Tech 45: Unit 1

Introduction to Manufacturing Facilities, Design, and Processes:
Green Design Principles and Applications
Manufacturing facilities consist of things that provide services:

Buildings, factories (plants), equipment, people, processing machines, tooling, vehicles, instruments, materials, material moving/handling equipment, storage devices, aisles, offices, restrooms, receiving & shipping docks, parking lots, drive ways, and other things that provide services to manufacturing personnel.
Obi, Chapters 4, 5, & 6

- Manufacturing machines
- Tools and production tooling
- Manufacturing processes
Manufacturing Plants or Facilities
Conventional Lathe or Turning Machine
Computer Numerically-Controlled Lathe
Turning Processes
Conventional Milling Machine
CNC Milling Machine
Milling Processes
Drilling Machines
Drilling Processes

- Twist Drill
- Reamer
- Tap
- Counterbore
Sawing Machines
Sawing Processes
Surface Grinding Process
Cylindrical Grinder
Pedestal Grinder
Sanding and Finishing Machines
Power Shearing Machine
Shearing, Trimming, Punching, and Blanking Processes

Shearing force

Upper blade (punch)

Sheet metal

Clearance

Lower blade (die)

Scrap

Blank

Hole

Slug

Punching force

Punch

Sheet metal

Clearance

Scrap / slug

Die

Trimmed part

Scrap

Die

Shear metal
Coiline
Hole Punching Machines
Notching Machines
Notching Process

Scrap

Notched section
Sheet Metal Bending Machines
Sheet Metal Bending Processes

Press Brake

Hydraulic ram
Sheet metal

Punch
Die

Sheet metal
Punch

Pressure pad
Punch

V-die
Wipe die
Sheet metal
Sheet Metal Welding Machines
Pressing/Forging Machines
Metal Forming Processes
Metal Forming Processes: Drawing and Forging

Drawing force

Blank

Drawn part
Metal Casting Equipment
Metal Casting Process

- Ladle
- Molten Metal
- Open Riser
- Riser
- Pouring Cup
- Sprue
- Cope
- Drag
- Core
- Casting
- Chaplet
- Gate
- Runner
- Flask
- Parting Line
Permanent Casting Equipment

- Mold Half
- Sprue
- Runner
- Molten Metal
- Ladle
- Core Pin
- Core Pin
- Cavity
- Core
- Mold Half
- Casting
Die Casting Process

- Clamping Unit
- Tie Bar
- Moveable Platen
- Casting
- Ejector Die
- Cover Die
- Hydraulic Cylinder
- Plunger
- Inlet
- Shot Chamber
- Rear Platen
- Clamping Bar
- Ejection System
- Stationary Platen
- Gooseneck
- Holding Pot Furnace
- Molten Metal
Centrifugal Casting Process

- Ladle
- Molten metal
- Top rollers
- Mold
- Casting
- Motor
- Bottom rollers
- Pouring basin
- Finished casting
Rapid Prototyping
Heat Treating Machine

Hardness Testing Machine
Compression Molding Machines
Blow Molding Machine
Sawing Machines
Planing Machine

Jointer
Hand Tools
Hand Tools
Hand Tools
Assembling Tools
Cutting Tools
Jigs and Fixtures
Production Tooling
Production Tooling
Production Tooling
Material Handling and Conference Room
Material Handling System
Manufacturing facilities design and material handling greatly affect the productivity and profitability of a company.

Project managers/engineers are entrusted with the responsibility of facilities design and material handling.
These leaders must achieve their stated goals in order to be entrusted with bigger projects in the future.

Manufacturing facilities design is the organization of the company’s physical facilities to promote the efficient use of the company’s resources such as people, equipment, material, and energy.

Facilities design includes plant location, plant layout, building design, and material handling.
• Building design is an architectural job; the architect reports to the facilities design project manager.

• Layout is the physical arrangement of production machines and equipment, workstations, people, location of materials of all kinds and stages, and material handling equipment.
• The plant layout (whether for new or existing facilities) is the end result of a manufacturing facility design project.

• Major relayouts of plants (averaging 18 months) occur as a result of changes in product design, methods, materials, and process.
• Material handling, defined as moving material, accounts for about 50% of all injuries, and 40% - 80% of all operating costs.

