Introduction to Automation

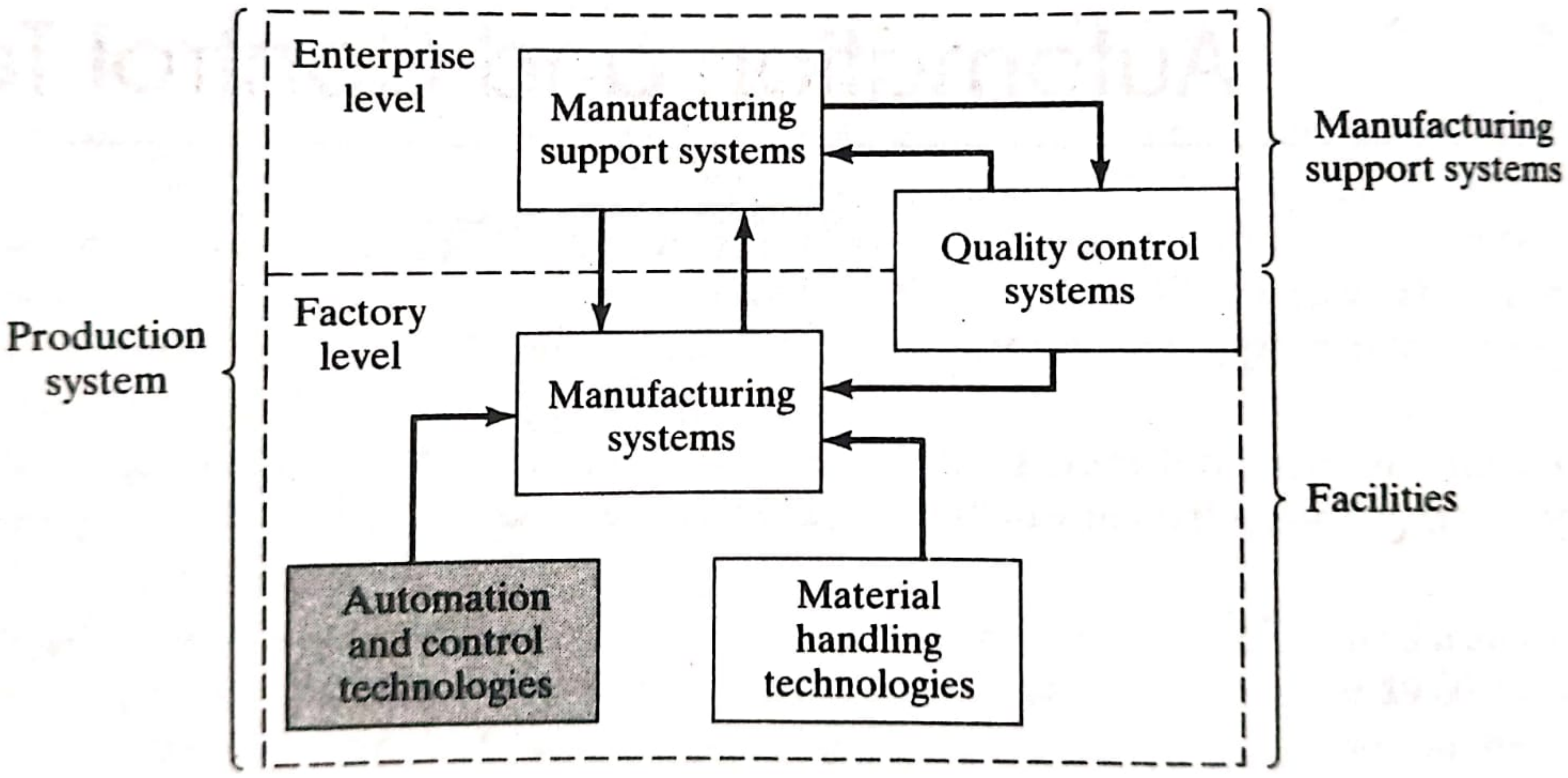
L-20

Contents

What is Automation

- Automation is the technology by which a process or procedure is accomplished without human assistance
- It is implemented using a program of instructions combined with a control system that executes the instructions
- To automate a process, power is required, both to drive the process itself and to operate the program and control system.
- Although automation can be applied in a wide variety of areas, it is most closely associated with the manufacturing industries.

