

INTRODUCTION TO AUTOMATION





Introduction to Automation

Definition

Automation is a set of technologies that results in operation of machines and systems without significant human intervention & achieve performance superior to manual operations.

Key areas of industrial automation

- ▷ Controls & signal processing
- ▷ Communication & networking
- ▷ Simulation, design & analysis
- ▷ Optimization
- ▷ Real time computing
- ▷ Database & storage



Introduction to Automation

Reasons for automation

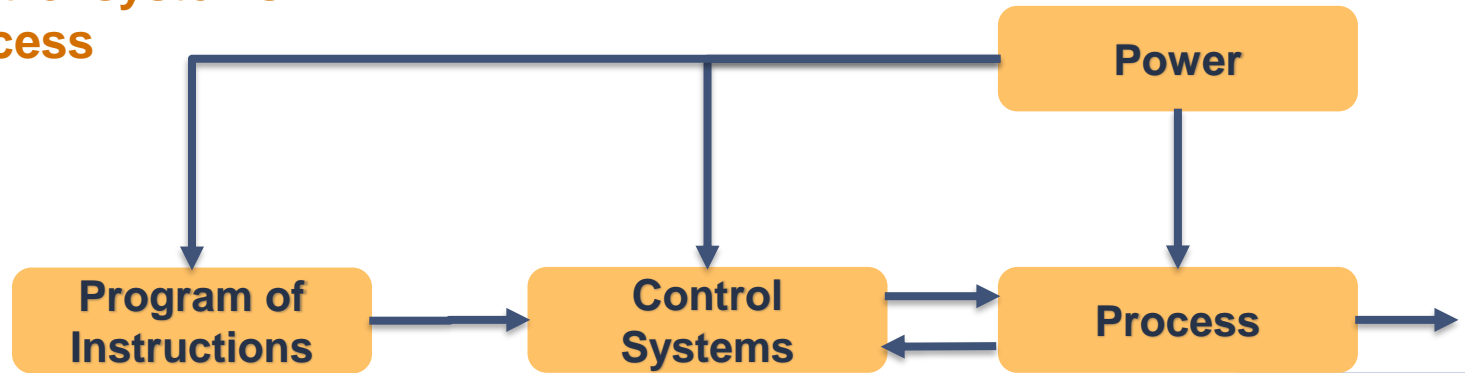
- ▷ To increase labour productivity
- ▷ To reduce labour cost
- ▷ To manage effect of labour shortage
- ▷ To reduce/eliminate routine manual & clerical tasks
- ▷ To improve worker safety
- ▷ To reduce manufacturing lead time
- ▷ To improve product quality
- ▷ To accomplish process that can not be done manually
- ▷ To avoid the high cost of not automating.



Introduction to Automation

Basic elements of automation system

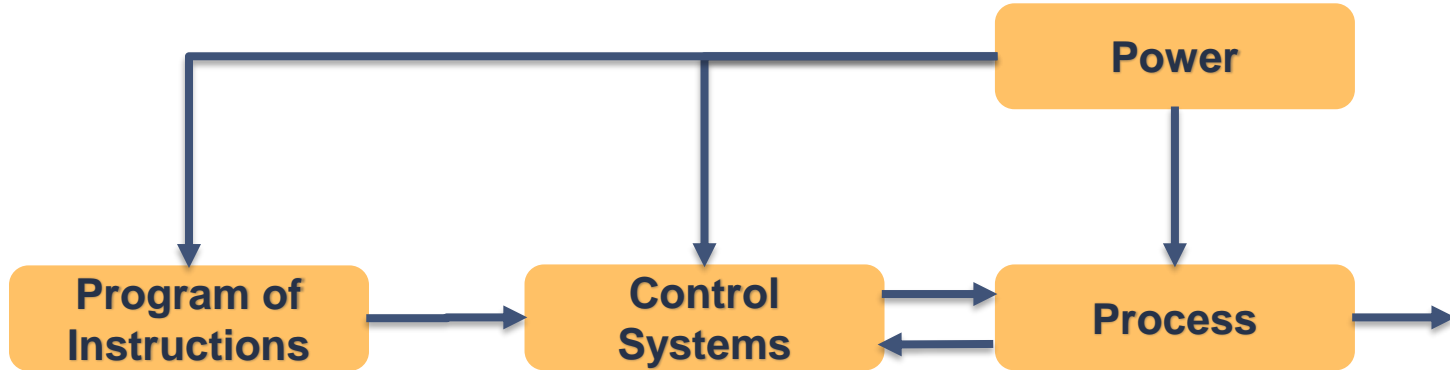
- ▷ Power
- ▷ Program of instructions
- ▷ Control systems
- ▷ Process





Basic Elements of Automation

- Energy conversion
- Requirements of complete systems
- Mainly electrical



Set of instruction

- Work cycles
- Decision making in programmed cycle

- Open loop control system
- Closed loop control system



Control Systems

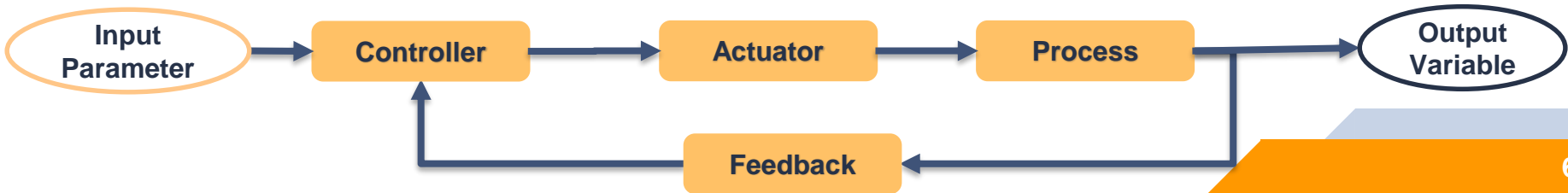
Open Loop System:

If a human operator is available to monitor and control a manufacturing process, open loop control may be acceptable.



