

## UNIT I– Flexible Manufacturing System

A flexible manufacturing system is group of processing stations interconnected by means of an automated material handling and storage systems, and controlled by an integrated computer system.

### **FMS Flexibility:**

The three capabilities that a manufacturing system must process in order to the flexible

1. The ability to identify and distinguish among the different incoming part or product styles processed by the system.
2. Quick changeover of operating instructions.
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 enables of the systems flexibility.

### **Types of flexibility;**

The flexibility allows a mixed model manufacturing system to cope with level of variation in part or product style without interruptions in production for changeover between models. It is generally a desirable feature of a manufacturing system.

The feature of flexibility is broadly classified in to following ways

1. Machine flexibility
2. Part flexibility
3. Route flexibility
4. Volume flexibility
5. Man flexibility.

FMS technology is approaches to simultaneously manufacture different parts in the shortest time possible, with the highest quality and at the lowest costs possible. To do this a maximum of management of management information must be available for the FMS host to work with. When this is achieved there are several types of flexibility available; to an FMS user.

1. FMS user flexibility
2. FMS supplier flexibility.

#### **1. FMS user flexibility**

The first area is that in which the FMS user is interested. This most important area for the available flexibilities are provided for the FMS user to be able to satisfy the demands of their customers.

#### **2. FMS supplier flexibility.**

The second type of flexibility concerns the method of applying FMSs.this is of extreme interest to the FMS host supplier. Every FMS application's different, and no. of

FMS supplier can start from scratch to supply a FMS host solution every time for each new FMS user. A supplier's solution need to be flexible enough to integrate the different machine types in to different FMS configurations and layouts for different product mixes.

### **Components of FMS systems;**

- ⌘ Workstations
- ⌘ Material handling and storage
- ⌘ Computer control system
- ⌘ Human resources

## 1. Workstations

The first element in the FMS is work stations; it may,

- ⌘ Load/unload stations
- ⌘ Machining stations
- ⌘ Other processing stations
- ⌘ Assembly

## 2. Material handling and storage systems

For the below mentioned functions are the material handling device

- ⌘ Random, independent movement of work parts between stations.
- ⌘ Handle a variety of work part configurations.
- ⌘ Temporary storage.
- ⌘ Convenient access for loading and unloading work part control's.
- ⌘ Compatible with computer

The material handling is classified into two types they are,

- ☐ Primary material handling
- ☐ Secondary material handling

The material handling function in a FMS is often shared between two systems:

1. **Primary handling system** - establishes the basic layout of the FMS and is responsible for moving work parts between stations in the system.
2. **Secondary handling system** - consists of transfer devices, automatic pallet changers, and similar mechanisms located at the workstations in the FMS.

### 3. Computer control system

- ☐ Workstation control
- ☐ Distribution of control instructions to workstations
- ☐ Production control
- ☐ Traffic control
- ☐ Shuttle control
- ☐ Work piece monitoring
- ☐ Tool control
- ☐ Performance monitoring and reporting
- ☐ Diagnostics

## Benefits of FMS

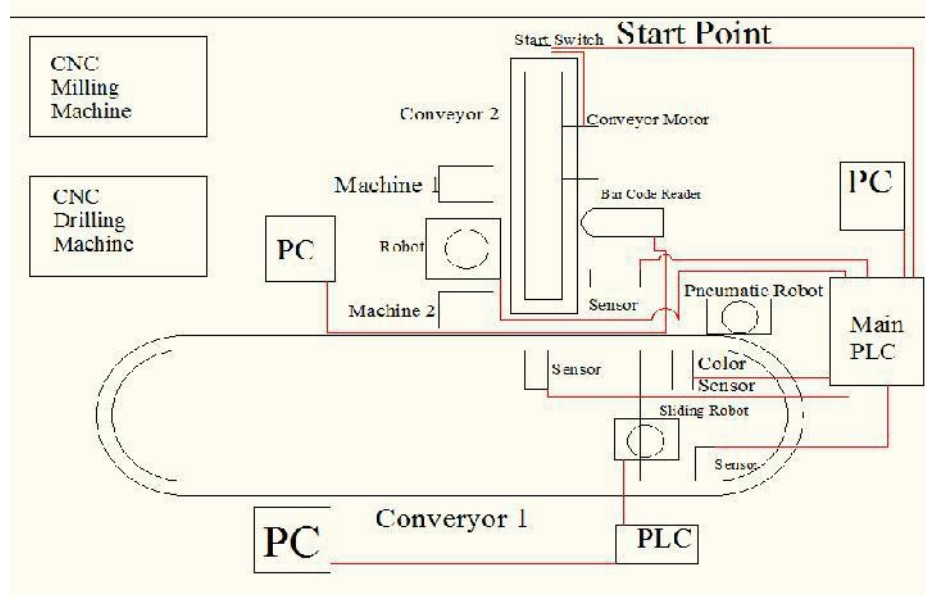
The various benefits are listed below,

- ⌘ Higher machine utilization
- ⌘ Reduced work in process

- ⌘ Lower manufacturing lead time
- ⌘ Greater flexibility in production scheduling.

### Types of FMS;

- ⌘ Flexible manufacturing module (FMM)
- ⌘ Flexible manufacturing cell (FMC)
- ⌘ Flexible manufacturing group (FMG)
- ⌘ Flexible fabrication-machining-assembly system (FFMAS)



### FMS layout

- ☞ In-line layout
- ☞ Loop layout
- ☞ Ladder layout
- ☞ Open field layout
- ☞ Robot centered layout

### FMS Projected

- ☞ Production Planning and Control - PPC
- ☞ Master Production Planning - MPP
- ☞ Manufacturing Requirements Planning - MRP
- ☞ Manufacturing Resource Planning - MRPII
- ☞ Factory Data Collection - FDC
- ☞ Flexible manufacturing module - (FMM)
- ☞ Flexible manufacturing cell - (FMC)
- ☞ Flexible manufacturing group - (FMG)

- ☞ Flexible fabrication-machining – FFM
- ☞ Automated Guided Vehicle – AGV.

### **Group technology**

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take the advantage of their similarities in manufacturing and design. Similar parts are arranged in to part families.

