Course Information

- Course description
- Two technical papers & presentations
- Title page, title, course, lift, student name
- Abstract (approx. 100 words) & Table of Contents
- Introduction/Background/restriction/significance
- Discussion: terminology; comparisons/assessments (similarities & differences); methodology, technology, applications, cost trade-offs; benefits, limitations; implications for management, labor & society; conclusions; cite references; page numbers
- Reference list
- Use professional style, structure and format (note journal paper used as model)
- Project demo & report
- Webpage:

What is an abstract?

- Brief summary that contains the substance (essence) of the paper
- It should capture the main ideas and highlight the author’s principal findings
- Example

>>>> Refer to paper of any credible refereed technical journal for an example.
Representative Topics Covered

- Computer-aided concurrent engineering (CACE); Design for Manufacturability (DFM)
- Flexible manufacturing systems (FMSs)
- Computer numerical control (CNC); Direct/distributed numerical control (DNC)
- Computer-aided process planning (CAPP), including expert system applications
- Industrial robot applications, including off-line programming
- Production planning & control, including JIT and SAP
- Product/process simulation
- Data entry systems
- Automated inspection systems & quality engineering
- Productivity engineering, including manufacturing cost analysis
- MRP vs. JIT production systems; JIT vs. lean manufacturing
- Applications in CIM
- Other topics: Automation & human labor; green manufacturing; AHP (decision support tools)

Project Ideas

- Sensor application - Learn how various sensors work; define a problem that involves logic and control
- Robotic application - Expand your knowledge of the mobile robot; design an application that requires advanced logic of the system, such as complex computer logic; integrate the robotic system with a conveyor, a parts indexing table, or a vision system
- Welding robots - Learn both robot programming and welding process fundamentals design a weldment; program the robot system to weld it
- PLC - Learn the programming and I/O operation of PLCs; design a system to simulate a manufacturing operation; work with industrial grade PLC control components
- APS - Automated Storage/Retrieval System - Microcomputer control of warehousing operation; learn how to program and control the storage and retrieval of parts; integrate both an industrial grade roller conveyor and an industrial grade APS system
- Model CNC milling system - Build a model machining system; program the computer to mill (router tool) a cutting path, e.g., tiger hawk, on a workpiece
- Machine vision - Learn the fundamentals of data capture and processing; define an application; program the machine vision system to carry out the plan
- Coordinate measuring machine (CMM) - Interface CMM to computer to take part measurements as part of a manufacturing automation environment; design an industrial welding robot simulation environment; create example; download robot program to welding robot
- Other - Define another application that allows you to learn something about technology (hardware or software) that supports computer integrated manufacturing
Today’s Topics

- Challenge for manufacturers
- Just in Time (JIT) production system
- Manufacturing systems
- Cost considerations
- Manufacturing process models
- Factors affecting manufacturing practice
- System trade-offs

Challenge for Manufacturers

- Effectively compete in a worldwide marketplace
- Smart buyer of technology
- Manage change

Manufacturing Theme for the 2001’s & Beyond

- Low cost manufacturing
- High quality (reliable) products
- Increased productivity (better use of limited resources)
- Reduced cycle time
- Reduced environmental impact
Just in Time (JIT) Production

Reduce cost by eliminating waste — any element of production that does not add value to the final product.

Waste is found in:
- Overproduction
- Inventory
- Conveyance
- Defects & correction
- Waiting
- Processing

Manufacturing Systems

- Definition
- Manufacturing system components
- Computer control system functions
- Human resources
- Classification of manufacturing systems

What is Manufacturing?

- "Manufacturing encompasses all those functions from the receipt of product definition to the satisfactory completion of an end item." In other words, from a set of drawings and specifications (product design department) to a finished product (made by the factory) placed on the shipping platform.
- Industrial activity that changes the form of raw materials to create products.
- More simply, manufacturing is the transformation of (raw) materials into products that meet customers’ demands.
Types of Manufacturing

- Batch manufacturing — small lots & large variety
- Mass production — large quantities & standard products
- Continuous process industry — large volume of single (flow) product

Basic Manufacturing Processes (metalworking industries)

- Casting & molding
- Forming & shaping
- Machining (material removal)
- Joining & assembly
- Finishing (surface treatments)
- Heat treating

Definition: Manufacturing System

A manufacturing system is a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.
Manufacturing System Components

- What are they?
- How are they combined?
- How are they organized?
- Production machines
- Material handling system
- Computer control system
- Human resources

Computer Control System

- Communication
- Download part programs
- Material handling system control
- Schedule production
- Failure diagnosis
- Safety monitoring
- Quality control
- Operations management

Human Resources

- Direct labor (physical labor)—perform manual work; load/unload & control machines; change tools
- Indirect labor—set up machines; material handling; inspection; CNC programmers; computer operators; maintenance/repair personnel; supervisors
### Classification of Manufacturing Systems

- Types of operations
- Number of workstations & layout
- Level of automation
- Part or product variety (how to handle; types of flexibility)

