UNIT 3 AUTOMATED MATERIAL HANDLING

Structure

3.1 INTRODUCTION

Automated material handling (AMH) systems improve efficiency of transportation, storage and retrieval of materials. Examples are computerized conveyors, and automated storage and retrieval systems (AS/RS) in which computers direct automatic loaders to pick and place items. Automated guided vehicle (AGV) systems use embedded floor wires to direct driverless vehicles to various locations in the plant. Benefits of AMH systems include quicker material movement, lower inventories and storage space, reduced product damage and higher labour productivity.

Objectives

After studying this unit, you should be able to understand the

- importance of AGV in a computer-integrated manufacturing system,
- role of industrial robots in a computer-integrated manufacturing systems, and
- alternative for automated material handling system.

3.2 INTRODUCTION TO AGVS

A material-handling system can be simply defined as an integrated system involving such activities as handling, and controlling of materials. Materials include all kinds of raw material, work-in-progress, sub-assemblies, and finished assemblies. The main motto of an effective material-handling system is to ensure that the material in the right amount is safely delivered to the desired destination at the right time and at minimum cost. It is an integral part of any manufacturing activity. Role of AGVs and Robots have become strategic with respect to the modern material handling practices followed in the present day industry. The next section deals with the automated guided vehicles (AGVs). In Section 3.2, we have introduced the modern industrial robots and the attributes related with them, which are essential for their understanding.

3.2.1 Automated Guided Vehicles

Automated guided vehicle systems (AGVs), commonly known as driverless vehicles, are turning out to be an important part of the automated manufacturing system. With the shift from mass production to mid-volume and mid-variety, flexible manufacturing systems, are increasingly in use. They require not only machine flexibility but also material-handling, storage, and retrieval flexibility. Hence, the importance of AGVs has grown in manifold. It is a battery-powered driverless vehicle with programming capabilities for destination, path selection, and positioning. The AGVs belongs to a class of highly flexible, intelligent, and versatile material-handling systems used to transport materials from various loading locations to various unloading locations throughout the facility. The capability related to collision avoidance is nicely inbuilt in AGVS. Therefore, the vehicle comes to a dead stop before any damage is done to the personnel, materials, or structures. They are becoming an integral part of flexible manufacturing system installations.

Now-a-days, AGVS are versatile in nature and possess flexible material-handling system. They use modern microprocessor technology to guide a vehicle along a prescribed path and makes correction if the vehicle strays from the path. A system controller receives instructions directly from the host computer, communicates with other vehicles, and issues appropriate commands to each vehicle. To avoid collision, communication is necessary among the AGVs. To facilitate the communication, they are connected through a wire in the floor or by radio.

3.2.2 Components of AGVS

There are four main components of an automated guided vehicle system. They are as follows :

- ***The Vehicle*** **:** It is used to move the material within the system without a human operator.
- ***The Guide Path*** **:** It guides the vehicle to move along the path.
- ***The Control Unit*****:** It monitors and directs system operations including feedback on moves, inventory, and vehicles.
- ***The Computer Interface*** **:** It is connected with other computers and systems such as mainframe host computer, the Automated Storage and Retrieval System (AS/RS), and the Flexible Manufacturing System.

3.2.3 Different Types of AGVS

There are different types of automated guided vehicles that are able to cater different service requirements. The vehicle types include :

- AGVS towing vehicles
- AGVS unit load transporters
- AGVS pallet trucks
- AGVS forklift trucks
- AGVS light-load transporters
- AGVS assembly line vehicles

The level of sophistication of the AGVS has increased to allow automatic positioning and pickup and drop-off (P/D) of cargo, and they also perform P/D services between machining work centers, storage racks, and the AS/RS. They are also capable of two-way travel on the same path and real-time dispatching under the control of the computer. The different types of AGVS are discussed in the section to follow.

