UNIT – V
Computer-Aided Quality Control

INTRODUCTION

The quality control (QC) function has traditionally been performed using manual inspection methods and statistical sampling procedures.

- **Manual inspection** is generally a time-consuming procedure which involves precise, yet monotonous work. If often requires that parts be removed from the vicinity of the production machines to a separate inspection area. This causes delays and often constitutes a bottleneck in the manufacturing schedule.
- Inherent in the use of **statistical sampling** procedures is acknowledgment of the risk that some defective parts will slip through. Indeed, statistical quality control attempts to guarantee that a certain expected or average fraction defect rate will be generated during the production/inspection process. The nature of traditional statistical QC procedures is that something less than 100% good quality must be tolerated.
- There is another aspect of the traditional QC inspection process which detracts from its usefulness. It is often performed after the fact. The measurements are taken and the quality is determined after the parts are already made. If the parts are defective, they must be scrapped or reworked at a cost which is often greater than their original costto manufacture.

All of these various factors are driving the quality control function toward what we are calling computer-aided quality control (CAQC). Other terms that have been applied to describe this movement are "computer-aided inspection" (CAI) and "computer-aided testing" (CAT).

The objectives of computer-aided quality control are ambitious, yet straight forward. They are:

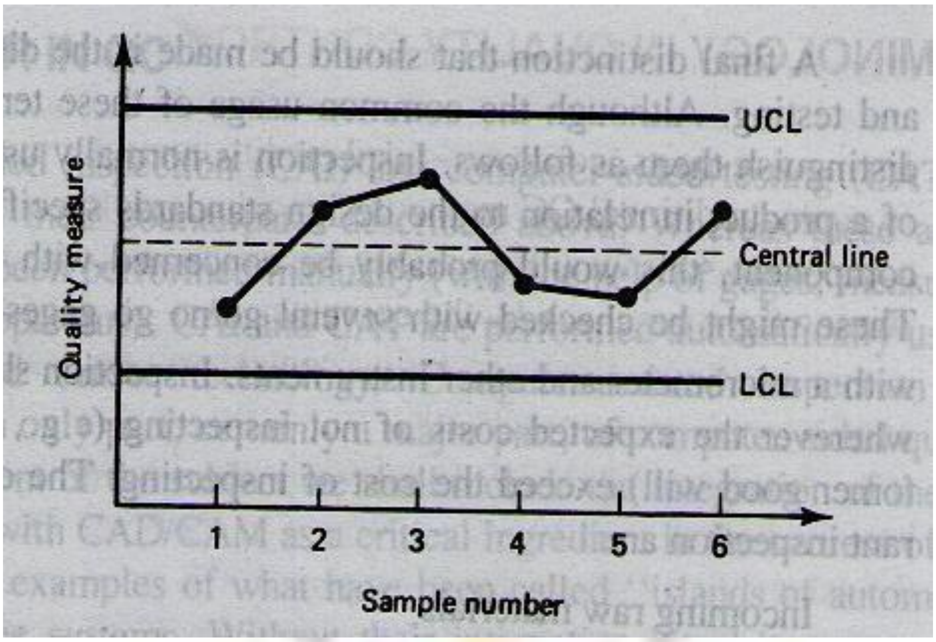
1. To improve product quality
2. To increase productivity in the inspection process
3. To increase productivity and reduce lead times in manufacturing

The strategy for achieving these objectives is basically to automate the inspection process through the application of computers combined with advanced sensor technology. Wherever technically possible and economically feasible, inspection will be done on a 100% basis rather than sampling.

TERMINOLOGY IN QUALITY CONTROL

- ✓ **Quality** in a manufacturing context can be defined as the degree to which a product or its components conform to certain standards that have been specified by the designer. The design standards generally relate to the materials, dimensions and tolerances, appearance, performance, reliability, and any other measurable characteristic of the product.
- ✓ **Quality assurance (QA)** is concerned with those activities which will maximize the probability that the product and its components will be manufactured within the design specifications. These activities should start in the product design area, where the designer can make decisions among alternatives that might have quality consequences. QA activities continue in manufacturing planning, where decisions relative to production equipment, tooling, methods, and motivation of employees will all have an influence on quality.
- ✓ **Quality control** is concerned with those activities related to inspection of product and component quality, detection of poor quality, and corrective action necessary to eliminate poor quality. These activities also involve the planning of inspection procedures and the specification of the gages and measuring instruments needed to perform the inspections.
- ✓ **Statistical** QC is generally divided into two categories: **acceptance sampling** and **control charts.**
  - Acceptance sampling is a procedure in which a sample is drawn from a batch of parts in order to assess the quality level of the batch and to determine whether the batch should be accepted or rejected. Acceptance sampling is based on the statistical notion that the quality of a random sample drawn from a larger population will be representative of the quality of that population.
  - Control charts are used to keep a record over time of certain measured data colected from a process. A company would use control charts to monitor its own production processes. The central line indicates the expected quality level of the process. The upper and lower control limits (UCL and LCL) are statistical measures of the variation in the process which would be tolerated

without concluding that the process has erred. when these limits are exceeded, it usually means that something has changed the process, and an investigation should be initiated to deteimine the cause



