Product Planning & Development (21-423)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session #16

Course Description

- Instructor
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  - Website: Sharif.edu/~fvalilai
- Recommended prerequisite
  - Manufacturing process I (21-418)
- Class time
  - Sunday-Tuesday 18:00-19:30
- Course evaluation
  - Mid-term (25%)
  - Final exam (40%)
  - Quiz (5%)
  - Exercise (Manufacturing Lab.) (30%)

Session reference

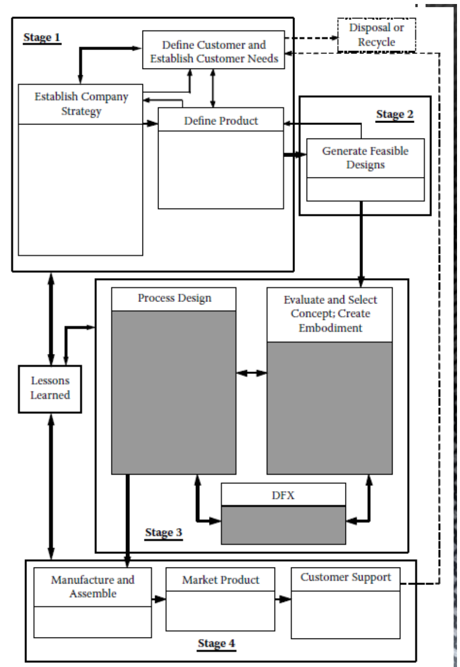
- Reference:
  - Edward B., "Integrated product and process design and development : the product realization process", CRC Press, 2010
  - John Priest, Jose Sanchez; "Product Development and Design for Manufacturing: A Collaborative Approach to Producibility and Reliability, Second Edition", CRC Press, 2001
  - Mital et al. , "Product Development A Structured Approach to Consumer Product Development, Design, and Manufacture", Butterworth-Heinemann, 2008

Course Description *(Continued..)*

- ***Contents:***
- *Product development in the changing Global world*
- *Stages of Product Development*
- *The Structure of the Product Design Process*
- *Early design: Requirement definition and conceptual Design*
- *Trade-off analyses: Optimization using cost and utility Metrics*
- *Detailed design: Analysis and Modeling*
- *Design Review: Designing to Ensure Quality*
- *Production System; Strategies, planning, and methodologies*
- *Production System Development*
- *Planning and Preparation for Efficient Development*
- *Supply chain: Logistics, packaging, supply chain, and the environment*

Design Review: Designing to Ensure Quality

- Designing for Assembly and Disassembly



Design Review: Designing to Ensure Quality

- Designing for Assembly and Disassembly
- A consumer product often is an assemblage of several individual components.
- Each component has been planned, designed, and manufactured separately. Only after they are assembled into the final product can they effectively perform their intended function
- Assembly of a product is a function of design parameters that are both
  - Intensive (material properties) and extensive (physical attributes) in nature
  - such design parameters includes shape, size, material compatibility, flexibility, and thermal conductivity

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *In an engineering context, disassembly is the organized process of taking apart a systematically assembled product (assembly of components).*
- *Products may be disassembled to enable maintenance, enhance serviceability and/or to affect end of life objectives, such as product reuse, remanufacture, and recycling*

Design Review: Designing to Ensure Quality

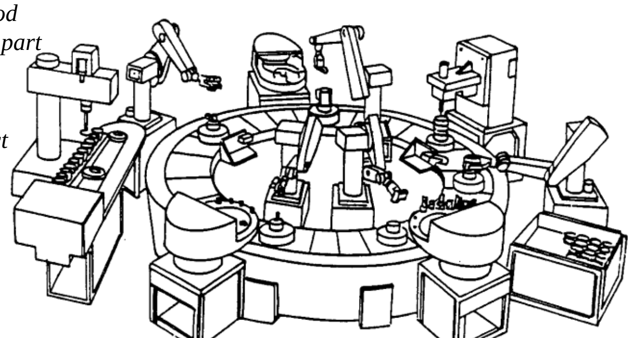
- *Designing for Assembly and Disassembly*
- *Design for assembly*
  - *Design for assembly (DFA) seeks to simplify the product so that the cost of assembly is reduced.*
  - *Consequently, applications of DFA principles to product design usually result in improved quality and reliability and a reduction in production equipment and part inventory*
  - *DFA, in principle, recognizes the need to analyze the design of both the part and the whole product for any assembly problems early in the process to cut costs during the entire product cycle.*

