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Internal Assessment Test 1 – OCT. 2022

Sub:	Automation and Robotics					Sub Code:	18ME732	Branch:	ME
Date:	21.10.22	Duration:	90 min’s	Max Marks:	50	Sem / Sec:	VII/A&B		OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1	Define automation? Explain basic elements of an automation system with a neat sketch	[10]	CO1	L2
2	Explain levels of Automation with a neat sketch?	[10]	CO1	L2
3	Explain briefly steps involved and hardware components in Analog to digital conversion process with neat sketch	[10]	CO2	L2
4	What is an automated production line? Explain general configurations of an automated production line and its system configurations with suitable diagrams	[10]	CO2	L2
5	Explain different types of Continuous control systems used in automated systems	[10]	CO1	L2
6.	What is storage buffer? Mention the reasons for usage of storage buffers in automation	[10]	CO2	L2

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Scheme of Evaluation

Question number	Particulars	Marks distribution
1.	Definition Diagram of basic elements Explanation of basic elements	2 marks 2 marks 6 marks
2.	Levels of Automation.	5*2=10 marks
3.	Sketch Steps in ADC	4 marks 6 marks
4.	Automated production line System configurations Diagrams	2 marks 4 marks 4 marks
5.	Different control system 4 Continuous control system Diagrams Explanation	2 marks 4x1=4marks 4x1=4marks
6.	Storage Buffer Reasons	2 marks 8 marks

1. *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.

Basic elements of an automated system

An automated system consists of three basic elements:

(1) *power* to accomplish the process and operate the system.
(2) a *program of instructions* to direct the process, and
(3) a control system to actuate the instructions.

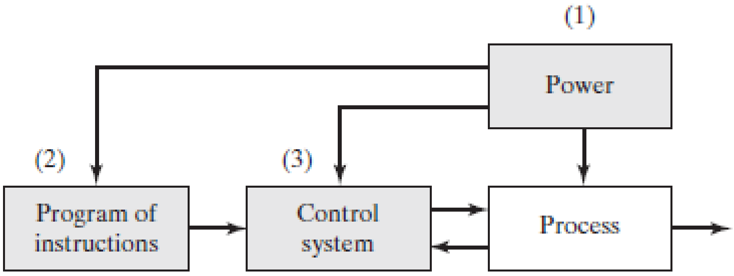

Figure 4.2 Elements of an automated system: (1) power, (2) program of instructions, and (3) control systems.

Fig.1 Basic elements of an automated system

1. Power to accomplish the automated process

An automated system is used to operate some process, and power is required to drive the process as well as the controls. The principal source of power in automated systems is electricity. Electric power has many advantages in automated as well as non-automated processes.

In addition to driving the manufacturing process itself, power is also required for the following material handling functions:

- *Loading and unloading the work unit.* All of the processes listed in Table 4.1 are accomplished on discrete parts. These parts must be moved into the proper position and orientation for the process to be performed, and power is required for this transport and placement function. At the conclusion of the process, the work unit must be removed. If the process is completely automated, then some form of mechanized power is used. If the process is manually operated or semi automated, then human power may be used to position and locate the work unit.
- *Material transport between operations.* In addition to loading and unloading at a given operation, the work units must be moved between operations.

Power for Automation.

Above and beyond the basic power requirements for the manufacturing operation, additional power is required for automation. The additional power is used for the following functions:

- *Controller unit.* Modern industrial controllers are based on digital computers, which require electrical power to read the program of instructions, perform the control calculations, and execute the instructions by transmitting the proper commands to actuating devices.
- *Power to actuate the control signals.* The commands sent by the controller unit are carried out by means of electromechanical devices, such as switches and motors, called *actuators* The commands are generally transmitted by means of low-voltage control signals. To accomplish the commands, the actuators require more power, and so the control signals must be amplified to provide the proper power level for the actuating device.

