DAV UNIVERSITY

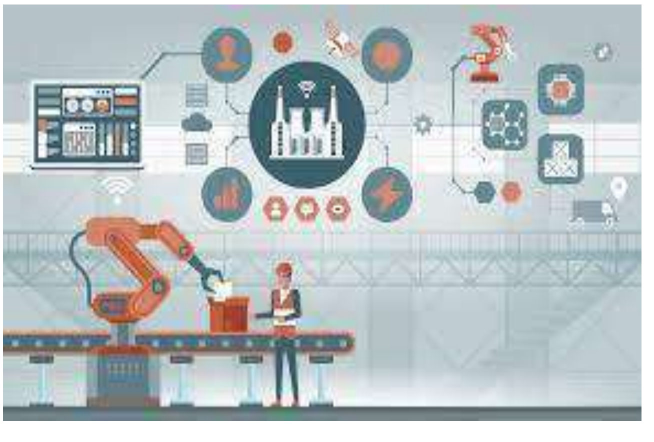
(Empowering Students with 21st Century Skills)

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

FOR

MANUFACTURING AUTOMATION LAB (MED-352)



Vision of the Department

The Mechanical Engineering Department aims to be recognized as an outstanding educational centre to develop innovative engineers who are proficient in advanced fields of engineering and technology and can contribute effectively to the industry as well as for socio-economic upliftment of the society.

Mission of the Department

M1: To impart outcome-based education with a research orientation to the students to develop them as globally competitive engineers.

M2: To imbibe the students with academic, leadership and entrepreneurship skills needed by the industry in particular and society in general.

M3: To adopt flexibility and dynamism in designing the programme structures to cope up with emerging market needs.

M4: Establishment of liaison with top R & D organizations/Industries and leading educational institutions for practical exposure of the students and faculty as well as to the state of the art.

Programme Educational Outcomes (PEOs)

After the successful completion of undergraduate course, Mechanical Engineering, Graduates will be able to:

PEO1: Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable.

PEO2: Apply analytical, computational and experimental techniques to address the challenges faced in mechanical and allied engineering streams.

PEO3: Communicate effectively using conventional platforms as well as innovative / online tools and demonstrate collaboration, networking & entrepreneurial skills.

PEO4: Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career, organizational and societal goals.

Program Outcomes (POs) - B. Tech. Mechanical Engineering

PO1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO) - B. Tech. Mechanical Engineering

PSO1: **Academic Competence:** Apply mechanical and interdisciplinary knowledge to analyze, design and manufacture products to address the needs of the society.

PSO2: Professional Competence: Apply state of the art tools and techniques to conceptualize, design and introduce new products, processes, systems and services.

DAV UNIVERSITY

(Empowering Students with 21st Century Skills)

Department of Mechanical Engineering

L	T	P	Credits
3	0	2	4

Course Code	MED 352								
Course Title	**Manufacturing Automation Lab**								
Course Outcomes	On the completion of the course the student will be able to: **CO1:** To understand the fundamental principles of automation. **CO2:** To gain knowledge of design of automated assembly systems. **CO3:** To understand the concept of group technology. **CO4:** To understand the application of automation in flexible manufacturing systems								
Examination Mode	Practical								
Assessment Tools	Continuous Assessment (CA)				MSE	MSP	ESE	ESP	Total
	Quiz	Assignment/ Project Work	Attendance	Lab Performance					
Weightage	-	-	-	20%	-	30%	-	50%	100

S. No.	LIST OF EXPERIEMENTS	CO Mapping
1.	To study the fundamentals of automation and its types.	CO1
2.	Study and report on Pneumatic and Hydraulic Automation system.	CO1
3.	Study and report on micro controller and its application.	CO2
4.	Study and report on flexible manufacturing system.	CO2
5.	Study and report on Industrial Robotics: Sensors and Actuators	CO3
6.	Study and report on Different Automated Machinery	CO3
7.	Study and report on Modular Automation System: Casting shop, Machine shop, Press Shop	CO4
8.	Study and report on Economic analysis of Automation.	CO4
9.	Assignment 1	CO1
10.	Assignment 2	CO4

Mapping of COs with PO(s)

CO's / PO's	CO-1	CO-2	CO-3	CO-4
PO-1	3	3	3	3
PO-2	3	3	3	3
PO-3	2	2	2	2
PO-4	1	1	1	1
PO-5	1	1	1	1
PO-6	3	3	3	3
PO-7	3	3	3	3
PO-8	2	2	2	2
PO-9	1	1	1	1
PO-10	1	1	1	1
PO-11	1	1	1	1
PO-12	2	2	2	2

1- Slight (Low) 2- Moderate (Medium) 3- Substantiate (High)

Mapping of COs with PSO(s)

COs / PSOs	CO-1	CO-2	CO-3	CO-4
PSO-1	3	3	2	3
PSO-2	3	3	2	3

1- Slight (Low) 2- Moderate (Medium) 3- Substantiate (High)

EXPERIMENT NO: 1

Experiment 1: To study the fundamentals of automation and its types.

Introduction: Automation is the technology by which a process or procedure is accomplished without human assistance. Automation is implemented using a program of instructions combined with a control system that executes the instructions. Power is required to drive the process and to operate the program and control system. Although automation can be applied in a wide variety of areas, it is most closed associated with the manufacturing industries.

There is not always a clear distinction between worker-machine systems and automated systems, because many worker-machine systems operate with some degree of automation. Two levels of automation can be identified: semi-automated and fully automated.

A semi-automated machine performs a portion of the work cycle under some form of program control, and a human worker tends to the machine for the remainder of the cycle, by loading and unloading it, or by performing some other task each cycle.

A fully automated machine is distinguished from its semi-automated counterpart by its capacity to operate for an extended period of time with no human attention. Extended period of time means longer than one work cycle; a worker is not required to be present during each cycle. Instead, the worker may need to tend the machine every tenth cycle, or every hundredth cycle. An example of this type of operation is found in many injection moulding plants, where the moulding machines run on automatic cycles, but periodically the moulded parts at the machine must be collected by a worker.

In certain fully automated processes, one or more workers are required to be present to continuously monitor the operation, and make sure that it performs according to the intended specifications. Examples of these kinds of automated processes include complex chemical processes, oil refineries, and nuclear power plants. The workers do not actively participate in the process except to make occasional adjustments in the equipment settings, perform periodic maintenance, and spring into action if something goes wrong.

Understand, Simplify and Automate the process:

Following the USA Principle is a good first step in any automation project.

The USA Principle is a common sense approach to automation projects. Similar procedures have been suggested in the manufacturing and automation trade literature, but none has a more captivating title than this one.

USA stands for:

1. Understand the existing process
2. Simplify the process
3. Automate the process.

It may turn out that automation of the process is unnecessary or cannot be cost justified after it has been simplified. If automation seems a feasible solution to improving productivity, quality, or other measure of performance, then the following ten strategies provide a road map to search for these improvements. These ten strategies seem as relevant and appropriate today as they did in 1980. We refer to them as strategies for automation and production systems because some of them are applicable whether the process is a candidate for automation or just for simplification.

1) Specialization of operations

The first strategy involves the use of special-purpose equipment designed to perform one operation with the greatest possible efficiency. This is analogous to the concept of labour specialization, which is employed to improve labour productivity.

2) Combined operations

Production occurs as a sequence of operations. Complex parts may require dozens, or even hundreds, of processing steps. The strategy of combined operations involves reducing the number of distinct production machines or workstations through which the part must be routed.

This is accomplished by performing more than one operation at a given machine, thereby reducing the number of separate machines needed.

Since each machine typically involves a setup, setup time can usually be saved as a consequence of this strategy. Material handling effort and non-operation time are also reduced.

Manufacturing lead time is reduced for better customer service.

3) Simultaneous operations

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

4) Integration of operations

Another strategy is to link several workstations together into a single integrated mechanism, using automated work handling devices to transfer parts between stations. In effect, this reduces the number of separate machines through which the product must be scheduled.
With more than one workstation, several parts can be processed simultaneously, thereby increasing the overall output of the system.

5) Increased flexibility

This strategy attempts to achieve maximum utilization of equipment for job shop and medium volume situations by using the same equipment for a variety of parts or 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 less work-in-process.

6) Improved material handling and storage

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

7) On-line inspection

Inspection for quality of work is traditionally performed after the process is completed. 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 the product is being made.
This reduces scrap and brings the overall quality of product closer to the nominal specifications intended by the designer.

8) Process control and optimization

This includes a wide range of control schemes intended to operate the individual processes and associated equipment more efficiently. By this strategy, the individual process times can be reduced and product quality improved.

9) Plant operations control

Whereas the previous strategy was concerned with the control of the individual manufacturing process, this strategy is concerned with control at the plant level. It attempts to manage and coordinate the aggregate operations in the plant more efficiently.
Its implementation usually involves a high level of computer networking within the factory.

10) Computer-integrated manufacturing (CIM)

Taking the previous strategy one level higher, we have the integration of factory operations with engineering design and the business functions of the firm.

- It is a hardware which converts a controller command signal into a change in a physical parameter
- It requires amplifier to strengthen the controller command

Types

- Electrical
- Hydraulic
- Pneumatic

Reasons for Automating

Companies undertake projects in automation and computer-integrated manufacturing for good reasons, some of which are the following:

1) Increase labour productivity

Automating a manufacturing operation invariably increases production rate and labour productivity. This means greater output per hour of labour input.

2) Reduce labour cost

Increasing labour cost has been, and continues to be, the trend in the world's industrialized societies. Consequently, higher investment in automation has become economically justifiable to replace manual operations.
Machines are increasingly being substituted for human labour to reduce unit product cost.

3) Mitigate the effects of labour shortages

There is a general shortage of labour in many advanced nations, and this has stimulated the development of automated operations as a substitute for labour.

4) Reduce or eliminate routine manual and clerical tasks

An argument can be put forth that there is social value in automating operations that are routine, boring, fatiguing, and possibly irksome. Automating such tasks improves the general level of working conditions.

5) Improve worker safety

Automating a given operation and transferring the worker from active participation in the process to a monitoring role, or removing the worker from the operation altogether, makes the work safer. The safety and physical well-being of the worker has become a national objective with the enactment of the Occupational Safety and Health Act (OSHA) in 1970. This has provided an impetus for automation.

6) **Improve product quality**

Automation not only results in higher production rates than manual operation, it also performs the manufacturing process with greater consistency and conformity to quality specifications.

7) **Reduce manufacturing lead time**

Automation helps reduce the elapsed time between customer order and product delivery, providing a competitive advantage to the manufacturer for future orders. By reducing manufacturing lead time, the manufacturer also reduces work-in-process inventory.

