Lecture 19
Design for Manufacture
Design for Assembly

DFM

- Design's decisions will have significant impact on the costs associated with the manufacture of the product
  - Piece part costs
  - Cost of quality
    - yield
    - process precision
  - Set-up costs
  - Labor content
  - Throughput
  - Flexibility

Design for Manufacture

- Broad term applied to a variety of tool, guidelines, and methods to ensure
  - Low cost parts
    - Piece parts are built using the lowest cost process possible
    - Design dimensions/tolerances are specified with *thought.*
  - Low cost assembly
    - DFA
  - Low cost processes
    - Processes are designed to target the critical to function characteristics

Tradeoffs

- Piece part simplicity vs. assembly time
- Variety vs. integrality
- Manufacturability vs. performance

DFM Iteration

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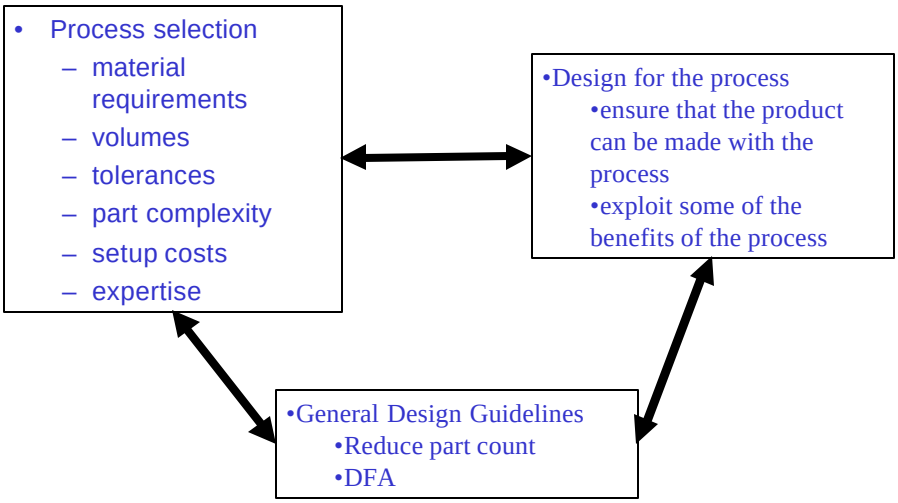

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DFM Support Processes

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- Simultaneous Engineering / Cross-functional teams
- Design for Manufacturing Reviews
- DFM Guidelines
- DFM Metrics
- Simulation software

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Simultaneous Engineering / Cross-functional teams

- Simultaneously design the product and the process
- Prevents *over-the-wall design*
- Cross-functional teams continually evaluate each others work and have input on the whole product/process design

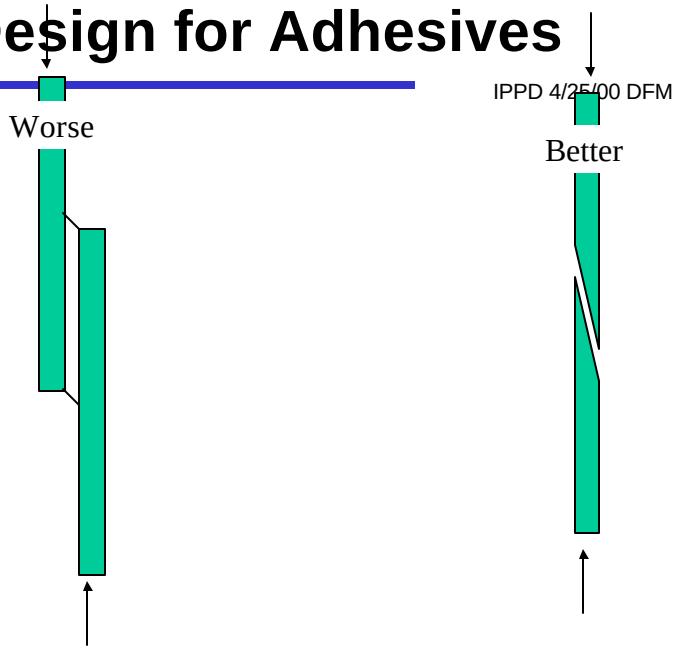
DFM Reviews

- Formal reviews where experts are brought in to evaluate the manufacturability of the product
- Formalized gate
- Problems
  - Often not taken seriously
  - "we never can get design to make changes, we'll just wait until we get it to make it manufacturable"

DFM Guidelines

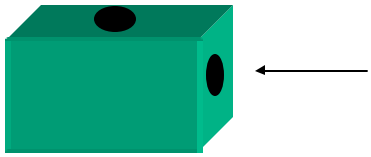
- Formalized lists of guidelines for a specific manufacturing process
- Developed by manufacturing to generate rules for design to follow
- Can be either computer based or book based
- Heuristics rather than quantitative
- Problems
  - Just sit on the desk - never used

Design for Adhesives



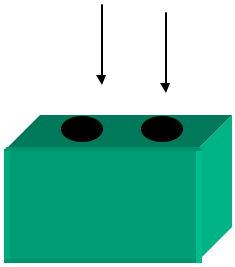
CNC Guidelines

Worse



Two-directions

Better



Single direction

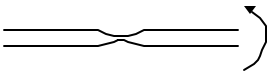
Guideline: Reduce number of setups. Benefits both time and variation.