- *Data acquisition and information processing.* In most control systems, data must be collected from the process and used as input to the control algorithms. In addition, for some processes, it is a legal requirement that records be kept of process performance and/or product quality. These data acquisition and record-keeping functions require power, although in modest amounts.

2. Program of instructions

The actions performed by an automated process are defined by a program of instructions. Whether the manufacturing operation involves low, medium, or high production, each part or product requires one or more processing steps that are unique to that part or product. These processing steps are performed during a work cycle. A new part is completed at the end of each work cycle (in some manufacturing operations, more than one part is produced during the work cycle: for example, a plastic injection molding operation may produce multiple parts each cycle using a multiple cavity mold). The particular processing steps for the work cycle are specified in a work cycle program, called *part programs* in numerical control.

3. Control System

The control element of the automated system executes the program of instructions. The control system causes the process to accomplish its defined function, which is to perform some manufacturing operation.
The controls in an automated system can be either closed loop or open loop. A ***closedloop control system***, also known as a *feedback control system*, is one in which the output variable is compared with an input parameter, and any difference between the two is used to drive the output into agreement with the input.

2. LEVELS OF AUTOMATION

Automated systems can be applied to various levels of factory operations. One normally associates automation with the individual production machines. However, the production machine itself is made up of subsystems that may themselves be automated.

Five levels of automation can be identified, and their hierarchy is depicted in Figure
1. Device level. This is the lowest level in the automation hierarchy. It includes the actuators, sensors, and other hardware components that comprise the machine level. The devices are combined into the individual control loops of the machine, for example, the feedback control loop for one axis of a CNC machine or one joint of an industrial robot.

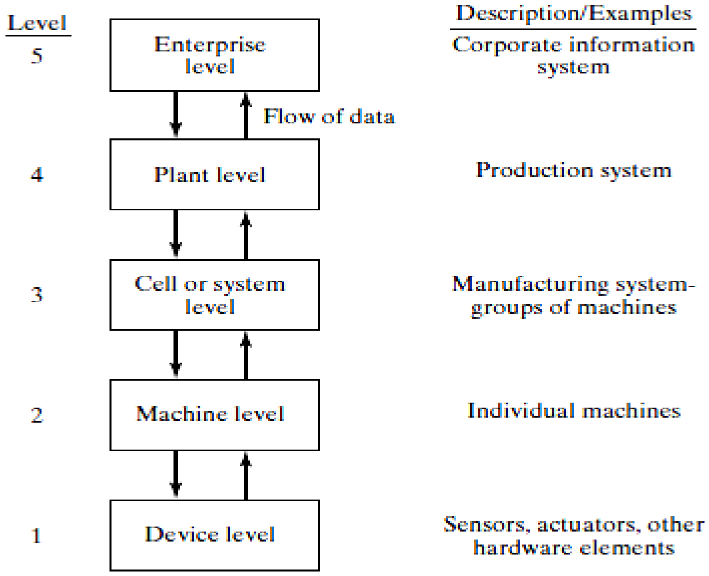

Figure 4.6 Five levels of automation and control in manufacturing.

2. Machine level. 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 and making sure that each step is properly executed.

3. Cell or system level. This is the manufacturing cell or system level, which operates under instructions from the plant level. A manufacturing cell or system is a group of machines or workstations connected and supported by a material handling system, computer, and other equipment appropriate to the manufacturing process. Production lines are included in this level. Functions include part dispatching and machine loading, coordination among machines and material handling system, and collecting and evaluating inspection data.

4. Plant level. This is the factory or production systems level. It receives instructions from the corporate information system and translates them into operational plans for production. Likely functions include order processing, process planning, inventory control, purchasing, material requirements planning, shop floor control, and quality control.

5. ***Enterprise level***. This is the highest level, consisting of the corporate information system. It is concerned with all of the functions necessary to manage the company: marketing and sales, accounting, design, research, aggregate planning, and master production scheduling. The corporate information system is usually managed using Enterprise Resource Planning.