8) **Accomplish processes that cannot be done manually**

Certain operations cannot be accomplished without the aid of a machine. These processes require precision, miniaturization, or complexity of geometry that cannot be achieved manually. Examples include certain integrated circuit fabrication operations, rapid prototyping processes based on computer graphics (CAD) models, and the machining of complex, mathematically defined surfaces using computer numerical control. These processes can only be realized by computer-controlled systems.

9) **Avoid the high cost of not automating**

There is a significant competitive advantage gained in automating a manufacturing plant. The advantage cannot always be demonstrated on a company's project authorization form. The benefits of automation often show up in unexpected and intangible ways, such as in improved quality, higher sales, better labour relations, and better company image. Companies that do not automate are likely to find themselves at a competitive disadvantage with their customers, their employees, and the general public.

TYPES OF AUTOMATION:

Automated production systems can be classified into three basic types:

1. Fixed automation,
2. Programmable automation, and
3. Flexible automation.

FIXEDAUTOMATION It is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. The 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. The typical features of fixed automation are:

a. High initial investment for custom–Engineered equipment;
b. High production rates; and
c. Relatively inflexible in accommodating product changes.

The 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, thus making the unit cost attractive compared to alternative methods of production. Examples of fixed automation include mechanized assembly and machining transfer lines.

PROGRAMMABLEAUTOMATION In this the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program, which is a 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. Some of the features that characterize programmable automation are:

a. High investment in general-purpose equipment;
b. Low production rates relative to fixed automation;
c. Flexibility to deal with changes in product configuration; and
d. Most suitable for batch production.

Automated production systems that are programmable are used in low and medium volume production. The parts or products are typically made in batches. To produce each new batch of a different product, the system must be reprogrammed with the set of machine instructions that correspond to the new product. The 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. This changeover procedure takes time. Consequently, the typical cycle for given product includes a period during which the setup and reprogramming takes place, followed by a period in which the batch is produced. Examples of programmed automation include numerically controlled machine tools and industrial robots

FLEXIBLEAUTOMATION It is an extension of programmable automation. A flexible automated system is one that is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next. There is no production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, and machine setting). Consequently, the system can produce various combinations and schedules of products instead of requiring that they be made in separate batches. The features of flexible automation can be summarized as follows:

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

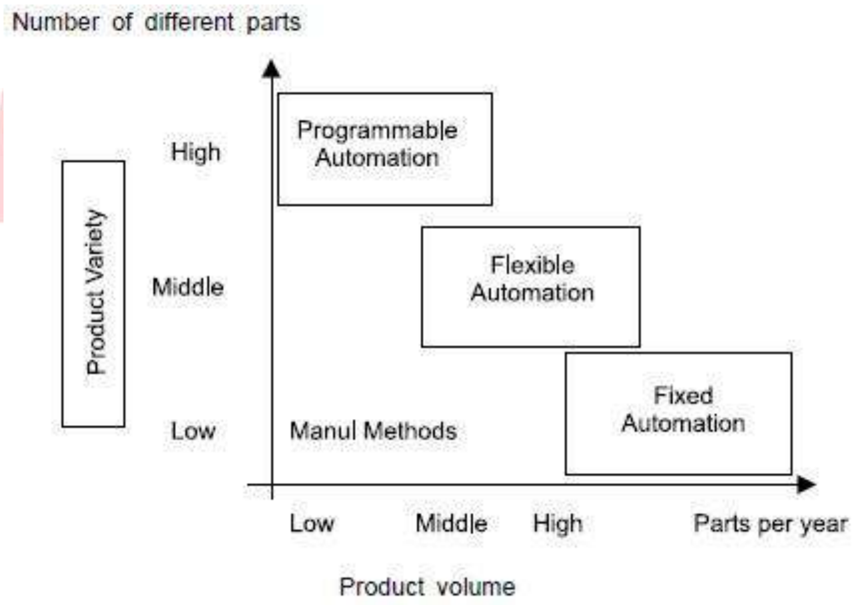
The essential features that distinguish flexible automation from programmable automation are:

1. The capacity to change part programs with no lost production time; and
2. The capability to changeover the physical setup, again with no lost production time.

These features allow the automated production system to continue production without the downtime between batches that is characteristic of programmable automation. Changing the part programs is generally accomplished by preparing the programs off-line on a computer system and electronically transmitting the programs to the automated production system. Therefore, the time required to do the programming for the next job does not interrupt production on the current job. Advances in computer systems technology are largely responsible for this programming capability in flexible automation. Changing the physical setup between parts is accomplished by making the changeover off-line and then moving it into place simultaneously as the next part comes into position for processing.

The use of pallet fixtures that hold the parts and transfer into position at the workplace is one way of implementing this approach. For these approaches to be successful; the variety of parts that can be made on a flexible automated production system is usually more limited than a system controlled by programmable automation.

The relative positions of the three types of automation for different production volumes and product varieties are depicted in the following figure.



EXPERIMENT NO: 2

Experiment 2: To Study and report on Pneumatic and Hydraulic Automation system.

INTRODUCTION:

PNEUMATICS:

1) Sequencing circuit

Let A be the first cylinder (Pushing) and B be second cylinder (feeding) as shown in the Figure 2.1. First cylinder A extends and brings under stamping station where cylinder B is located. Cylinder B then extends and stamps the job. Cylinder A can return back only cylinder B has retracted fully.

Represent the control task using notational form

Cylinder A advancing step is designated as A+

Cylinder A retracting step is designated as A- Cylinder B advancing step is designated as B+

Cylinder B retracting step is designated as B-

Therefore, given sequence for clamping and stamping is A+B+A-B-

Input Signals

Cylinder A – Limit switch at home position ao

Limit switch at home position a1

Cylinder B - Limit switch at home position bo

Limit switch at home position b1

Output Signal

Forward motion of cylinder A (A+)

Return motion of cylinder A (A-)

Forward motion of cylinder B(B+)

Return motion of cylinder B(B+)

Usually start signal is also required along with b0 signal for obtaining A+ motion.

1. A+ action generates sensor signal a1, which is used for B+ motion
2. B+ action generates sensor signal b1, which is used for A- motion
3. A- action generates sensor signal a0, which is used for B- motion
4. B- action generates sensor signal b0, which is used for B- motion

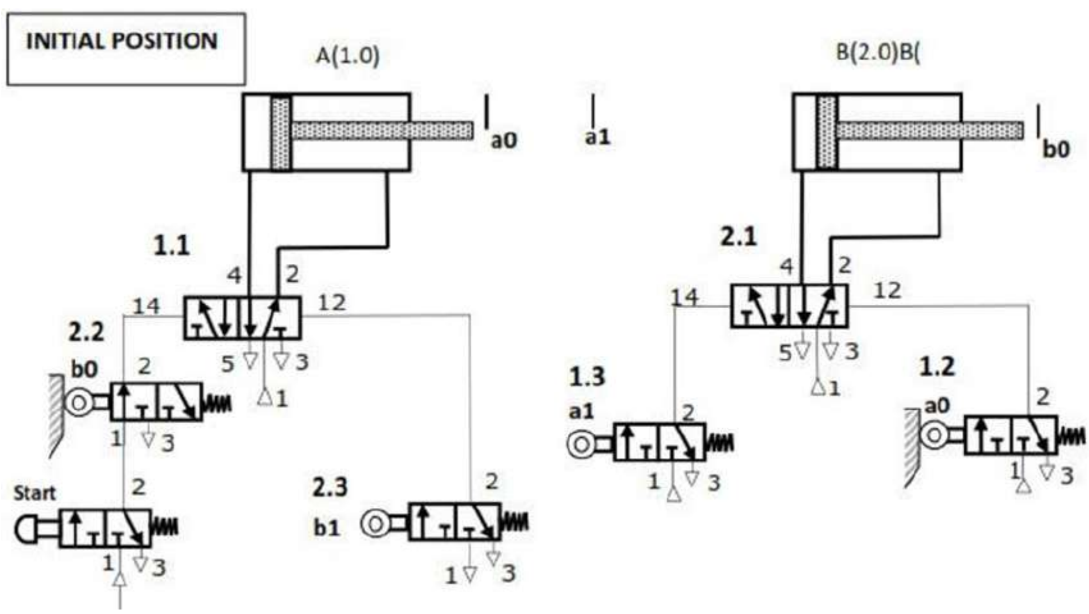


Fig. 2.1 Sequential operation of two double acting cylinders

Analysis of pneumatic circuit

1. When the start button is pressed, the signal appears at port 14 of valve 1.1 through limit switch signal b0.
2. Check for the presence of the signal at the other end (12) of valve 1.1. Notice that the signal is not present at port 12 of valve 1.1. (Because b1 is not pressed). There is no signal conflict and valve 1.1 is able to move. So A advances to forward position.

3. When cylinder A fully extends, it generates a limit switch signal a1, which is applied to port 14 of the valve 2.1. Cylinder B advances to forward position.
4. Check for the presence of the signal at the other end (12) of valve 2.1. Signal is not present at port 12 of valve 2.1 (because a0 is not pressed, A is already in extended position now) and hence there is no signal conflict
5. Signal applied to port 14 of the valve 2.1 causes the shifting of DCV 2.1 and cylinder B extends.
6. When cylinder B fully extends, it generates a limit switch signal b1, which is applied to port 12 of valve 1.1. Cylinder A returns and ao is pressed. There is no signal conflict, as ao and a1 are mutually exclusive signals.
7. When the cylinder A is fully retracted, it generates a limit switch signal a0, which is applied to port 12 of the valve 2.1. Cylinder B retracts.

HYDRAULICS:

1) HYDRAULIC CYLINDER SEQUENCING CIRCUITS

Hydraulic cylinders can be operated sequentially using a sequence valve. Figure 2.2 shows that two sequence valves are used to sequence the operation of two double-acting cylinders.

− When the DCV is actuated to its right-envelope mode, the bending cylinder (B) retracts fully and then the clamp cylinder (A) retracts.

− This sequence of cylinder operation is controlled by sequence valves. This hydraulic circuit can be used in a production operation such as drilling.

− Cylinder A is used as a clamp cylinder and cylinder B as a drill cylinder.

− Cylinder A extends and clamps a work piece. Then cylinder B extends to drive a spindle to drill a hole. Cylinder B retracts the drill spindle and then cylinder A retracts to release the work piece for removal.