Closed Loop System:

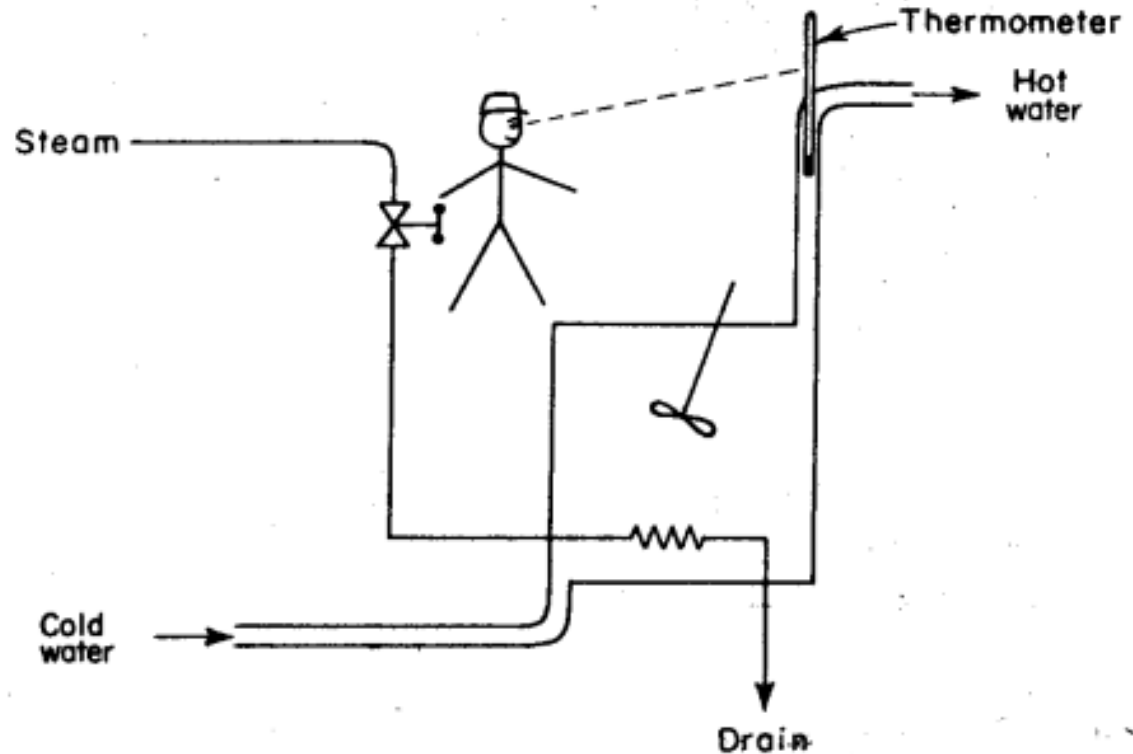
If a manufacturing process is automated, then it requires closed loop control, also known as feedback control.





Control Systems

Open Loop System:
If a human operator is available to monitor and control a manufacturing process, open loop control may be acceptable.

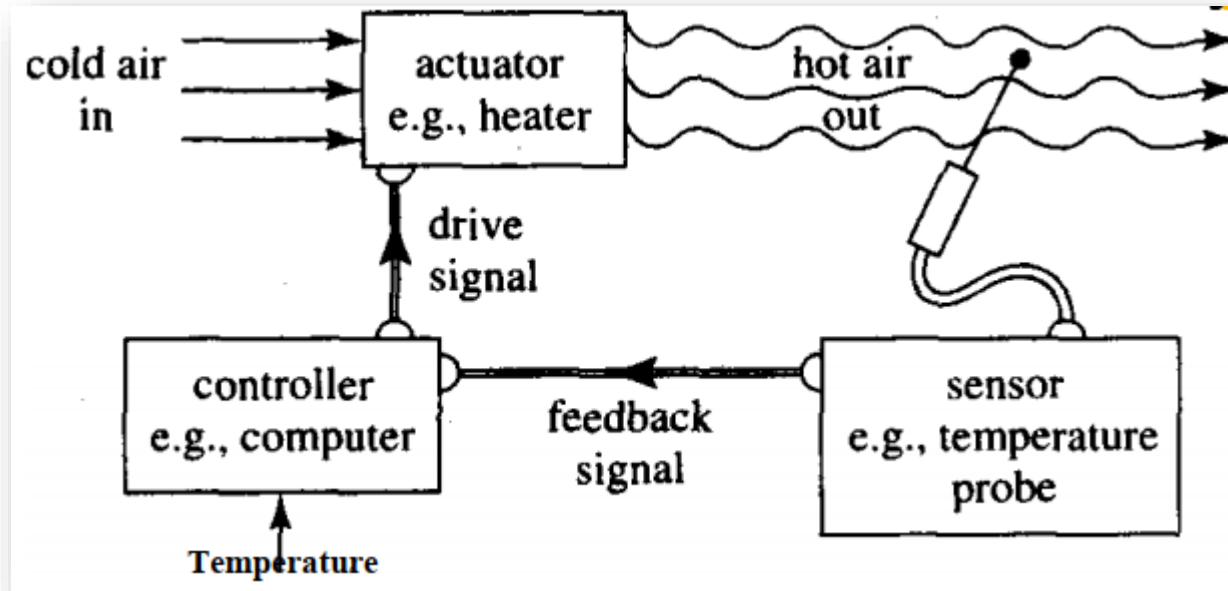




Control Systems

Closed Loop System:

If a manufacturing process is automated, then it requires closed loop control, also known as feedback control.





Advanced Automation Functions

■ To enhance performance and safety

- ▷ Safety monitoring
- ▷ Maintenance and repair diagnostics
- ▷ Error detection and recovery

■ It can be list of actions to be done by worker / maintenance or can be set of instruction that performs automatically safety measure, error detection and recovery tasks



Advanced Automation Functions

Safety, maintenance & repair diagnosis

■ Safety

- ▶ To protect human workers in the vicinity of the system
- ▶ To protect equipment associated with the system

■ Maintenance and repair diagnostics

Capabilities of an automated system to assist in the identification of the source of potential or actual malfunctioning & failures of systems.

- ▶ Status monitoring
- ▶ Failure diagnostics
- ▶ Recommend repair procedure



Advanced Automation Functions

Error detection and recovery

■ Detection

- ▶ Random errors
- ▶ Systematic errors
- ▶ aberrations

■ Problems in error detection

- ▶ To automate all of the possible errors that can generated in a process
- ▶ To setup/specify appropriate sensor system & software so that system is capable of recognizing each error



Advanced Automation Functions

Error detection and recovery

■ Recovery

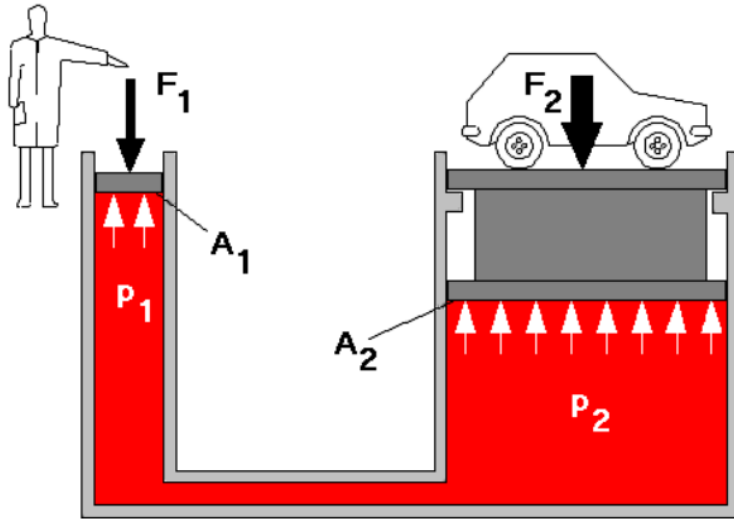
- ▷ Make adjustment at the end of the current work cycle
- ▷ Make adjustments during current cycle
- ▷ Stop the process to invoke corrective action
- ▷ Stop the process & call for help