AGVS Towing Vehicle

AGVS towing vehicles were the earliest variety to be introduced. A towing vehicle is an automated guided tractor. A wide variety of tractors can be used, such as flatbed trailers, pallet trucks, custom trailers, and bin trailers. Different types of loading equipment used for loading and unloading the trailer include an AGV-pulled train, hand pallet truck, cranes, forklift truck, automatic transfer equipment, manual labor, shuttle transfer, and programmed automatic loading and unloading device.

AGVS Pallet Trucks

AGVS pallet trucks are designed to lift, maneuver, and transport palletized loads. It is used for picking up or dropping off loads from and on to floor level, than removing the need for fixed load stands. No special accessories are needed for loading and unloading the AGVS pallet except that the loads should be on a pallet. It is basically used in floor-level loading and unloading operation. Loading and unloading can be done in two ways viz. automatically or manually. For the transportation of load, the normal course followed by the vehicle is determined by the storage area destination. Normal operations carried out in pallet trucks are :

(i) loads are pulled off onto a spur,

(ii) lowering of the pallet forks to the floor,

(iii) pulling out from the pallet, and

(iv) finally automatically returns empty to the loading area.

AGVS Forklift Trucks

An AGVS forklift truck has the capability to pick up and drop off palletized loads both at floor level and on stands, and the pickup height can be different from the drop-off height. They are capable of picking up and dropping off a palletized load automatically. It has the ability to position its forks at any height so that conveyors or load stands with different heights in the material-handling system can be serviced. AGVS forklift trucks are one of the most expensive AGVS types. Therefore, they are used in the case of full automation. The truck is accoutered with sensors at the fork end, so that it can handle high-level stacking on its own. These systems have the advantage of greater flexibility in integrating with other subsystems with various loading and unloading heights throughout the material handling system.

AGVS Light Load Transporters

They are applied in handling small, light parts over a moderate distance and distribute the parts between storage and number of work stations.

AGVS Assembly-Line Vehicles

AGVS assembly line vehicles are an acclimatization of the light-load transporters for applications involving serial assembly processes. The guided vehicle carries major sub-assemblies such as motors, transmissions, or even automobiles. As the vehicle moves from one station to the next, succeeding assembly operations are performed. After the loading of part onto the vehicle, the vehicle moves to an assembly area and stops for assembly. As the assembly process is completed, the operator releases the vehicle that proceeds to the next part's staging area for new parts. After that the vehicle moves forward to the next assembly station. The process is repeated until the final unloading station is reached.

The main advantage of the AGVS assembly line is its lower expense and ease of installation compared with "hard" assembly lines. The line can be easily reconfigured by altering the guide path and by reprogramming. Variable speeds and dwell intervals can be easily programmed into the system. However, an extensive planning and complex computer control is needed in the case of overall integration. Some of the guiding factors determining the functioning of the AGVS are :

(i) Guidance Systems

(ii) Routing

(iii) AGVS Control Systems

(iv) Load Transfers

(v) Interfacing with other subsystems

Next section deals with the guidance systems designed for keeping the vehicle on predetermined path.

3.2.4 Guidance Systems for AGVS

The main purpose of a guidance system is to keep the vehicle in the predestinated path. The main advantage of AGVS guidance system is that the guide path can be changed easily at low cost compared to the high cost of modifying fixed-path equipment such as conveyors, chains, and tow lines. Many guidance systems are available and their selection will depend on need, application, and environmental constraints. Some of the familiar guidance systems are wire-guided guidance system, optical guidance system, inertial guidance system, infrared guidance system, laser guidance system, and teaching-type guidance system.

3.2.5 Routing of the AGVS

AGVS routing means determining how the vehicle conforms the path and takes a shortest path between the two points. The commonly used methods are : "*frequency selection method* " and the "*path switch selection method* ".

3.2.6 AGVS Control Systems

Three types of AGVS control systems are available.

(i) Computer-controlled system

(ii) Remote dispatch control system

(iii) Manual control system

Computer Controlled System

Here, all the exchanges and AGVS vehicle movements are controlled and monitored by the system controller. A detailed sketch of the computer-controlled system is shown in Figure 3.1. The guide path controller controls the guide path of the AGVS and transfers the information to the AGVS process controller. Movements of AGVS vehicle are directly controlled by the AGVS process controller.