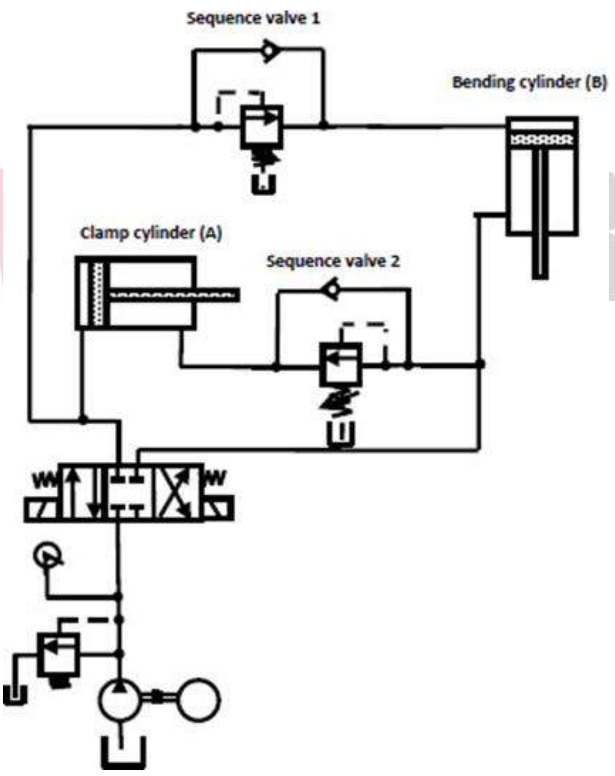


Figure 2.2 sequential circuit

2) AUTOMATIC CYLINDER RECIPROCATING SYSTEM

The hydraulic circuit shown in Fig. 2.3 produces continuous reciprocation of a double-acting cylinder using two sequence valves. Each sequence valve senses the completion of stroke by the corresponding build-up pressure. Each check valve and the corresponding pilot line prevent the shifting of the four-way valve until the particular stroke of the cylinder is completed.

− The check valves are needed to allow pilot oil to leave either end of the DCV while the pilot pressure is applied to the opposite end. This permits the spool of the DCV to shift as required.

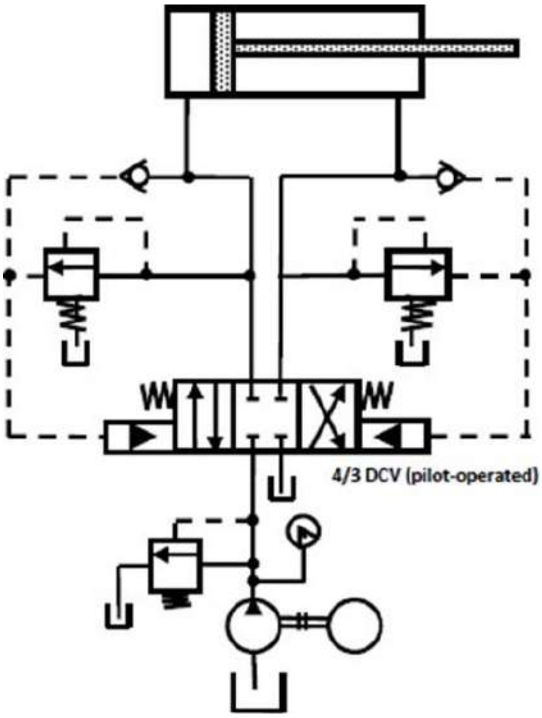


Figure 2.3 Automatic reciprocating system

EXPERIMENT NO: 3

Experiment 3: Study and report on micro controller and its application.

Introduction:

A microcontroller is a small, low-cost, and self-contained computer-on-a-chip that can be used as an embedded system. In Modern terminology, it's called Microcontroller because they have an execution time in the order of microseconds. While, the speed of Microcontroller Programming have increased over the years, but the name stuck. As much as, for the controller part, a microcontroller consists of a microprocessor unit, RAM, ROM, and some extra peripherals.

1. Attribute of Microcontroller

Any electric appliance used to store, measure & display the information otherwise measures comprise of a chip in it. The microcontroller's basic structure includes different components.

1) CPU

The microcontroller is called a CPU device, used to carry & decode the data & finally completes the allocated task effectively. By using a central processing unit, all the microcontroller components are connected to a particular system. Instruction fetched through the programmable memory can be decoded through the CPU.

2) Memory

In a microcontroller, the memory chip works like a microprocessor because it stores all the data as well as programs. Microcontrollers are designed with some amount of RAM/ROM/flash memory to store the program source code.

3) I/O Ports

Basically, these ports are used to interface otherwise drive different appliances like LEDs, LCDs, printers, etc.

4) Serial Ports

Serial ports are used to provide serial interfaces between microcontroller as well as a variety of other peripherals like parallel port.

5) Timers

A microcontroller includes timers otherwise counters. These are used to manage all the operations of timing and counting in a microcontroller. The main function of the counter is to count outside pulses whereas the operations which are performed through timers are clock functions, pulse generations, modulations, measuring frequency, making oscillations, etc.

6) ADC (Analog to Digital Converter)

ADC is the acronym of analog to digital converter. The main function of ADC is to change the signals from analog to digital. For ADC, the required input signals are analog and the production of a digital signal is used in different digital applications like measurement devices.

7) DAC (Digital to Analog Converter)

The acronym of DAC is digital to analog converter, used to perform reverse functions to ADC. Generally, this device is used to manage analog devices such as DC motors, etc.

8) Interpret Control

This controller is employed for giving delayed control for a working program. The interpret can be internal or external.

9) Special Functioning Block

Some special microcontrollers designed for special devices like robots, space systems include a special function block. This block has extra ports to carry out some particular operations.

2. How it works?

The Microcontroller is a high-speed device, but it's slower than a computer, so every instruction executed in microcontroller at a breakneck speed. When the power supply is turned ON, the quartz oscillator was enabled by the control logic register. In the first few milliseconds, while the early preparation is in progress, the parasite capacitors are being charged.

When the Voltage level reaches its max value and frequency of quartz oscillator becomes stable the process of writing bits on special function registers start. Everything occurs according to the clock of the oscillator, and overall electronics start working. All this takes very few nanoseconds.

3. Functions of Microcontroller

The microcontroller can be considered as self-contained systems with a processor memory, and peripherals can be used as an 8051 Microcontroller. Since, the majority of microcontrollers in use today are embedded in other types of machinery, such as automobiles, telephones appliances and peripherals for computer systems.

4. Microcontroller Applications

However, they have a lot of use on Microcontrollers. Such as,

- Industrial automation
- Communication applications
- Motor control applications
- Test and measurement
- Medical applications
- Automobiles
- Appliances
- Computer Systems
- Security Alarms
- Electronic Measurements Instruments

5. Types of Microcontroller

PIC Microcontroller

PIC Stands for Peripheral Interface Controller is a kind of microcontroller components was used in the development of electronics, computer robotics, and similar devices. Even though the PIC was produced by Microchip technology and based on hardware computing architecture, here the code and data are placed in separate registers to increase the input and output. PIC has a built-in data memory, data bus and dedicated microprocessor for preparing all I/O purposes and methods.

ARM Microcontroller

ARM stands for Advanced RISC Machine. It's the most popular Microcontrollers Programming in the digital embedded system world, and most of the industries prefer only ARM microcontrollers since it consists of significant features to implement products with an excellent appearance. It is cost sensitive and high-performance device which has been used in a wide range of application such as Industrial Instrument control systems, wireless networking and sensors, and automotive body systems, etc.

8051 Microcontroller

Intel created 8051 microcontrollers in 1981. It is an 8bit microcontroller. It's made with 40 pins DIP (Dual inline package), 4kb if ROM storage and 128 bytes of RAM storage, 2 16-bit timer. It consists of are four parallel 8 bit ports, which are programmable as well as addressable as per the specification.

AVR Microcontroller

AVR stands for Alf and Vegard's RISC Processor. It was the modified Harvard architecture machine, where program and data were stored in the separate physical memory system that appears in different address spaces, but having the ability to browse information things from program memory victimization particular directions. AVR isn't associate degree signifier and doesn't symbolize something specially.

MSP Microcontroller

MSP stands for Mixed Signal Processor. It's the family from Texas Instruments. Built around a 16 -bit CPU, the MSP is designed for low cost and respectively, low power dissipation embedded statements. It's the controller's appearance is directly related to the 16-bit data bus, and seven addressing modes and the decreased instructions set, which allows a shorter, denser programming code for fast performance.

The Range of Microcontroller is an IC chip that executes programs for controlling other device or machines. It is a micro-device which is used for control of other device machines that's why it's called Microcontrollers Programming.

6. Advantages of Microcontrollers Types

The advantages of microcontrollers include the following.

- Dependable
- Reusable
- Energy-efficient
- Cost-effective
- It requires less time to operate
- These are flexible & very small
- Because of their high integration, its size & cost of the system can be decreased.
- Interfacing of the microcontroller is easy with additional ROM, RAM & I/O ports.
- Many tasks can be performed, so the human effect can be reduced.
- It is simple to use, troubleshooting & maintaining the system is simple.
- It works like a microcomputer without any digital parts

7. Disadvantages of Microcontrollers

The disadvantages of the microcontrollers types include the following.

- Programming Complexity
- Electrostatic Sensitivity

- Interfacing with high-power devices cannot possible.
- Its structure is more complex as compared with microprocessors.
- Generally, it is used in microdevices
- It simply performs incomplete no. of executions simultaneously.
- It is generally used in micro equipment
- It has a more complex structure as compared to a microprocessor
- The microcontroller cannot interface a higher power device directly
- It only performed a limited number of executions simultaneously

EXPERIMENT NO: 4

Experiment 4: Study and report on flexible manufacturing system.

4.1 What is a Flexible Manufacturing System?

A flexible manufacturing system (FMS) is a highly automated GT machine cell, consisting of one or more processing stations (usually CNC machine tools), interconnected by an automated material handling and storage system and controlled by a distributed computer system. The reason the FMS is called flexible is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns.

An FMS relies on the principles of group technology. No manufacturing system can be completely flexible. There are limits to the range of parts or products that can be made in an FMS. Accordingly, a flexible manufacturing system is designed to produce parts (or products) within a defined range of styles, sizes, and processes. In other words, an FMS is capable of producing a single part family or a limited range of part families.

A more appropriate term for FMS would be flexible automated manufacturing system. The use of the word "automated" would distinguish this type of production technology from other manufacturing systems that are flexible but not automated, such as a manned GT machine cell. The word "flexible" would distinguish it from other manufacturing systems that are highly automated but not flexible, such as a conventional transfer line.

4.2 Flexibility

The three capabilities that a manufacturing system must possess in order to be flexible were identified as (1) the ability to identify the different incoming part or product styles processed by the system, (2) quick changeover of operating instructions, and (3) quick changeover of physical setup. Flexibility is an attribute that applies to both manual and automated systems. In manual systems, the human workers are often the enablers of the system's flexibility.