Advantages of group technology

- ☞ Product design benefits- 10 % reduction in the number of drawings
- ☞ Tooling and setup benefits – 69 % reduction of setup time.
- ☞ Materials handling benefits
- ☞ Production and inventory control benefits
- ☞ -70 % reduction in production time
- ☞ -62 % reduction in work in process inventories
- ☞ -82 % reduction in overdue orders
- ☞ Employee satisfaction
- ☞ Process planning procedures

### **Group technology (GT);**

Group technology (GT) is a manufacturing philosophy to increase production efficiency by grouping a variety of parts having similarities of shape, dimension, and/or process route.

Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take the advantage of their similarities in manufacturing and design.

### **Part family;**

A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture.

### **Design attributes:**

- ☞ Part configuration (round or prismatic)
- ☞ Dimensional envelope (length to diameter ratio)
- ☞ Surface integrity (surface roughness, dimensional tolerances)
- ☞ Material type
- ☞ Raw material state (casting, forging, bar stock, etc.)

### **Manufacturing attributes:**

- ☞ Operations and operation sequences (turning, milling, etc.)
- ☞ Batch sizes
- ☞ Machine tools
- ☞ Cutting tools
- ☞ Work holding devices
- ☞ Processing times

### **Benefits of Group Technology**

Group technology, when successfully implemented, offers many benefits to industries. GT benefits can be realized in a manufacturing organization in the following areas:

1. Production design
2. Tooling and setups
3. Materials handling
4. Production and inventory control
5. Process planning Management and employees.

### **1. Benefits in product Design**

The main advantages of GT for product design come in cost and time savings, because design engineers can quickly and easily search the database for parts that either presently exist or can be used with slight modifications, rather than issuing new part numbers.

A similar cost savings can be realized in the elimination of two or more identical parts with different part numbers. Another advantage is the standardization of designs. Design features such as corner radii, tolerances, chamfers, counter bores and surface finishes can be standardized with GT.

### **2. Benefits in Tooling and Setups**

In the area of tooling, group jigs and fixtures are designed to accommodate every member of a part family. Also work holding devices are designed to use special adapters in such a way that this general fixture can accept each part family member. Since setup times are very short between parts in a family, a group layout can also result in dramatic reductions in setup times.

### **3. Benefits in material handling:**

GT facilitates a group layout of the shop. Since machines are arranged as cells, in a group layout, the materials handling cost can be reduced by reducing travel and facilitating increased automation.

### **4. Benefits in production and inventory Control**

GT simplifies production and planning control. The complexity of the problem has been reduced from a large portion of the shop to smaller groups of machines. The production scheduling is simplified to a small number of parts through the machines in that cell.

### **5. Benefits in Process Planning**

The concept of group technologies are parts classification and coding that leads to an automated process planning system. Grouping parts allows an examination of the various planning/route sheets for all members of a particular family. Once this has been accomplished, the same basic plans can be applied to other members, thereby optimizing the shop for the group.

### **6. Benefits to Management and Employees**

It is understood that GT simplifies the environment of the manufacturing firm, which provides significant benefit to management.

- ⌘ Simplification reduces the cumbersome paper work.
- ⌘ Simplification also improves the work environment.

In the GT work environment, the supervisor has in – depth knowledge of the work performed and better control.

### **3.3. General methods used for part families;**

1. Visual inspection,
2. Parts classification and coding system, and
3. Production flow analysis.

### **Production Flow analysis;**

Production Flow analysis (PFA) is a method for identifying part families and associated machine groupings that uses the information contained on production route sheets rather on part drawings.

Various steps of PFA

1. Data collection
2. Part sorting and routing
3. PFA chart
4. Analysis

### **Parts classification and coding system**

1. System based on part design attributes
2. System based on manufacturing attributes
3. System based on design and manufacturing attributes

### **Code structures used in GT application;**

- ⌘ Attribute codes (or polycodes or chain type structure).
- ⌘ Hierarchical codes (or monocodes or tree structure).
- ⌘ Decision-tree codes (or hybrid codes or mixed codes).

### **Coding systems;**

Coding is the systematic process of establishing an alphanumeric value for parts on selected part features. Classification is the grouping of parts based on code values. This method is the most time consuming of the three methods, in parts classification and coding, similarities among parts are identified and these similarities are related in a coding system. Three categories of part similarities can be distinguished

1. Design attributes which are concerned with part characteristics such as, geometry, size and material, and
2. Manufacturing attributes consider the processing steps required to make a part.
3. system based on both attributes.

There are three basic coding structures

1. Hierarchical codes (or monocodes)
2. Attributes codes (or polycodes)
3. Decision tree codes (or hybrid codes)

### **Cellular manufacturing;**

Cellular manufacturing (CM) is an application of group technology in which dissimilar machines have been aggregated into cells, each of which is dedicated to the production of a part family.

The machines in a multi station system with variable routing may be manually operated, semi-automatic, or fully automated. When manually operated or semi automatic the machine groups are often called machine cells, and the use of these cells in a factory is called cellular manufacturing.

### **Design considerations guiding the cell-formation.;**

- ⊗ Parts/products to be fully completed in the cell.
- ⊗ Higher operator utilization.
- ⊗ Fewer operations than equipment.
  
- ⊗ Balanced equipment utilization in the cell.

### **Types of cell design**

1. Single machine cell
2. Group machine cell with manual handling
3. Group machine cell with semi-integrated handling
4. Flexible manufacturing system

### **Determining the best machine arrangement**

``Factors to be considered:

- ⊗ Volume of work to be done by the cell
- ⊗ Variations in process routings of the parts

## **FUNDAMENTALS OF ROBOTICS**

Robots are devices that are programmed to move parts, or to do work with a tool. Robotics is a multidisciplinary engineering field dedicated to the development of autonomous devices, including manipulators and mobile vehicles.

Roboticians develop man-made mechanical devices that can move by themselves, whose motion must be modelled, planned, sensed, actuated and controlled, and whose motion behaviour can be influenced by “programming”. Robots are called “intelligent” if they succeed in moving in safe interaction with an unstructured environment, while autonomously achieving their specified tasks.