Automation and control technologies in the production system



1) Basic Elements of an automated system

a) Power to accomplish the automated process

The principal source of power in automated system is electricity. Electric power has many advantages in automated as well as non-automated processes.

- Electrical power is widely available at moderate cost. It is an important part of our industrial infrastructure
- Electrical power can be readily converted to alternative energy forms: mechanical, thermal, light, acoustic, hydraulic and pneumatic
- Electrical power at low levels can be used to accomplish functions such as signal transmission, information processing and data storage and communication
- Electrical energy can be stored in long-life batteries for use in locations where an external source of electrical power is not conveniently available

Contd.

Power for the Process:

- Loading and unloading the work unit
- Material transport between operations

TABLE 3.1 Common Manufacturing Processes and Their Power Requirements

Process	Power Form	Action Accomplished
Casting	Thermal	Melting the metal before pouring into a mold cavity where solidification occurs.
Electric discharge machining (EDM)	Electrical	Metal removal is accomplished by a series of discrete electrical discharges between electrode (tool) and workpiece. The electric discharges cause very high localized temperatures that melt the metal.
Forging	Mechanical	Metal workpart is deformed by opposing dies. Workparts are often heated in advance of deformation, thus thermal power is also required.
Heat treating	Thermal	Metallic work unit is heated to temperature below melting point to effect microstructural changes.
Injection molding	Thermal and mechanical	Heat is used to raise temperature of polymer to highly plastic consistency, and mechanical force is used to inject the polymer melt into a mold cavity.
Laser beam cutting	Light and thermal	A highly coherent light beam is used to cut material by vaporization and melting.
Machining	Mechanical	Cutting of metal is accomplished by relative motion between tool and workpiece.
Sheet metal punching and blanking	Mechanical	Mechanical power is used to shear metal sheets and plates.
Welding	Thermal (maybe mechanical)	Most welding processes use heat to cause fusion and coalescence of two (or more) metal parts at their contacting surfaces. Some welding processes also apply mechanical pressure to the surfaces.

Contd.

Power for Automation:

- Controller unit
- Power to actuate the control signals
- Data acquisition and information processing