Figure 3.1 : Computer-controlled Architecture for AGVS Control

Remote Dispatch Control System

Here, a human operator controls the movement of AGVS through a remote control station. The control system sends destination instructions directly to the vehicle.

Manual Control System

In this type of system, the operator loads the vehicle and enters a destination into the onboard control panel of the vehicle. The efficiency of the system depends on the skill of the operator.

3.2.7 Interface with Other Subsystems

The computer-controlled system can link the AGVS materials-handling system with other subsystems in the organisation. These subsystems include:

(i) Automated storage and retrieval systems.

(ii) Computer numerical control (CNC) machines.

(iii) Shop floor control system.

(iv) Process control equipment.

(v) Flexible manufacturing systems.

They may be linked by a distributed data processing network and the host computer. In the distributed data processing network, the system control computers communicate with each other directly without the intermediate or host computer.

In the next section, we will elucidate the main features considered for designing the AGVS system.

3.2.8 AGVS Design Features

Many design features pertaining to AGVS are common to other material handling systems. However, there are several special features unique to the AGVS, such as stopping accuracy, facilities, safety, and maintenance.

A very important attribute of the AGVS system is "Stopping Accuracy" and it varies considerably with the nature and requirements of the system. A system with automatic load transfer requires high stopping accuracy. In case of manual load transfer, lower stopping accuracy is required. In addition to that, unit load transporters are used for systems that require higher accuracy. In an AGVS, the stopping accuracy is provided by the feedback of Computer Control Systems. Stopping accuracy depends on the applications, for example, ± 0.001 inch for machine tool interfaces, $\pm$ 1 inch or more for towing and light-load vehicles, and $\pm$ 3 inch for a manual system.

Many considerations are undertaken while designing the AGVS, like incorporation of automatic door-opening devices, elevators etc. Safety features such as emergency contact bumpers and stop buttons, object detectors, automatic warning signals, and stopping devices must be built in the AGVS. These features must be of paramount importance in the minds of the designers so as to avoid the human injuries and damage to other equipment, materials, and vehicle itself.

3.2.9 System Design of AGVS

The decision process related to the system design is very complex in nature. A number of issues are to be addressed which includes:

(i) Guide path layout

(ii) Number of vehicles required

(iii) Flow path design

(iv) Selection of guide path type and vehicle type

(v) Type of flow path within the layout

(vi) Location and number of load transfer points and load transfer station storage space.

Operational issues such as the routes used by the vehicles during operation are also taken into consideration. There must be a synergy between the operational and design features for the successful implementation of AGVS.

3.2.10 Flow Path Design

The flow path design is one of the most important processes in the AGVS design. Some of the important decisions involved in flow path design are:

(i) Type of guide path layout.

(ii) Flow path within the layout.

(iii) The number and locations of load transfer points.

(iv) Load transfer function station storage space.

Areas of application of the AGVS determine the critical issues like guide path layout, P/D (Place and Delivery) location points, and load transfer station storage space. However, the complexity of controls and economic considerations influence the direction of flows.

Vehicle blocking, congestion, and unloaded vehicle travel are the issues to be taken into consideration and depend on the number of the vehicles and the requests for vehicles from various pickup and delivery stations. Simulation is used to develop the realistic design under aforementioned circumstances. The type of information required for developing a simulation model would include layout of departments, aisles, location of load transfer stations, and charts containing the material flow intensities between departments.

Required Number of AGVS

Estimation of the number of AGVs required in the system is an important element of the system design. Here, we provide a simple mathematical analysis for the determination of the number of vehicles. The following notations are used :

D_d = Total average loaded travel distance.

D_c = Total average empty travel distance.

N_{dr} = Number of deliveries required per hour.

T_f = Traffic factor that accounts for blocking of vehicles and waiting of vehicles in line and at intersection. If there is no congestion, the traffic factor is 1. However, when more vehicles are involved, the traffic factor value will certainly be less than 1. Normally, T_f lies between 0.85 and 1.

v = Vehicle speed.