To develop the concept of flexibility in an automated manufacturing system, consider a machine cell consisting of two CNC machine tools that are loaded and unloaded by an industrial robot from a parts storage system, perhaps in the arrangement depicted in Figure 4.1.

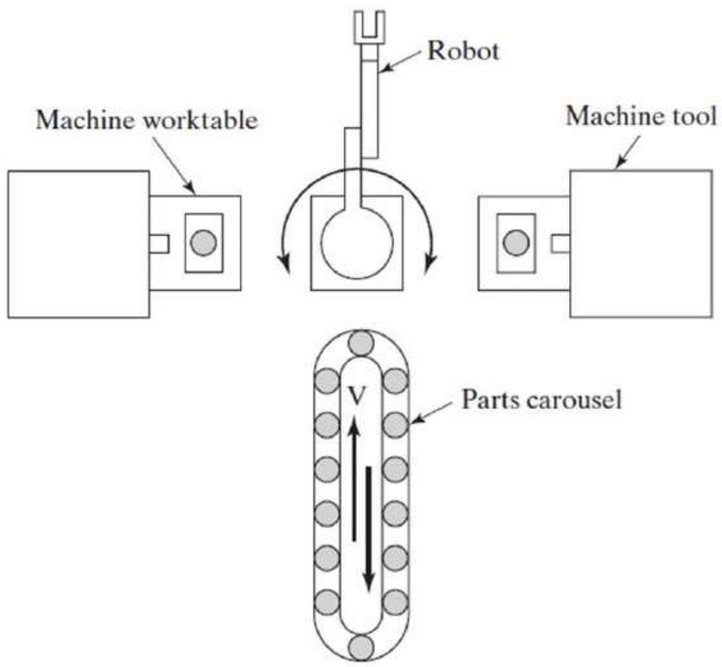


Figure 4.1 Automated manufacturing cell with two machine tools and robot.

The cell operates unattended for extended periods of time. Periodically, a worker must unload completed parts from the storage system and replace them with new work parts. By any definition, this is an automated manufacturing cell, but is it a flexible manufacturing cell? One might argue yes, it is flexible because the cell consists of CNC machine tools, and CNC machines are flexible because they can be programmed to machine different part configurations. However, if the cell only operates in a batch mode, in which the same part style is produced by both machines in lots of several hundred units, then this does not qualify as flexible manufacturing.

To qualify as being flexible, an automated manufacturing system should satisfy the following four tests of flexibility:

1. Part-variety test: Can the system process different part or product styles in a mixed model (non-batch) mode?
2. Schedule-change test: Can the system readily accept changes in production schedule, that is, changes in part mix and/or production quantities?
3. Error-recovery test: Can the system recover gracefully from equipment malfunctions and breakdowns, so that production is not completely disrupted?
4. New-part test: Can new part designs be introduced into the existing part mix with relative ease if their features qualify them as being members of the part family for which the system was designed? Also, can design changes be made in existing parts without undue challenge to the system?

If the answer to all of these questions is "yes" for a given manufacturing system, then the system is flexible. The most important tests are (1) and (2). Test (3) is applicable to multimachine systems but in single-machine systems when the one machine breaks down it is difficult to avoid a halt in production. Test (4) would seem to not apply to systems designed for a part family whose members are all known in advance. However, such a system may have to deal with design changes to members of that existing part family. Getting back to the robotic work cell, the four tests of flexibility are satisfied if the cell (1) can machine different part configurations in a mix rather than in batches; (2) permits changes in production schedule (changes in part mix); (3) is capable of continuing to operate even though one machine experiences a breakdown (e.g., while repairs are being made on the broken machine, its work is temporarily reassigned to the other machine), and (4) can accommodate new part designs if the NC part programs are written off-line and then downloaded to the system for execution. The fourth capability requires the new part to be within the part family intended for the FMS, so that the tooling used by the CNC machines as well as the end effect or of the robot are compatible with the new part design.

4.3 Types of FMS

Each FMS is designed for a specific application, that is, a specific family of parts and processes. Therefore, each FMS is custom-engineered and unique. Given these circumstances, one would expect to find a great variety of system designs to satisfy a wide variety of application requirements.

Flexible manufacturing systems can be distinguished according to the kinds of operations they perform: processing operations or assembly operations. An FMS is usually designed to perform one or the other but rarely both. A difference that is applicable to machining systems is whether the system will process rotational parts or non-rotational parts. Flexible machining systems with multiple stations that process rotational parts are less common than systems that process non-rotational parts. Two other ways to classify flexible manufacturing systems are by number of machines and level of flexibility.

Number of Machines: Flexible manufacturing systems have a certain number of processing machines. The following are typical categories: (1) single-machine cell, (2) flexible manufacturing cell, and (3) flexible manufacturing system.

A single-machine cell consists of one CNC machining centre combined with a parts storage system for unattended operation, as in Figure 4.2.

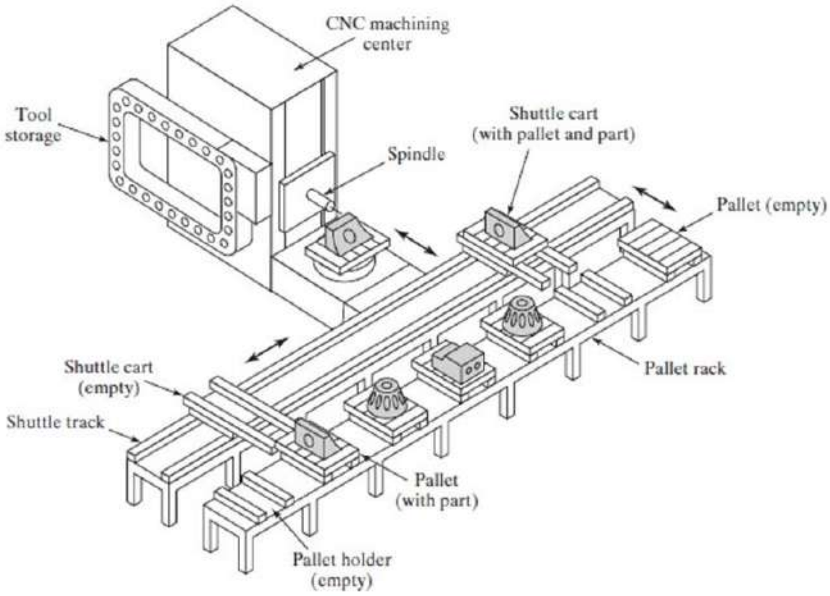


Figure 4.2 Single-machine cell consisting of one CNC machining centre and parts storage Unit

Completed parts are periodically unloaded from the parts-storage unit, and raw work parts are loaded into it. The cell can be designed to operate in a batch mode, a flexible mode, or a combination of the two. When operated in a batch mode, the machine processes parts of a single style in specified lot sizes and is then changed over to process a batch of the next part style. When operated in a flexible mode, the system satisfies three of the four flexibility tests. It is capable of (1) processing different part styles, (2) responding to changes in production schedule, and (4)accepting new part introductions. Test (3), error recovery, cannot be satisfied because if the single machine breaks down, production stops.

A flexible manufacturing cell (FMC) consists of two or three processing workstations (typically CNC machining centres or turning centres) plus a parts-handling system. The partshandling system is connected to a load/unload station. The handling system usually includes a limited parts-storage capacity. One possible FMC is illustrated in Figure 4.3. A flexible manufacturing cell satisfies the four flexibility tests discussed previously

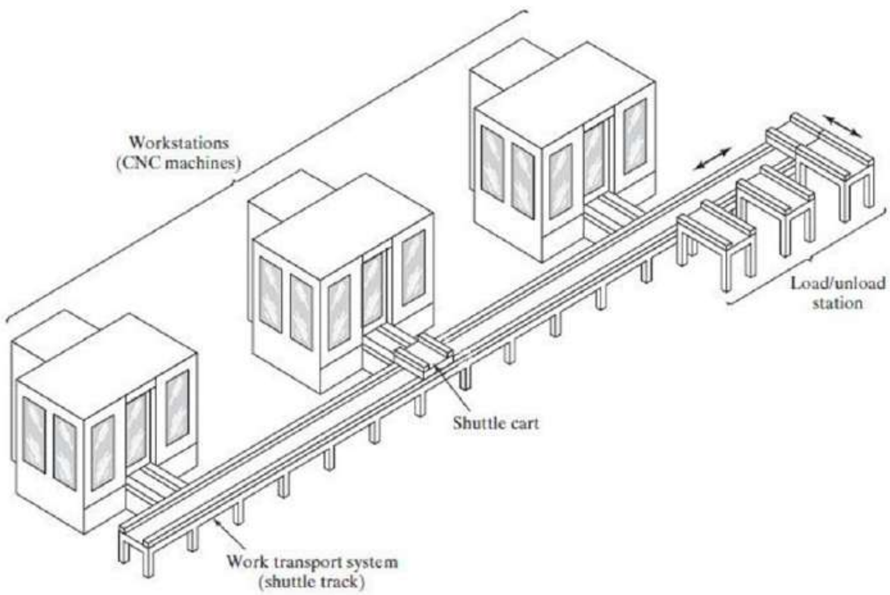


Figure 4.3 A flexible manufacturing cell consisting of three identical processing stations (CNC machining centres), a load/unload station, and a parts-handling system

A flexible manufacturing system (FMS) has four or more processing stations connected mechanically by a common parts-handling system and electronically by a distributed computer system. Thus, an important distinction between an FMS and an FMC is the number of machines: an FMC has two or three machines, while an FMS has four or more.3 There are usually other differences as well. One is that the FMS generally includes non-processing workstations that support production but do not directly participate in it. These other stations include part/pallet washing stations, inspection stations, and so on. Another difference is that the computer control system of an FMS is generally more sophisticated, often including functions not always found in a cell, such as diagnostics and tool monitoring. These additional functions are needed more in an FMS than in an FMC because the FMS is more complex.

Level of Flexibility: Another way to classify flexible manufacturing systems is according to the level of flexibility designed into the system. Two categories of flexibility are discussed here: (1) dedicated and (2) random-order.