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Design for assembly*
  - *Different Methods of Assembly*
  - *Manual assembly*
    - *Manual assembly is a process characterized by operations performed manually, with or without the aid of simple, general-purpose tools, such as screw drivers and pliers*
    - *The cost per unit is constant, and the process requires little initial investment*
    - *Although this is the most flexible and adaptable assembly method, there usually is an upper limit to the production volume, and labor costs (including benefits, workers compensation due to fatigue and injury, and overhead for maintaining a clean and healthy environment) are higher*

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Design for assembly*
  - *Different Methods of Assembly*
  - *Automatic assembly*
    - *Often referred to as fixed automation, this method uses either synchronous indexing machines and part feeders or nonsynchronous machines*
    - *The system generally is built for a single product and the cost per unit decreases with increasing volume of production*



Design Review: Designing to Ensure Quality

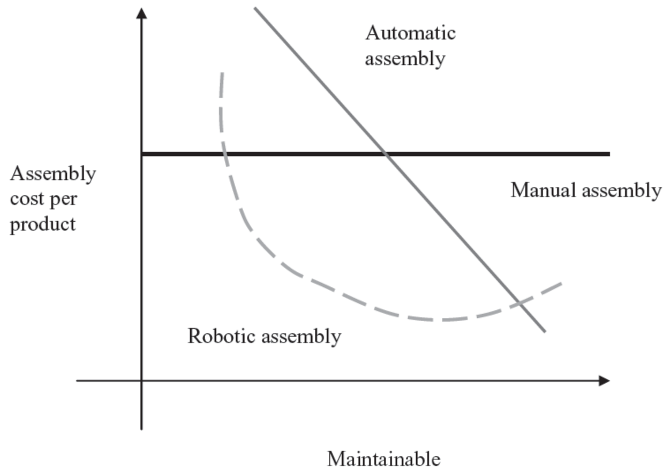
- Designing for Assembly and Disassembly
- Design for assembly
  - Different Methods of Assembly
  - Fixed or hard automation
    - Fixed or hard automation characteristically involves a custom built machine that assembles only one specific product and entails a large capital investment.
    - As production volume increases, the fraction of the capital investment compared to the total manufacturing cost decreases.
    - Indexing tables, parts feeders, and automatic controls typify this inherently rigid assembly method.

Design Review: Designing to Ensure Quality

- Designing for Assembly and Disassembly
- Design for assembly
  - Different Methods of Assembly
  - Robotic assembly
    - This form of assembly is best suited for those products whose production volume lies between the manual and automatic assembly methods.
    - This method of product assembly is the most flexible and can achieve volumes closer to the automatic assembly methods.
    - Soft automation or robotic assembly incorporates the use of robotic assembly systems.
    - Although this type of assembly method can have large capital costs, its flexibility often helps offset the expense across many different products.

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Design for assembly*
  - *Different Methods of Assembly*



Design Review: Designing to Ensure Quality

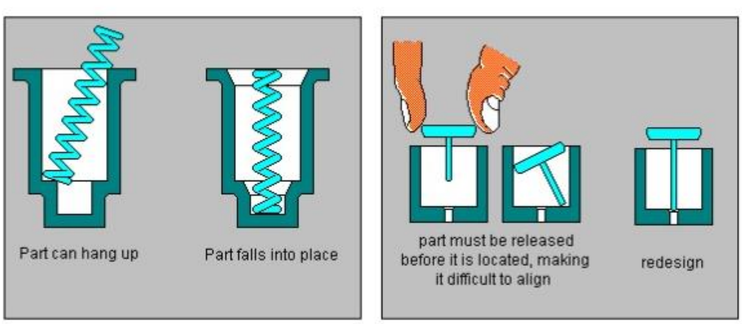
- *Designing for Assembly and Disassembly*
- *Design guidelines for different modes of assembly*
  - *Manual Assembly*
    - *Eliminate the need for decision making by the worker, including making final adjustments*
    - *Eliminate excess parts and combine two or more parts into one, if functionally possible*
    - *Avoid or minimize the need to reorient the part during the assembly process*
    - *Minimize the total number of individual parts, if possible. To facilitate this objective, multipurpose components may be used.*