Hydraulic and Pneumatic Systems

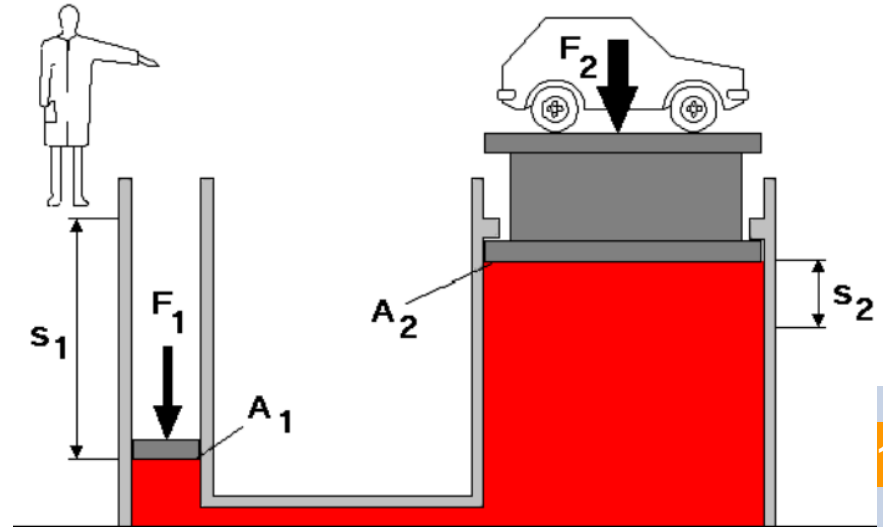
Hydraulic Fluid Transmission

- F = Force (N)
- P = Pressure (N/m²)
- A = Area (m²)



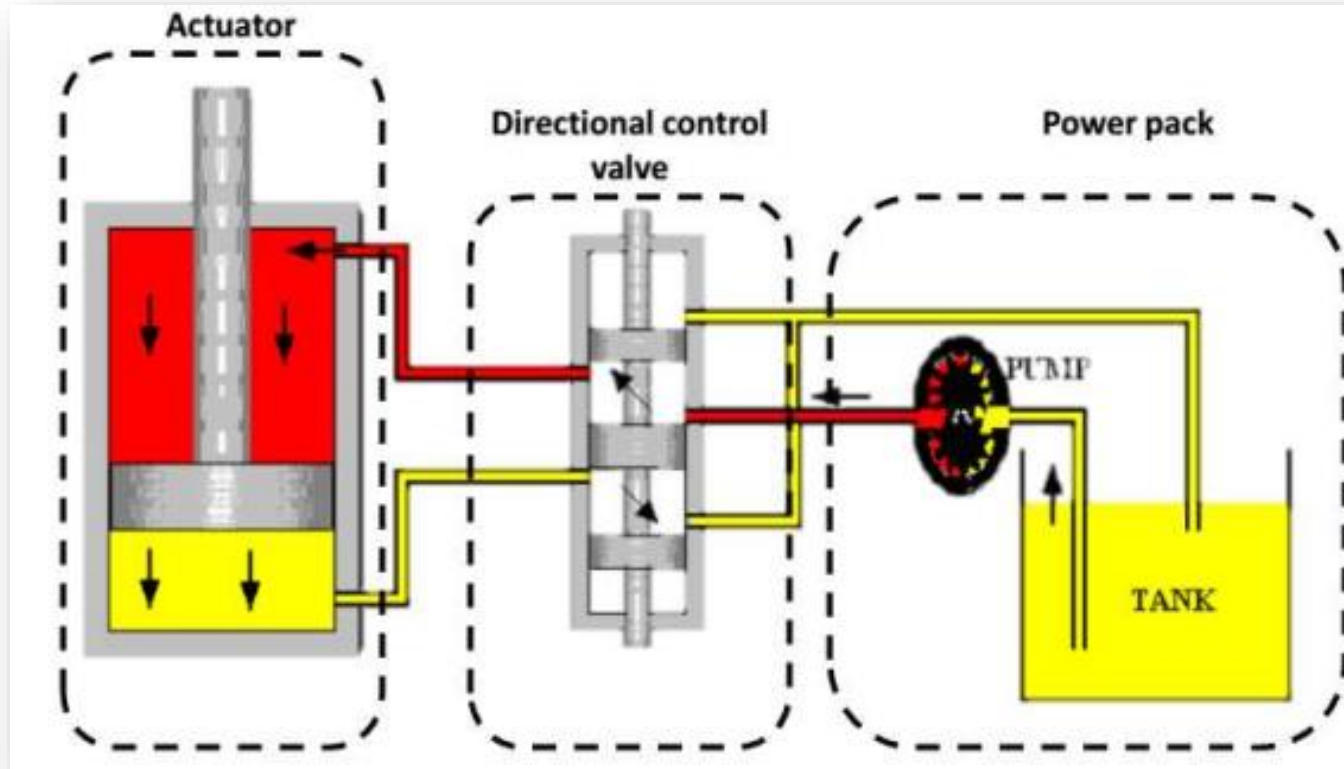
Hydraulic Fluid Compensation

- S = Displacement (m)
- A = Area (m²)