A dedicated FMS is designed to produce a limited variety of part styles, and the complete population of parts is known in advance. The part family may be based on product commonality rather than geometric similarity. The product design is considered stable, so the system can be designed with a certain amount of process specialization to make the operations more efficient. Instead of being general purpose, the machines can be designed for the specific processes required to make the limited part family, thus increasing the production rate of the system. In some instances, the machine sequence may be identical or nearly identical for all parts processed, so a transfer line may be appropriate, in which the workstations possess the necessary flexibility to process the different parts in the mix. Indeed, the term flexible transfer line is sometimes used for this case.
A random-order FMS is more appropriate when the following circumstances apply: (1) the part family is large, (2) there are substantial variations in part configurations, (3) new part designs will be introduced into the system and engineering changes will be made to parts currently produced, and (4) the production schedule is subject to change from day-to-day. To accommodate these variations, the random-order FMS must be more flexible than the dedicated FMS. It is equipped with general-purpose machines to deal with the product variations and is capable of processing parts in various sequences (random order). A more sophisticated computer control system is required for this FMS type.

The trade-off between flexibility and productivity can be seen in these two system types. The dedicated FMS is less flexible but capable of higher production rates. The random-order FMS is more flexible but at the cost of lower production rates.

4.4 FMS Components

The three basic components of a flexible manufacturing system are (1) workstations, (2) material handling and storage system, and (3) computer control system.

4.5 FMS Benefits

A number of benefits can be expected in successful FMS applications. The principal benefits are the following:
- Increased machine utilization: Flexible manufacturing systems achieve a higher average utilization than machines in a conventional job or batch machine shop. Reasons for this include (1) 24 hr per day operation, (2) automatic tool changing of machine tools, (3) automatic pallet changing at workstations, (4) queues of parts at stations, and (5) dynamic scheduling of production that compensates for irregularities.
- Fewer machines required: Because of higher machine utilization, fewer machines are required compared to a batch production plant of equivalent capacity.
- Reduction in factory floor space: Compared to a batch production plant of equivalent capacity, an FMS generally requires less floor area.
- Greater responsiveness to change: A flexible manufacturing system improves response capability to part design changes, introduction of new parts, changes in production schedule and product mix, machine breakdowns, and cutting tool failures. Adjustments can be made in the production schedule from one day to the next to respond to rush orders and special customer requests.
- Reduced inventory requirements: Because different parts are processed together rather than separately in batches, work-in-process is less than in batch production. For the same reason, final parts inventories are also reduced compared to make-to stock production systems.
- Lower manufacturing lead times: Closely correlated with reduced work-in-process is the time spent in process by the parts. This means faster customer deliveries.
- Reduced direct labor requirements and higher labor productivity: Higher production rates and lower reliance on direct labor mean greater productivity per labor hour with an FMS than with conventional production methods.
- Opportunity for unattended production: The high level of automation in a flexible manufacturing system allows it to operate for extended periods of time without human attention. In the most optimistic scenario, parts and tools are loaded into the system at the end of the day shift, the FMS continues to operate throughout the night, and the finished parts are unloaded the next morning.

4.6 FMS Applications

Flexible automation is applicable to a variety of manufacturing operations. FMS technology is most widely applied in machining operations. Other applications include sheet metal press working and assembly. Historically, most of the applications of flexible machining systems have been in milling and drilling operations (non-rotational parts), using CNC machining centres. FMS applications for turning (rotational parts) were much less common until recently, and the systems that are installed tend to consist of fewer machines. For example, single-machine cells consisting of parts-storage units, parts-loading robots, and CNC turning centres are widely used today, although not always in a flexible mode. Additional manufacturing operations in which efforts have been made to develop flexible automated systems include sheet metal stamping and assembly.

EXPERIMENT NO: 5

Experiment 5: Study and report on Industrial Robotics: Sensors and Actuators.

INTRODUCTION:

Robot is an automatically controlled material handling unit that is widely used in the manufacturing industry. It is generally used for high volume production and better quality. Implementation of robot technology with integration of automatic system can contribute to increasing of productivity of the company and enhances the profitability of the company.

The word 'robot' first appeared in 1921 in the Czech playwright Karel Capek's play 'Rossum's Universal Robots'. The word is linked to Czech words

Robota (meaning work) and Robotnik (meaning-slave). Computer Aided Manufactures International of USA describes the meaning of robot as a device that performs functions ordinarily ascribed to human beings, or operates with what appears to human intelligence. Another definition from Robot Institute of America is a programmable multi- function manipulator designed to move and manipulate material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of specified tasks.

ISO defines a robot as: A robot is an automatically controlled, reprogrammable, multipurpose, manipulative machine with several reprogrammable axes, which is either fixed in a place or mobile for use in industrial automation application.

There are a number of successful examples of robot applications such as:

- Robots perform more than 98% of the spot welding on Ford's Taurus and Sable cars in U.S.A.
- A robot drills 660 holes in the vertical tail fins of a F-16 fighter in 3 hours at General Dynamics compared to 24 man-hours when the job was done manually.
- Robots insert disk drives into personal computers and snap keys onto electronic typewriter keyboards.

5.1 INDUSTRIAL ROBOTS

The industry continues to grow and expand. Currently, there are approximately thirty robot manufacturers in the United States and over five hundred worldwide. The annual growth rate of the industry is approximately 36 percent per year, and continued market expansion is expected. RIA estimates that annual sales volumes for 1998 will be in the $2 billion range; for the year 2000 it is predicted to be about $7 billion. Spot-welding still remains the largest application area for robots today.

Competitive forces are beginning to segment the market with many manufacturers focusing on specific industries or applications. This specialization approach will speed technological advancements and enhance robot capabilities in specific areas. More attention is being paid lately by manufacturers to sensor integration. More and more robots are sold with standard or optional capabilities, such as vision and tactile sensors and even fuzzy logic controls.

The development of the industrial robot represents a logical evolution of automated equipment, combining certain features of fixed automation and human labor. Robots can be thought of as specialized machine tools with a degree of flexibility that distinguishes them from fixed-purpose automation. By the addition of sensory devices, robots are gaining the ability to adapt to their work environment and modify their actions based on work-condition variations. Industrial robots are becoming "smarter" mechanical workers and are now widely accepted as valuable productivity-improvement tools.

Industrial robots are properly thought of as machines or mechanical arms. It is inappropriate to think of them as mechanical people. A robot is essentially a mechanical arm that is bolted to the floor, a machine, the ceiling, or, in some cases, the wall, fitted with its mechanical hand, and taught to do repetitive tasks in a controlled, ordered environment. In most cases, it possesses neither the ability to move about the plant nor the ability to see or feel the part it is working on. Exceptions to these general rules exist in certain instances. However, even with these limitations, robots make outstanding contributions toward the improvement of manufacturing operations. Robots fill the gap between the specialized and limited capabilities normally associated with fixed automation and the extreme flexibility of human labor.

5.2 ROBOT PHYSICAL CONFIGURATIONS

Commercially available industrial robots have one of the following four configurations:

1. Cartesian coordinate configuration
2. Polar coordinate configuration
3. Cylindrical coordinate configuration

4. Jointed arm configuration

Cartesian Coordinates

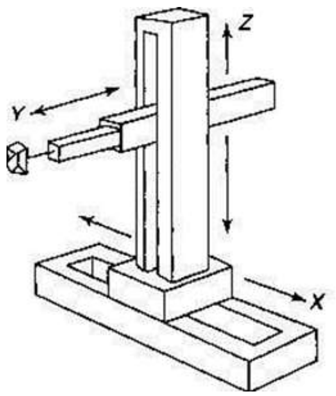


Figure 5.1 Typical Motions of a Cartesian or Rectilinear Robot

Positioning may be done by linear motion along three principal axes: left and right, in and out, and up and down. These axes known respectively, as the artesian axes X, Y and Z. Figure 5.1 shows a typical manipulator arm for a Cartesian coordinates robot. The work area or work envelope serviced by the Cartesian-coordinates robot's arm is a big box-shaped area. Programming motion for Cartesian- coordinates robot consist of specifying to the controller the X, Y and Z values of a desired point to be reached. The robot then moves along each axis to the desired point. This is one of the simplest types of robots.

Cylindrical Coordinates

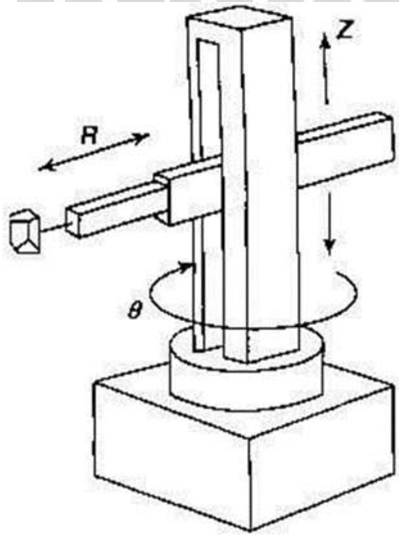


Figure 5.2 Typical Motions of a Cylindrical Robot

In this type of robot there is a rotary motion at the base followed by the two linear motions. The axes for the cylindrical coordinates are θ, the base rotational axis; R (reach) the in-and-out axis; and Z, the up-and down axis. The work area is the space between two concentric cylinders of the same height. The inner cylinder represents the reach of the arm with the arm fully retracted, and the outer cylinder represents the reach of the arm with the arm fully extended. Figure 5.2 shows the typical cylindrical robot.

Spherical or Polar Coordinate

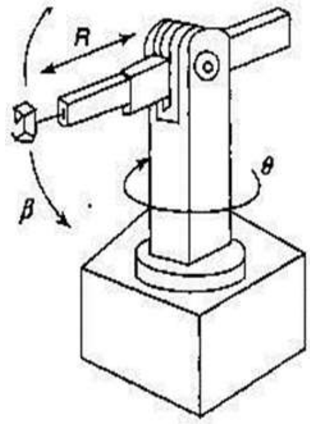


Figure 5.3 Typical Motions of a Spherical Robot

This type of robot uses mostly rotational axes. The axes for the spherical coordinates are θ, the rotational axis; R, the reach axis; and β, the bend-up-and-down axis. The work area serviced by a polar- coordinates robot is the space between two concentric hemispheres. The reach of the arm defines the inner hemisphere when it is fully retracted along the R axis. The reach of the arm defines outer hemisphere when it is fully straightened along the R axis. Figure 5.3 shows the typical robot.

Jointed arm configuration

The jointed arm configuration is similar in appearance to the human arm, as shown in Figure 5.4. The arm consists of several straight members connected by joints which are analogous to the human shoulder, elbow, and wrist. The robot arm is mounted to a base which can be rotated to provide the robot with the capacity to work within a quasi-spherical space.

