastic.

Ask: does one part need to move relative to other parts during actual use? If not, maybe it can be manufactured as a single segmented part.

Design Guidelines for Manual Assembly

- eliminate the need for workers to make decisions or adjustments.
- ensure accessibility and visibility.
- eliminate the need for assembly tools and gauges (i.e. prefer self-locating parts).

Jigs & Fixtures



Design Guidelines for Manual Assembly

- minimize the number of different parts - use "standard" parts.
- minimize the number of parts.
- avoid or minimize part orientation during assembly (i.e. prefer symmetrical parts).
- prefer easily handled parts that do not tangle or nest within one another.

Design Guidelines for Automated Assembly

- reduce the number of different components by considering
 - does the part move relative to other parts?
 - must the part be isolated from other parts (electrical, vibration, etc.)?
 - must the part be separate to allow assembly (cover plates, etc.)?
- use self-aligning and self-locating features
- avoid screws/bolts

Use the largest, heaviest part as base, and start there, so you don't have to flip it the device part-way through.

Avoiding flexible/fragile parts and precise orientation is a stronger need for automated assembly. Strive for a low center of gravity, making the object stable during assembly process.

Other DFA Suggestions

Rather than have 15 separate parts, make modules of 5 parts each and then combine the resulting three modules.

If you see several screws of different lengths in your design – can they all be the same length?

Color coding for multiple types of a part is helpful. The colored bands on electrical resistors are a classic example, but can apply to other components too.

Avoid having to reorient the assembly as you proceed; you don't want to reach around the back. And always try to eliminate fasteners.

If you can't eliminate fasteners, make sure they're accessible and your tools can get to them. Flats (flat surfaces for secure joining between components) are essential.

If orientation matters, make sure the part isn't symmetrical leading to accidental reversing.

Q: Please say more about how and why fasteners are useful, vs. eliminating them.

A: Snap fit is easier for plastic, but you can also spring-load metal for a snap-fit effect. Snap fit can be completely inappropriate if you expect the joint to be disassembled and reassembled.

Design Guidelines for Automated Assembly

- use the largest and most rigid part as the assembly base and fixture.
- Assembly should be performed in a layered, bottom-up manner.
- use standard components and materials.

Design Guidelines for Automated Assembly

- avoid tangling or nesting parts.
- avoid flexible and fragile parts.
- avoid parts that require orientation.
- use parts that can be fed automatically.
- design parts with a low centre of gravity.

Basic DFA Guidelines

- Minimize part count by incorporating multiple functions into single parts
- Modularize multiple parts into single subassemblies
- Assemble in open space, not in confined spaces; never bury important components
- Make parts such that it is easy to identify how they should be oriented for insertion
- Prefer self-locating parts

Basic DFA Guidelines

- Standardize to reduce part variety
- Maximize part symmetry
- Eliminate tangly parts
- Color code parts that are different but shaped similarly
- Prevent nesting of parts; prefer stacked assemblies
- Provide alignment features

Basic DFA Guidelines

- Design the mating features for easy insertion
- Insert new parts into an assembly from above
- Eliminate re-orientation of both parts and assemblies
- Eliminate fasteners

Basic DFA Guidelines

- Place fasteners away from obstructions; design in fastener access
- Deep channels should be sufficiently wide to provide access to fastening tools; eliminate channels if possible
- Provide flats for uniform fastening and fastening ease
- Ensure sufficient space between fasteners and other features for a fastening tool
- Prefer easily handled parts