MER 507
Design for Manufacturing
Winter, 2011

Professor: Dean Poeth, Ph.D., P.E., C.Mfg.E.

Class: Tuesday & Thursday 4:30-6:10 p.m.

Room: Steinmetz NWSE 210

Office: Graduate Center, Room 221

Office Hours: By appointment

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Description: This course will introduce the student to the principles of design for manufacturing. The course will begin by examining modern manufacturing operations including machining, casting, forging, welding, brazing, soldering, finishing, heat treating, assembly, plastic materials processing, powder metallurgy, and specialized manufacturing processes. This section will also include electronics manufacturing, covering both through-hole technology and surface mount devices. For each manufacturing process, capabilities and limitations will be discussed and how they relate to part design and cost. Design for manufacturing principles will be examined, including how the designer affects manufacturing cost, lean manufacturing, six sigma, value stream analysis, manufacturing rate, the cost of quality, process flexibility, process simulation, and process economics.

Text: There is no textbook for this class. Class notes will be used.

Course Objectives:

- Understand modern manufacturing operations, including their capabilities, limitations, and how to design for lowest cost.
- Gain insight into how designers influence manufacturing schedule and cost.
- Learn how to analyze products and be able to improve their manufacturability and lower costs.
- Understand the relationship between customer desires, functional requirements, product materials, product design, and manufacturing process selection.
- Be able to examine a product and determine how it was manufactured and why.
- Be able to explain the importance of human-factors in manufacturing and assembly, and how it relates to design.
- Understand how and why value stream analysis is used to lower manufacturing costs.
- Understand the advantages and disadvantages of hard (inflexible) and soft (flexible) manufacturing automation.

Part One: Manufacturing Processes and the Fundamentals of Design for Manufacturing (DFM)

January 4. Tuesday.
Course introduction
Academic integrity
Why study DFM?
The history of manufacturing and DFM
Interchangable parts, Henry Ford and mass production
Case study: The M-15 Teletype
Discussion: Trends in technology: the computer hard drive, the Bolova watch

January 6. Thursday.
In-class group design project (materials supplied by the instructor)
An introduction to manufacturing processes
Casting
- The casting process
- Sand casting
- Investment casting
- Shell molding
- Lost foam casting
- Casting defects
- Casting economics

January 11. Tuesday
An introduction to manufacturing processes (continued)
Forming Operations
- Hot working processes
- Forging
- Forging economics
- Rolling
- Extrusion
- Tube and pipe making
- Cold working processes
- Thread rolling
- Cold forging
- Cold heading
- Press work and sheet metal

Machining processes
- Chip formation
- High speed machining videos
- Turning operations
- Drilling, reaming, and taping operations
- Milling operations
- Grinding operations
- Sawing operations
- Machining economics

January 13. Thursday.

- Welding processes
  - Welding power supplies
  - Arc welding
    - Shielded metal arc welding
    - Gas tungsten arc welding
    - Gas metal arc welding
    - Flux-cored arc welding
    - Submerged arc welding
    - Plasma arc welding
  - Resistance welding
  - Oxyfuel welding
  - Electron beam welding
  - Laser welding
  - Welding defects
- Solid-state welding
  - Diffusion welding
  - Roll bonding
  - Forge welding
- Soldering processes
  - Heat sources
  - Fluxes
  - Alloys
  - Wetting theory
  - Disadvantages of soldering
- Brazing processes
  - Heat sources
  - Fluxes
  - Alloys
  - Disadvantages of brazing
- Discussion section: Upcoming tour of Ball Metal Container Corporation

January 18. Tuesday.

Tour of Ball Metal Container Corporation. Tour starts promptly at 5:15 p.m.
No open toe shoes
No loose clothing

January 20. Thursday.

- Specialized machining processes
  - Electro-discharge machining (EDM)
    - Sinking EDM
    - Wire EDM
  - Water jet machining
  - Chemical machining
  - Electrochemical machining (ECM)
- General disadvantages of specialized machining processes
- Powder metallurgy
  - Atomization
  - Die compaction
  - Cold isostatic pressing

- Hot isostatic pressing
- Sintering
- Advantages and disadvantages of powder metallurgy

January 25. Tuesday.