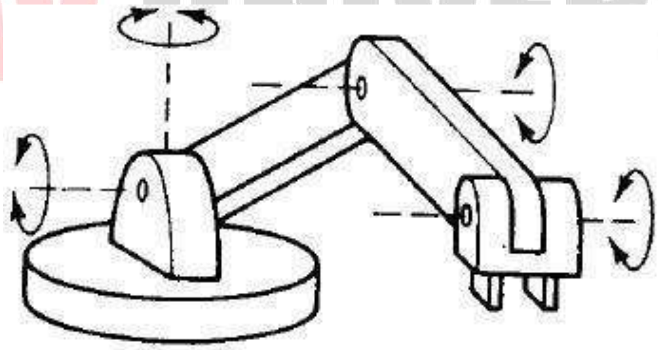


Figure 5.4 Typical Motions of a Cylindrical Robot

5.3 ROBOT COMPONENTS

A robot, as a system, consists of the following elements, which are integrated together to form a whole:

Manipulator, or rover This is the main body of the robot and consists of the links, the joints, and other structural elements of the robot. Without other elements, the manipulator alone is not a robot.

End effecter This is the part that is connected to the last joint (hand) of a manipulator, which generally handles objects, makes connection to other machines, or performs the required tasks. Robot manufacturers generally do not design or sell end effectors. In most cases, all they supply is a simple gripper. Generally, the hand of a robot has provisions for connecting specialty end effectors that are specifically designed for a purpose. This is the job of a company's engineers or outside consultants to design and install the end effecter on the robot and to make it work for the given situation. A welding torch, a paint spray gun, a glue-laying device, and a parts handler are but a few of the possibilities. In most cases, the action of the end effecter is either controlled by the robot's controller, or the controller communicates with the end effectors' controlling device (such as a PLC).

Actuators Actuators are the “muscles” of the manipulators. Common types of actuators are servomotors, stepper motors, pneumatic cylinders, and hydraulic cylinders. Actuators are controlled by the controller.

Sensors Sensors are used to collect information about the internal state of the robot or to communicate with the outside environment. As in humans, the robot controller needs to know where each link of the robot is in order to know the robot’s configuration. Even in absolute darkness, you still know where your arms and legs are! This is because feedback sensors in your central nervous system embedded in your muscle tendons send information to your brain. The brain uses this information to determine the length of your muscles, and thus, the state of your arms, legs, etc. The same is true for robots; sensors integrated into the robot send information about each joint or link to the controller, which determines the configuration of the robot. Robots are often equipped with external sensory devices such as a vision system, touch and tactile sensors, speech synthesizers, etc., which enable the robot to communicate with the outside world.

Controller The controller is rather similar to your cerebellum, and although it does not have the power of your brain, it still controls your motions. The controller receives its data from the computer, controls the motions of the actuators, and coordinates the motions with the sensory feedback information. Suppose that in order for the robot to pick up a part from a bin, it is necessary that its first joint be at 36°. If the joint is not already at this magnitude, the controller will send a signal to the actuator (a current to an electric motor, air to a pneumatic cylinder, or a signal to a hydraulic servo valve), causing it to move. It will then measure the change in the joint angle through the feedback sensor attached to the joint (a potentiometer, an encoder, etc.). When the joint reaches the desired value, the signal is stopped. In more sophisticated robots, the velocity and the force exerted by the robot are also controlled by the controller.

Processor The processor is brain of the robot. It calculates the motions of the robot’s joints, determines how much and how fast each joint must move to achieve the desired location and speeds, and oversees the coordinated actions of the controller and the sensors. The processor is generally a computer, which works like all other computers, but is dedicated to a single purpose. It requires an operating system, programs, peripheral equipment such as monitors, and has many of the same limitations and capabilities of a PC processor.

Software There are perhaps three groups of software that are used in a robot. One is the operating system, which operates the computer. The second is the robotic software, which calculates the necessary motions of each joint based on the kinematic equations of the robot. This information is sent to the controller. This software may be at many different levels, from machine language to sophisticated languages used by modern robots. The third group is the collection of routines and application programs that are developed in order to use the peripheral devices of the robots, such as vision routines, or to perform specific tasks.

It is important to note that in many systems, the controller and the processor are placed in the same unit. Although these two units are in the same box, and even if they are integrated into the same circuit, they have two separate functions.

5.4 ROBOT CHARACTERISTICS

The following definitions are used to characterize robot specifications:

Payload: Payload is the weight a robot can carry and still remain within its other specifications. For example, a robot’s maximum load capacity may be much larger than its specified payload, but at the maximum level, it may become less accurate, may not follow its intended path accurately, or may have excessive deflections. The payload of robots compared with their own weight is usually very small. For example, Fanuc Robotics LR Mate™ robot has a mechanical weight of 86 lbs and a payload of 6.6 lbs, and the M-16i™ robot has a mechanical weight of 694 lbs and a payload of 36 lbs.

Reach: Reach is the maximum distance a robot can reach within its work envelope. Many points within the work envelope of the robot may be reached with any desired orientation (called dexterous). However, for other points, close to the limit of robot’s reach capability, orientation cannot be specified as desired (called nondexterous point). Reach is a function of the robot’s joint lengths and its configuration.

Precision (validity): Precision is defined as how accurately a specified point can be reached. This is a function of the resolution of the actuators, as well as its feedback devices. Most industrial robots can have precision of 0.001 inch or better.

Repeatability (variability): Repeatability is how accurately the same position can be reached if the motion is repeated many times. Suppose that a robot is driven to the same point 100 times. Since many factors may affect the accuracy of the position, the robot may not reach the same point every time, but will be within a certain radius from the desired point. The radius of a circle that is formed by this repeated motion is called repeatability. Repeatability is much more important that precision. If a robot is not precise, it will generally show a consistent error, which can be predicted and thus corrected through programming. As an example, suppose that a robot is consistently off 0.06 inch to the right. In that case, all desired points can be specified at 0.06 inch to the left, and thus the error can be eliminated. However, if the error is random, it cannot be predicted and thus cannot be eliminated. Repeatability defines the extent of this random error. Repeatability is usually specified for a certain number of runs. More tests yield larger (bad for manufacturers) and more realistic (good for the users) results. Manufacturers must specify repeatability in conjunction with the number of tests, the applied payload during the tests, and the orientation of the arm. For example, the repeatability of an arm in a vertical direction will be different from when the arm is tested in a horizontal configuration. Most industrial robots have repeatability in the 0.001 inch range.

5.5 BASIC ROBOT MOTIONS

Whatever the configuration, the purpose of the robot is to perform a useful task. To accomplish the task, an end effecter, or hand, is attached to the end of the robot's arm. It is this end effecter which adapts the general-purpose robot to a particular task. To do the task, the robot arm must be capable of moving the end effecter through a sequence of motions and/or positions.

Six degrees of freedom

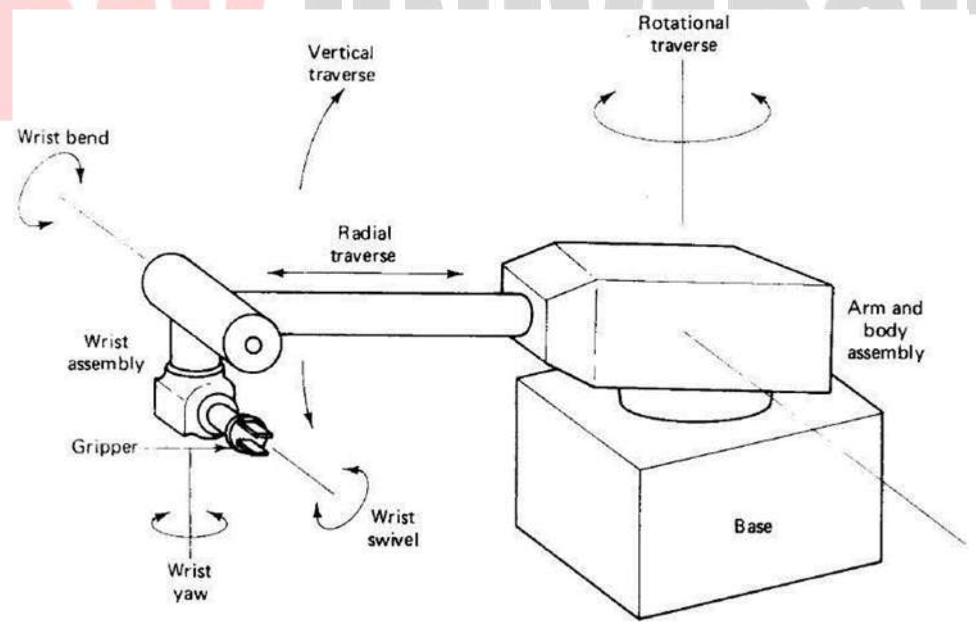


Figure 5.6 Typical six degrees of freedom in robot motion

There are six basic motions, or degrees of freedom, which provide the robot with the capability to move the end effecter through the required sequence of motions. There are six degrees of freedom are intended to emulate the versatility of movement possessed by the human arm. Not all robots are equipped with the ability to move in all six degrees. The six basic motions consist of three arm the body motions and three wrist motions, as illustrated in Figure 5.6 polar type robot. These motions are described below.

Arm and body motions:

1. Vertical transverse: up-and-down motions of the arm, caused by pivoting the entire arm about a horizontal axis or moving the arm along a vertical slide
2. Radial transverse: extension and retraction of the arm (in-and-out movement)

3. Rotational transverse: rotation about the vertical axis (right or left swivel of the robot arm)
4. Wrist swivel: rotation of the wrist
5. Wrist bend: up-or-down movement of the wrist, which also involves a rotational movement
6. Wrist yaw: right-or-left swivel of the wrist

Additional axes of motion are possible, for example, by putting the robot on a track or slide. The slide would be mounted in the floor or in an overhead track system, thus providing a conventional six- axis robot with a seventh degree of freedom. The gripper device is not normally considered to be an additional axis of motion.

Motion systems

Similar to NC machine tool systems, the motion systems of industrial robots can be classified as either point-to-point (PTP) or contouring (also called continuous path).

In PTP, the robot’s movement is controlled from one point location in space to another. Each point is programmed into the robot’s control memory and then played back during the work cycle. No particular attention is given to the path followed by the robot in its move from one point to the next. Point-to-point robots would be quite capable of performing certain kinds of productive operations, such as machine loading and unloading, pick-and-place activities, and spot welding.

Contouring robots have the capability to follow a closely spaced locus of point which describe a smooth compound curve. The memory and control requirements are greater for contouring robots than for PPT because the complete path taken by the robot must be remembered rather than merely the end points of the motion sequence. However, in certain industrial operations, continuous control of the work cycle path is essential to the use of robot in the operation. Examples of these operations are paint spraying, continuous welding processes, and grasping objects moving along a conveyor.