b) Program of Instructions

(i) Work cycle programs

The typical sequence of steps include

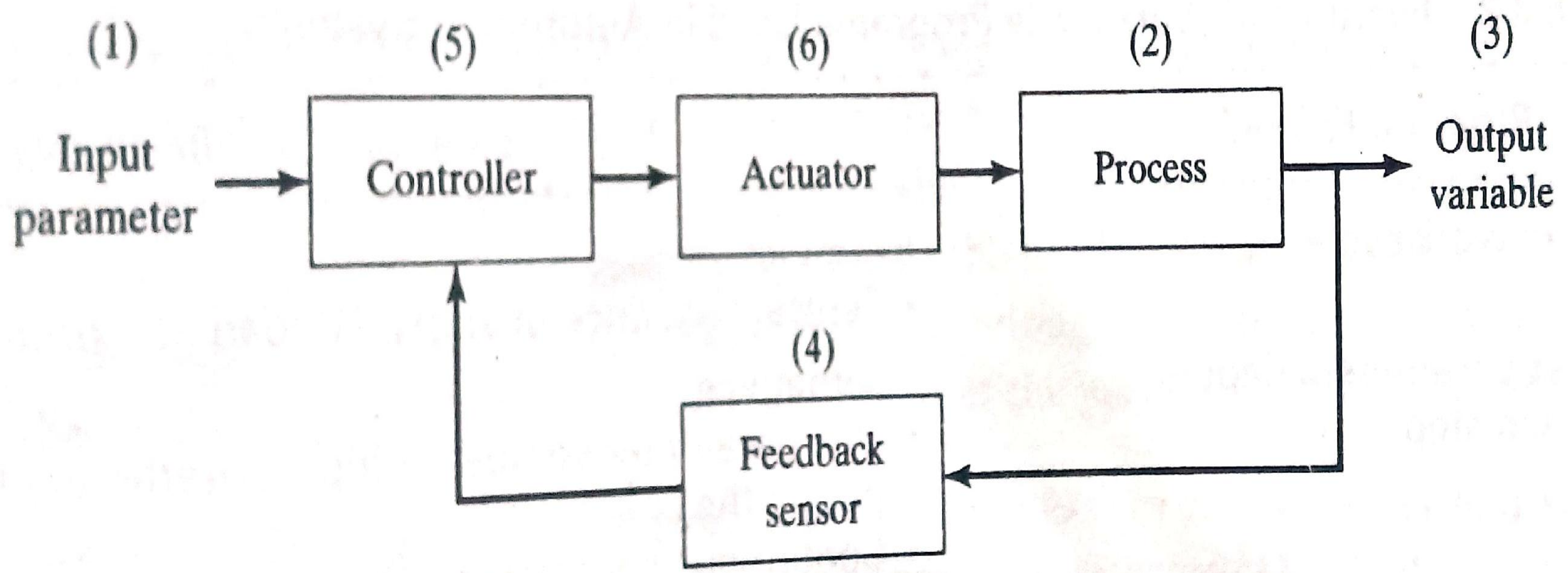
1. Load the part into the production machine
2. Perform the process
3. Unload the part

Decision-making in the programmed work cycle previously includes 1. the number and sequence of processing steps 2. The process parameter changes in each step. Now it includes dealings on

- Operator interaction
- Different part or product styles processes by the system
- Variations in the starting work units.

C) Control System

Closed loop control system consists of six basic elements



Contd.

Open loop systems are usually appropriate when the following conditions apply

(1) The actions performed by the control system are simple

(2) The actuating function is very reliable

(3) Any reaction forces opposing the actuation are small enough to have no effect on the actuation

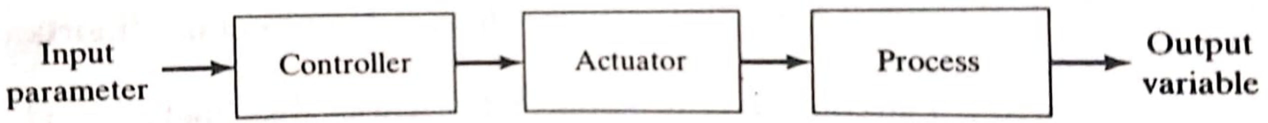


Figure 3.4 An open loop control system.

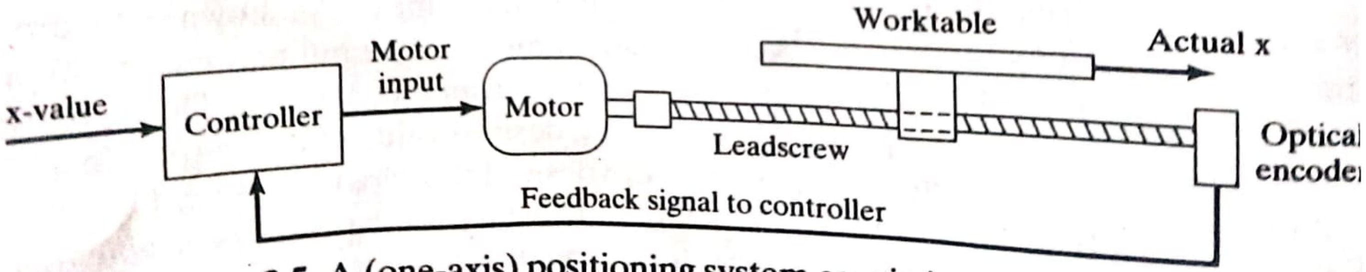


Figure 3.5 A (one-axis) positioning system consisting of a leadscrew …iven by a dc servomotor.