Design for Assembly

- Reduce assembly time by
  - Integral parts
  - Remove fasteners
  - Minimize assembly time

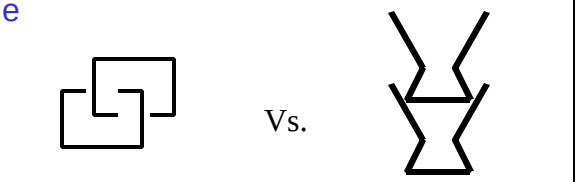
Minimize part count through integral parts

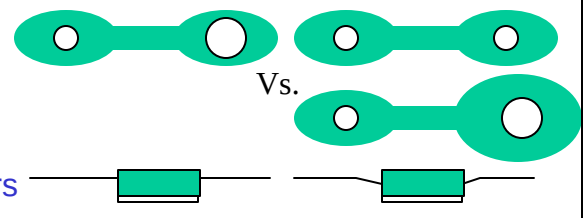
- Identify
  - parts that can be made of the same material
  - parts that don't move relative to each other
  - parts that do move but can use
    - integral joints
    - flexures
- Problems
  - Reduce modularization
  - Increase complexity
- Benefits
  - Reduced assembly
  - Reduced tolerance stack-ups



Minimize assembly time

- Easy to get part
  - parts don't tangle
- Easy to orient part
  - symmetrical or very unsymmetrical parts
- Easy to assemble parts
  - self aligning
  - lead-in chamfers





Minimize fasteners

- Options
  - Press fits
  - Adhesives
  - Snap-fits
  - Integral parts
- Problems
  - fasteners are stronger
  - fasteners can be used to locate parts
  - temperature insensitive
  - less sensitive to part variation

DFM metrics

- Quantitative evaluations that are used to put a metric on the manufacturability of a product.
- The goal is to improve the metrics through design changes
- Examples
  - Boothroyd and Dewhurst's complexity
  - Yield
  - # of manuf. Rule violations

Boothroyd and Dewhurst Complexity factor

- Total number of parts N_P
- Total number of part types N_T
- Total number of interfaces N_i

$$Complexity = \sqrt{N_T + N_{P+} N_i}$$

Yield

- Calculation of the number of parts that will not pass inspection.
- Ways to calculate
  - Models of the product
  - Statistical correlation with historical data

Yield based on Model

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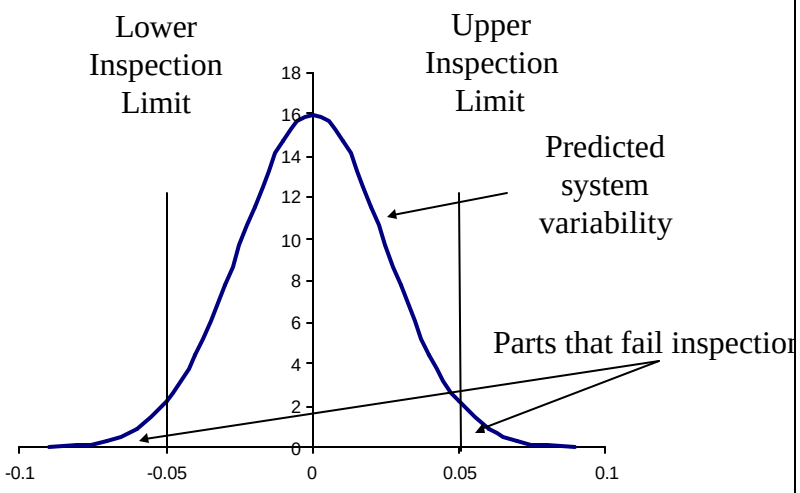

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Yield based on Statistical Analysis

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- Use historical data to determine the product characteristics that are highly correlated with yield problems
- SMT example
  - Process technology
  - Number of parts
  - Number of interconnects
  - Volume
  - ….

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Simulation software

- Used to simulate the “as built” state of a product
- Examples
  - Mold flow (injection molding)
  - CNC simulations
- Problems
  - Don’t give guidance on the changes
  - Time consuming

Collect the DFM guidelines and review

Fixtured vs. Determinate Assembly

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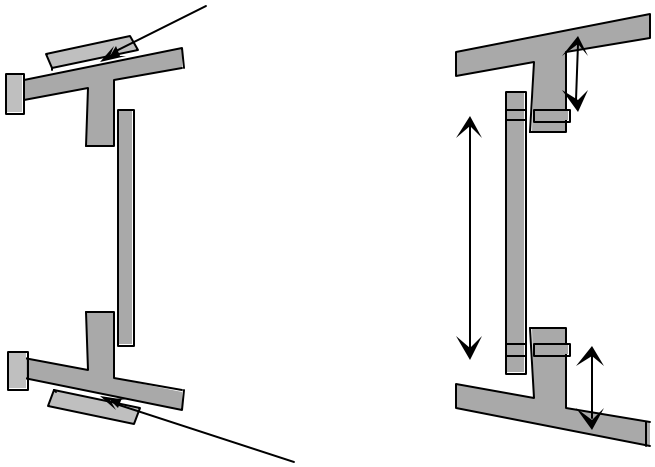

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Fixtured vs. Determinate

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	Fixtured	Determinate
Locaiton	Fixtures	Precision holes
Flexibility of fixture	Low	High
Precision requirements	Low	High
Ability to rework	Low	High
Assembly Time	High	Low

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Sub-assemblies

- Build ups
  - Parts (bulkheads, doors, etc) are built up of many parts that are assembled in dedicated fixtures
- Monolithic
  - parts are machined out of a large
    - forging, or
    - billet
  - to make a single piece

Monolithic vs. build up

	Monolithic		Build up
	Near net shape forging	Billet	
Cycle time	High	Low	flexible
Ability to increase throughput	Low	Low/med	high
Crack resistance	Med	Med.	High
"Quality"	High/med	High	Med/low

Lecture 20:

- VARIATION RISK MANAGEMENT, THE ROLE OF QUALITY

- No readings