5.6 ACTUATORS

Actuators are the muscles of robots. If you imagine that the links and the joints are the skeleton of the robot, the actuators act as muscles, which move or rotate the links to change the configuration of robots. The actuator must have enough power to accelerate and decelerate the links and to carry the loads, yet be light, economical, accurate, responsive, reliable, and easy to maintain.

There are many types of actuators available, and, undoubtedly, there will be more varieties available in the future. The following types are noteworthy:

- Electric motors
    - Servomotors
    - Stepper motors
    - Direct-drive electric motors
- Hydraulic actuators
- Pneumatic actuators
- Shape memory metal actuators
- Magnetostrictive actuators

Electric motors — especially servomotors — are the most commonly used robotic actuators. Hydraulic systems were very popular for large robots in the past and are still around in many places, but are not used in new robots as often any more. Pneumatic cylinders are used in robots that have 1/2 degree of freedom, on- off type joints, as well as for insertion purposes. Direct drive electric motors, the shape memory metal type-actuators, and others like them are mostly in research and development stage and may become more useful in the near future.

END EFFECTORS

In the terminology of robotics, an end effecter can be defined as a device which is attached to the robot's wrist to perform a specific task. The task might be work part handling, spot welding, spray painting, or any of a great variety of other functions. The possibilities are limited only by the imagination and ingenuity of the applications engineers who design robot systems. (Economic considerations might also impose a few limitations.) The end effecter is the special-purpose tooling which enables the robot to perform a particular job. It is usually custom engineered for that job, either by the company that owns the robot or by the company that sold the robot. Most robot manufacturers have engineering groups which design and fabricate end effectors or provide advice to their customers on end effecter design.

For purposes of organization, we will divide the various types of end effectors into two categories: grippers and tools. The following two sections discuss these two categories.

GRIPPERS

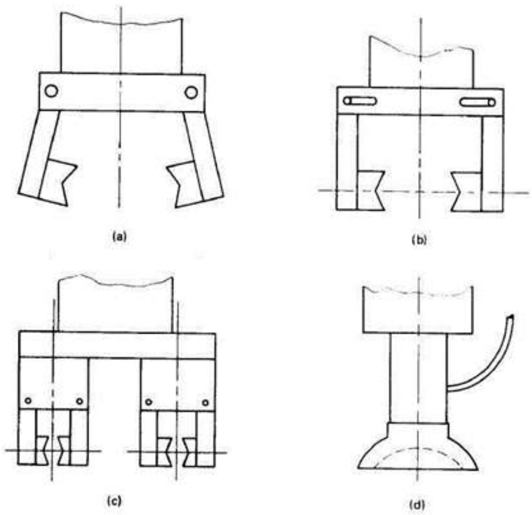


Figure5.7 Sample gripper designs: (a) pivot action grippe; (b) slide action gripper; (c) double gripper-pivot action mechanism; (d) vacuum-operated hand

Grippers are end effectors used to grasp and hold objects. The objects are generally work parts that are to be moved by the robot. These part-handling applications include machine loading and unloading, picking parts from a conveyor, and arranging parts onto a pallet. In addition to work parts, other objects handled by robot grippers include cartons, bottles, raw materials, and tools. We tend to think of grippers as mechanical grasping devices, but there are alternative ways of holding objects involving the use of magnets, suction cups, or other means.

Mechanical Grippers

A mechanical gripper is an end effecter that uses mechanical fingers actuated by a mechanism to grasp an object. The fingers, sometimes called jaws, are the appendages of the gripper that actually make contact with the object. The fingers are either attached to the mechanism or are an integral part of the mechanism. If the fingers are of the attachable type, then they can be detached and replaced. The use of replaceable fingers allows for wear and interchangeability.

Vacuum cups

Vacuum cups, also called suction cups, can be used as gripper devices for handling certain types of objects. The usual requirements on the objects to be handled are that they be flat, smooth, and clean, conditions necessary to form a satisfactory vacuum between the object and the suction cup. The suction cups of robot gripper are typically made of elastic material such as rubber or soft plastic. An exception would be when the object to be handled is composed of a soft material. In this case, the suction cup would be made of a hard substance.

Magnetic Grippers

Magnetic grippers can be a very feasible means of handling ferrous materials. The stainless steel plate would not be an appropriate application for a magnetic gripper because 18-8 stainless steel is not attracted by a magnet. Other steels, however, including certain types of stainless steel, would be suitable candidates for this means of handling, especially when the materials are handled in sheet or plate form.

In general, magnetic grippers offer the following advantages in robotic handling applications:

o Pickup times are very fast.
o Variations in part size can be tolerated. The gripper does not have to be designed for one particular work part.
o They have the ability to handle metal parts with holes (not possible with vacuum grippers).
o They require only one surface for gripping.

Disadvantages with magnetic grippers include the residual magnetism remaining in the work piece which may cause a problem in subsequent handling, and the possible side slippage and other errors which limit the precision of this means of handling.

Adhesive Gripper

Gripper designs in which an adhesive substance performs the grasping action can be used to handle fabrics and other lightweight materials. The requirements on the items to be handled are that they must be gripped on one side only and that other forms of grasping such as a vacuum or magnet are not appropriate. One of the potential limitations of an adhesive gripper is that the adhesive substance loses its tackiness on repeated Usage. Consequently, its reliability as a gripping device is diminished with each successive operation cycle. To overcome this limitation, the adhesive material is loaded in the form of a continuous ribbon into a feeding mechanism that is attached to the robot wrist. The feeding mechanism operates in a manner similar to a typewriter ribbon mechanism.

TOOLS AS END EFFECTORS

In many applications, the robot is required to manipulate a tool rather than a work part. In a limited number of these applications, the end effecter is a gripper that is designed to grasp and handle the tool. The reason for using a gripper in these applications is that there may be more than one tool to be used by the robot in the work cycle. The use of a gripper permits the tools to be exchanged during the cycle, and thus facilitates this multi tool handling function.

In most of the robot applications in which a tool is manipulated, the tool is attached directly to the robot wrist. In these cases the tool is the end effecter. Some examples of tools used as end effectors in robot applications include:

- Spot-welding tools
- Arc-welding torch
- Spray-painting nozzle
- Rotating spindles for operations such as:

o wire brushing o drilling o rounding o grinding

- Liquid cement applicators for assembly
- Heating torches
- Water jet cutting tool

5.7 ROBOTIC SENSORS

For certain robot applications, the type of workstation control using interlocks is not adequate. The robot must take on more humanlike senses and capabilities in order to perform the task in a satisfactory way. These senses and capabilities include vision and hand-eye coordination, touch, and hearing. Accordingly, we will divide the types of sensors used in robotics into the following three categories:

1. Vision sensors

2. Tactile and proximity sensors

3. Voice sensors

Vision sensors

This is one of the areas that is receiving a lot of attention in robotics research. Computerized visions systems will be an important technology in future automated factories. Robot vision is made possible by means of a video camera, a sufficient light source, and a computer programmed to process image data. The camera is mounted either on the robot or in a fixed position above the robot so that its field of vision includes the robot's work volume. The computer software enables the vision system to sense the presence of an object and its position and orientation. Vision capability would enable the robot to carry out the following kinds of operations:

• Retrieve parts which are randomly oriented on a conveyor. Recognize particular parts which are intermixed with other objects. Perform visual inspection tasks. • Perform assembly operations which require alignment.

All of these operations have been accomplished in research laboratories. It is merely a matter of time and economics before vision sensors become a common feature in robot applications.

Tactile and proximity sensors

Tactile sensors provide the robot with the capability to respond to contact forces between itself and other objects within its work volume. Tactile sensors can be divided into two types:

1. Touch sensors
2. Stress sensors (also called force sensors)

Touch sensors are used simply to indicate whether contact has been made with an object. A simple micros which can serve the purpose of a touch sensor. Stress sensors are used to measure the magnitude of the contact force. Strain gage devices are typically employed in force-measuring sensors.

Potential uses of robots with tactile sensing capabilities would be in assembly and inspection operations. In assembly, the robot could perform delicate part alignment and joining operations. In inspection, touch sensing would be useful in gauging operations and dimensional-measuring activities. Proximity sensors are used to sense when one object is close to another object. On a robot, the proximity sensor would be located on or near the end effecter. This sensing capability can be engineered by means of optical-proximity devices, eddy-current proximity detectors, magnetic-field sensors, or other devices.

In robotics, proximity sensors might be used to indicate the presence or absence of a work part or other object. They could also be helpful in preventing injury to the robot's human coworkers in the factory.

Voice sensors

Another area of robotics research is voice sensing or voice programming. Voice programming can be defined as the oral communication of commands to the robot or other machine. The robot controller is equipped with a speech recognition system which analyzes the voice input and compares it with a set of stored word patterns. When a match is found between the input and the stored vocabulary word, the robot performs some action which corresponds to that word.

Voice sensors would be useful in robot programming to speed up the programming procedure, just as it does in NC programming. It would also be beneficial in especially hazardous working environments for performing unique operations such as maintenance and repair work. The robot could be placed in the hazardous environment and remotely commanded to perform the repair chores by means of step-by-step instructions.

EXPERIMENT NO: 6

Experiment 6: Study and report on Different Automated Machinery.

INTRODUCTION:

Students are instructed to prepare report on automated machinery. In report following points should be included:

- Automated machine name
- Manufacturing company
- Name of end user
- Function
- Drawing/Image
- Specifications
- Utilities required to operate machine
- Skills required to operate machine
- Cost
- Benefits
- Etc

EXPERIMENT NO: 7

Experiment 7: Study and report on Modular Automation System: Casting shop, Machine shop, Press Shop

INTRODUCTION:

1. What is Modular Automation?

The word, "modular", basically means smaller parts of a whole that can be arranged in a different order. It can be applied to a production line, a manufacturing plant, or products.

"Modular automation" is the next phase of factory automation where the same production line is separated into mobile modules and can quickly reconfigure itself to serve different needs.

Imagine each module as a Lego piece on wheels. Each module would carry equipment to serve a different purpose and can be easily integrated with another module. For example, a production line that typically packages apples can be reconfigured to package bananas.

In the near future, there may come an era in which all production equipment will be selfpropelled by autonomous mobile robots while communicating wirelessly, and layout changes will be guided by AI.

2. Benefits of Modular Automation

The flexibility of repurposing the same production line for different processes can improve productivity while saving space and labor. The results are more cost savings, faster time-to-market, and less downtime.