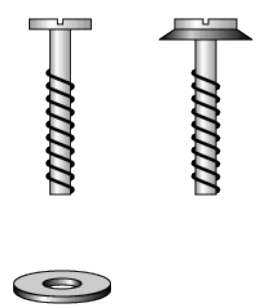
Design Review: Designing to Ensure Quality

- Designing for Assembly and Disassembly
- Design guidelines for different modes of assembly
  - Automatic Assembly
    - Self-aligning and self-locating features need to be incorporated into the design to facilitate assembly.
    - As with all other Design For X principles, use a high percentage of standard parts
    - Avoid the possibility of parts tangling, nesting, or shingling during feeding
    - Avoid flexible, fragile, and abrasive parts

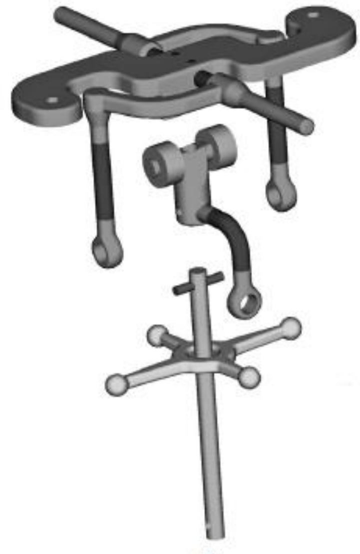
Design Review: Designing to Ensure Quality

- Designing for Assembly and Disassembly
- Design guidelines for different modes of assembly
  - Automatic Assembly



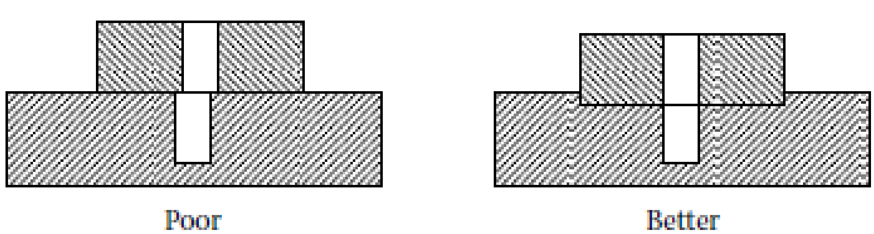


Design Review: Designing to Ensure Quality



Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Design guidelines for different modes of assembly*



Design Review: Designing to Ensure Quality

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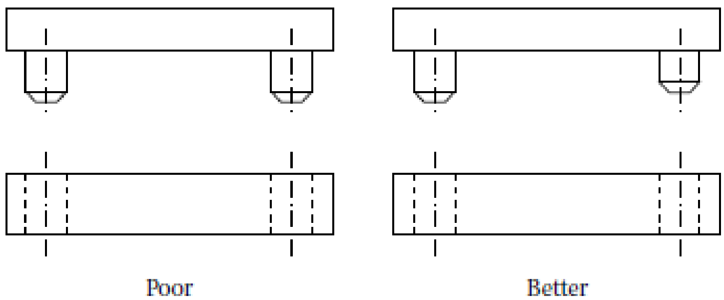

Design Review: Designing to Ensure Quality

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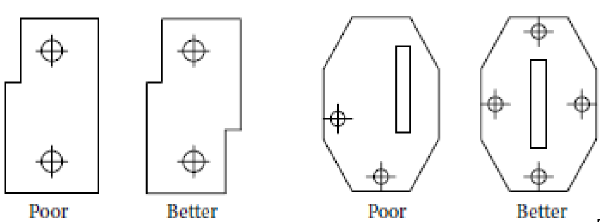
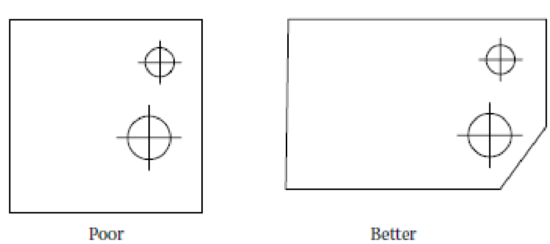