This definition implies that a device can only be called a “robot” if it contains a movable mechanism, influenced by sensing, planning, actuation and control components. It does not imply that a minimum number of these components must be implemented in software, or be changeable by the “consumer” who uses the device; for example, the motion behaviour can have been hard-wired into the device by the manufacturer.

So, the presented definition, as well as the rest of the material in this part of the WEBook, covers not just “pure” robotics or only “intelligent” robots, but rather the somewhat broader domain of

**robotics and automation.** This includes “dumb” robots such as: metal and woodworking machines, “intelligent” washing machines, dish washers and pool cleaning robots, etc. These examples all have sensing, planning and control, but often not in individually separated components. For example, the sensing and planning behaviour of the pool cleaning robot have been integrated into the mechanical design of the device, by the intelligence of the human developer.

Robotics is, to a very large extent, all about system integration, achieving a task by an actuated mechanical device, via an “intelligent” integration of components, many of which it shares with other domains, such as systems and control, computer science, character animation, machine design, computer vision, artificial intelligence, cognitive science, biomechanics, etc. In addition, the boundaries of robotics cannot be clearly defined, since also its “core” ideas, concepts and algorithms are being applied in an ever increasing number of “external” applications, and, vice versa, core technology from other domains (vision, biology, cognitive science or biomechanics, for example) are becoming crucial components in more and more modern robotic systems.

### Definition

The term comes from a Czech word, *robota*, meaning "forced labor." The word *robot* first appeared in a 1920 play by Czech writer Karel Capek, R.U.R.: Rossum's Universal Robots. In the play, the robots eventually overthrow their human creators.

An automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either, fixed in place or mobile for use in industrial automation applications. An industrial robot is defined by ISO as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot). Typical applications of robots include welding, painting, assembly, pick and place (such as packaging, palletizing and SMT), product inspection, and testing; all accomplished with high endurance, speed, and precision.

### Robot Anatomy

The anatomy of robot is also known as structure of robot. The basic components or sections in anatomy of robots are as follows.

The RIA (Robotics Industries Association) has officially given the definition for Industrial Robots. According to RIA, “*An Industrial Robot* is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks.”





The *Anatomy* of Industrial Robots deals with the assembling of outer components of a robot such as wrist, arm, and body. Before jumping into Robot Configurations, here are some of the key facts about robot anatomy.

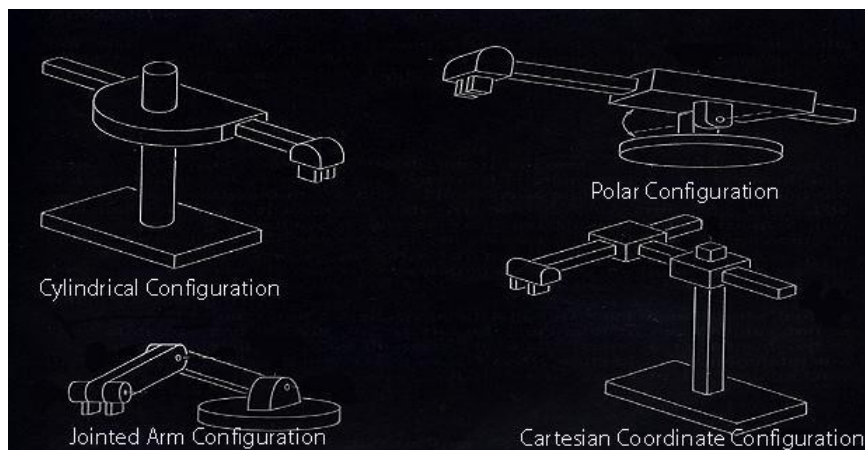
- ⌘ **End Effectors:** A hand of a robot is considered as end effectors. *The* grippers and tools are the two significant types of end effectors. The grippers are used to pick and place an object, while the tools are used to carry out operations like spray painting, spot welding, etc. on a work piece.
- ⌘ **Robot Joints:** The joints in an industrial robot are helpful to perform sliding and rotating movements of a component.
- ⌘ **Manipulator:** The manipulators in a robot are developed by the integration of links and joints. In the body and arm, it is applied for moving the tools in the work volume. It is also used in the wrist to adjust the tools.
- ⌘ **Kinematics:** It concerns with the assembling of robot links and joints. It is also used to illustrate the robot motions.

### Co-ordinate System

A coordinate system defines a plane or space by axes from a fixed point called the origin. Robot targets and positions are located by measurements along the axes of coordinate systems. A robot uses several coordinate systems, each suitable for specific types of jogging or programming.

The Robots are mostly divided into four major configurations based on their appearances, sizes, etc. such as:

- ⌘ Cylindrical Configuration,
- ⌘ Polar Configuration,
- ⌘ Jointed Arm Configuration, and
- ⌘ Cartesian Co-ordinate Configuration.



### Cylindrical Configuration:

This kind of robots incorporates a slide in the horizontal position and a column in the vertical position. It also includes a robot arm at the end of the slide. Here, the slide is capable of moving in up & down motion with the help of the column. In addition, it can reach the work space in a rotary movement as like a cylinder.

Example: GMF Model M1A Robot.

Advantages:

- ⌘ Increased rigidity, and
- ⌘ Capacity of carrying high payloads.

Disadvantages:

- ⌘ Floor space required is more, and
- ⌘ Less work volume.

### **Polar Configuration:**

The polar configuration robots will possess an arm, which can move up and down. It comprises of a rotational base along with a pivot. It has one linear & two rotary joints that allows the robot to operate in a spherical work volume. It is also stated as Spherical Coordinate Robots. Example: Unimate 2000 Series Robot.

Advantages: Long reach capability in the horizontal position.

Disadvantages:

- ⌘ Vertical reach is low.

### **Jointed Arm Configuration:**

The arm in these configuration robots looks almost like a human arm. It gets three rotary joints and three wrist axes, which form into six degrees of freedoms. As a result, it has the capability to be controlled at any adjustments in the work space. These types of robots are used for performing several operations like *spray painting*, *spot welding*, *arc welding*, and more. Example: Cincinnati Milacron T3 776 Robot

Advantages:

- ⌘ Increased flexibility,
- ⌘ Huge work volume, and
- ⌘ Quick operation.