T_h = Loading and unloading time.

The total time per delivery per vehicle (T_{dv}) is given by the sum of loaded travel time, loading and unloading time, and empty travel time as follows :

$$T_{dv} = \frac{D_d}{v} + T_h + \frac{D_c}{v}$$

Number of deliveries per vehicle per hour

$$N_d = \frac{60\,T_f}{T_{dv}}$$

Number of automated guided vehicles = N_{dr}/N_d

The treatise discussed here provides an approximate estimate of number of vehicles.

Example 3.1

Pradeep Engineering is contemplating to integrate the AGVS and AS/RS with their flexible manufacturing system. It is also in the process of determination of number of AGVSs for its manufacturing system. It has to deliver 67 pieces per hour. The company has decided in favour of installing a wire guided path system and the unit load AGVS. The following data has been collected as shown in Table 3.1.

Table 3.1 : Data Pertaining to the AGVS in the Industry

Vehicle Speed	200 ft/min
Average loaded travel distance per delivery	600ft
Average empty travel distance per delivery	400 ft
Pickup time	0.25 min
Drop-off time	0.25 min
Traffic factor	0.75

The total time per delivery per vehicle (T_{dv}) is given by

$$T_{dv} = \frac{D_d}{v} + T_h + \frac{D_c}{v}$$

$$= \frac{600}{200} + 0.25 + 0.25 + \frac{400}{200} = 5.5$$

Number of deliveries per vehicle per hour,

$$N_d = \frac{60 T_f}{T_{dv}} = \frac{60\ (0.75)}{5.5} = 8.18$$

Hence, the number of vehicles required = 67/8.18 = 8 vehicles.

Example 3.2

An automated manufacturing system for machining crankshafts in a forging industry is planning to implement AGVs in the organisation. There are five CNC workstations (A, B, C, D, E) and a load-unload station (F). Approximate time of moving the crankshaft on AGVS between stations is shown in Table 3.2.

Table 3.2 : Approximate Time of Moving the Crankshaft on AGVS between Stations

	A	B	C	D	E	F
A	-	2				1
B	2.5	-	2.5			
C		3	-	1.0		
D			2	-	0.5	
E				1.5	-	1.0
F	0.5				0.5	

One hundred crankshafts are machined in every 8-h shift and the operations on the crankshaft are performed in sequence from station A through E. Taking an assumption that every pickup and drop-off operation takes approximately 0.75 min, determine the number of AGVSs to meet the demand of moving 100 crankshafts. The load factor is assumed to be 0.75 and the traffic factor 0.95.

Solution

In this problem, the empty travel times of the AGV is not known though load factor is known to us. Here, load factor refers to the percentage of time the AGVS carries the load.

Total travel time of a crankshaft from a pickup operation to a drop-off operation = 1 + 2.5 + 3 + 2.0 + 1.5 + 0.5 = 10.50.

Total pickup and drop-off time = 4.50 min because there are only six stations including the pickup and drop-off station and each takes 0.75 min.

Total transit time = 10.50 + 4.50 = 15.00 min.

Considering that there are delays due to congestion and there is empty travel of AGVs:

Total AGVS travel time for one crankshaft = 10.00/ (traffic factor × load factor) = 10.00/ (0.75 × 0.95) = 14.03 min.

Total available time per shift = 8 hr/ shift × total time per crankshaft)/ available time = 100 × 14.03 / 480 = 2.92 vehicles.

This means that approximately 3 vehicles are required.

SAQ 1

(a) Discuss the following types of AGVSs and their applications:

   (i) AGVS towing vehicle

   (ii) AGVS unit load transporters

   (iii) AGVS pallet trucks

   (iv) AGVS forklift trucks

   (v) AGVS light-load transporters

   (vi) AGVS assembly-line vehicles

(b) Discuss various types of guidance system.

(c) Describe the following types of AGVS control methods:

   (i) Computer-controlled system

   (ii) Remote dispatch control system

   (iii) Manual control system.