3. Analog to Digital Conversions

Analog-to-Digital Converters

The procedure for converting an analog signal from the process into digital form typically consists of the following steps and hardware devices, as illustrated in Figure 6.9:

1. ***Sensor and transducer***. This is the measuring device that generates the analog signal

2. ***Signal conditioning***. The continuous analog signal from the transducer may require conditioning to render it into more suitable form. Common signal conditioning steps include (1) filtering to remove random noise and (2) conversion from one signal form to another, for example, converting a current into a voltage.

3. ***Multiplexer***. The multiplexer is a switching device connected in series with each input channel from the process; it is used to time-share the analog-to-digital converter (ADC) among the input channels. The alternative is to have a separate ADC for each input channel, which would be costly for a large application with many input channels. Because the process variables need only be sampled periodically, using a multiplexer provides a cost-effective alternative to dedicated ADCs for each channel.

4. ***Amplifier***. Amplifiers are used to scale the incoming signal up or down to be compatible with the range of the analog-to-digital converter.

5. ***Analog-to-digital converter***. As its name indicates, the function of the ADC is to convert the incoming analog signal into its digital counterpart.

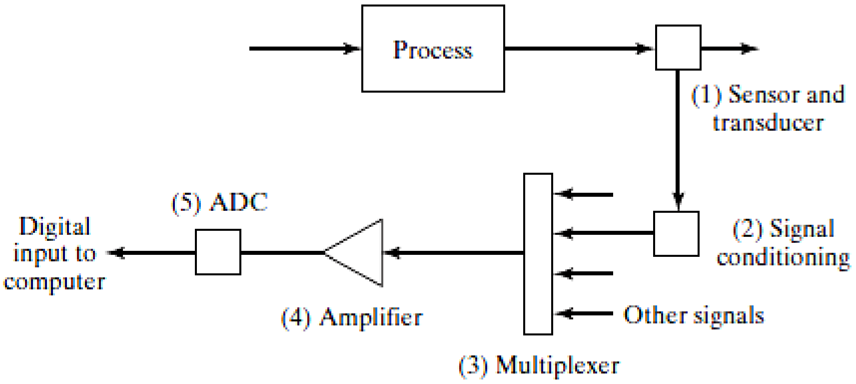

Figure 6.9 Steps in analog-to-digital conversion of continuous analog signals from process.

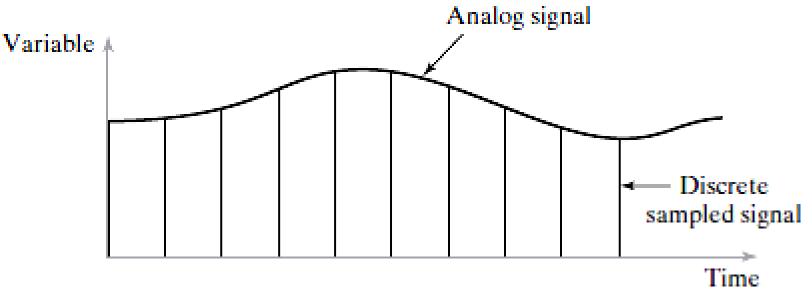

Figure 6.10 Analog signal converted into series of discrete sampled data by analog-to-digital converter.

Consider the operation of the ADC, which is the heart of the conversion process. Analog-to-digital conversion occurs in three steps: (1) sampling, (2) quantization, and (3) encoding. Sampling consists of converting the continuous signal into a series of discrete analog signals at periodic intervals, as shown in Figure 6.10. In quantization, each discrete analog signal is assigned to one of a finite number of previously defined amplitude levels. The amplitude levels are discrete values of voltage ranging over the full scale of the ADC

In the encoding step, the discrete amplitude levels obtained during quantization are converted into digital code, representing the amplitude level as a sequence of binary digits. In selecting an analog-to-digital converter for a given application, the following factors are relevant: (1) sampling rate, (2) conversion time, (3) resolution, and (4) conversion method.