Disadvantages:

- ⌘ Very expensive,
- ⌘ Difficult operating procedures, and
- ⌘ Plenty of components.

### **Cartesian Co-ordinate configuration:**

These robots are also called as *XYZ robots*, because it is equipped with three rotary joints for assembling XYZ axes. The robots will process in a rectangular work space by means of this three joints movement. It is capable of carrying high payloads with the help of its rigid structure. It is mainly integrated in some functions like pick and place, material handling, loading and unloading, and so on. Additionally, this configuration adds a name of Gantry Robot. Example: IBM 7565 Robot.

Advantages:

- ⌘ Highly accurate & speed,

- ⊗ Fewer cost,
- ⊗ Simple operating procedures, and
- ⊗ High payloads.

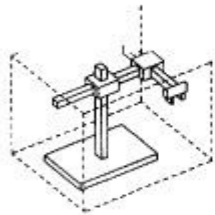
**Disadvantages:**

- ⊗ Less work envelope, and
- ⊗ Reduced flexibility.

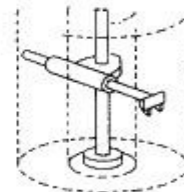
**Work Envelop**

It is the shape created when a [manipulator](#) reaches forward, backward, up and down. These distances are determined by the length of a [robot's arm](#) and the design of its axes. Each axis contributes its own range of motion.

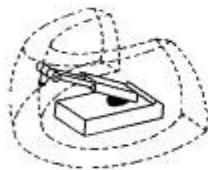
A robot can only perform within the confines of this [work envelope](#). Still, many of the [robots](#) are designed with considerable flexibility. Some have the ability to reach behind themselves. Gantry robots defy traditional constraints of work envelopes. They move along track systems to create large work spaces.



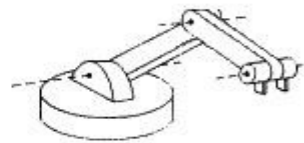
Rectangular Coordinate Robot



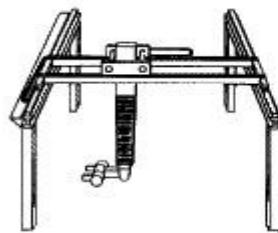
Cylindrical Coordinate Robot



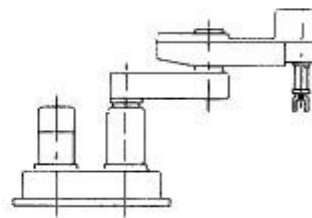
Spherical Coordinate Robot



Articulated Arm Robot



Gantry Robot



SCARA Robot

**Technical Features of an Industrial Robot**

The technical features of an industrial robot determine its efficiency and effectiveness at performing a given task. The following are some of the most important among these technical features.

**Robot Classification**

**Degree of Freedom (D.O.F)** - Each joint on the robot introduces a degree of freedom. Each dof can be a slider, rotary, or other type of actuator. Robots typically have 5 or 6 degrees of freedom. 3 of the degrees of freedom allow positioning in 3D space, while the other 2 or 3 are used for orientation of the end effector. 6 degrees of freedom are enough to allow the robot to reach all positions and orientations in 3D space. 5 D.O.F requires a restriction to 2D space, or else it limits orientations. 5 D.O.F robots are commonly used for handling tools such as arc welders.

**Work Volume/Workspace** – The robot tends to have a fixed and limited geometry. The work envelope is the boundary of positions in space that the robot can reach. For a Cartesian robot (like an overhead crane) the workspace might be a square, for more sophisticated robots the workspace might be a shape that looks like a ‘clump of intersecting bubbles’.

**The Pneumatic Robot-** The pick and place machine is the simplest of the robots. Pneumatic powered, it has no servo motors driving the axes, but an air cylinder instead. As such, each stroke is to an end stop, that is generally adjustable for a few millimeters, via a micrometer type screw. A popular application is to pick and place small components into an assembly, maybe from a vibratory bowl feeder to an assembly fixture.

Pick and Place units are fast, accurate and very cost effective.

### **The Scara Robots.**

Scara means Selective, Compliant, Robot arm. This robot is especially designed for assembly automation and uses 4-axes of motion, each axes driven by a servo motor. The two joints have a motor each and the base has a rotate axis.

The forth axis is the vertical axis that generally inserts a component. This arrangement makes a very "stiff" arrangement that is ideally suited for accurate insertion. The Scara is the least expensive of the servo powered robots and are usually small and can be very fast. The photo at left is of an Epson robot. Take a look at this page for more details- **The Scara Robots.**



### **The Gantry Robot.**

This type of robot is generally mounted direct to the shop floor and usually has a large work envelope.

It can be used for material handling applications and I used them for stacking and de-stacking steel blanks, that were laser welded into tailored blanks.

They can be pneumatic powered but the cost of servo drives for industrial robotics is getting so competitive that today the air powered types are few and far between.



### **Cartesian robots.**

These machines are usually mounted on a table and are similar in concept to the gantry robot but on a smaller scale. The axes can be air or servo motor powered and are generally offered in modules, that are complete and can be bolted together, to form the motions required.

### **The 6-Axes Industrial Robot Arm.**

Maybe the most recognized industrial robot. It is available in a wide range of sizes and payloads, They can be small enough to mount on a table.



Applications are universal in the field of industrial robotics. The robot arm can be found in all types of uses, from assembly to welding to painting and material handling.

### **Speed of Motion**

1. **Point-to-point (PTP) control robot:** is capable of moving from one point to another point. The locations are recorded in the control memory. PTP robots do not control the path to get from one point to the next point. Common applications include component insertion, spot welding, whole drilling, machine loading and unloading, and crude assembly operations.
2. **Continuous-path (CP) control robot:** with CP control, the robot can stop at any specified point along the controlled path. All the points along the path must be stored explicitly in the robot's control memory. Typical applications include spray painting, finishing, gluing, and arc welding operations.
3. **Controlled-path robot:** the control equipment can generate paths of different geometry such as straight lines, circles, and interpolated curves with a high degree of accuracy. All controlled-path robots have a servo capability to correct their path.