2) Advanced Automation Functions

Two reasons for providing an automated system with a safety monitoring capability (i) To protect human workers in the vicinity of the system (ii) to protect the equipment associated with the system

a) Safety Monitoring

Possible responses to various hazards might include one or more of the following:

(i) Complete stoppage of the automated system
(ii) Sounding an alarm
(iii) Reducing the operating speed of the process
(iv) Taking corrective actions to recover from safety violation

Contd.

List of possible sensors and their applications for safety monitoring:

(i) Limit switches to detect proper positioning of a part in a workholding device so that the processing cycle can begin.

(ii) Photoelectric sensors triggered by the interruption of a light beam; this could be used to indicate that a part is in the proper position or to detect the presence of a human intruder into the work cell

(iii) Temperature sensors to indicate that a metal workpart is hot enough to proceed with a hot forging operation. If the workpart is not sufficiently heated, then the metal's ductility may be too low, and the forging dies might be damaged during the operation

(iv) Heat or smoke detectors to sense fire hazards

(v) Pressure-sensititive floor pads to detect human intruders into the work cell

(vi) Machine vision systems to supervise the automated system and its surroundings.

b) Maintenance and Repair Diagnostics

Maintenance and repair diagnostics refers to the capabilities of an automated system to assist in the identification of the source of potential or actual malfunctions and failures of the system. Three modes of operation are typical of a modern maintenance and repair diagnostics subsystem.

(i) Status monitoring

(ii) Failure diagnostics

(iii) Recommendation

c) Error Detection and Recovery

The possible errors can be classified into one of three general categories

(i) Random errors (ii) systematic errors (iii) aberration random errors

Two main design problems in error detection are (i) to anticipate all of the possible errors that can occur in a given process (ii) To specify the appropriate sensor systems and associated interpretive software so that the system is capable of recognizing each error.

Error recovery

Devising appropriate strategies and procedures that will either correct or compensate for the variety of errors that can occur in the process. The types of strategies can be classified as follows:

1. Make adjustments at the end of the current work cycle
2. Make adjustments during the current cycle
3. Stop the process to invoke corrective action
4. Stop the process and call for help

Contd.

TABLE 3.3 Error Detection Step in an Automated Machining Cell: Error Categories and Possible Malfunctions Within Each Category