The sampling rate is the rate at which the continuous analog signals are sampled or polled. A higher sampling rate means that the continuous waveform of the analog signal can be more closely approximated. When the incoming signals are multiplexed, the maximum possible sampling rate for each signal is the maximum sampling rate of the ADC divided by the number of channels that are processed through the multiplexer. For example, if the maximum sampling rate of the ADC is 1,000 samples/sec, and there are 10 input channels through the multiplexer, then the maximum sampling rate for each input line is 1,000>10 = 100 sample>sec. (This ignores time losses due to multiplexer switching.)

The maximum possible sampling rate of an ADC is limited by the ADC conversion time. Conversion time of an ADC is the time interval between the application of an incoming signal and the determination of the digital value by the quantization and encoding steps of the conversion procedure. Conversion time depends on (1) the type of conversion procedure used by the ADC and (2) the number of bits n used to define the converted digital value.

4. An automated production line consists of multiple workstations that are automated and linked together by a work handling system that transfers parts from one station to the next, as depicted in Figure 16.1. A raw work part enters one end of the line, and the processing steps are performed sequentially as the part progresses forward (from left to right in the drawing). The line may include inspection stations to perform intermediate quality checks. Also, manual stations may be located along the line to perform certain operations that are difficult or uneconomical to automate. Each station performs a different operation, so all operations must be performed to complete each work unit. Multiple parts are processed simultaneously on the line, one part at each station. In the simplest form of production line, the number of parts on the line at any moment is equal to the number of workstations, as in the figure. In more complicated lines, provision is made for temporary parts storage between stations, in which case there are more parts than stations.

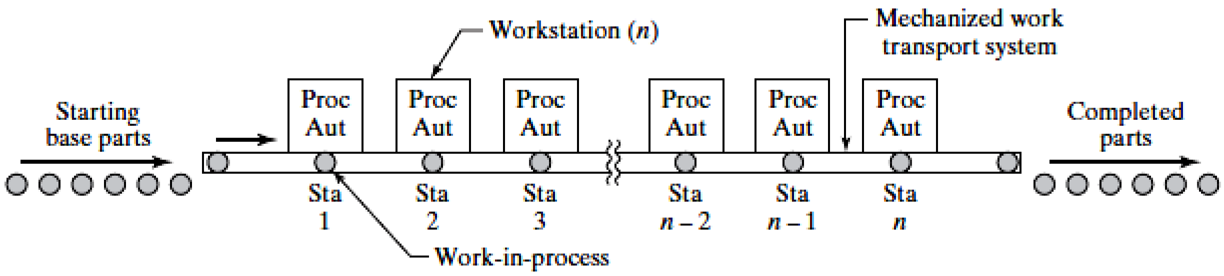

Figure 16.1 General configuration of an automated production line. Key: Proc = processing operation, Aut = automated workstation.

Work Part Transport

The work part transport system moves parts between stations on the line. Transport mechanisms used on automated production lines are usually either synchronous or asynchronous but rarely continuous. Synchronous transport has been the traditional means of moving parts in a transfer line. However, asynchronous transport provides certain advantages over synchronous transport: (1) they are more flexible, (2) they permit queues of parts to form between workstations to act as storage buffers it is easier to rearrange or expand the production line. These advantages come at a higher first cost. Continuous work transport systems, although widely used on manual assembly lines, are uncommon on automated lines due to the difficulty in providing accurate registration between the station work heads and the continuously moving parts.