### **Need of Robot and its Application**

#### **Industrial Applications**

Industrial robots are used to assemble the vehicle parts, as shown in the figure. As the assembly of the machine parts is a repetitive task to be performed, the robots are conveniently used instead of using mankind (which is more costly and less précised compared to robots.)

#### **Auto Industry:**

The auto industry is the largest users of robots, which automate the production of various components and then help, assemble them on the finished vehicle. Car production is the primary example of the employment of large and complex robots for producing products. Robots are used in that process for the painting, welding and assembly of the cars. Robots are good for such tasks because the tasks can be accurately defined and must be performed the same every time, with little need for feedback to control the exact process being performed.

#### **Material Transfer, Machine Loading and Unloading**

There are many robot applications in which the robot is required to move a work part or other material from one location to another. The most basic of these applications is where the robot picks the part up from one position and transfers it to another position. In other applications, the robot is used to load and/or unload a production machine of some type.

Material transfer applications are defined as operations in which the primary objective is to move a part from one location to another location. They are usually considered to be among the most straightforward of robot applications to implement. The applications usually require a relatively unsophisticated robot, and interlocking requirements with other equipments are typically

uncomplicated. These are the pick and place operations. The machine loading and unloading applications are material handling operations in which the robot is used to service a production machine by transferring parts to and/or from the machine.

- Robots have been successfully applied to accomplish the loading and/or unloading function in the production operations. Die casting
- Plastic molding
- Forging and related operations
- Machining operations
- Stamping press operations

The other industrial applications of robotics include processing operations such as spot welding, continuous arc welding; spray coating, also in assembly of machine parts and their inspection.

## ROBOT PROGRAMMING

According to the *consistent* performance by the robots in industries, the robot programming can be divided in two common types such as:

- ☐ Leadthrough Programming Method
- ☐ Textual Robot Languages

### Leadthrough Programming Method:

During this programming method, the traveling of robots is based on the desired movements, and it is stored in the external controller memory. There are two modes of a control system in this method such as a *run mode* and *teach mode*. The program is taught in the teach mode, and it is executed in the run mode. The leadthrough programming method can be done by two methods namely:

- Powered Leadthrough Method
- Manual Leadthrough Method

#### a) Powered Leadthrough Method:

The powered leadthrough is the *common* programming method in the industries. A *teach pendant* is incorporated in this method for controlling the motors available in the joints. It is also used to operate the robot wrist and arm through a sequence of points. The playback of an operation is done by recording these points. The control of complex geometric moves is *difficult* to perform in the teach pendant. As a result, this method is good for *point to point* movements. Some of the key applications are spot welding, machine loading & unloading, and part transfer process.

#### b) Manual Leadthrough Method:

In this method, the robot's *end effector* is moved physically by the programmer at the desired movements. Sometimes, it may be difficult to move large robot arm manually. To get rid of it a *teach button* is implemented in the wrist for special programming. The manual leadthrough method is also known as *Walk Through method*. It is mainly used to perform continuous path movements. This method is best for spray painting and arc welding operations.

## Robot Programming Methods

There are three basic methods for programming industrial robots but currently over 90% are programmed using the teach method.

## **Teach Method**

The logic for the program can be generated either using a menu based system or simply using a text editor but the main characteristic of this method is the means by which the robot is taught the positional data. A teach pendant with controls to drive the robot in a number of different co-ordinate systems is used to manually drive the robot to the desired locations.

These locations are then stored with names that can be used within the robot program. The co-ordinate systems available on a standard jointed arm robot are :-

### ***JointCo-ordinates***

The robot joints are driven independently in either direction.

### ***GlobalCo-ordinates***

The tool centre point of the robot can be driven along the X, Y or Z axes of the robots global axis system. Rotations of the tool around these axes can also be performed

### ***ToolCo-ordinates***

Similar to the global co-ordinate system but the axes of this one are attached to the tool centre point of the robot and therefore move with it. This system is especially useful when the tool is near to the workpiece.

### ***WorkpieceCo-ordinates***

With many robots it is possible to set up a co-ordinate system at any point within the working area. These can be especially useful where small adjustments to the program are required as it is easier to make them along a major axis of the co-ordinate system than along a general line. The effect of this is similar to moving the position and orientation of the global co-ordinate system.

This method of programming is very simple to use where simple movements are required. It does have the disadvantage that the robot can be out of production for a long time during reprogramming. While this is not a problem where robots do the same task for their entire life, this is becoming less common and some robotic welding systems are performing tasks only a few times before being reprogrammed.

## **Lead Through**

This system of programming was initially popular but has now almost disappeared. It is still however used by many paint spraying robots. The robot is programmed by being physically moved through the task by an operator. This is exceedingly difficult where large robots are being used and sometimes a smaller version of the robot is used for this purpose. Any hesitations or inaccuracies that are introduced into the program cannot be edited out easily without reprogramming the whole task. The robot controller simply records the joint positions at a fixed time interval and then plays this back.

## **Off-line Programming**

Similar to the way in which CAD systems are being used to generate NC programs for milling machines it is also possible to program robots from CAD data. The CAD models of the components are used along with models of the robots being used and the fixturing required. The program structure is built up in much the same way as for teach programming but intelligent tools are

available which allow the CAD data to be used to generate sequences of location and process information. At present there are only a few companies using this technology as it is still in its infancy but its use is increasing each year. The benefits of this form of programming are:-

- ⌘ Reduced down time for programming.
- ⌘ Programming tools make programming easier.
- ⌘ Enables concurrent engineering and reduces product lead time.
- ⌘ Assists cell design and allows process optimisation

## **Programming Languages for Robotics**

This article is all about giving an introduction about some of the programming languages which are used to design Robots.

There are many programming languages which we use while building Robots, we have a few programming languages which we always prefer to use in designing. Actually the programming languages which we use mainly depend on the hardware one is using in building robots.

Some of them are- URBI, C and BASIC. URBI is an open source language. In this article we will try to know more about these languages. Let's start with URBI.