3.3 INTRODUCTION TO INDUSTRIAL ROBOTS

An industrial robot is a general-purpose, programmable machine possessing certain anthropomorphic characteristics. Mechanical arm is the most common characteristic of an industrial arm and is used to perform various industrial tasks. Making decisions, capability to communicate with other machines, and capability to respond to sensory inputs are the important attributes of an industrial robot. These capabilities allow the robots to be more versatile in nature. It involves the coordinated control of multiple axes (joints) and use dedicated digital computers as controllers.

The various reasons for the commercial and technological importance of industrial robots include the following :

(i) Robots can be substituted for humans in hazardous or uncomfortable work environments. A robot performs its work cycle with a consistency and repeatability that cannot be attained by humans.

(ii) Robots can be reprogrammed. When the production run of the current task is completed, a robot can be reprogrammed and equipped with necessary tooling to perform an altogether different task.

(iii) Robots are controlled by computers and can therefore be connected to other computer systems to achieve computer integrated manufacturing.

3.3.1 Robot Anatomy

A robot joint is a mechanism that permits relative movement between parts of a robot arm. The joints of a robot are designed to enable the robot to move its end-effector along a path from one position to another as desired. The basic movements required for the desired motion of most industrial robots are :

Rotational Movement

This enables the robot to place its arm in any direction on a horizontal direction.

Radial Movement

This helps the robot to move its end-effector radially to reach distant points.

Vertical Movement

This enables the robot to take its end-effector to different heights.

These degrees of freedom, in combination with others or independently, define the complete motion of the end-effector. Individual joints of the robot arm are responsible for the accomplishment of different movements. The joint movements are in synergy with the relative motion of adjoining links. Depending on the nature of this relative motion, the joints are classified as *prismatic* or *revolute*.

3.3.2 Robot Classification

Robots are being classified on the basis of their physical configuration and control systems adopted. These classifications are briefly described as follows :

Classification on the Basis of Physical Configurations

On the basis of physical configuration industrial robots are classified in four different types. They are :

(i) cartesian configuration,

(ii) cylindrical configuration,

(iii) polar configuration, and

(iv) jointed-arm configuration.

Cartesian Configuration

Robots having cartesian configurations consist of links connected by linear joints (L). As the configuration has three perpendicular slides, they are also called rectilinear robots. Robot having a similar configuration is known as *Gantry Robots*. Its structure resembles a gantry-type crane.

Cylindrical Configuration

In the cylindrical configuration, robots have one rotatory (R) joint at the base and linear (L) joints succeed to connect the links. The space in which this robot operates is cylindrical in shape, hence the name cylindrical configuration.

Polar Configuration

Polar robots have a work space of spherical shape. In general, the arm is linked to the base with a twisting (T) joint and rotatory (R) and or linear (L) joints. The designation of the arm for this arm can be TRL or TRR. Robots with the description of TRL are also called spherical robots. Those having the designation of TRR are called as articulated robots. It resembles a human arm in terms of configuration.

Jointed-Arm Configuration

The combination of cylindrical and articulated configurations is known as jointed-arm configuration. The arm of the robot is connected to the base with a twisting joint. Rotatory joints are used to connect the links in the arm. Generally, the rotation takes place in the vertical plane. Popular robot falling under this category is called SCARA (Selective Compliance Assembly Robot Arm). It is basically used for the assembly purpose.

In the next section, we will elicit the classification based on the control systems.

3.3.3 Classification based on Control Systems

On the basis of the control systems adopted, robots are classified into the following categories :

(i) Point-to-point (PTP) control robot

(ii) Continuous-path (CP) control robot

(iii) Controlled-path robot

Point-to-Point (PTP) Control Robot

The PTP robot is capable of moving from one point to the other point. The locations are recorded in the control memory. The paths are not controlled by the path guide. Instead the desired path is traced by programming a series of points. Component insertion, spot welding, hole drilling, machine loading, unloading and crude assembly are some of the common applications of this type of robot.

