Lecture outline

- This lecture will cover:
  1. Type of production
  2. Plant layouts
  3. Type of automation
  4. Automation Strategies

Type of Production

- Three types of productions according to the quantity of products
  - Batch production
  - Job shop production
  - Mass production

Job Shop Production

- Low production volume (1-1000/year)
- Lot size is small (one of a kind)
- Specific customer orders will trigger the production
- Customized design and greater variety
- Equipment: Flexible and general purpose
- Skill: relatively high
- Material handling equipment: flexible (no standard path of material flow)
- Example: Aircraft, machine tools, prototypes

Batch Production

- Production of medium sizes of same products or parts (100-10000/year)
- Produce only once or with regular interval
- Continuous demand: production rate > demand rate.
- Equipment: general purpose equipment but with high usage rate.
- Specially designed jigs and fixtures.
- Example: books, clothing, furniture, some industrial machinery.
Mass production
- Continuous dedicated production of large quantities of one product (with limited model variations) (10000 or above/year)
- Very high production and demand rate.
- Equipment: Specific purpose machine with being completely dedicated to the particular products
- Investment in machines and tooling is very high
- Skill level of labour tends to be lower.

Plant layouts
- Arrangement of physical facilities in a production plant.
- The physical size, quantity, and variety of products being manufactured often determine the plant layouts.
  ✓ Fixed-position Layout.
  ✓ Process Layout.
  ✓ Product Flow Layout.
  ✓ Cellular Layout.

Fixed-position Layout
- Product remains in one location. Workers and equipment move around the product
- Usually associated with Job shop production type in which complex products are fabricated in very low quantity
- Ship or aircraft production

Fixed-position Layout

Process Layout
- The production machines are arranged into groups according to general type of manufacturing processes
- Flexible for different parts
- Typical in job shop production and batch production
Process Layout

- Processing and assembly facilities are placed along the line of flow of the product.
- Plants (workers and stations) are designed specifically for the production of certain specific product(s).
- One product or one class of products in large quantity.
- Typical for batch productions.

Product Flow layout

- Machines are arranged into cells.
- Each cell is organized to specialize in the production of a particular part family (a set of similar products).
- Reduced work piece handling, lower setup times, less in progress inventory, shorter lead time.

Cellular Layout

Composite view
Automation

Automation: the technology associated with the application of complex mechanical, electronic and computer based systems to operate and control production.

- A reduced or no human intervention
- It usually refers a combination of:
  - Computerisation of information processing activities.
  - Automation of physical manufacturing activities in the factory.

Automation - Examples

- Automatic machine tools to process the parts,
- Automatic assembly machines,
- Industrial robots,
- Automatic material handling and storage systems,
- Automatic inspection systems,
- Process control systems,
- Computer systems for planning, data collection, and decision making to support manufacturing activities.

Reasons for Automating

- Increase productivity,
- Reduce cost of labour,
- Mitigate labour shortage,
- Reduce or eliminate routine manual and clerical tasks - trend of labour toward service sector - people prefer white colour work to blue colour work (tedious, dirt jobs),
Reasons for Automating

- Improve safety - better relation with workers,
- High cost of raw materials - requires greater efficiency in materials,
- Improved product quality,
- Reduced manufacturing lead time.
- Reduced work in-process inventory
- High cost of not automating

Reasons for Not Automating

- Task is too technologically difficult to automate,
- Short product life cycle.
- Customised product – one-of-a-kind,
- Flexibility in coping with changing demand – adaptability.

Types of Automation

- Fixed Automation
- Programmable Automation
- Flexible Automation

Fixed Automation

- A system in which the sequence of the processing or assembly operation is fixed by the equipment configuration.
- The operation in the sequence are usually simple.
- It is the integration and coordination of many such operations make the system very complex.
- Consists of workstations connected by conveyers or machine transfer lines.

Fixed Automation

- High initial investment for customised equipment (Jig, Die, etc.)
- Very efficient - High production rate (no extra operations).
- Relatively inflexible in accommodating product changes.
Fixed Automation: Economic justification

- For the products with high demands and volumes
- The high initial cost spread over a very large number of units. So the cost for each unit is low.
- Automobile production, automatic chemical production plant, etc

Programmable Automation

- The production equipment is designed with the capability to change the sequence of operations to accommodate different product configuration.
- Operation sequence controlled by a program (a set of instruction codes - system can read and interpret)
- New programs can be prepared and entered into the equipment to adopt to a new product.

Programmable Automation

- High investment in general-purpose equipment (flexible).
- Low production rates relative to fixed automation (not efficient)
- Flexibility to deal with changes in product configuration.
- Most suitable for job shop batch production

Programmable Automation - Economic Justification

- Used in low to medium production
- Made in batch
- The changeover procedure takes time
  ✓ Reprogrammed
  ✓ Set-up the machine must be changed (tools, fixtures, setting, etc)

Programmable Automation

- Automatic press line
- CNC milling machine
- Mitsubishi welding robot (Video clip)
Flexible Automation
- An extension of programmable automation – using digital computer capable to produce
  - Various combinations of products
  - Various schedule of products (instead of batch production)
  - With virtually no time lost

Differences from Programmable Automation
- Continuous production without the downtime between batches
- Ability to change part programs with no lost production time
- Capability to change the physical setup with no lost production time.