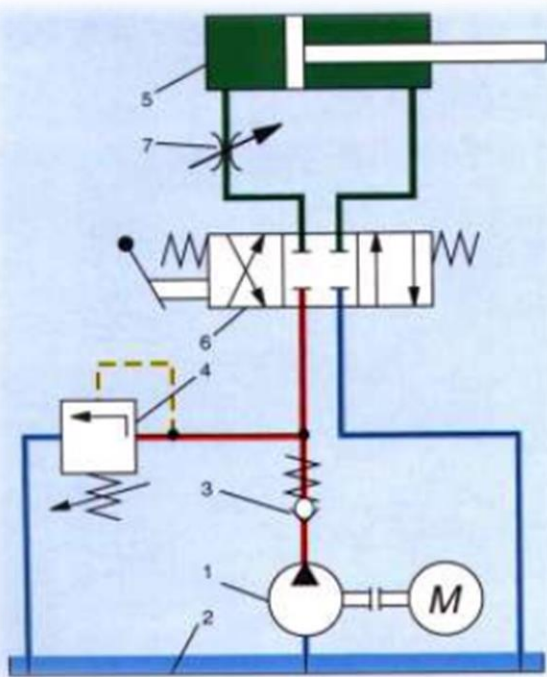


Hydraulic Systems

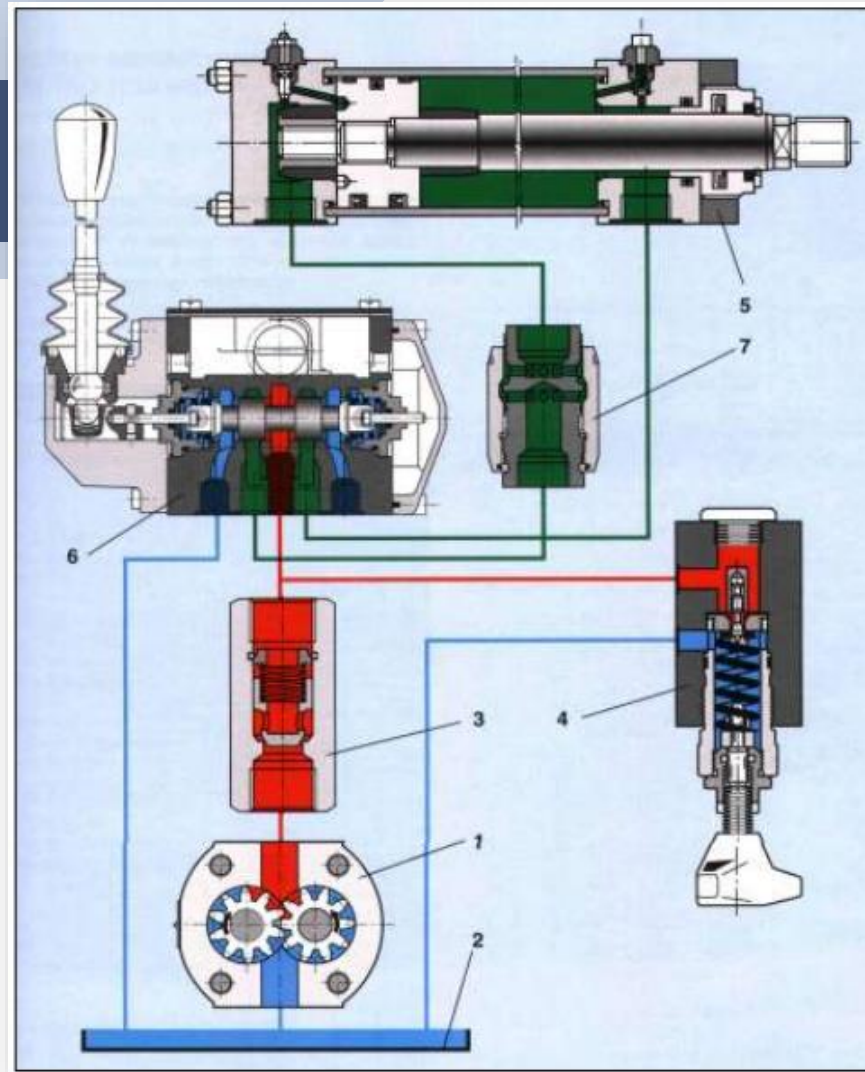




Hydraulic Systems



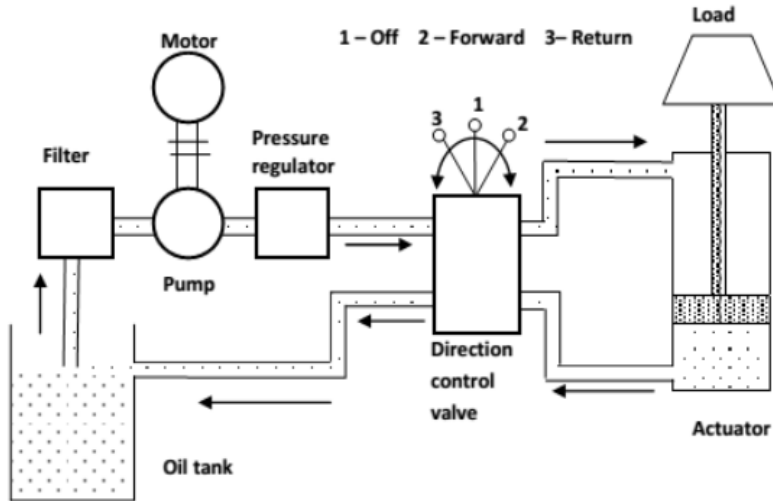
1. Pump
2. Oil Tank
3. Flow Control Valve
4. Pressure relief Valve
5. Hydraulic Cylinder
6. Directional Control Valve
7. Throttle Valve



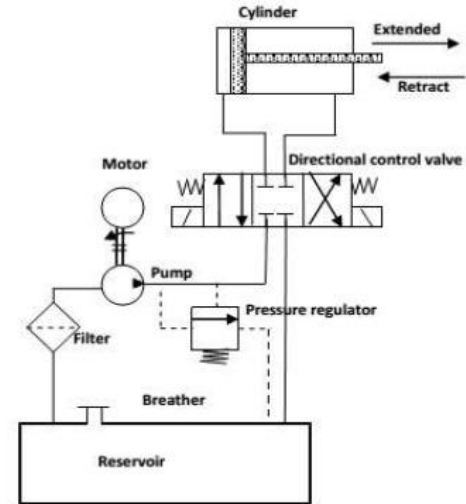


Basic Components of Hydraulic System

Hydraulic systems are power-transmitting assemblies employing pressurized liquid as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 1.1 shows a simple circuit of a hydraulic system with basic components.



Components of a hydraulic system

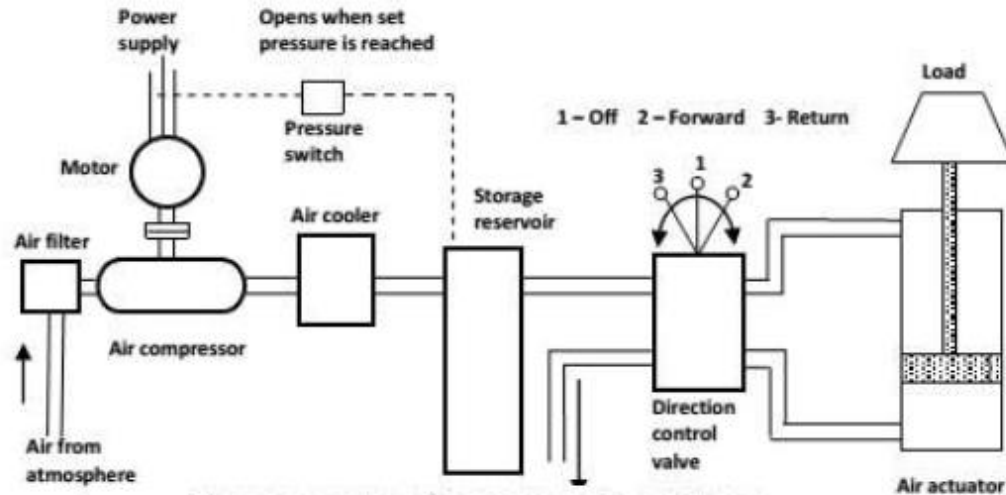


Components of a hydraulic system (shown using symbols).



