ME6703 - COMPUTER INTEGRATED MANUFACTURING SYSTEMS
SYLLABUS

UNIT I - INTRODUCTION

UNIT II - PRODUCTION PLANNING AND CONTROL AND COMPUTERISED PROCESS PLANNING
10

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UNIT V - INDUSTRIAL ROBOTICS
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TEXT BOOK:

TOTAL : 45 PERIODS
UNIT I – Introduction (10)

- Brief introduction to CAD and CAM
- Manufacturing Planning, Manufacturing control
- Introduction to CAD/CAM
- Concurrent Engineering-CIM concepts
- Computerized elements of CIM system
- Types of production
- Manufacturing models and Metrics
- Mathematical models of Production Performance – Simple Problems
- Manufacturing Control – Simple Problems
- Basic Elements of an Automated system
- Levels of Automation
- Lean Production
- Just-In-Time Production.
Product Development Cycle
Sequential Vs Concurrent Engineering

Sequential Vs Concurrent Engineering

Sequential Product Design Vs Concurrent Product Design Approach

- Better collaboration between different phases
- Shorter total time to market

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Implementation of Concurrent Engineering
Computer-Aided Techniques

- CAD (Computer-Aided Design)
- CAE (Computer-Aided Engineering)
- CAPP (Computer-Aided Process Planning)
- PPC (Production Planning and Control)
- ERP (Enterprise Resource Planning)
- CAM (Computer-Aided Manufacturing)
- CAQ (Computer-Aided Quality Assurance)
Interface between CAD/CAM

- Idea for part (CAD) → Design file or model (CAM)
- Physical part (Machining) ← Toolpaths, machine instructions (e.g. G-code)
Computer Integrated Manufacturing (CIM) is the manufacturing approach of using computers to control the entire production process.

In a CIM system functional areas such as Design, Analysis, Planning, Purchasing, Cost Accounting, Inventory Control and Distribution are linked through the Computer with factory floor functions such as Materials Handling and Management, providing Direct Control and Monitoring of all the operations.
CIM Wheel
Computerized Elements of CIM System
Activities of CIM

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Benefits of CIM

- Manufacturing engineers are required to achieve the following objectives to be competitive in a global context,
  - Reduction in inventory
  - Lower the cost of the product
  - Reduce waste
  - Improve quality
  - Increase flexibility in manufacturing to achieve immediate and rapid response to:
    - Product & Production changes
    - Process & Equipment change
    - Change of personnel

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Application of **Physical** and **Chemical** processes to alter the geometry, properties, and/or appearance of a given starting material to make parts or products.
Transformation of materials into items of greater value by means of one or more **Processing** and/or **Assembly** operations

- Manufacturing adds *value* to the material

- Examples:
  - Converting iron ore to steel adds value
  - Transforming sand into glass adds value
Manufacturing Defined - Economic Definition

Starting material → Material in processing → Completed part or product

Manufacturing process

Value added
Production Quantity

Number of units of a given part or product produced annually by the plant

- Three quantity ranges:
  1. Low production – 1 to 100 units
  2. Medium production – 100 to 10,000 units
  3. High production – 10,000 to millions of units
Production Types

Production Systems

Batch Production

Continuous Production

Job Shop Production

Mass Production

Flow Production
Types of Production Facility

- Job shop
- Batch production
- Cellular manufacturing
- Fixed position layout
- Process layout
- Cellular layout
- Product layout

Product variety vs. Production quantity graph:
- Quantity
- Flow line
- Mass production

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Variety of metrics used by successful manufacturing to help managing company’s operations

**Quantitative metrics used to:**
- Track performance in successive periods (i.e. months & years)
- Try out new technologies & new systems to determine company’s merits
- Identify problems with performance
- Compare alternative methods
- Make good decisions
Manufacturing Metrics can be divided into 2 basic categories:

1) Production performance measure
2) Manufacturing Costs
Production concepts and Mathematical Models

Metrics that indicates Production Performance:

- Production Rate (Rp)
- Production Capacity (PC)
- Utilization (U)
- Availability (A)
- Manufacturing Lead Time (MLT)
- Work-In-Progress (WIP)
Production concepts and Mathematical Models

Metrics that indicates Manufacturing Costs:

- Labor & material costs
- Costs of producing products
- Cost of operating a given piece of equipment
Typical cycle time for a production operation:

\[ T_c = T_o + T_h + T_{th} \]

- where \( T_c \) = Cycle Time,
- \( T_o \) = Processing Time for the Operation
- \( T_h \) = Material Handling Time (e.g., loading and unloading the production machine)
- \( T_{th} \) = Tool Handling Time (e.g., time to change tools)
Production Rate (Rp)

- In manufacturing, the **number of goods** that can be **produced** during a given **period of time**. Alternatively, the amount of **time** it takes to produce one unit of a good.