• Therefore, project managers must try to provide proper return on investment (ROI) to justify their plans and proposals.
Meyers & Stephens, Chapter 1: Introduction to Manufacturing Facilities Des. & Material Handling

To reduce costs the 5 S’s principles will help. They include: Sifting (organization), sorting (arrangement), sweeping (cleaning), spick & span (hygiene), and strict (discipline)
Lean Thinking and Lean Manufacturing

• A Japanese word for waste is muda, defined as any expense that does not help produce value
Lean Thinking and Lean Manufacturing

• The eight (8) kinds of muda are: Overproduction, waiting, transportation, processing, inventory, motion, rework, and poor people utilization.

• The project manager’s goal is to eliminate or reduce these costs
Lean Thinking and Lean Manufacturing

• Kaizen is a Japanese word for constant or continuous improvement which project managers must get used to.
• Kanban or pull system is a signal board that communicates the need for material and visually tells the operator to produce another unit or quantity.
Lean Thinking and Lean Manufacturing

- Value-stream mapping (VSM) is the process of assessing each component of production steps to determine the extent to which it contributes to operational efficiency or product quality.
The Goals of Manufacturing Facilities Des. & Material Handling

- Minimize unit and project costs
- Optimize quality
- Promote the effective use of people, equipment, space, and energy
- Provide for employee convenience, safety, and comfort
The Goals of Manufacturing Facilities Des. & Material Handling

- Control project cost
- Achieve production start date
- Build flexibility into the plan
- Reduce or eliminate excessive inventory
- Achieve miscellaneous goals
The Manufacturing Facilities Design Procedure (24 steps)

• Determine what will be produced
• Determine how many will be made per unit of time
• Determine what parts should be made or purchased
The Manufacturing Facilities Design Procedure (24 steps)

• Determine how each part is to be made
• Determine the sequence of assembly
• Determine the plant rate (takt time)
• Determine the number of machines needed
• See pages 11-13 for the rest
• This is our challenge this semester
Types & Sources of Manufacturing Facilities Design Projects

New facility
New product
Design changes
Cost reduction
Retrofit
Computers and Simulation in Manufacturing Facilities Design

• Uses and advantages of CAD in facilities design
• Advantages of simulation facilities design
The presentation of the project occurs at a management meeting where the project manager presents the plan.

This presentation is similar to first class project report and presentation.
Selling the Layout

• Using the product model, you can cover the following:
  – The goal of the project is …(usually related to cost reduction)
  – The volume and plant rate
  – The product
  – The make or buy decisions
  – The process
Selling the Layout

- Using the layout, you can cover the following:
  - The process design or flow of each part
  - Assembly and packout
  - The operations chart and flow process chart
  - The activity relationships and dimensionless block diagrams
Selling the Layout

• Using the layout, you can cover the following:
  - The auxiliary services
  - The employee services
  - The office
  - The area allocation diagram
Selling the Layout

Approval
Sourcing
Installation
Engineering pilot
Production start
Debugging
Some Emerging Green-Related Needs

- Strong and growing presence of major employer aircraft and airline industries
- Significant presence of automotive and motor-cycle industries
- Presence of growing healthcare industry
- Presence of huge and growing shipping and transportation industries
- Presence of numerous residential buildings and commercial establishments
Some Emerging Green Tech Industries
What They All Need

- They all need clean or reduced energy
- They all need to use green materials
- They all need green policies
- They all need knowledgeable workforce
Potential Cost Factors

• Purchase and installation of equipment
  – Wind turbines and supporting equipment
  – Solar panels and supporting equipment
  – Biodiesel engines
  – Hybrid engines
  – Biofuel systems
  – Green material processing equipment
  – Training of instructors and personnel
• Hiring of new instructors (if needed)
• Additional facilities (if needed)
• Support for new (additional) students (if needed)
Green Tech Systems
The 12 Principles of Green Engineering
Principle 1

• Designers need to strive to ensure that all material and energy inputs and outputs are as inherently non-hazardous as possible.
Principle 2

- It is better to prevent waste than to treat or clean up waste after it is formed.
Principle 2 (cont.)