Basic Components of Pneumatic System

A pneumatic system carries power by employing compressed gas, generally air, as a fluid for transmitting energy from an energy-generating source to an energy-using point to accomplish useful work. Figure 1.3 shows a simple circuit of a pneumatic system with basic components.



Components of a pneumatic system.



Comparison Hydraulic and Pneumatic System

S. No.	Hydraulic System	Pneumatic System
1.	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2.	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3.	Generally designed as closed system	Usually designed as open system
4.	The system slows down when leakage occurs	Leakage does not affect the system much
5.	Valve operations are difficult	Valve operations are easy
6.	Heavier in weight	Lighter in weight
7.	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8.	Automatic lubrication is provided	Special arrangements for lubrication are needed



Automation Principles & Strategies

USA Principle

- U – understand the existing process
- S – simplify the process
- A – automate the process

Understand

Simplify

Automate



Automation Principles & Strategies

Understand

- Input-output relationship
- Process charts, flow charts
- Mathematical Modelling

Simplify

- Simplification/ elimination
- Integration
- Purpose of each step

Automate

- Automation strategies
- Migration strategies



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Specialization of Operation

Combined Operation

Integration of Operation

Simultaneous Operation

Increased Flexibility

Improved Material Handling & Storage

Online Inspection

Process Control & Optimization

Plant operation control

CIM: Computer Integrated Manufacturing



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

■ Specialization of operations:

- ▶ **First strategy involves the use of special purpose equipment designed to perform one operation with the greatest possible efficiency.**
- ▶ **Analogous to the concept of labor specializations, which has been employed to improve labor productivity.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Combined operations:

- ▶ **Production occurs as a sequence of operations. Complex parts may require dozens, or even hundreds, of processing steps.**
- ▶ **Strategy of combined operations involves reducing the no. of machines or workstations through which the part must be routed.**
- ▶ **Accomplished by performing more than 01 operation at a given machine.**
- ▶ **Material handling effort and non-operation time are also reduced.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Integration of operations:

- ▶ **Another strategy is to link several workstations into a single integrated mechanism using automated work handling devices to transfer parts between stations.**
- ▶ **In effect, this reduces the no. of separate machines though which the product must be scheduled.**
- ▶ **With more than 01 workstation, several parts can be processed simultaneously, thereby increasing the overall output of the system.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Simultaneous operations:

- ▶ **A logical extension of the combined operations strategy is to perform at the same time the operations that are combined at one workstation.**
- ▶ **In effect, two or more processing (or assembly) operations are being performed simultaneously on the same workpart, thus reducing total processing time.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Increase Flexibility:

- ▶ **Achieve max. utilization of equipment for job shop and medium volume situations by using the same equipment for a variety of products.**
- ▶ **It involves the use of the flexible automation concepts.**
- ▶ **Prime objectives are to reduce setup time and programming time for the production machine.**
- ▶ **This normally translates into lower manufacturing lead time and lower work-in-process.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Improved material handling and storage systems:

- ▶ **A great opportunity for reducing non-productive time exists in the use of automated material handling and storage systems.**
- ▶ **Typical benefits included reduced work-in-process and shorter manufacturing lead times.**



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

On-line inspection:

- ▶ **Inspection for quality of work is traditionally performed after the process.**
- ▶ This means that any poor quality product has already been produced by the time it is inspected.
- ▶ **Incorporating inspection into the manufacturing process permits corrections to the process as product is being made.**
- ▶ Reduces scrap and brings the overall quality of product closer to the nominal specifications intended by the designer



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Process control and optimization:

- ▶ This includes a wide range of control schemes intended to operate the individual process and associated equipment more efficiency.
- ▶ Individual process times can be reduced and product quality improved

Plant operations control:

- ▶ This strategy is concerned with control at the plant level of computer networking within the factory



Automation Principles & Strategies

Ten Strategies of Automation and Production Systems

Computer integrated manufacturing (CIM):

- ▶ Taking the previous strategy one step further, the integration of factory operations with engineering design and many of the other business functions of the firm.
- ▶ CIM involves extensive use of computer applications, computer data bases, and computer networking in the company



Automation Principles & Strategies

Automation Migration Strategy

- Introduction of new product in shortest possible time
- Avoids risk commitment at initial stage of product development
- Allows automation to introduce gradually as product gets final design

Different Phase of Automation Migration Strategy are:

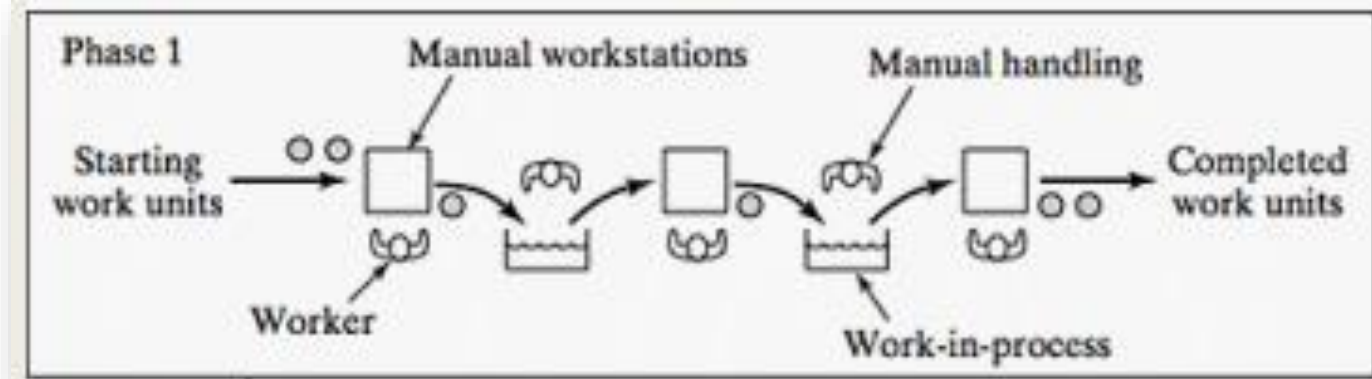
- ▷ Phase 1 : Manual Production
- ▷ Phase II: Automated Production
- ▷ Phase III: Automation Integrated Production



Automation Principles & Strategies

Phase I (Manual Production)

- Manual production using single-station manned cells operating independently.
- Used for introduction of the new product for reasons already mentioned: quick and low-cost tooling to get started.