- For manufacturing and construction, a higher production rate can lead to a decrease in quality.

- Usually expressed in hourly rate

- Consider 3 types of production – **Job Shop, Batch Prod & Mass Productions**
In **Batch Production**, time to process one batch of Q work units is

**Batch time**, \( Tb = Tsu + QTc \)

where;

- \( Tb \) = batch processing time (min)
- \( Tsu \) = setup time to prepare for the batch (min)
- \( Q \) = batch quantity (pc)
- \( Tc \) = operation cycle time per work unit (min/cycle)

Assuming one work unit is completed each cycle, thus \( Tc \) also has units of min/piece
By dividing batch time with batch qty:

- Average production time per work unit for the given machine, \( T_p = \frac{T_b}{Q} \)
- Production rate, \( R_p = \frac{1}{T_p} \)
- The average production rate for the machine, \( R_p = \frac{60}{T_p} \)
  
  \( R_p = \) hourly production rate (pc/hr)
  
  \( T_p = \) average production time per work unit (min/pc)
  
  \( 60 = \) constant to convert minutes to hours
In **Job Shop Production**, when \( Q = 1 \);

- The production time per work unit, \( T_p \) is:

\[
T_p = T_{\text{s}} + T_c
\]

- \( T_{\text{s}} = \) Setup time to prepare for the batch (min)
- \( T_c = \) Operation cycle time per work unit (min/cycle)

- If \( Q > 1 \), revert to batch production case
The machine production rate is determined by taking the reciprocal of $T_c$,

$$R_c = \frac{60}{T_c}$$

Where,

- $R_c =$ theoretical or ideal production rate / cycle rate (cycles/hr)
- $T_c =$ ideal cycle time (min/cycle)
- $60 =$ constant to convert minutes to hours
Production Capacity defined as: the **maximum rate of output** that a production facility is able to produce under a given set of assumed operating conditions

$$PC = n \times Sw \times Hs \times Rp$$

*Where,*
- $PC$ = weekly production capacity of the facility (output units/wk)
- $n$ = no. of work centers working in parallel producing in the facility
- $Sw$ = no. of shifts per period (shift/wk)
- $Hs$ = hr/shift (hr)
- $Rp$ = hourly production rate of each work center (output units/hr)

- Work center manufacturing system in the plant typically consisting of one worker & one machine
Utilization = amount of output of a production facility relative to its capacity

\[ U = \frac{Q}{PC} \]

U = utilization of the facility
Q = actual qty produced by the facility during a given time period (i.e. pc/wk)
PC = production capacity for the same period (i.e. pc/wk)

- Utilization can be assessed for the entire plant/any other productive resources (i.e. labor)
- It is often defined as the proportion of time that the facility is operating relative to the time available
- Usually expressed in %
Availability

- Availability = a common measure of reliability for equipment
- Especially appropriate for automated production equipment:

\[
A = \frac{MTBF}{MTBF - MTTR}
\]

\(A\) = availability (typically in %)
\(MTBF\) = mean time between failures (hr)
\(MTTR\) = mean time to repair (hr)

- MTBF indicates the average length of time between breakdowns of equipment
- MTTR indicates the average time required to service the equipment & put back into operation when breakdown occurs
Manufacturing Lead time (BATCH)

✓ Manufacturing Lead Time, MLT = total time required to process a given part or product through the plant
✓ Simplified form:

\[ MLT = n_o (T_{su} + QT_c + T_{no}) \]

MLT = average Manufacturing Lead Time for a part/product (min)
\( n_o \) = no. of separate operations (machines)
Tsu = setup time for operation
Q = qty of part/product
Tc = operation cycle time
Tno = non-operation time
Work-In-Process

\[
WIP = \frac{AU(\text{PC})(\text{MLT})}{S_w H_{sh}}
\]

WIP = work-in-process in the facility (pc)
A = availability
U = utilization
PC = production capacity of the facility (pc/wk)
MLT = manufacturing lead time (hr)
Sw = no. of shifts per week (shift/wk)
Hsh = hours per shift (hr/shift)

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Costs of Manufacturing Operations

- Fixed costs - remain constant for any output level
- Variable costs - vary in proportion to production output level

- Adding fixed and variable costs
  \[ TC = FC + VC(Q) \]
  
  where
  \( TC \) = total costs
  \( FC \) = fixed costs (e.g., building, equipment, taxes)
  \( VC \) = variable costs (e.g., labor, materials, utilities)
  \( Q \) = output level

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Fixed and Variable Costs
Manufacturing Costs

Alternative classification of manufacturing costs:

1. Direct labor - wages and benefits paid to workers
2. Materials - costs of raw materials
3. Overhead - all of the other expenses associated with running the manufacturing firm
Basic Elements of an Automated System