Flexible Automation
- High investment for customised equipment.
- Continuous production of various mixtures of products.
- Medium production rate.
- Flexibility to deal with product design variations.

Flexible Automation - Example
- Philmac flexible automation cell

Variables affecting Automation
- The degree of automation is a function of the quality of unit produced and product variety

Production quantity:
- Low production: 1 to 100 units/year.
- Medium quantity: 100-10,000 units/year.
- High production: 10,000 to millions of units/year.

Product variety refers to the different product designs or types that are produced in a factory.

Economic justification for automation
- Graph showing the relationship between product variety and production quantity.
Example: Assume that your task is to “automate” the “Sand casting process”. The tasks involved are (VOB2- 6:30 to 7:30)

- Creating a pattern materials
- Building a mould in sand
- Pouring the mould
- Removal of the cast part
- Grinding the part for finishing

Automation strategies

1. **Specialisation of operations**: use of special purpose equipment designed to perform one operation with great efficiency.

2. **Combined operations**: reduction of the number of distinct production machines or workstations probably accomplished by more than one work to be given to one machine – save set-up time, material handling effort. Production occurs as a sequence of operations.

3. **Simultaneous operations**: two or more operations performed simultaneously on the same workstation.

4. **Integration of operations**: link several workstations into a single integrated mechanism using automated work handling devices to transfer parts between stations.

5. **Increased flexibility**: use the same equipment for a variety of products using flexible automation - reduce setup time and programming time.

6. **Improved material handling and storage**: use of automated systems to handling and transferring of the materials.

7. **On-line inspection**: early warning and correction system, higher quality.

8. **Process control and optimisation**: more efficient process and equipment use.

9. **Plant operations control**: This concerns the control of the whole plant operations. Management and coordination of different departments in the plant.

10. **Computer integrated manufacturing**: extensive use of computers to the whole company.
Multi-stage manufacturing

Computerisation of Information processing activities
- CAD (Computer aided design)
- CAM (Computer aided manufacturing)
- CAD/CAM
- CIM (Computer integrated manufacturing)

**CAD**
- The technology concerned with the use of computer systems to perform or assist certain functions in product design:
  - Creation and modification
  - Analysis
    - Stress-strain analysis of components
    - Dynamic response of mechanisms
    - Heat-transfer calculations
  - Optimization of a design.

**CAM**
- The technology concerned with the use of computer systems to perform or assist certain functions in production
  - Plan
  - Manage
  - Control
  - the operations of a manufacturing plant through either direct or indirect computer interface with the plant’s production.

**CAD - examples**
- Conceptual design
- Drafting, prototyping
- Design layout
- Modeling
- Assembly design
- Analysis
- Bill of material (BOM)

**Applications**
- **Computer monitoring & control**: The computer is connected directly to the manufacturing process for the purpose of monitoring or controlling the process.
  - Observing the process and associated equipment
  - Collect data from process
  - Controlling the process based on the data analysis
Applications

- **Manufacturing support applications**: The computer is used in support of the production operations in the plant.
- Computer is used “off-line” to provide
  - Plans
  - Schedules
  - Forecasts
  - Information
  To manage production resources more effectively.

CAM - Example

- Numerical control Path planning - determine machining type (drilling, milling), method (rough, detail, depth of cut), tools (size, shape), geometry.
- Numerical control part programming
- Computer aided process planning
- Material requirement planning

CAD/CAM

- An integration of design and manufacturing activities by means of computer systems
- Provide direct link between design and manufacturing
- Handle the flow of information

Advantages of CAD/CAM

- Increase productivity
- Reduce cost
- Improve product quality
- Reduce manufacturing lead time
- Reduce in-process inventory
- Flexibility

Product cycle with CAD/CAM

CIM

- All of the company’s operations related to the production functions are incorporated in an integrated computer system.
- Functions:
  - Design products
  - Plan productions
  - Control operations
  - Perform various business related functions needed in manufacturing
CIM Integrates

- Design,
- Production engineering,
- Production control – Automation, scheduling,
- Manufacturing functions – analysis and simulation,
- Sales and marketing – strategic planning,
- Financial control,
- Management,
- Maintenance.

Automation and CIM

- **Automation**
  - Involves physical activities
  - Focus on equipments
  - Only include manufacturing processes

- **CIM**
  - Involves information processing activities
  - Use of computer technology
  - Include both manufacturing processes and design/Planning.

Last words on automation

- Productivity improvement has been a critical issue for most companies in the developed countries to survive in the current highly competitive global markets.
- In 70s and 80s, most CEO’s believed that automation was the answer for it.
- However, we now have found that the answer lies in strategies which are more concerned with organisation and management rather than technology and hardware alone.
- Automation can support such strategies. Without strategies, automation typically leads only to more “expensive” failure.