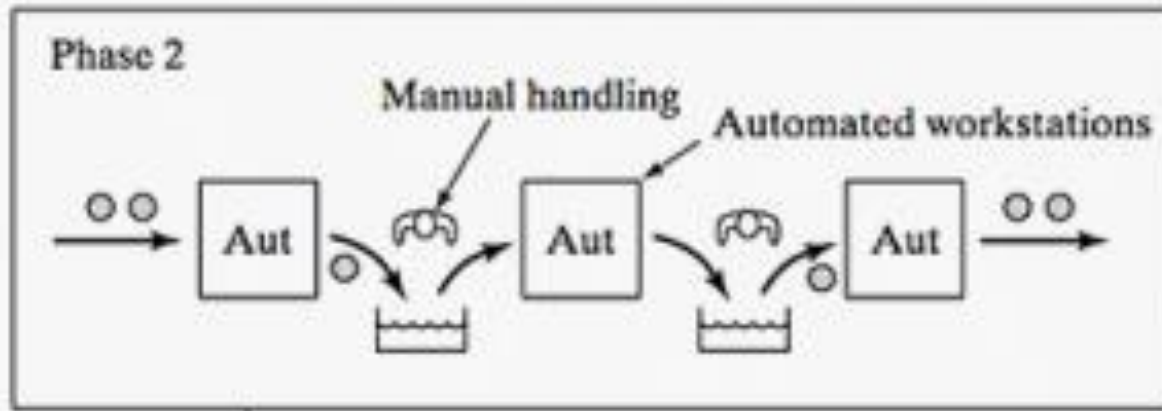




Automation Principles & Strategies

Phase II (Automated Production)

- Using single-station automated cells operating independently.
- As demand for the product grows, and it becomes clear that automation can be justified, then the single stations are automated to reduce labor and increase production rate.
- Work units are still moved between workstations manually

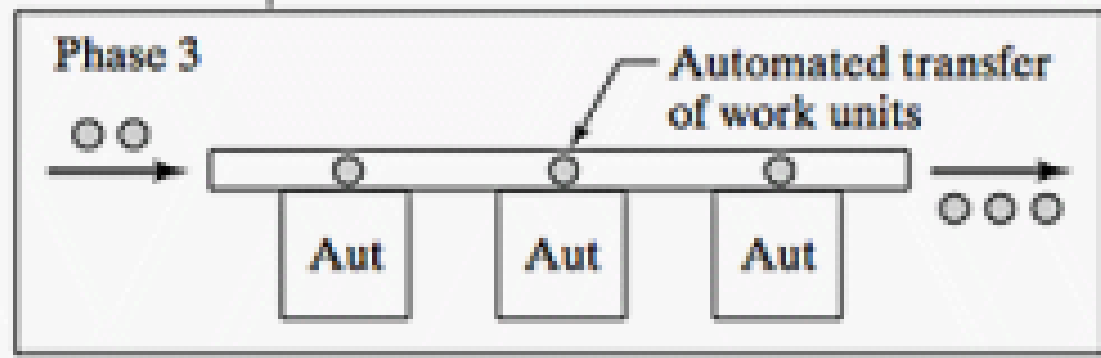




Automation Principles & Strategies

Phase III (Automation Integrated Production)

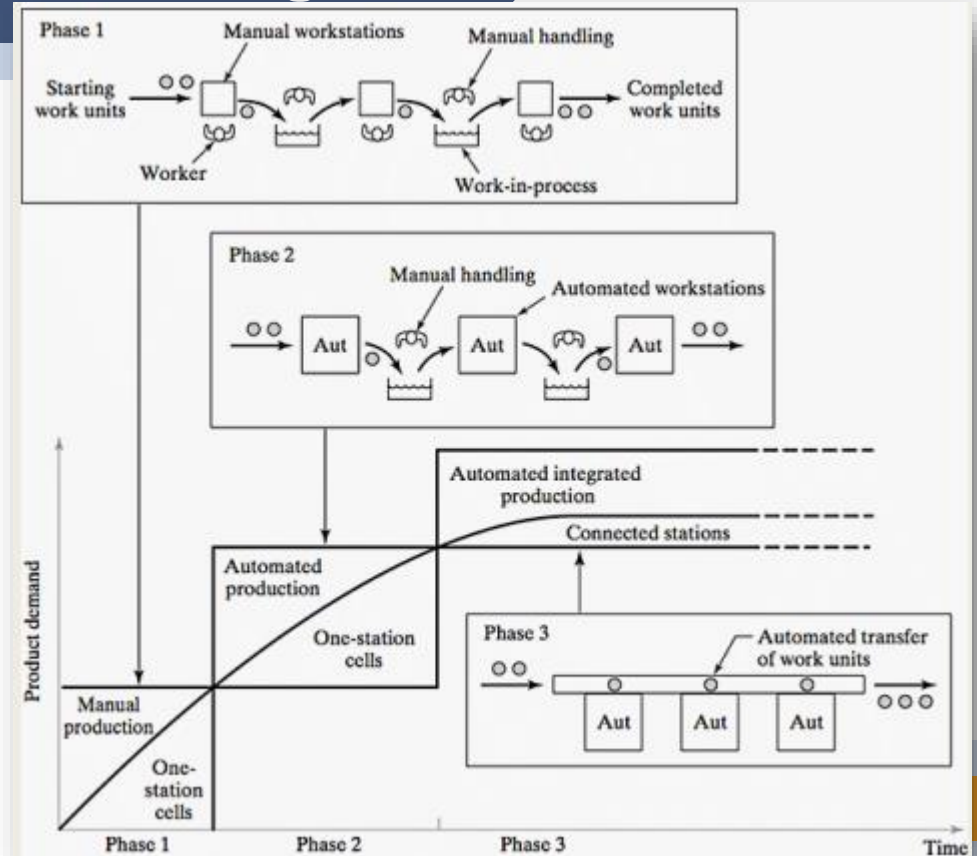
- Using a multi-station automated system with serial operations and automated transfer of work units between stations.
- When the company is certain that the product will be produced in mass quantities and for several years, then integration of the single-station automated cells is warranted to further reduce labor and increase production rate.





Automation Principles & Strategies

- ▶ **Phase I**
Manual Production
- ▶ **Phase II**
Automated Production
- ▶ **Phase III**
Automation Integrated Production





Automation Principles & Strategies

Advantages of such a strategy include:

- It allows introduction of the new product in the shortest possible time, since production cells based on manual workstations are the easiest to design and implement.
- It allows automation to be introduced gradually (in planned phases), as demand for the product grows, engineering changes in the product are made, and time is allowed to do a thorough design job on the automated manufacturing system.
- It avoids the commitment to a high level of automation from the start, since there is always a risk that demand for the product will not justify it



Automation Manufacturing Systems

Automated Production/ Manufacturing Systems can be classified into three basic types:

- **Fixed automation**
- **Programmable automation**
- **Flexible automation**

Fixed automation

- **System in which the sequence of processing (or assembly) operations is fixed by the equipment configuration.**
- **Operations in the sequence are usually simple. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex.**



Automation Manufacturing Systems

Fixed automation

- The typical features of fixed automation are:
 - ▷ High initial investment for custom-Engineered equipment.
 - ▷ High production rates
 - ▷ Relatively inflexible in accommodating product changes.

Economic justification for fixed automation is found in products with very high demand rates and volumes. The high initial cost of the equipment can be spread over a very large number of units

Examples: Mechanized assembly and machining transfer lines.