**URBI** : URBI stands for Universal Real-time Behavior Interface. It is a client/server based interpreted language in which Robot works as a client and controller as a server. It makes us to learn about the commands which we give to Robots and receive messages from them. The interpreter and wrapped server are called as "URBI Engine". The URBI Engine uses commands from Client and receives messages to it. This language allows user to work on basic Perception-action principle. The users just have to write some simple loops on the basis of this principle directly in URBI.

**PYTHON** : There is another language which is used in designing Robots. Python is an object-oriented language which is used to access and control Robots. Python is an interpreted language; this language has an application in working with mobile robots, particularly those manufactured by different companies. With python it is possible to use a single program for controlling many different robots. However Python is slower than C++ but it has some good sides as well as it proved very easy to interact with robots using this language, it is highly portable and can be run in windows and MAC OSX plus it can easily be extendable using C and C++ language. Python is a very reliable language for string manipulation and text processing.

**ROBOTC** : Other Languages which we use are C, C++ and C # etc. or their implementation, like ROBOTC, ROBOTC is an implementation of C language. If we are designing a simple Robot, we do not need assembly code, but in complex designing we need well-defined codes. ROBOTC is another programming language which is C-based. It is actually a text based programming language. The commands which we want to give to our Robot, first written on the screen in the form of simple text, now as we know that Robot is a kind of machine and a machine only understands machine language. So these commands need to be converted in machine language so that robot can easily understand and do whatever it is instructed to do.

Although commands are given in text form (called as codes) but this language is very specific about the commands which is provided as instruction. If we do even a minor change in given text it will not accept it as command. If the command which is provided to it is correct it colorizes that text, and we came to know that the given command in text form is correct (as we have shown in our example given below). Programming done in ROBOTC is very easy to do. Commands given are very straightforward. Like if we want our robot to switch on any hardware part, we just have to give code



regarding to that action in text form. Suppose we want robot to turn motor of port, we just have to give command in this way:

Although program above is not exactly shown in the way in which it should be written, this is just to provide you a visualization of what we have told you. This is not written in an appropriate manner. ROBOTC provide advantage of speed, a Robot programmed in ROBOTC programming supports 45 times more speed than provided by other programming based on C plus it has a very powerful debugging feature.

## **UNIT IV - Computer Integrated Manufacturing System**

Computer Integrated Manufacturing, known as CIM, is the phrase used to describe the complete automation of a manufacturing plant, with all processes functioning under computer control and digital information tying them together. The heart of computer integrated manufacturing is CAD/CAM. Computer-aided design (CAD) and computer-aided manufacturing (CAM) systems are essential to reducing cycle times in the organization. CAD/CAM is a high technology integrating tool between design and manufacturing. CAD techniques make use of group technology to create similar geometries for quick retrieval. CAD/CAM integrated systems provide design/drafting, planning and scheduling, and fabrication capabilities. CAD provides the electronic part images, and CAM provides the facility for tool path cutters to take on the raw piece.

### **CIM Concept Vs CIM Technology**

- ⌘ CIM is both a concept and a technology.
- ⌘ For top management, CIM is a concept, a blueprint for success.
  - ⌘ For middle managers and line managers, CIM is a technology

### **Concept or Technology**

“Some people view CIM as a concept, while others merely as a technology. It is actually both. A good analogy of CIM is man, for what we mean by the word man presupposes both the mind and the body. Similarly, CIM represents both the concept and the technology. The concept leads to the technology which, in turn, broadens the concept.”

### **The meaning and origin of CIM**

The CIM will be used to mean the integration of business, engineering, manufacturing and management information that spans company functions from marketing to product distribution

### **CIM – Definition;**

CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency.

Computer integrated manufacturing is defined as the effective use of computers to design the products, plan the production, control the operations and perform the various business related functions needed in a manufacturing firm.

### **Objective of CIM;**

- ⌘ The main aim of CIM is to use the advanced information processing technology into all areas of manufacturing industry in order
- ⌘ To make the total process more productive and efficient;
- ⌘ increase product reliability;

- ⌘ Decrease the cost of production and maintenance relating to the manufacturing system as well as to the product; and
- ⌘ Reduce the number of hazardous jobs and

### **Subsystems in computer-integrated manufacturing**

A computer-integrated manufacturing system is not the same as a *"lights-out" factory*, which would run completely independent of human intervention, although it is a big step in that direction. Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers. Some or all of the following subsystems may be found in a CIM operation:

### **CIM system – Hardware & Software;**

- ⌘ CIM Hardware consists of manufacturing equipments and Computer related hard ware with the office equipment.
- ⌘ CIM Software consists of computer programs to carry out the various functions and transfer the data from various areas of the industry.

### **Elements of CIM hardware;**

Manufacturing equipment such as CNC machines, robots, DNC / FMS systems, work holding and tool handling devices, Storage devices, sensors, shop floor data collection devices, inspection machine etc.

Computers ,Controllers, CAD /CAM systems, workstations, data entry terminals, bar code readers, printers ,plotters, modems, cables, connectors etc.

### **Elements of CIM software;**

- ⌘ MIS- management information system
- ⌘ Sales, marketing, finance
- ⌘ Data base management
- ⌘ Modeling and design
- ⌘ Analysis, simulation, communications
- ⌘ Monitoring, production control
- ⌘ Manufacturing area control, job tracking
- ⌘ Inventory control
- ⌘ Shop floor data collection,
- ⌘ Order entry, materials handling, Device drivers,
- ⌘ Process planning, manufacturing facilities
- ⌘ Work flow automation.

### **Computer/Aided Process Planning;**

- ⌘ CAPP refers to computer/aided process planning.
- ⌘ CAPP is used to overcome the drawbacks of manual process planning.
- ⌘ With the use of computers on the process planning one can reduce the routine clerical work of manufacturing engineers.
- ⌘ Also it provides the opportunity to generate rational, consistent and optimal plans.
- ⌘ Computer aided process planning system offers the potential for reducing the routine clerical work of manufacturing engineers.

