Mechanical Assembly Systems

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Body Drop, Ford Motor Company, Highland Park, 1913
Complicated products require more assembly.....

Model T Ford >1,000 parts

which can then become a bottleneck
Pratt & Whitney JT9D

>10,000 parts

>100,000 parts

Boeing 747

>10,000 parts
To solve this problem, Ford developed the moving assembly line.
See GM front end assembly
Requirements;

1. Work design (balance steps, ergonomics)
2. Designs that work (DFA)
3. Interchangeable parts

John Hall’s breech design demonstrated interchangeability at Harper’s Ferry in 1827.
Time Estimation for Assembly

1. Handling
   1. pick up
   2. orient

2. Insertion
   1. location (obstructed view? Self locating?)
   2. hold down and resistance
   3. securing method
Handling Issues

Symmetry

<table>
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<th>0</th>
<th>180</th>
<th>180</th>
<th>90</th>
<th>360</th>
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<tr>
<td>β</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td>180</td>
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Size

- very small
- sharp

Fragile/Sharp

Nest/Tangle

- will tangle
- cannot tangle

Slippery/Flexible

- slippery
- flexible
Insertion Issues

Alignment

- self-locating
- holding down and alignment required for subsequent operation

Obstructed Access/View

Insertion Force

- difficult to insert
- easy to insert
- part can hang-up
- part falls into place
1 - screw(2) (steel) not easy to align

2 - cover(steel) not easy to align - assembly worker’s fingers must be used to align edges

3 - spring(steel) (closed ends) subject to continuous cycling and must be spring steel

4 - piston stop(plastic) edge is chamfered for ease of alignment

5 - piston(aluminum) obstructed access for insertion of spindle into bottom of bore

6 - main block(plastic) depth of bore is 28mm with small through hole for piston spindle
Boothroyd/Dewhurst Design Rules

1. Reduce part count and part types
2. Strive to eliminate adjustments
3. Design parts to be self-aligning and self-locating
4. Ensure adequate access and unrestricted vision
5. Ensure the ease of handling of parts from bulk
6. Minimize the need for reorientations during assembly
7. Design parts that cannot be installed incorrectly
8. Maximize part symmetry if possible or make parts obviously asymmetrical
Rules to reduce part count

1. During operation of the product, does the part move relative to all other parts already assembled?  
   Only gross motion should be considered – small motions that can be accommodated by elastic hinges, for example, are not sufficient for a positive answer.

2. Must the part be of a different material than or be isolated from all other parts already assembled?  
   Only fundamental reasons concerned with material properties are acceptable.

3. Must the part be separate from all other parts already assembled because otherwise necessary assembly or disassembly of other separate parts would be impossible?
Redesign: Pneumatic Piston Sub-Assembly

1 - snap on cover and stop (plastic)

2 - spring (steel)

3 - piston (aluminum)

4 - main block (plastic)
Classification

1. Manual Assembly
2. Robot Assembly (small to medium, simple, medium volume)
3. Special Purpose Transfer Line Assembly (small, simple and high volume)
Automatic assembly machines used to assemble toaster switches at the rate of 45 switches per minute, which is approximately 5 million assemblies per shift year. The assembly machine was made by The Bodine Corp.

Rules for design for high speed-automatic assembly

- Automatic part handling & Automatic insertion
  - Automatic handling of the part is the principal concern

- Rules for efficient automatic part handling
  - be easily separated from bulk
  - be easily conveyed along the track of a vibratory or hopper feeder
  - be readily oriented in high speed feeding devices

- Rules for automatic insertion
  - Avoid the need for reorientations during assembly
  - Parts, that are not secured immediately on insertion, are fully located
  - be easily aligned (e.g. leads, lips, tapers, chamfers)
  - Layered fashion assembly from above
  - Avoid the need for high insertion forces
Robot Assembly

One arm robot assembly

Multi-station robot assembly
Surface mount technology requires that chips are placed and then heated to bond the leads. See Kalpakjian Ch 30
Robot Assembly

Layout of robot assembly station in Sony video recorder head assembly system and overview of Sony VCR head assembly system showing robots with muti-tool turrets.

Rules for design for Robot assembly

- Reduce part count
- Make parts self-aligning in assembly (e.g. leads, lips, chamfers, etc.)
- Parts which are not secured immediately on insertion are self-locating in the assembly
- Parts must all be gripped and inserted using the same robot gripper
- Layered fashion assembly from above
- Avoid the need for reorienting the partial assembly or manipulating previously assembled parts
- Parts must be easily handled from bulk
- Part orientation
Design for Disassembly

1. Reduce the number of components
2. Reduce the number of separate fasteners
3. Provide open access and visibility for separation points
4. Avoid orientation changes during disassembly
5. Avoid non-rigid parts
6. Use common tools and equipment
7. Design for ease of handling and cleaning of all components
8. Reduce number of different materials
9. Enable simultaneous separation & disassembly
10. Facilitate the sorting of non-compatible materials
But often only a small amount of disassembly takes place before shredding

Usual steps:

- Identification
- Sorting
- Cleaning
- Separating
- Neutralizing contaminants
- Shredding
- Reprocessing
- Recycling

Automobile shredder from Lieberman (Invent. & Tech. Fall 2000)
Chain of Delivery of Quality
Summary

1. Product Complexity and Ford’s Sol’n
2. Three requirements
   1. Work Design
   2. DFA
   3. Interchangeable parts
3. Why always manual?
4. Other systems (automatic assembly)
5. Other issues