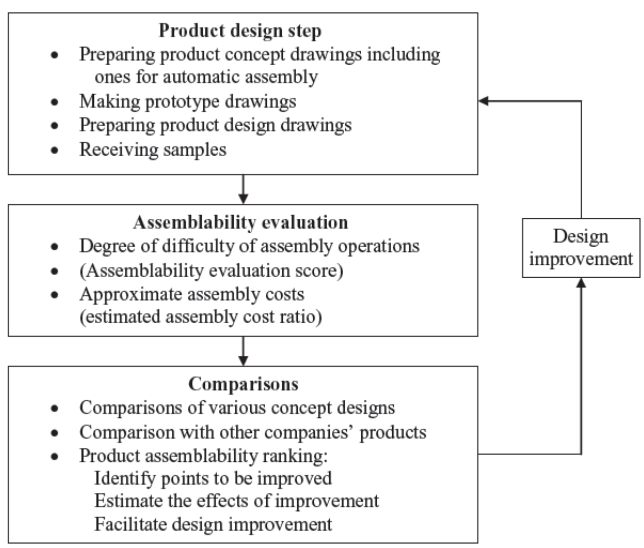


Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *Several methods for assembly evaluation exist, such as*
    - *The Hitachi assembly evaluation method.*
    - *The Lucas DFA method.*
    - *The Fujitsu productivity evaluation system.*
    - *The Boothroyd Dewhurst DFA method.*
    - *The AT&T DFA method.*
    - *The Sony DFA method.*
    - *SAPPHIRE (a software package used to analyze ease of product assembly).*

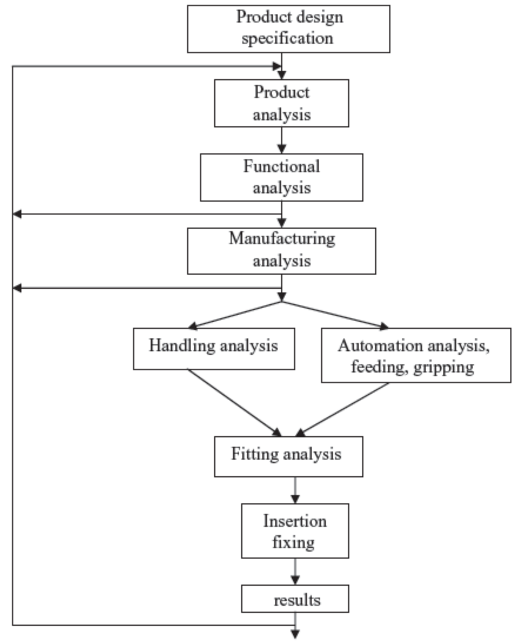
Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Hitachi assembly evaluation method.*
  - *This method aims to facilitate design improvements by identifying weaknesses in the design at the earliest stage in the process by using an assemblability evaluation score and an assembly cost ratio*
  - *Assemblability evaluation score ratio (E) assesses design quality by determining the difficulty of operations,*
  - *Assembly cost ratio (K), which projects elements of assembly cost*



Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Lucas DFA method.*
  - *The Lucas method is based on a point scale that gives a relative measure of the difficulty associated with assembly.*
  - *This method is based on three separate and sequential analyses, which are described by means of the assembly sequence flowchart*
  - *The functional analysis ➔ design efficiency (DE) >=60%*
  - *Feeding/handling ratio =2.5*
  - *Fitting ratio =1.5*
  - *cost of manufacturing each component*



Design Review: Designing to Ensure (

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Lucas DFA method.*

Lucas Manual Handling Analysis (Handling Index=$A+B+C+D$)

	Score
A. Size and weight of part	
Very small, requires tools	1.5
Convenient, hands only	1
Large and/or heavy, requires more than one hand	1.5
Large and/or heavy, requires hoist or two people	3
B. Handling difficulties	
Delicate	0.4
Flexible	0.6
Sticky	0.5
Tangible	0.8
Severely nesting	0.7
Sharp or abrasive	0.3
Untouchable	0.5
Gripping problem, slippery	0.2
No handling difficulties	0
C. Orientation of part	
Symmetrical, no orientation required	0
End to end, easy to see	0.1
End to end, not visible	0.5
D. Rotational orientation of part	
Rotational symmetry	0
Rotational orientation, easy to see	0.2
Rotational orientation, hard to see	0.4