Benefits of Modular Automation:	Helpful for Industries Requiring Small Batches:
• Free layout	• Food & beverage
• Productivity improvement	• Chemicals
• High-mix low-volume production	• Pharmaceuticals
• Resolving labor shortage	• Medical
• Space-saving	• Textiles
• Energy-saving	• Marine
• Cost-saving	• Printing
• Faster time-to-market	• Packaging

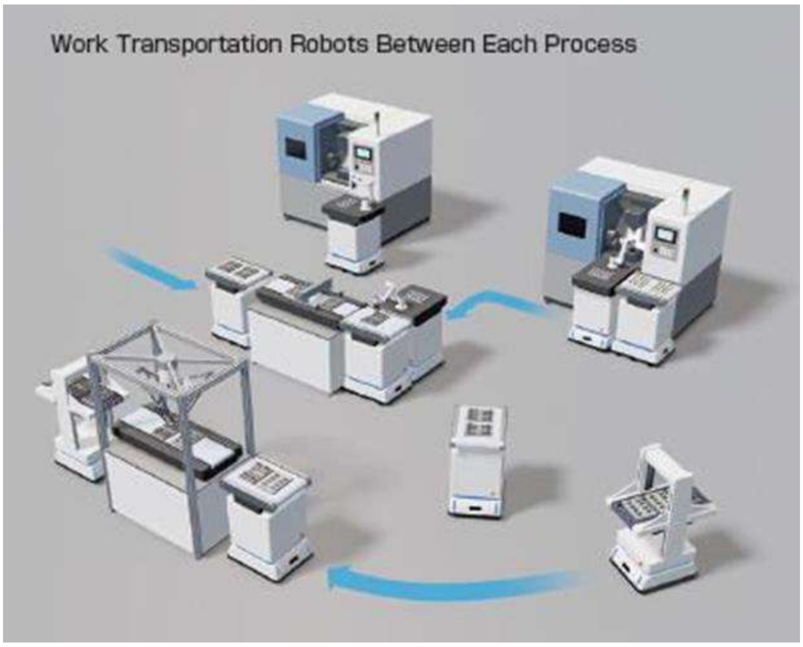
3. Types of Modular Automation

There are two main types of modular automation: semi-mobile and fully mobile.

Semi-Mobile Modular Automation

In semi-mobile modular automation, parts are transferred by transportation robots.

Semi-mobile modular automation lines have certain modules fixed to the floor. However, by integrating mobile robots with certain conveyor modules, mobile parts transfer becomes possible, and production efficiency can be improved by eliminating the manual transfer of parts between different process stations. A mobile robot with a small turning radius can work in a limited space and improve space efficiency.



Fully-Mobile Modular Automation

In fully mobile modular automation, every module can move and reconfigure itself.

By modularizing and mobilizing the entire production line, more layouts can be customized for different needs. In order to realize complete modularization, it is best to standardize on the same product technology in order to shorten the learning curve and simplify the wiring. Since modules are designed to be mobile, it is also necessary to consider making the device lighter and more compact.

4. Modular Automation Components

For many years, manufacturers have used modular systems to automate a wide range of assembly processes. They know that a properly designed system increases productivity, lowers costs and ensures manufacturing quality.

Modular automation can be as simple as a one-axis device or a complex multiaxis system. Either configuration requires a prime mover, which is a rotary actuator or linear slide. As more axes or motions are needed, two or more linear or rotary actuators with fixturing and tooling are required with an application-specific end-effector. To maximize system life, speed and accuracy must be considered, and each component properly sized.

Many component suppliers provide sizing software that saves time and lessens design risk by enabling engineers to input their requirements and print out a list of product models and sizes that will meet their needs. These suppliers will also review a particular application and make specific recommendations for the best choice of components, whether standard or specialized.

When designing a modular automation system, a manufacturer might be inclined to begin with the prime mover, which carries the majority of the load. However, the better choice is to start with the end-effector and work backwards to the prime mover. This is because any prime mover that carries the end-effector must have the required capacity for the effector and its payload.

End-effectors

The most common end-effector used in modular automation is a gripper. Another type is vacuum cups. Each end-effector (and accompanying tooling) must be the correct type and size to ensure proper grasping of the part while withstanding dynamic loads associated with motion.

Grippers can be small enough to handle tiny electrical components or large enough to lift engine blocks. Some suppliers offer a wide variety of specialized grippers, including those made of stainless steel or plastic for harsh environments.

The gripper's jaws can pivot or move at an angle or in a parallel motion. Angular grippers tend to cost less and provide a fairly wide jaw opening relative to the distance from the jaw pivot point. Parallel grippers are popular because they provide consistent positioning of the workload, particularly when the part being handled has varying dimensions.

Angular and parallel grippers can have two to four moving jaws, depending on the application requirements. In some cases, three-jaw grippers are used because they can easily center round parts.

Manufacturers need to decide if they want to use grippers with synchronized or nonsynchronized jaws. Synchronized jaws are controlled or coupled to ensure that the part is consistently placed in the same position. Non-synchronized jaws move independently and compensate for the position of the part during gripping.

Grippers are usually powered pneumatically, although electric-powered grippers are growing in popularity. Pneumatic grippers provide a great deal of force relative to their size and weight. Electric grippers tend to produce less force, but offer more flexibility regarding jaw positioning and level of grip force. They can weigh more than a comparable pneumatic gripper, depending on the motor size.
Some applications will require that the gripper retain the part in the event of a power loss. This can be accomplished through the use of internal springs or built-in jaw locking mechanisms.
Vacuum cups provide an effective way to grasp flat and contoured part surfaces. These cups are usually round, come in a wide range of sizes and styles, and are relatively inexpensive.
Vacuum cups are made of rubber and include a flared lip to form a flexible seal against a workpiece. This design allows the cup to be evacuated with a vacuum pump. Several cups can be connected to a central pump, or a small vacuum pump can be used for each cup.
Industrial vacuum cups usually employ a metal fitting for mounting the cup and connecting a vacuum source to allow the inner volume to be evacuated. These cups can be flat or have various configurations that incorporate bellows.
A flat cup works well for grabbing flat surfaces and for applications with a shear load. Cups with bellows are designed for heavy parts that are convex or concave.
The correct number of vacuum cups required for an automation system will vary. For example, a system with rapidly moving contoured pieces might require two vacuum cups rather than one. Multiple cups increase the total area and achieve a desired load capacity (lifting and shear), while providing a generous safety factor.
Prime Movers
A rotary actuator or linear slide can be the prime mover in a modular automation system. It can also provide secondary motion or rotate the end-effector with a wrist motion. The actuator is usually pneumatic, although more electric actuators have been used in recent years.
The actuator must be configured to produce the exact amount of rotation required. Its rotation can be output via a keyed shaft, a hub or a flat mounting surface. Some rotary actuators offer up to five positions, allowing for more flexibility.
The actuator must be properly sized to handle the load and kinetic energy generated at the end of rotational travel. The actuator can also be outfitted with shock absorbers to increase its kinetic energy capability. This is necessary because most actuators can rotate a greater load than they are able to stop.
Linear slides are driven pneumatically or with electricity, depending on the application. Pneumatic slides provide cost-effective guided linear motion, while offering two, three or more positions.
These slides are available in a saddle or carriage configuration, where the load-carrying member moves between two end plates on a bearing system. The slides are also available in a cantilever or thruster style, where a tool plate supported by a bearing system reaches out to support an overhung load.

Electric slides provide more flexibility. Their positioning is almost infinite, depending on the type of motor and control package used to power the unit. Electric slides also are becoming more costeffective, as the cost of electric motors and controls continues to decline.
These slides come in saddle and cantilever configurations. Saddle-type slides can be driven by a ballscrew, belt or linear motor. Belt and linear motors provide the highest speeds.
Linear slides feature either of two types of bearing systems. The first incorporates round shafts with either linear ball bushings or composite bearings to support the load. The second uses profile rail bearings combined with either a cross roller or a reciprocating ball-bearing carriage. Slides that incorporate the profile rail typically have a higher load capacity with less deflection.
Finally, linear slides can be easily combined to provide multiaxis motion. Some suppliers allow the direct attachment of one slide to another. Others offer transition plates that allow for a versatile connection. As always, the slides must be properly sized for load capacity, deflection, speed and kinetic energy.
Five Considerations When Sizing a Gripper

- Motion. Remember that gripper acceleration and deceleration create inertia, which can increase the gripper’s lift capability requirements. Also make sure the jaw tooling is properly designed so it encapsulates the part as it moves.
- Environment. Oil and Teflon spray are often present in assembly work areas. Be aware that both can make work areas slippery.
- External Forces. These include machining that takes place as the gripper holds a part.
- Orientation. Forces can be applied to a part from several different directions.
- Part Presentation. Know precisely how the part will be presented to the gripper.

Top Five Considerations When Building a Modular Automation System

- Environment. How often will the actuators be exposed to heat, dust, wash-downs, and other environmental extremes? • Part Weight and Size. Always take into account the geometry, dimensions and mass of the parts or components in motion.
- Motion Sequence and Strokes. Know the exact stroke distance (in inches or millimetres). How many axes of motion are there?
- Cycle Time. Keep it as short as necessary.
- Space Constraints or External Forces. Are there dimensional constraints or additional motions and forces being applied to the actuators? If so, plan accordingly.

EXPERIMENT NO: 8

Experiment 8: Study and report on Economic analysis of Automation.

INTRODUCTION:

Refer article "Automation and a Changing Economy" by Conor McKey, Ethan Pollack and Alastair Fitzpayne and give answers of following questions:

- List economic benefits and drawbacks of automation.
- List five tasks which were previously done manually but currently automatic.
- Which type of employment will decrease due to automation and increase due to automation?
- Objectives that guide policy agenda for addressing the challenges posed by automation and the inadequacies of our existing supports.

Assignment1:
CO1
Prepare case study report on automation implementation strategy/ USA principle applied by any industry and make presentation of the same.

Assignment 2
CO2

1. Name three of the four conditions under which automated production lines are appropriate.
2. What is an automated production line?
3. What is a pallet fixture, as the term is used in the context of an automated production line?
4. What is a dial-indexing machine?
5. Why are continuous work transport systems uncommon on automated production lines?

Assignment 3
CO3
Identify microcontroller used in any machine and prepare 1-2 pages report of specifications. (Refer experiment 3 for parameter list)

Assignment 4
CO4
List principles of design for automated manufacturing**.**

Assignment 5
CO5

1) Name three production situations in which FMS technology can be applied.
2) What is a flexible manufacturing system?
3) What are the three capabilities that a manufacturing system must possess in order to be flexible?
4) Name the four tests of flexibility that a manufacturing system must satisfy in order to be classified as flexible.
5) Name the seven functions performed by human resources in an FMS.

Assignment for bright students
Design a small automated system.