System Configurations

Although Figure 16.1 shows the flow of work to be in a straight line, the work flow can actually take several different forms: (1) in-line, (2) segmented in-line, and (3) rotary. The in-line configuration consists of a sequence of stations in a straight line arrangement, as in Figure 16.1. This configuration is common for machining big work pieces, such as automotive engine blocks, engine heads, and transmission cases. Because these parts require a large number of operations, a production line with many stations is needed. The in-line configuration can accommodate a large number of stations. In-line systems can also be designed with integrated storage buffers along the flow path

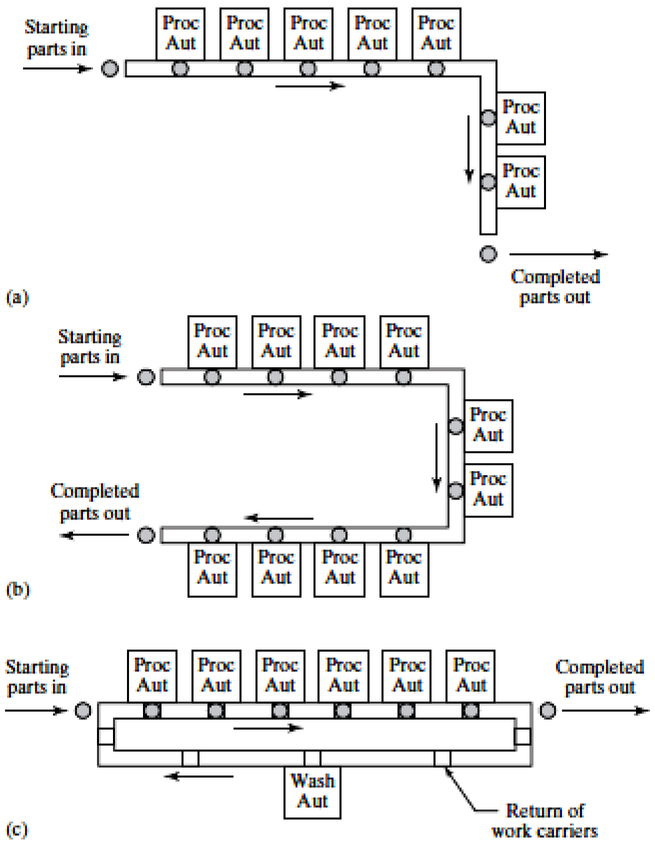

Figure 16.2 Several possible layouts of the segmented in-line configuration of an automated production line: (a) L-shaped, (b) U-shaped, and (c) rectangular. Key: Proc = processing operation, Aut = automated workstation, Wash = work carrier washing station.

The segmented in-line configuration consists of two or more straight-line transfer sections, where the segments are usually perpendicular to each other. Figure 16.2 shows several possible layouts of the segmented in-line category. There are a number of reasons for designing a production line in these configurations rather than in a pure straight line: (1) available floor space may limit the length of the line, (2) a workpiece in a segmented in-line configuration can be reoriented to present different surfaces for machining, and (3) the rectangular layout provides for swift return of work-holding fixtures to the front of the line for reuse.

Figure 16.3 shows two transfer lines that perform metal machining operations on automotive castings. The first line, on the left-hand side, is a segmented in-line configuration in the shape of a rectangle. Pallet fixtures are used in this line to position the starting castings at the workstations for machining. It is a palletized transfer line. The second line, on the right side, is a conventional in-line configuration. When processing on the first line is completed, the parts are manually transferred to the second line, where they are reoriented to present different surfaces for machining. In this line the parts are moved individually by the transfer mechanism, using no pallet fixtures. It is a free transfer line.