Plastics
- Introduction to polymers
- Thermo plastics
- Thermosetting plastics

Plastic processing operations
- Injection molding
- Advantages and disadvantages of injection molding
- Compression molding
- Transfer molding
- Blow molding
- Extrusion
- Auxiliary plastic processing equipment

January 27. Thursday.

Electronics manufacturing
- Printed circuit board fabrication
  - FR4
  - Masking
  - Etching
  - Plating
  - Solder mask
  - Silk screen
  - Conformal coating
  - Potting electronic assemblies
- Electronic components
  - Passive
  - Active
- Through-hole technology
- Surface mount technology
- Circuit board assembly
- Solder paste
- Wave soldering
- Cleaning

Part Two: Design for Manufacturing (DFM) Concepts and Applications

February 1. Tuesday.
The design process
- Conceptual design
- Embodiment design
- Detail design
- Planning for manufacture
- Planning for distribution
- Planning for use
- Planning for end of life

Green design
Design mistakes
Design for welding
- Case study: The failure of the Schenectady T2 Tanker
- Case study: The sinking of the Alexander L. Kielland Accommodation Platform
- Weld joint distortion
- Weld joint residual stress
- Joint accessability
- Design solutions

February 3. Thursday.
Design for electronics
Series and parallel reliability models
Combined series-parallel systems
Review for midterm examination

February 8. Tuesday.
Midterm examination. Bring a calculator and spare batteries.

February 10. Thursday.
Review of midterm examination
Design for manual assembly
- Case study: The PT Cruiser
- Case study: Plastic wagon manufacturing

Design for automatic assembly
- Flexible automation
- Hard automation
- Economics of automation

February 15. Tuesday.
Successful cost reduction methods
- Cost reduction for small volume manufacturing
- Case study: Muntzing a design for lower cost
- Case study: Zenith televisions
- Manufacturing process mapping

Lean/six sigma methods

February 17. Thursday.
Cost reduction (continued)
Product-process integration
Statistical analysis of product-process integration
Calculation of process capability indices: Cp & Cpk
Simulation modeling and analysis

February 22. Tuesday.
Simulation modeling and analysis (continued)
How to build a fact-based cost estimate
In-class group project: Building a process map and cost estimate using simulation.

February 24. Thursday.
Case study: Flashlight manufacturing
In-class group project: How could this design be improved?

March 1. Tuesday.
In-class group project: DFM reviews of parts drawings. Identify the high-cost features and improve the design

March 3. Thursday.
Group DFM analysis (parts supplied by the instructor)
Case study: How to build one 4-engine heavy bomber every hour.
Henry Ford revisited: Ford and DFM

March 8. Thursday.
Review of design for manufacturing principles
The future of design, manufacturing, and DFM
Review for final exam

Date: TBD.
Final exam. Bring a calculator and spare batteries.

Grading:
Final course grades will be based on the following:

Homework 25%
Twenty points will be devoted to writing. This includes grammar, spelling, use of complete sentences, clarity of expression, etc.
Midterm Exam 30%
Final Exam 40%
Class preparation/participation/quizzes 5%

Graded Assignments must be typed, double-spaced, Arial 11 font. All assignments must be stapled and are due in hardcopy at or before the beginning of class. No email submissions. Late assignment deduction: 10% per day. Writing quality (including spelling and grammar) as well as content will be evaluated. Assignments must be within the prescribed page limits. Students may work together on assignments, but each must turn-in a separate and original submission for grading.

Mid-Term and Final Exams: These exams will cover all elements of the course, including but not limited to lectures, handouts, in-class demonstrations, homework assignments, in-class projects, and factory tours. Tests will be approximately 45-60 minutes in length and cover important concepts and skills for each topic covered. All tests are closed book, closed notes. You will need a calculator and spare batteries.

Laptops are permitted for class-related work only (e.g., class note taking). Web surfing, texting, checking email, and other non-class related activities are distracting to fellow students and are therefore prohibited except during breaks.

Academic Integrity. You are expected to practice academic honesty in every aspect of this course. Make sure you are familiar with the Union Graduate College Student Handbook, especially the section entitled Academic Honesty and Student Conduct Policies which begins on page 30 (http://www.uniongraduatecollege.edu/pdf/UGCStudentHandbook.pdf). Students who engage in academic misconduct are subject to university disciplinary procedures, as well as consequences with regard to this course.

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