- "End of pipe" technologies
- Containment systems for storage and disposal
- Expensive
- Constant monitoring
- Potential to fail
Principle 3

• Separation and purification operations should be a component of the design framework.
The catalyst is soluble in one of the reagents and remains soluble when the other reagent is added. As the reaction goes on, and the product builds up, the catalyst precipitates from the mixture as oil. This oil—liquid clathrate—remains to be an active catalyst, as the reagents are able to penetrate into it. When all the reagents are converted into products, the oily catalyst turns into a sticky solid, which can be easily separated and recycled.

Principle 4

• System components should be designed to maximize mass, energy and temporal efficiency.
Principle 4 (cont.)

- Process intensification
- Sophisticated actuator-control systems
Principle 5

- System components should be output pulled rather than input pushed through the use of energy and materials.

*(Le Chatlier’s Principle)*

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**Le Chatelier's Principle**

"If a system in equilibrium is subjected to a stress, the equilibrium will shift in the direction which tends to relieve that stress."
Principle 5 (cont.)

• Just in time manufacturing
  – Production is based on demand
  – eliminates waste due to overproduction and lowers warehousing costs
  – supplies are closely monitored and quickly altered to meet changing demands
  – small and accurate resupply deliveries must be made just as they are needed
Principle 6

• Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse or beneficial disposition.
Principle 6 (cont.)

• The amount of complexity built into a product whether at the macro, micro, or molecular scale is usually a function of resource expenditures.
  – High complexity, low entropy – reuse
  – Lower complexity – value-conserving recycling where possible or beneficial disposition

• Natural systems can also be recognized as having complexity
Principle 6 (cont.)

- Case for modular, standardized, platform-based, upgradable design
Principle 7

• Targeted durability, not immortality, should be a design goal.
Principle 7 (cont.)

• Products that last well beyond their useful commercial life often result in environmental problems ranging from solid waste to persistence and bioaccumulation.

• Repair and maintenance must also be considered.

• Must balance targeted lifetime with durability and robustness in anticipated operating conditions.
Principle 7 (cont.)

• Biodegradable plastics
Principle 8

- Design for unnecessary capacity or capability should be considered a design flaw. This includes engineering “one size fits all” solutions.
Principle 8 (cont.)

• While product agility and product flexibility can be desirable, the cost in terms of materials and energy for unusable capacity and capability can be high.

• There is also a tendency to design for the worst case scenario such that the same product or process can be utilized regardless of spatial or temporal conditions.
Principle 8 (cont.)

- A single laundry detergent formulation that is intended to work anywhere in the US and must be designed to work in the most extreme hard water conditions
  - Phosphates were added as builders to remove hardness of water
  - Phosphates, by their high nutrient value, can cause eutrophication in water bodies
Principle 9

• Multi-component products should strive for material unification to promote disassembly and value retention. 
  *(minimize material diversity)*
Principle 9 (cont.)

• Selected automobile designers are reducing the number of plastics by developing different forms of polymers to have new material characteristics that improve ease of disassembly and recyclability.

• This technology is currently applied to the design of multilayer components, such as door and instrument panels.
Principle 9 (cont.)

• For example, components can be produced using a single material, such as metallocene polyolefins, that are engineered to have the various and necessary design properties.

• Through the use of this monomaterial design strategy, it is no longer necessary to disassemble the door or instrument panel for recovery and recycling.
Principle 10

• Design of processes and systems must include integration and interconnectivity with available energy and materials flows.
Principle 10 (cont.)

Kalundborg Industrial Symbiosis - 1995

Drawn by D. B. Holmest based on information from various sources, including L. K. Evans, N. Gertler, and Y. Christensen.
Principle 11

• Performance metrics include designing for performance in commercial “after-life”.
Principle 11 (cont.)

"When we reuse our products — much less recycle them — we keep our costs down significantly," says Rob Fischmann, head of worldwide recycling at Kodak. "The second-time cost for these cameras is essentially zero."
Principle 12

• Design should be based on renewable and readily available inputs.
Principle 12 (cont.)

- With cooperative development from Mitsui Chemicals Inc. and Cargill-Dow, LLC, SANYO achieved the world's first bio-plastic (polylactic acid) optical disc in 9/2003.

- Use corn as base material to derive polylactic acid with its optical property and exact structure.

- Roughly 85 corn kernels is needed to make one disc and one ear of corn to make 10 discs. The world corn production is about 600 million tons, less than 0.1% is needed to make 10 billion discs (current annual worldwide demand).