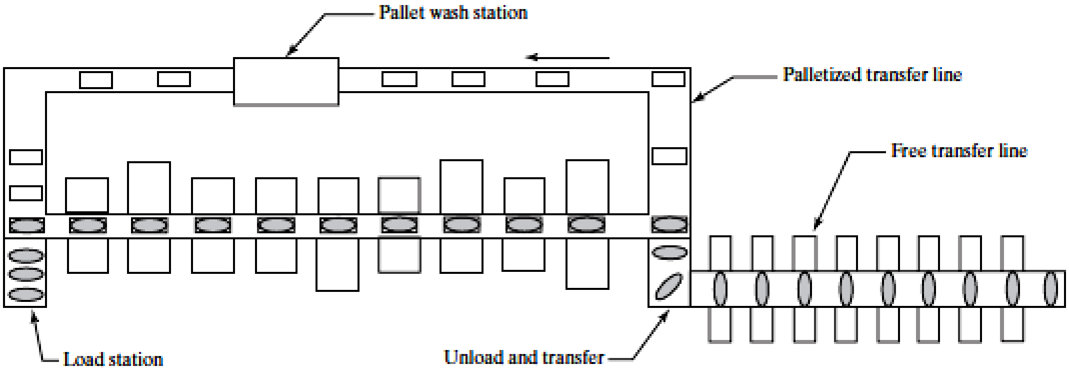

Figure 16.3 Two machining transfer lines. On the left is a segmented in-line configuration that uses pallet fixtures to locate the work parts. The return loop brings the pallets back to the front of the line. On the right, the second transfer line is an in-line configuration. The manual station between the lines is used to reorient the parts, represented as ovals. Pallet fixtures are represented as rectangles.

In the rotary configuration, the work parts are attached to fixtures around the periphery of a circular worktable, and the table is indexed (rotated in fixed angular amounts) to present the parts to workstations for processing. A typical arrangement is illustrated in Figure 16.4. The worktable is often referred to as a dial, and the equipment is called a *dial-indexing machine*.

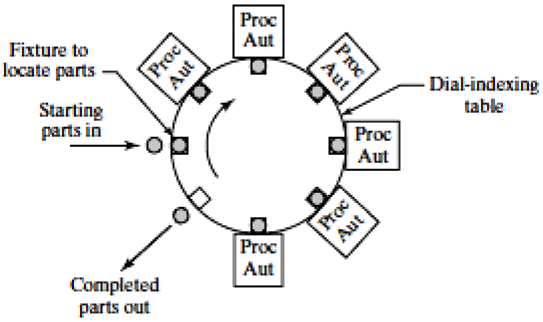

Figure 16.4 Rotary indexing machine (dial-indexing machine). Key: Proc = processing operation, Aut = automated workstation.

5. Continuous Control systems

In continuous control, the usual objective is to maintain the value of an output variable at a desired level, similar to the operation of a feedback control system.

Regulatory Control: In regulatory control, the objective is to maintain process performance at a certain level or within a given tolerance band of that level. This is appropriate, for example, when the performance attribute is some measure of product quality, and it is important to keep the quality at the specified level or within a specified range. In many applications, the performance measure of the process, sometimes called the *index of performance*, must be calculated based on several output variables of the process. Except for this feature, regulatory control is to the overall process what feedback control is to an individual control loop in the process, as suggested by Figure 5.2.

The trouble with regulatory control (and also with a simple feedback control loop) is that compensating action is taken only after a disturbance has affected the process output. An error must be present for any control action to be taken. The presence of an error means that the output of the process is different from the desired value.

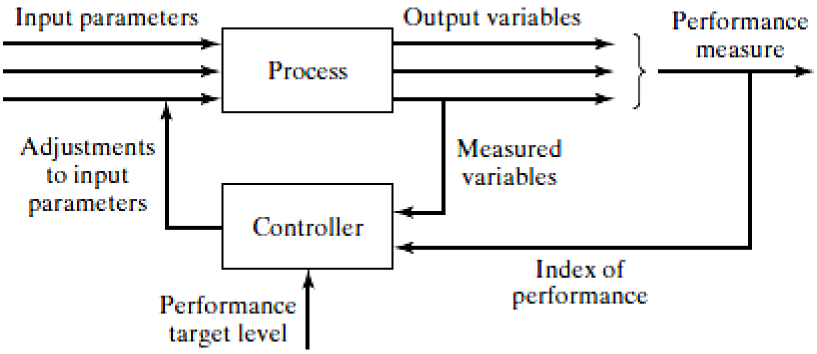

Figure 5.2 Regulatory control.