Automation Manufacturing Systems

Programmable automation

- Equipment is designed with the capability to change the sequence of operations to accommodate different product configurations.
- **Operation sequence is controlled by a program (set of instructions coded) so that the system can read and interpret them.**
- New programs can be prepared and entered into the equipment to produce new products.

Features that characterize programmable automation are:

- ▷ High investment in general-purpose equipment
- ▷ Low production rates relative to fixed automation
- ▷ Flexibility to deal with changes in product configuration
- ▷ Most suitable for batch production



Automation Manufacturing Systems

Programmable automation

Programmable are used in low and medium volume production. The parts or products are typically made in batches. Physical setup of the machine must also be changed over: Tools must be loaded, fixtures must be attached to the machine table also be changed machine settings must be entered

Examples of programmed automation include numerically controlled machine tools and industrial robots.



Automation Manufacturing Systems

Flexible Automation

- Capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next.
- No production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, and machine setting).
- Can produce various combinations and schedules of products instead of requiring that they be made in separate batches.

Features of flexible automation can be summarized as follows:

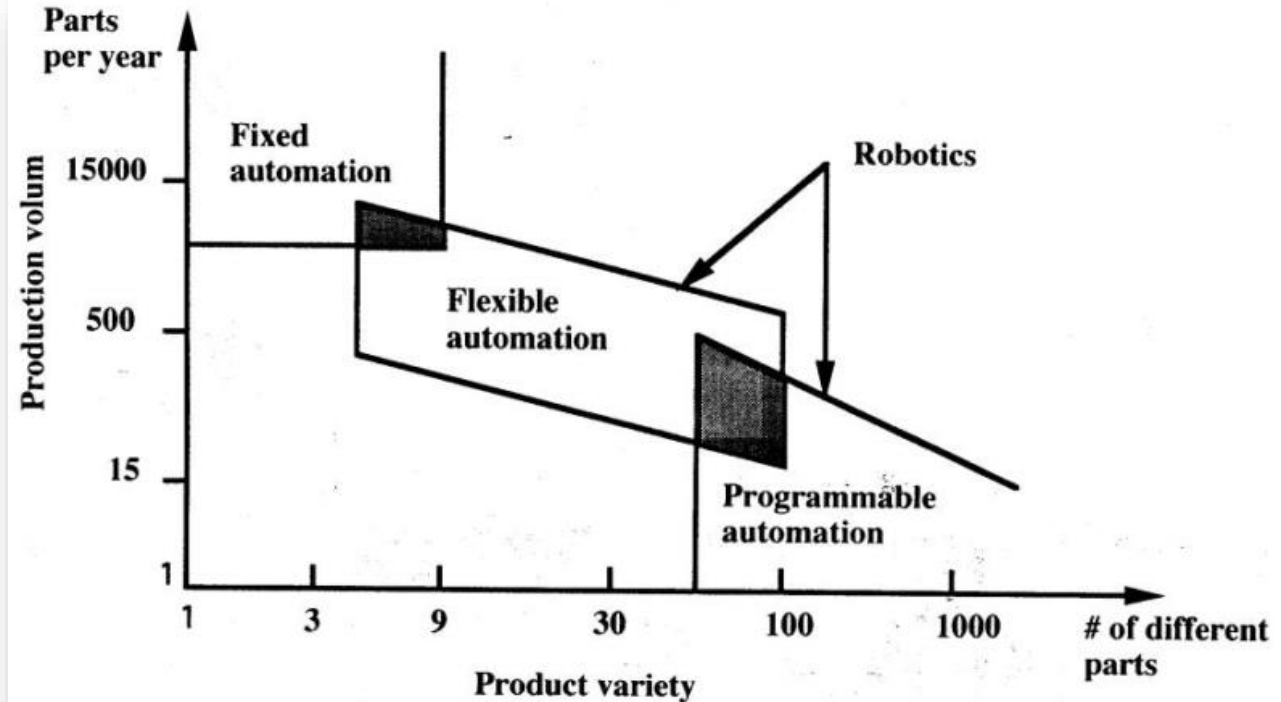
- ▷ High investment for a custom-engineered system.
- ▷ Continuous production of variable mixtures of products.
- ▷ Medium production rates.
- ▷ Flexibility to deal with product design variations



Automation Manufacturing Systems

Basic types:

- Fixed automation
- Programmable automation
- Flexible automation





Levels of Automation

Enterprise Level

Corporate Information Systems

Plant Level

Production Systems

Cell/System Level

Manufacturing System: Group of Machines

Machine Level

Individual Machines

Device Level

Sensors, Actuators and Hardware Elements

LEVEL 5

LEVEL 4

LEVEL 3

LEVEL 2

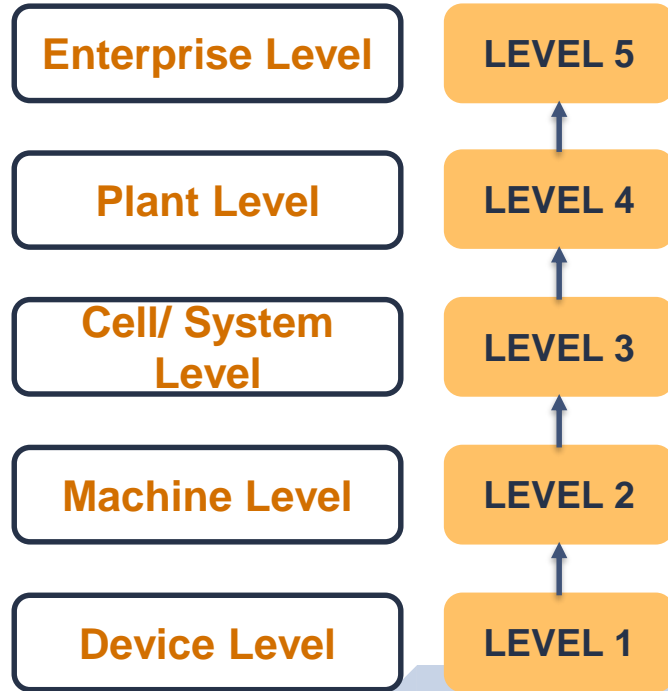
LEVEL 1



Levels of Automation

Device level (Level 1):

- This is the lowest level in automation hierarchy.
- Includes the actuators, sensors, and other hardware components that comprise the machine level.
- Devices are combined into the individual control loops of the machine
- Example, the feedback control loop for one axis of a CNC machine or one joint of an industrial robot