### **Retrieval type CAPP (Variant type) systems;**

For each part family a standard process plan is established and stored in computer files and then it is retrieved for new work parts which belong to that family. Because of the alterations that are made in the retrieved process plan, the CAPP system is known as variant system.

### **Generative CAPP system;**

Generative process planning involves the use of computer to create an individual process plan automatically without human assistance. The computer would employ a set of algorithms to progress through the various technical and logical decisions toward a final plan.

### **Variant or Retrieval approach;**

A retrieval CAPP system, also called a variant CAPP system, has been widely used in machining applications. The basic idea behind the retrieval CAPP is that similar parts will have similar process plans. In this system., a process plan for a new part is created by recalling., identifying and retrieving an existing plan for a similar part, and making the necessary modifications for the new part.

In fact, the variant CAPP is a computer – assisted extension of the manual approach. The computer assists by providing an efficient system for data management, retrieval, editing and high speed printing of the process plans. The retrieval CAPP system has the capacity to alter an existing process plan. That's why it is also known as variant CAPP system.

### **Procedure for using Retrieval CAPP system**

A retrieval CAPP system is based on the principles of group technology (GT) and parts classification and coding. In this system, for each part family a standard process plan (i.e., route sheet) is prepared and stored in computer files. Through classification and coding, a code number is generated. These codes are often used to identify the part family and the associated standard plan. The standard plan is retrieval and edited for the new part.

### **Variant CAPP system procedure.**

- Step 1: Define the coding scheme and then adopt existing coding or classification schemes to label parts for the purpose of classification. In some extreme cases, a new coding scheme maybe developed.
- Step 2: Group the parts into part families using the coding scheme defined in Step 1 based on some common part features. A standard plan is attached to each part family (see step 3). Often, a number of part types are associated with a family, thereby reducing the total number of standard process plan.
- Step 3: Develop a standard process plan for each part family based on the common features of the part types. This process plan can be used for every part type within the family with suitable modifications.
- Step 4: Retrieve and modify the standard plan when a new part enters the system, it is assigned to a part family based on the coding and classification scheme. Then the corresponding standard process plan is retrieved and modified to accommodate the unique features of the new part.

### **Advantages of Retrieval CAPP system:**

- ⌘ Once a standard plan has been written, a variety of parts can be planned.
- ⌘ Comparatively simple programming and installation ( compare with generative CAPP systems) is required to implement a planning system.
- ⌘ Efficient processing and evaluation of complicated activities and decisions, thus reducing the time and labour requirements.
- ⌘ Standardized procedures by structuring manufacturing knowledge of the process planners to company's needs.

- ⊘ Lower development and hardware cost.

### **Draw backs of Retrieval CAPP system**

- ⊘ The components to be planned are limited to similar components previously planned.
- ⊘ Maintaining consistency in editing is difficult.
- ⊘ Experienced process planners are still required to modify the standard plan for the specific component.

### **Generative approach;**

In the generative approach, an automatic computerized system is used to synthesize or generate each individual process plan automatically and without reference to any prior plan. The automatic computerized system normally consists of decision logic, formulas, technology algorithms and geometry based data to uniquely determine the many processing decisions required for generating process plans.

Unlike the retrieval CAPP no standard manufacturing plans are predefined or stored. Instead, the computer automatically generates a unique operation/ route sheet whenever the part is ordered. Thus the generative CAPP system automatically generates the process plan based on decision logics and pre-coded algorithms. The computer stores the rules of manufacturing and the equipment capabilities (not any group of process plans).

When using a system, a specific process plan for a specific part can be generated without any involvement of a process planner. The human role in running the system includes (i) inputting the GT code of the given part design, and (ii) monitoring the function.

### **Components of Generative CAPP system**

The various components of a generative system are,

- ⊘ A part description, which identifies a series of component characteristics, including geometric features, dimensions, tolerances and surface condition.
- ⊘ A subsystem to define the machining parameters for example using look – up tables and analytical results for cutting parameters.
- ⊘ A subsystem to select and sequence individual operations.
- ⊘ Decision logic is used to associate appropriate operations with features of a component, and heuristics and algorithms are used to calculate operation steps, times and sequences.
- ⊘ A database of available machines and tooling.
- ⊘ A report generator which prepares the process plan report.

### **Advantages of Generative CAPP**

The generative CAPP has the following advantages:

- ✧ It can generate consistent process plans rapidly.
- ✧ New components can be planned as easily as existing components.
- ✧ It has potential for integrating with an automated manufacturing facility to provide detailed control information.

### **Production Planning and control;**

Production planning and control may be defined as the direction as the direction and coordination of a firm's material and physical facilities towards the attainment of pre specified Production of goods, with production efficiency.

### **Production planning;**

Deciding which products to make, how many of each, and when they should be completed. Planning the manpower and equipment resources needed to accomplish the production plan. Scheduling the production and delivery of the parts and products ;

### **Production control;**

Production control is concerned with determining whether the necessary resources to implement the production plan have been provided or not.

### **Activities of production control**

- ✧ Shop floor control
- ✧ Inventory control
- ✧ Manufacturing resource planning (MRP II)
- ✧ Just-in-time manufacturing systems.

The term **production system** may refer to:

- ✧ In operations management and industrial engineering, a production system comprises both the technological elements (machines and tools) and organizational behavior (division of labor and information flow) needed to produce something.
- ✧ In computer science, a production system (or production rule system) is a computer program typically used to provide some form of artificial intelligence.
- ✧ Toyota Production System, organizes manufacturing and logistics at Toyota
- ✧ The Computer Animation Production System (CAPS) is a proprietary collection of software, scanning camera systems, servers, networked computer workstations, and custom desks developed by The Walt Disney Company together with Pixar in the late-1980s.
- ✧ Subsea Production Systems are typical wells located on the sea floor, shallow or deep water.

**Production control** is the activity of monitoring and controlling any particular production or operation. Production control is often run from a specific control room or operations room.

### **Basic Process Control Strategies**

In a simple control system, a process variable (PV) is measured and compared with a set point value (SP). A manipulated variable (MV, or output) signal is generated by the controller and sent to a final control element, which then influences the process variable to achieve stable control. The algorithm by which the controller develops its output signal is typically PID (Proportional-Integral-Derivative), but other algorithms may be used as well.