Feed forward Control. The strategy in feed forward control is to anticipate the effect of disturbances that will upset the process by sensing them and compensating for them before they affect the process. As shown in Figure 5.3, the feed forward control elements sense the presence of a disturbance and take corrective action by adjusting a process parameter that compensates for any effect the disturbance will have on the process. In the ideal case, the compensation is completely effective. However, complete compensation is unlikely because of delays and/or imperfections in the feedback measurements, actuator operations, and control algorithms, so feed forward control is usually combined with feedback control, as shown in the figure. Regulatory and feed forward control are more closely associated with the process industries than with discrete product manufacturing.

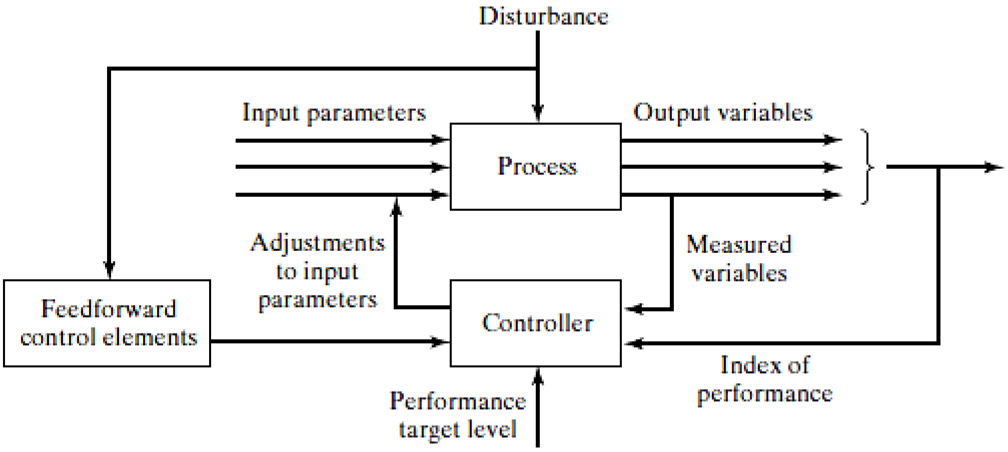

Figure 5.3 Feedforward control, combined with feedback control.

Steady-State Optimization: This term refers to a class of optimization techniques in which the process exhibits the following characteristics: (1) there is a well-defined index of performance, such as product cost, production rate, or process yield; (2) the relationship between the process variables and the index of performance is known; and (3) the values of the system parameters that optimize the index of performance can be determined mathematically. When these characteristics apply, the control algorithm is designed to make adjustments in the process parameters to drive the process toward the optimal state. The control system is open loop, as seen in Figure 5.4. Several mathematical techniques are available for solving steady-state optimal control problems, including differential calculus, calculus of variations, and various mathematical programming methods.

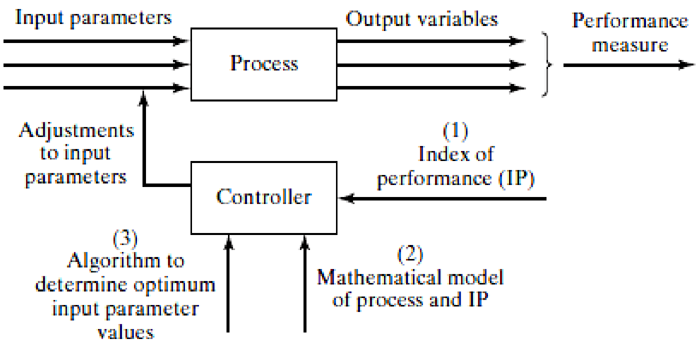

Figure 5.4 Steady-state (open loop) optimal control.