- ✓ Both acceptance sampling and control charts can be applied to two situations in quality control: fraction defects and measured variables.
  - In the **fraction-defect** case, the objective is to determine what proportion of the sample (and the population from which it came) are defective. This is often accomplished by a go/no go gage, which can quickly determine whether a part is within specification or not.
  - In the **measured-variable** case, the object is to determine the value of the quality characteristic of interest (e.g., dimension, resistance, hardness, etc.). This requires the use of a measuring instrument of some kind (e.g., micrometer, ohmeter, hardness tester, etc.) and is normally a more time-consuming manual process than the go/no go case.
- ✓ **Inspection** is normally used to examine a component of a product in relation to the design standards specified for it. For a mechanical component, this would probably be concerned with the dimensions of the part. These might be checked with several go/no go gages or they might be measured with a micro meter and other instruments. The corfion situations that warrant inspection are:
  - Incoming raw materials
  - At various stages during manufacturing (e.g., when the parts are moved

fromone production department to another)

- At the completion of processing on the parts
- Before shipping the final assembled product to the customer

✓ **Testing**, on the other hand, is normally associated with the functional aspects of the item, and it is often directed at the final product rather than its components. In this usage, testing consists of the observation of the final product during operation under actual or simulated conditions. If the product passes the test, it is deemed suitable for sale. Several categories of tests used for final product evaluation:

- Simple functional tests under normal or simulated normal operating conditions
- Functional tests in which the product is tested under extreme (usually adverse conditions)
- Fatigue or wear tests to determine how long the product will function until Failure.
- Overload tests to determine the level of safety factor built into the product
- Environmental testing to determine how well the product will perform under different environments (e.g., humidity, temperature)

THE COMPUTER IN QC

CAI and CAT are performed automatically using the latest computer and sensor technology. Computer-assisted inspection and testing methods form only part, certainly a major part, of computer-aided quality control. In our treatment of the subject we shall include the integration of the quality control function with CAD/CAM as a critical ingredient in the success of CAQC.

The implications of the use of computer-aided quality control are important. The automated methods of CAQC will result in significant changes from the traditional concepts and methods. The following list will summarize the important effects likely to result from CAQC.

1. With CAI and CAT, inspection and testing will typically be accom plished on a 100% basis rather than by the sampling procedures normally used in traditional QC.
2. Inspection during production will be integrated into the manufacturing process rather than requiring that the parts be taken to some inspection area. This will help to reduce the elapsed time to complete the parts. On line will have to be accomplished in much less time than with current manual techniques.
3. The use of noncontact sensors will become much more widely used with computer-aided inspection. With contact inspection devices, the part must usually be stopped and often repositioned to allow the inspection device to be applied properly. With

noncontact sensor devices, the part can often be inspected "on the fly." These devices,

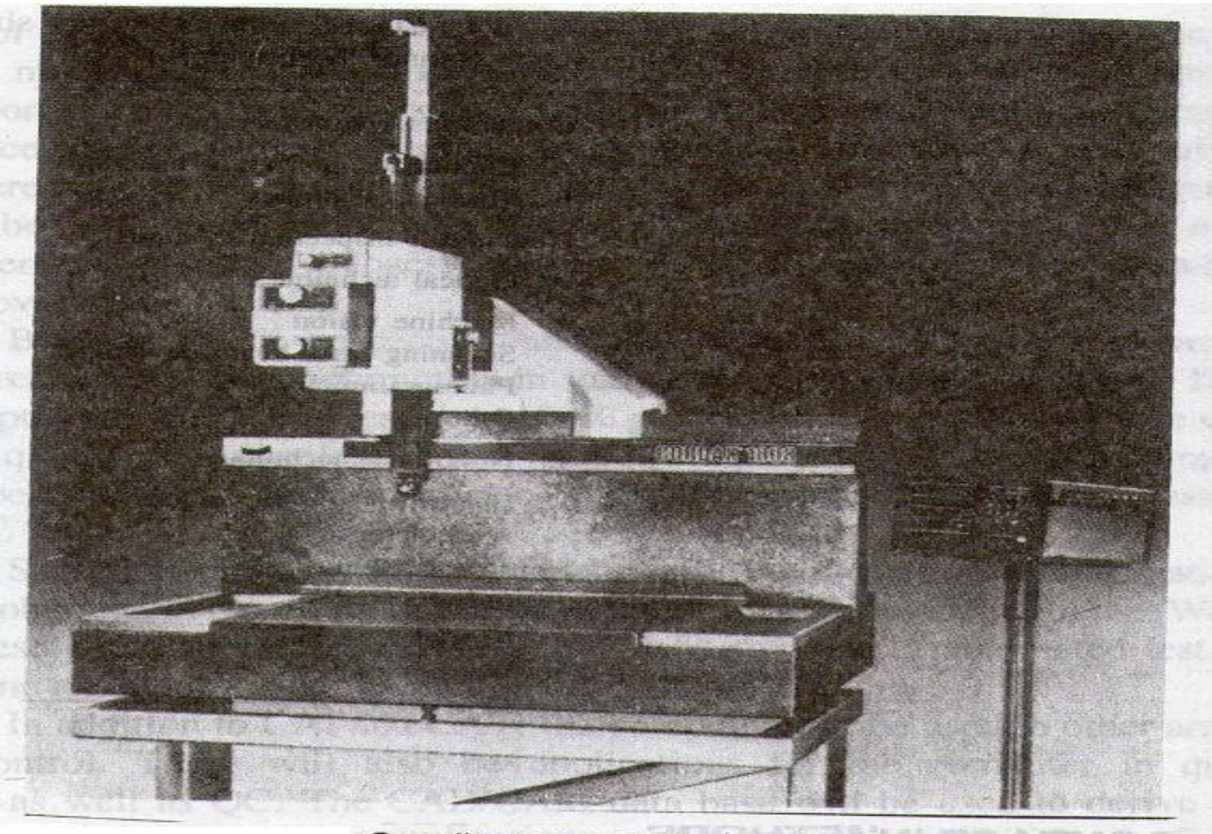
driven by the high-speed data processing capability of the computer, can complete the inspection in a small fraction of a second.