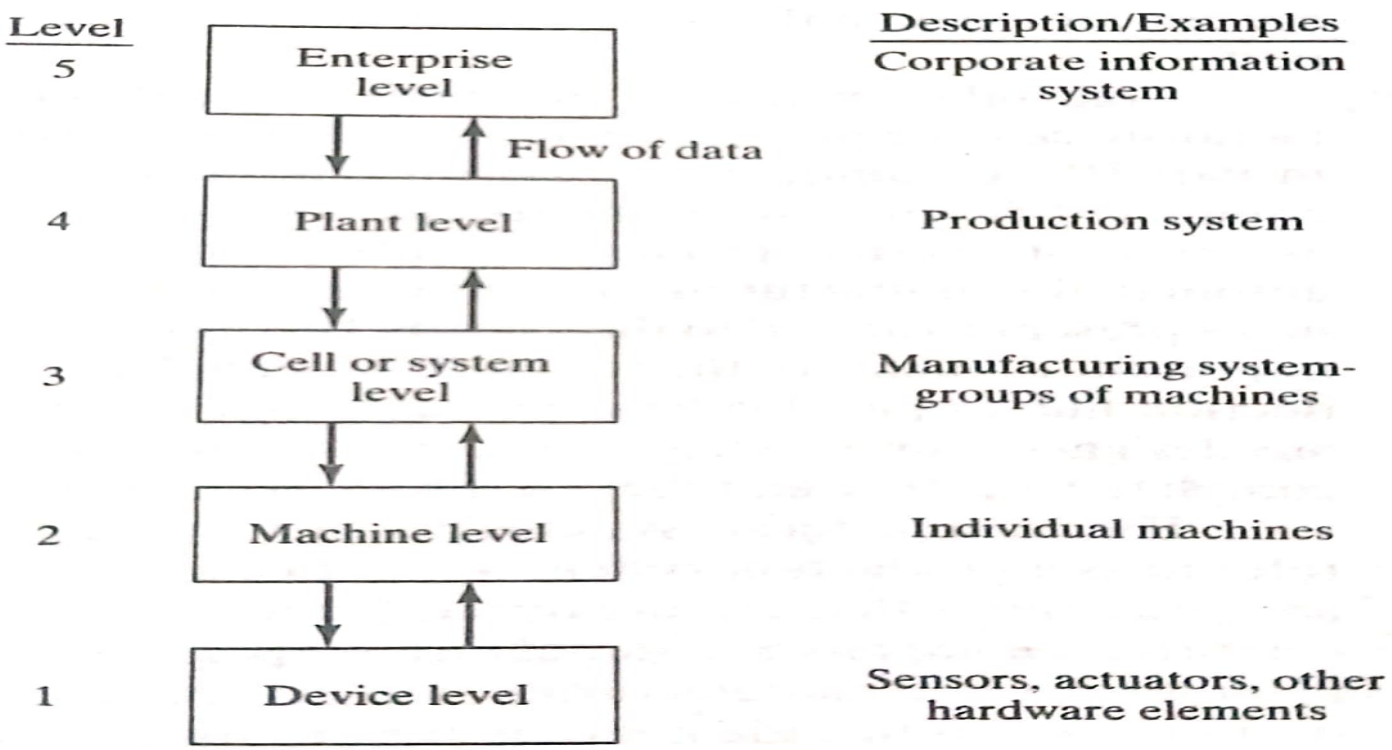
Error Categories	*Possible Malfunctions*
1. Machine and process	Loss of power, power overload, thermal deflection, cutting temperature too high, vibration, no coolant, chip fouling, wrong part program, defective part
2. Cutting tools	Tool breakage, tool wear-out, vibration, tool not present, wrong tool
3. Workholding fixture	Part not in fixture, clamps not actuated, part dislodged during machining, part deflection during machining, part breakage, chips causing location problems
4. Part storage unit	Workpart not present, wrong workpart, oversized or undersized workpart
5. Load/unload robot	Improper grasping of workpart, robot drops workpart, no part present at pickup

Contd.

TABLE 3.4 Error Recovery in an Automated Machining Cell: Possible Corrective Actions That Might Be Taken in Response to Errors Detected During the Operation

Errors Detected	*Possible Corrective Actions to Recover*
Part dimensions deviating due to thermal deflection of machine tool	Adjust coordinates in part program to compensate (category 1 corrective action)
Part dropped by robot during pickup	Reach for another part (category 2 corrective action)
Part is dimensionally oversized	Adjust part program to take a preliminary machining pass across the work surface (category 2 corrective action)
Chatter (tool vibration)	Increase or decrease cutting speed to change harmonic frequency (category 2 corrective action)
Cutting temperature too high	Reduce cutting speed (category 2 corrective action)
Failure of cutting tool	Replace cutting tool with another sharp tool (category 3 corrective action).
No more parts in parts storage unit	Call operator to resupply starting workparts (category 4 corrective action)
Chips fouling machining operation	Call operator to clear chips from work area (category 4 corrective action)

3) Levels of Automation



e 3.6 Five levels of automation and control in manufacturing