Adaptive Control: Steady-state optimal control operates as an open-loop system. It works successfully when there are no disturbances that invalidate the known relationship between process parameters and process performance. When such disturbances are present in the application, a self-correcting form of optimal control can be used, called *adaptive control*. Adaptive control combines feedback control and optimal control by measuring the relevant process variables during operation (as in feedback control) and using a control algorithm that attempts to optimize some index of performance (as in optimal control).

The general configuration of an adaptive control system is illustrated in Figure 5.5.

To evaluate its performance and respond accordingly, an adaptive control system performs three functions, as shown in the figure:

1. Identification. In this function, the current value of the index of performance of the system is determined, based on measurements collected from the process. Because the environment changes over time, system performance also changes. Accordingly, the identification function must be accomplished more or less continuously over time during system operation.

2. Decision. Once system performance is determined, the next function decides what changes should be made to improve performance. The decision function is implemented by means of the adaptive system's programmed algorithm. Depending on this algorithm, the decision may be to change one or more input parameters, alter some of the internal parameters of the controller, or make other changes.

3. Modification. The third function is to implement the decision. Whereas decision is a logic function, modification is concerned with physical changes in the system. It involves hardware rather than software. In modification, the system parameters or process inputs are altered using available actuators to drive the system toward a more optimal state.

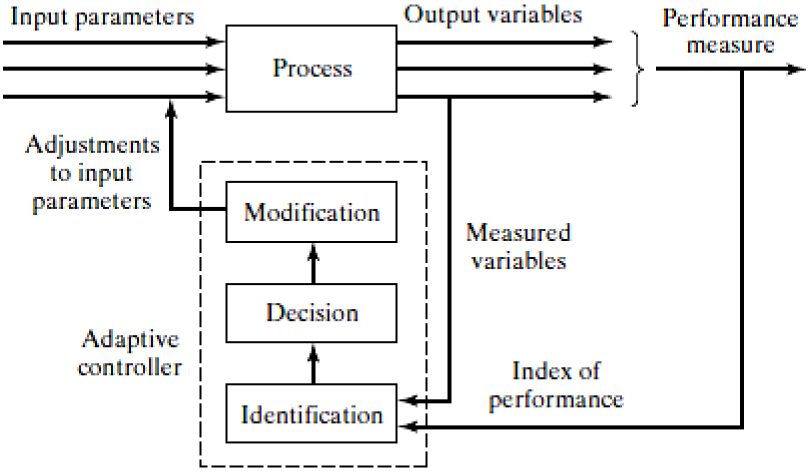

Figure 5.5 Configuration of an adaptive control system.

Discrete Control Systems

In discrete control, the parameters and variables of the system are changed at discrete moments in time, and the changes involve variables and parameters that are also discrete, typically binary (ON/OFF). The changes are defined in advance by means of a program of instructions.

6. **Storage Buffers**

Automated production lines can be designed with storage buffers. A storage buffer is a location in the production line where parts can be collected and temporarily stored before proceeding to downstream workstations. The storage buffers can be manually operated or automated. When it is automated, a storage buffer consists of a mechanism to accept parts from the upstream workstation, a place to store the parts, and a mechanism to supply parts to the downstream station. A key parameter of a storage buffer is its storage capacity, that is, the number of work parts it can hold. Storage buffers may be located between every pair of adjacent stations, or between line stages containing multiple stations.

There are several reasons why storage buffers are used on automated production lines:

- To reduce the impact of station breakdowns. Storage buffers between stages on a production line permit one stage to continue operation while the other stage is down for repairs.
- To provide a bank of parts to supply the line. Parts can be collected into a storage unit and automatically fed to a downstream manufacturing system. This permits untended operation of the system between refills.
- To provide a place to put the output of the line.
- To allow for curing time or other process delay. A curing time is required for some processes such as painting or adhesive application. The storage buffer is designed to provide sufficient time for curing to occur before supplying the parts to the downstream station.
- To smooth cycle time variations. Although this is generally not an issue in an automated line, it is relevant in manual production lines, where cycle time variations are an inherent feature of human performance.