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Lucas DFA method.*

Lucas Manual Fitting Analysis (Fitting Index=$A+B+C+D+E+F$)

	Score
A. Part placing and fastening	
Self-holding orientation	1.0
Requires holding	2.0
Plus one of the following:	
Self-securing (i.e., snaps)	1.3
Screwing	4.0
Riveting	4.0
B. Process direction	
Straight line from above	0
Straight line not from above	0.1
Not a straight line	1.6
Bending	4.0
C. Insertion	
Single insertion	0
Multiple insertions	0.7
Simultaneous multiple insertions	1.2
D. Access and/or vision	
Direct	0
E. Alignment	
Easy to align	0
Difficult to align	0.7
F. Insertion force	
No resistance to insertion	0
Resistance to insertion	0.6
Restricted	1.5

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Boothroyd-Dewhurst method of assembly evaluation is based on two principles:*
    - *The application of criteria to each part to determine if it should be separate from all other parts and*
    - *The estimation of the handling and assembly costs for each part using the appropriate assembly process.*
  - *The Boothroyd-Dewhurst method relies on an existing design, which is iteratively evaluated and improved.*
    - *1. Select an assembly method for each part.*
    - *2. Analyze the parts for the given assembly methods.*
    - *3. Refine the design in response to shortcomings identified by the analysis.*
    - *4. Refer back to step 2 until the analysis yields a satisfactory design.*

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Boothroyd-Dewhurst method of assembly evaluation is based on two principles:*
    - *The analysis generally is performed using a specific worksheet.*
    - *Tables and charts are used to estimate the part handling and part insertion time*
    - *Each table is based on a two-digit code, which in turn, is based on a part's size, weight, and geometric characteristics*

Boothroyd-Dewhurst Method to Evaluate Design for Assembly

A	B	C	D	E	F	G	H	I	Name of Assembly
Part ID	Number of Consecutive Identical Operations	2-Digit Handling Code	Manual Handling Time per Part	2-Digit Insertion Code	Manual Insertion Time per Part	Operation Time (BD+F)	Operation Cost	Essential Part?	
					Totals:	$T_m=$	$C_m=$	$N_m=$	

Design Review: Designing to Ensure Quality

- *Designing for Assembly and Disassembly*
- *Evaluating design for assembly*
  - *The Boothroyd-Dewhurst method of assembly evaluation is based on two principles:*

Boothroyd-Dewhurst Method to Evaluate Design for Assembly

A	B	C	D	E	F	G	H	I	Name of Assembly
Part ID	Number of Consecutive Identical Operations	2-Digit Handling Code	Manual Handling Time per Part	2-Digit Insertion Code	Manual Insertion Time per Part	Operation Time (BD+F)	Operation Cost	Essential Part?	
					Totals:	$T_m=$	$C_m=$	$N_m=$	

		Parts Easy to Grasp and Manipulate					Parts with Handling Difficulties				
		Thickness > 2 mm			Thickness ≤ 2 mm		Thickness > 2 mm			Thickness ≤ 2 mm	
		Size > 15 mm	Size 6–15 mm	Size < 6 mm	Size > 6 mm	Size ≤ 6 mm	Size > 15 mm	Size 6–15 mm	Size < 6 mm	Size > 6 mm	Size ≤ 6 mm
		0	1	2	3	4	5	6	7	8	9
(α+β)<360	0	1.13	1.43	1.88	1.69	2.18	1.84	2.17	2.65	2.45	2.98
360≤(α+β)≤540	1	1.5	1.8	2.25	2.06	2.55	2.25	2.57	3.06	3	3.38
540≤(α+β)≤720	2	1.8	2.1	2.55	2.36	2.85	2.57	2.9	3.38	3.18	3.7
(α+β)=720	3	1.95	2.25	2.7	2.51	3	2.73	3.06	3.55	3.34	4

Project

- *Phase 7*
  - *Product DFA Analysis*