This form of simple control may be improved upon and expanded for a greater range of process applications by interconnecting multiple controllers and/or redirecting measurement and control signals in more complex arrangements.

### **Concept of Shop floor control;**

The systems that accomplish the production planning, development of master schedule, capacity planning and materials requirement planning is called shop floor control. Shop floor control is defined as a method of controlling the work in process in the factory.

Shop floor control comprises the methods and systems used to prioritize, track, and report against production orders and schedules. It includes the procedures used to evaluate current resource status, labor, machine usage, and other information required to support the overall planning, scheduling, and costing systems related to shop floor operation. Shop floor control typically calculates work in process based on a percentage of completion for each order and operation that is useful in inventory valuations and materials planning.

Shop floor control is responsible for the detailed management of activities and the flow of materials inside the plant, including employees, materials, machines, and production time. Shop floor control activity typically begins after planning (e.g., with MRP, ERP); once planned, orders and purchase requisitions are created. Shop floor control attends to the following functions (sequentially):

- ✧ Planned orders
- ✧ Conversion of planned orders to process/production
- ✧ Production and process order scheduling
- ✧ Capacity requirements planning
- ✧ Material availability assessment
- ✧ Release of production/process orders
- ✧ Material withdrawals
- ✧ Order confirmations
- ✧ Goods receipt documentation
- ✧ Order settlement

Shop floor control may also include identifying and assessing vulnerabilities and risks due to the shop floor environment, employees, process, and the

technologies employed at the shop-floor level. Based on the assessment of these factors, shop floor control initiates measures to keep risk at an acceptable minimum level.

Best practices for shop floor control include:

- ⌘ Efficiently execute, prioritize, and release work orders to the shop floor with real-time status of progress and completion.
- ⌘ Deliver accurate and up-to-date information on materials consumption and availability, which is essential for reliable inventory planning and costing.
- ⌘ Effectively execute change management processes to ensure that the proper revision of products, bills of materials, and processes are always in place for production.
- ⌘ Automate shop floor equipment control and data collection to reduce human errors.
  - ⌘ Provide the correct manufacturing SOPs, technical drawings, and diagnostics to shop floor operators to reinforce training and ensure proper processing.
- ⌘ Download setup programs directly to equipment based on product and process specifications.

With fully interactive access to shop floor control software, supervisors can monitor shop activities and make better decisions on the spot, especially using mobile computing equipment.

Shop Floor Control are methods and systems used to prioritize, track, and report against production orders and schedules. They include the procedures used to evaluate current resource status, and the update of labor, machine hour, and other associated information as required to support the overall planning, scheduling, and costing systems.

### **Functions of shop floor control – SFC;**

- ⌘ Priority control and assignment of shop orders
- ⌘ Maintain information on work in process for MRP.
- ⌘ Monitor shop order status information.
- ⌘ Provide production output data for capacity control processes.

### **Shop floor control**

The three phases of shop floor control

1. Order release
2. Order scheduling
3. Order progress

### **Purpose of order release in SFC;**



The purpose of order release module is to provide the necessary documentation that accompanies an order as it processed through the shop. These documents collectively called as shop packets.

The order progress module performs the remaining three functions of SFC.

- ✧ To provide data relative to work in process
- ✧ Shop order status
- ✧ Capacity control.

### **Data structure:**

Data structure is a diagrammatic representation of a data base. It shows the record types used and the relationships between them. Data Base Management System consists of a collection of interrelated data and a set of programs to access that data.

### **Functions of a Data Management system;**

User functions:

- ✧ Data vault and document management
- ✧ Process and work flow management
- ✧ Product structure management
- ✧ Data classification and retrieval
- ✧ Project management

Utility functions:

- ✧ Data communication and notification
- ✧ Data transport
- ✧ Data translation
- ✧ Image services
- ✧ System administration.

### **Factory Data Collection System;**

FDC system is used to collect data for monitoring order progress in SFC. The following are important data collected by the FDC system.

- ✧ Number of products (piece counts) completed at a certain machine.
- ✧ Number of parts scrapped (or) Number of parts reworked.
- ✧ Direct labor time spent
- ✧ Equipment breakdown.

### **Purpose of data collection system;**

The purpose of the data collection system in shop floor control is to provide basic data for monitoring order progress.

In computerized SFC system the data are submitted to the order progress module for analysis and generation of work order status reports and exception reports.

**Types of data collection systems;**

- ⌘ On-line data collection systems
- ⌘ Off-line data collection systems

**Types of data collected from the shop floor;**

- ⌘ Machine data,
- ⌘ Operator data,
- ⌘ Tooling data,
- ⌘ Data relating to jobs to be done,
- ⌘ Materials data,
- ⌘ Materials handling data,
- ⌘ Scheduling data,
- ⌘ Process planning data, and
- ⌘ Inspection data.
- ⌘ Data collection techniques in shop floor control?
- ⌘ Job traveler
- ⌘ Employee time sheet
- ⌘ Operation tear strips or punched cards included with shop packet
- ⌘ Centralized shop floor terminals
- ⌘ Individual work centre terminals

**Computer process monitoring (Computer assisted data collection systems);**

Computer process monitoring is a data collection system in which the computer is directly connected to the workstation and associated equipment for the purpose of observing the operation.

**Components used to build a computer process monitoring system**

- ⌘ Transducers and sensors,
- ⌘ Analog to digital converters (ADC),
- ⌘ Multiplexers,
- ⌘ Real time clocks, and
- ⌘ Other electronic devices
- ⌘ Configurations of computer assisted data collection systems
- ⌘ Or (Automated data collection system)?
- ⌘ Data logging systems
- ⌘ Data acquisition systems
- ⌘ Multilevel scanning

**Types of data collection systems;**

- ⌘ On-line data collection systems
- ⌘ Off-line data collection systems

### **Factory Data Collection System**

- ☞ On-line versus batch systems
- ☞ Data input techniques
  - ☞ Job traveler
  - ☞ Employee time sheets
  - ☞ Operation tear strips
  - ☞ Prepunched cards
  - ☞ Providing key board based terminals