Continuous-Path (CP) Control Point

The movement along the controlled path is performed by the CP robot. Along the controlled path, with CP control, the robot can stop any specified point. In the robot's control memory, all the points must be stored explicitly. Straight-line motion is being carried out by these types of robots. Some continuous-path controlled robots also have the capability to follow a smooth curve path that has been defined by the programmer. Here, the programmer manually moves the robot arm through the desired path and the controller unit stores a large number of individual point locations along the path in memory.

Controlled-Path Robot

In controlled-path robots, the control equipment can develop paths of different geometry such as straight lines, circles, and interpolated curves with a high degree of accuracy. Good accuracy can be obtained at any point along the specified path. Only the start and finish points and the path definition function must be stored in the robot's control memory. It is important to mention that all controlled-path robots have a servo capability to correct their path.
In the next section, we will elicit the robotic applications in the industry.

3.3.4 Robotic Applications in the Industry

Work environment is one of the several characteristics that should be considered when selecting a robot application. The hazardous characteristics of industrial work tend to promote the substitution of robots for human labour. Hence, robots are being used in a wide field of applications in industry. Currently, robots are mostly used in the field of manufacturing. The applications can usually be classified into following characteristics :

(i) Material handling

(ii) Processing operations

(iii) Assembly and inspection

Application of the robots in the industry must be technically and economically viable for the industry.

Material Handling Applications

Material handling applications are those in which the robot moves the materials or parts from one place to another. The robot is equipped with a gripper type of end-effector to accomplish this type of transfer. The gripper must be designed to handle the specific part or parts that are to be moved. Within this application category are the following cases which are

(i) Material transfer, and

(ii) Machine loading/unloading.

In almost all the material handling applications, the part must be presented to the robot in familiar position and orientation.

Material Transfer

These are the operations in which the robot picks up the parts at one location and place them at a new location. The basic application in this category is pick and place operation, where robot picks up a part and deposits at a new location. Transferring parts from one conveyor to another is a classic example of this application. However, palletizing is a more complex example of the material transfer application. Here, the robots must retrieve parts, cartons, or other objects from one location and deposit them onto a pallet or other container with multiple locations.

Machine Loading/Unloading Operations

In machine loading and unloading operations, the parts are transferred into/from a machine. The three possible scenarios can be *machine loading*, *machine unloading*, *machine loading and unloading*. In the machine loading operations, the robot loads parts into machine, but the parts are unloaded from the machine by some other mechanism. In the unloading operations, the machines are unloaded using the robots. When both the earlier situations are present, then this can be placed into the third category.

Numerous applications of machine loading and unloading operations are as follows :

(i) Die casting operations

(ii) Metal machining operations

(iii) Plastic molding

(iv) Forging

(v) Heat treating

(vi) Press working

Robots as mentioned earlier are also used in the process industry. Numerous applications in this category are spot welding, continuous arc welding, spray painting, various rotating processes, and machining processes.

Spot Welding

Spot welding is a metal joining process in which two sheet metal parts are fused together at localized points of contact. It has got a widespread use in the automobile industry. The end-effector used here is a spot welding gun used to pinch the car panels together and perform the resistance welding process.

Continuous Arc Welding

Continuous arc welding is used to provide continuous welds rather than points in a spot welding process. As the working condition is tough, therefore automation is recommended in this case. The robotic cell consists of a robot, the welding apparatus (power unit, controller, welding tool, and wire feed mechanism), and a fixture that positions the components for the robot. The fixture might be mechanized with one or two degrees-of-freedom so that it can present different portions of the work to the robot for welding.

Spray Coating

Spray coating makes use of a spray gun directed at the object to be coated. Fluid flows through the nozzle of the spray gun and is dispersed and applied over the surface of the object. Here, robot applications consist of spray coating appliances, automobile car bodies, engines, and other parts, spray painting of wood products, and spraying of porcelain coating on bathroom fixtures.

Other Processing Applications

The list of other industrial processes that are being performed by robots is as follows :

(i) Drilling, routing and other machining process.

(ii) Laser cutting.

(iii) Riveting.

(iv) Grinding, wire brushing, and similar operations.

(v) Water jet cutting.

In the next section, we detail the assembly and inspection operations performed by the robots.