### Manufacturing Systems

- Mass production (transfer line)
- Computer integrated manufacturing system (CIM)
  - Special system
  - Flexible manufacturing system (FMS)
  - Flexible manufacturing cell (FMC)
- Stand-alone CNC

### Production Volume vs. Product Flexibility
Part Design Flexibility vs. Operating Flexibility

Cost Considerations
- Selling price of product
- Manufacturing cost
- Opportunities to reduce cost

Selling Price of Product
Manufacturing Cost

- Direct Labor: 10%
- Indirect Labor: 12%
- Plant/ Machine Energy & Deprec.: 10%
- Parts & Materials: 50%
- Plant/Machine Energy & Deprec.: 10%
- Mktg/Sales/Admin Cost: 25%

Opportunities to Reduce Cost

- Increase resource utilization
- Eliminate unnecessary operations
- More effective production scheduling
- Reduce required labor
- Improve maintenance, especially preventative
- Reduce scrap & rework
- Reduce required material handling
- Reduce inventory levels
- Reduce setup times

How Engineers Influence Economics

- Part tolerances
- Material & tooling selection
- Number of operations
- Product development lead time & design iterations
- Others: material flow; scrap management; implement new technology
Typical Distribution of Factory

- Vacations/Holidays: 34%
- Incomplete Use of 2nd & 3rd Shifts: 44%
- PRODUCTION: 6%
- Setup/Loading: 14%
- Idle Time: 2%

Thinking with Models

- Mathematical/Engineering
- Empirical/regression
- Neural network
- Genetic algorithm
- Other optimization methods
- Game theory

Types of Models

<table>
<thead>
<tr>
<th>Objective</th>
<th>Process</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce cost</td>
<td>Machining</td>
<td>Mathematical</td>
</tr>
<tr>
<td>Improve quality</td>
<td>Casting</td>
<td>ANN/Genetic algorithm</td>
</tr>
<tr>
<td>Process selection</td>
<td>Manufacturing</td>
<td>AHP</td>
</tr>
<tr>
<td>Improve resource utilization</td>
<td>Machining/Tool wear</td>
<td>Machine vision/regression</td>
</tr>
</tbody>
</table>
Manufacturing Process Models

- Machining model
- Casting model
- Welding model

Machining Model

- Input Parameters
  - Part Geometry
  - Part Material
  - Tolerance & Finish
  - Production Requirements

- Process Design
  - Machine Tool
  - Cutting Tool(s)
  - Depth of Cut
  - Feedrate
  - Cutting Speed

Model Output

- Production Cost
- Production Time
- Resources Used

Machining Process Monitoring

- Machining Parameters
  - Force
  - Dynamometer Data
  - Signal Processing

- ANN Model
  - Forces
  - Components

- Monitoring
  - Workpiece
  - Tool Wear
  - Monitoring
  - Surface Roughness

OPERATOR/DECISION MAKER

- Process in control?
  - Yes
  - No
  - Intervene
  - Continue
Casting Model

Input Parameters
- Part Geometry
- Part Material
- Tolerance & Finish
- Production Requirements

Process Design
- Casting Process
- Parting Line Location
- Gating & Riser(s)

Model Output
- Casting Geometry
- Production Cost
- Solidification Time
- Stresses & Defects

Casting Process Design
- Part orientation
- Parting line location
- Gate(s) and riser(s) design
- Pattern/mold design
- Process simulation

Casting Design Environment
- Shared Database
- Part & mold geometry
- Casting material properties
- Mold material properties
- Process types & characteristics

CAD System
- Laser Scanning

CAE Applications
- Dynamics
- Heat transfer
- FEM
- Design optimization

Performance Capability
- Resource availability
- Time estimation
- Cost estimation

Activity Manager
- CAM Applications
- CNC machining
- Rapid prototyping

Process Simulation
- Fluid flow
- Heat transfer
- Solidification
- Stress growth
- Defects/Quality criteria

Pattern/mold Design
- Parting line location
- Allowances & draft
- Rigging system
- Tolerance specification
- Shape constraints
Continuous Casting Model

- Neural Network
- Thickness
- Width
- Carbon%
- Superheat
- Casting Speed
- Cooling Rate

Welding Model

- Input Parameters:
  - Weldment Geometry
  - Weldment Material
  - Production Requirements
  - Weld Specification

- Process Parameters:
  - Power Supply
  - Weld Wire
  - Gas & Flowrate
  - Wire Feedrate
  - Weld Voltage
  - Stickout

- Model Output:
  - Production Cost
  - Production Time
  - Resources Used

Welding Process Control

- Determine process variable relationships
- Integrate CAD and weld analysis
- Develop advanced quality sensor
- Develop process correction algorithm
Experimental Setup

Sound Signal Repeatability

Good vs. Bad Welding
Welding Process Control

Factors Affecting Manufacturing Practice
- Trend in materials
- More automation
- Better integration
- Push for lowest cost
- Better environment for workers
- Better resource utilization
- Reduced environmental impact

System Trade-offs
- Advantages vs. disadvantages
- Plusses vs. minuses
- Plusses vs. other pluses
- Cost vs. benefits
- Optimization strategies