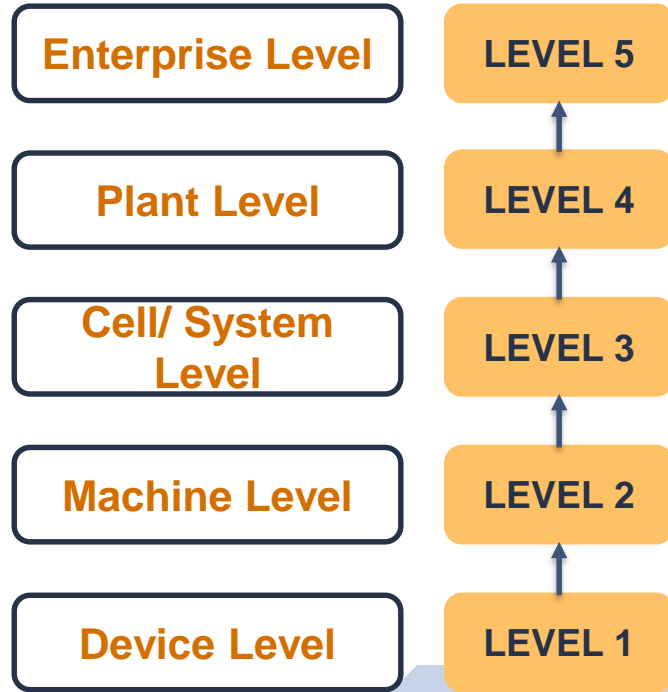




Levels of Automation

Machine level (Level 2):

- Hardware at the device level is assembled into individual machines.
- Examples include CNC machine tools and similar production equipment, industrial robots, powered conveyors, and automated guided vehicles.
- Control functions at this level include performing the sequence of steps in the program of instructions in the correct order
- Making sure that each step is properly executed.

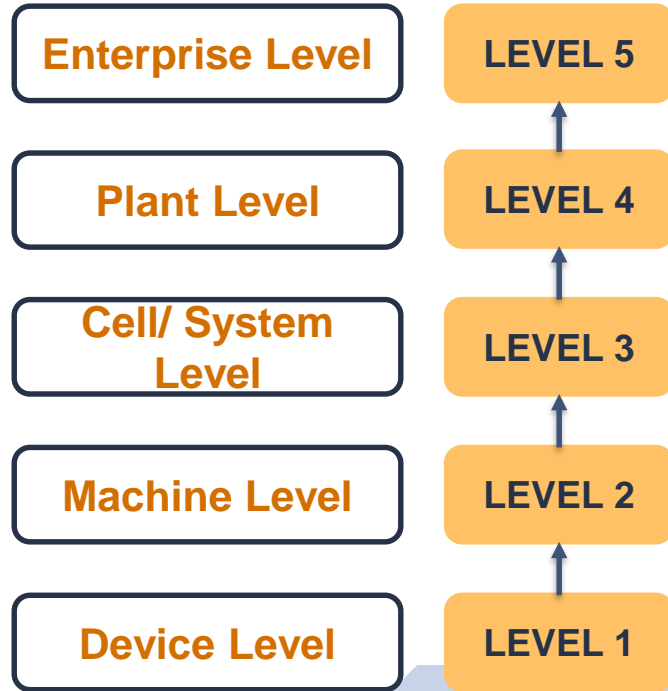




Levels of Automation

Cell or system level (Level 3):

- Operates under instructions from the plant level.
- Group of machines or workstations connected and supported by a material handling system, computer and other equipment.
- Production lines are included in this level. include part dispatching & M/C loading, coordination among m/c's & material handling system, and collecting and evaluating inspection data.

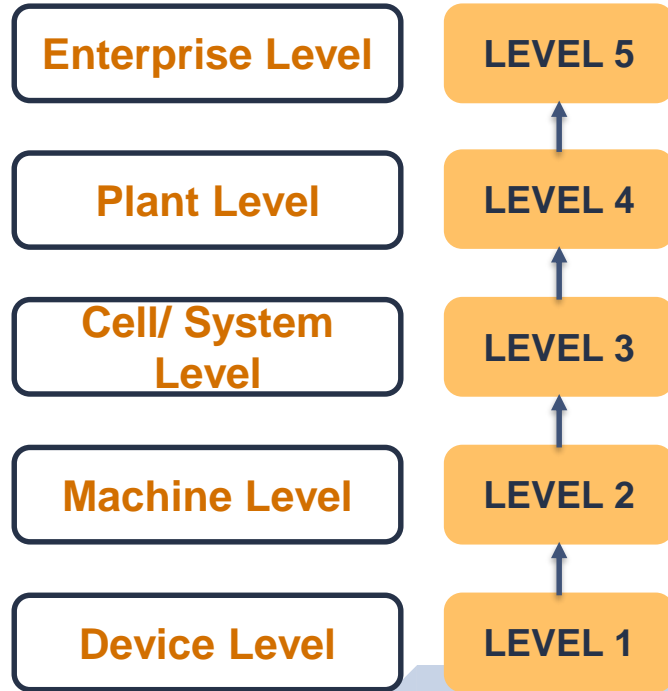




Levels of Automation

Plant level (Level 4):

- **Factory or production systems level.**
- **Receives instructions from the corporate information system and implement operational plans for production.**
- **Functions include:**
 - ▷ **order processing**
 - ▷ **process planning**
 - ▷ **inventory control**
 - ▷ **purchasing**
 - ▷ **material requirements planning**
 - ▷ **shop floor control**
 - ▷ **quality control**

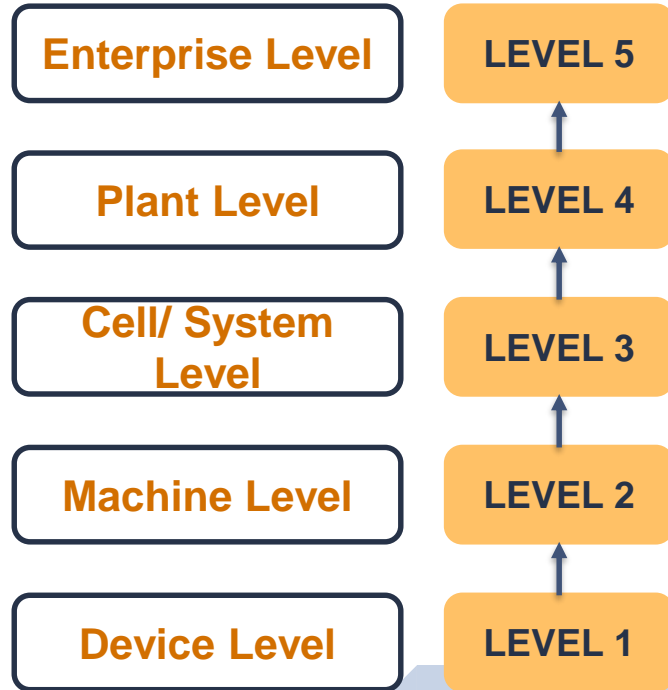




Levels of Automation

Enterprise level (Level 5):

- **Highest level consisting of the corporate information system.**
- **Concerned with all of the functions necessary to manage the company:**
 - ▷ **Marketing and sales,**
 - ▷ **Accounting**
 - ▷ **Design**
 - ▷ **Research**
 - ▷ **Aggregate planning**
 - ▷ **Master production scheduling.**





THANKS!