Assembly and Inspection

Assembly and inspection are hybrids of the previous two application categories: material handling and processing. Assembly and inspection applications can involve either the handling of materials or the manipulation of a tool. Assembly and inspection are traditionally labour-intensive, boring and highly repetitive activities. Hence, they are the fitting cases for the robotic applications.

Production rate is one of the important performance measures for such robotic applications. Therefore, industrially relevant problems have been presented and solved in the next section.

Example 3.3

Calculate the cycle and production rate for a single-machine robotic cell for an 8-hr shift if the system availability is 85%. Also determine the percent utilization of machine and robot. On average, the machine takes 35 sec. to process a part. The other robot operation times are as follows :

Robot picks a shaft from the conveyor	4.0 sec
Robot moves the shaft to the lathe	1.5 sec
Robot loads the shaft onto the lathe	1.0 sec
Robot unloads the shaft from the lathe	0.5 sec
Robot moves the conveyor	1.5 sec
Robot puts the shaft on the outgoing conveyor	0.5 sec
Robot moves from the output conveyor to the input conveyor	5.0 sec

Description of Solution Approach

The total cycle time of 49 seconds is obtained by adding all the activities of the robot including the machining time and other related activities. The production rate is the reciprocal of cycle time. The production rate considering system availability is therefore

Production rate $= \frac{1 \text{ unit}}{49 \text{ sec.}} (60\text{s}/\text{min})\,(60\text{min}/\text{h}) \left(\frac{8h}{\text{shift}}\right) (0.85\% \text{ uptime})$

= 500 units per shift

Machine Utilization = $\frac{\text{Machine cycle time}}{\text{Total cycle time}}$ = 35/49 = 0.7142 or 71.42%

Robot utilization = $\frac{\text{Robot cycle time}}{\text{Total cycle time}}$ = 14/49 = 0.2857 or 28.57

3.2.5 Double-Gripper Robot in a Single-Machine Cell

A double-gripper robot has two gripping devices attached to the wrist. They can be put into action independently. The double gripper can be used to handle a finished and unfinished items simultaneously. This helps in increase in the productivity. A numerical example has been given to clarify this point.

Example 3.4

In this case study, we elucidate the improvement in productivity with the use of double-handed grippers using the data in the previous example.

Solution

The operation sequence with double-handed gripper is

Machine cycle time = 35 sec.

Robot unloads the shaft from the lathe = 0.5 sec

Robot loads the part onto the machine = 1.0 sec
The total cycle time is 36.5 sec.

The production rate considering system availability is therefore

$$\text{Production rate} = \left(\frac{1}{36.5}\right)\left(\frac{60\text{s}}{\text{min}}\right)\left(\frac{60\text{s}}{\text{min}}\right)\left(\frac{8\text{h}}{\text{shift}}\right)(0.85 \text{ uptime})$$

= 671 units per shift.

The productivity increase obtained by using a double-handed gripper is
(617 – 500) / 500 = 0.234 or 23.4%.

SAQ 2

(a) Describe the physical components of a typical industrial robot.

(b) Discuss the following robot configurations

(i) Cartesian robot configuration

(ii) Cylindrical robot configuration

(iii) Polar robot configuration

(iv) Jointed-arm configuration

3.4 SUMMARY

In this unit, we have dealt with the automated guided vehicles and Robots used in the industry. Due to the industrial automation, many changes have taken place in the field of microprocessor, programmable controllers, industrial logic controls, computer numeric control (CNC) etc. Automated Guided Vehicle systems are material-handling systems that are flexible, reliable, inexpensive to operate, and easy to interface with systems such as FMSs, AS/RS, and other material handling systems. Robots have also played a vital role in the automation of the industry. Industrial robots now perform a wide variety of tasks and are used in all kinds of applications. For effective management of robot and AGV, it is important to understand the basics of robotics and AGVS. In this unit, we have attempted to cover such basic aspects related to Robots and AGVS.

3.5 KEY WORDS

AGVS Guide Path : Automated Guided Vehicle Systems. It guides the vehicle to move along the path.