4. The on-line noncontact sensors will be utilized as the measurement component of computerized feedback control systems. These systems will be capable of making adjustments to the process variables based on analysis of the data collected by the sensors. Data would be plotted. This would not only allow out of tolerance conditions to be identified, but gradual shifts in the process could also be uncovered and corrective action taken. By regulating the process in this manner, parts will be made much closer to the desired nominal dimension rather than merely within tolerance. Quality feedback control systems will help to reduce scrap losses and improve product quality.
5. With computer-aided inspection technology, it may no longer be necessary to settlefor less than perfection.
6. Robots will be used increasingly in future inspection applications
7. There will also be applications for the computer in quality assurance as well as QC. The CAD/CAM data base will be used to derive these various quality applications,
8. There will be CAI and CAT take its place, manual inspection activity will be reduced. Quality control personnel will have to become more computer-wise and technologically sophisticated to operate the more complex inspection and testing equipment and to manage the information that will result from these more automated methods.

CONTACT INSPECTION METHODS

The contact methods usually involve the use of coordinate measuring machines (CMM). Most of these machines today are either controlled by NC or computers. The coordinate measuring machine (CMM) is the most prominent example of the equipment used for contact inspection of workparts. It consists of a table which holds the part in a fixed, registered position and a movable head which holds a sensing probe. The probe can be moved in three directions, corresponding to the x, y, and z coordinates. During operation, the probe is brought into contact with the part surface to be measured and the three coordinate positions are indicated to a high level of accuracy.
Today's coordinate measuring machines are computer controlled. The operation of the machine is similar to an NC machine tool in which the movement of the measuring probe is either tape controlled or computer controlled. Programs and coordinate data can be

downloaded from a central computer, much in the manner of direct numerical control. Also similar to DNC is the capability to transmit data from the CMM back up to the host computer.



Coordinate measuring machine.

Savings in inspection time by using coordinate measuring machines are significant. Typically, between 5 and 10% of the time is required on a CMM com pared to traditional manual inspection methods. Other advantages include consistency in the inspection process from one part to the next which cannot be matched by manual inspection, and reductions in production delays to get approval of the first workpiece in a batch.

The coordinate measuring machine is physically located away from the production machine, usually in a separate area of the shop. Accordingly, the parts must be transported from the production area to the CMM. In fact, if inspection is required at several different stages of production, several moves will be involved. One possible approach to overcome this problem is to use inspection probes mounted in the spindle of the machine tool. These inspection probes are contact sensing devices that operate with the machine tool much like the coordinate measuring machine.

NONCONTACT INSPECTION METHODS

The noncontact methods are divided into two categories for our purposes:

1. Optical
   a. Machine vision
   b. Scanning laser beam devices
   c. Photogrammetry
2. Non Optical
   a. Electric Fiel techniques
   b. Radiation techniques
   c. Ultrasonic

NONCONTACT INSPECTION METHODS- OPTICAL

The advantages of noncontact inspection are:

1. It usually eliminates the need to reposition the work part.
2. Noncontact inspection is usually much faster than contact inspection.
3. It eliminates mechanical wear encountered with the contacting inspection probebecause it eliminates the probe.
4. It reduces potential danger to people, who must touch a hazardous material ifcontact inspection is used.
5. It removes the possibility of damage to the surface of a part which migh result duringcontact inspection.

Machine vision

Other names given to these systems include microprocessor-based television and computer vision. The typical machine vision system consists of a TV camera, a digital computer, and an interface between them that functions as a preprocessor. The combination of system hardware and software digitizes the picture and analyzes the image by comparing it with data stored in memory. The data are often in the form of a limited number of models of the objectswhich are to be inspected. There are several limitations of machine vision;

- The first limitation is concerned with the problem of dividing the picture into picture elements. This is very similar to the problem encountered in the development of graphics terminals for computer-aided design.

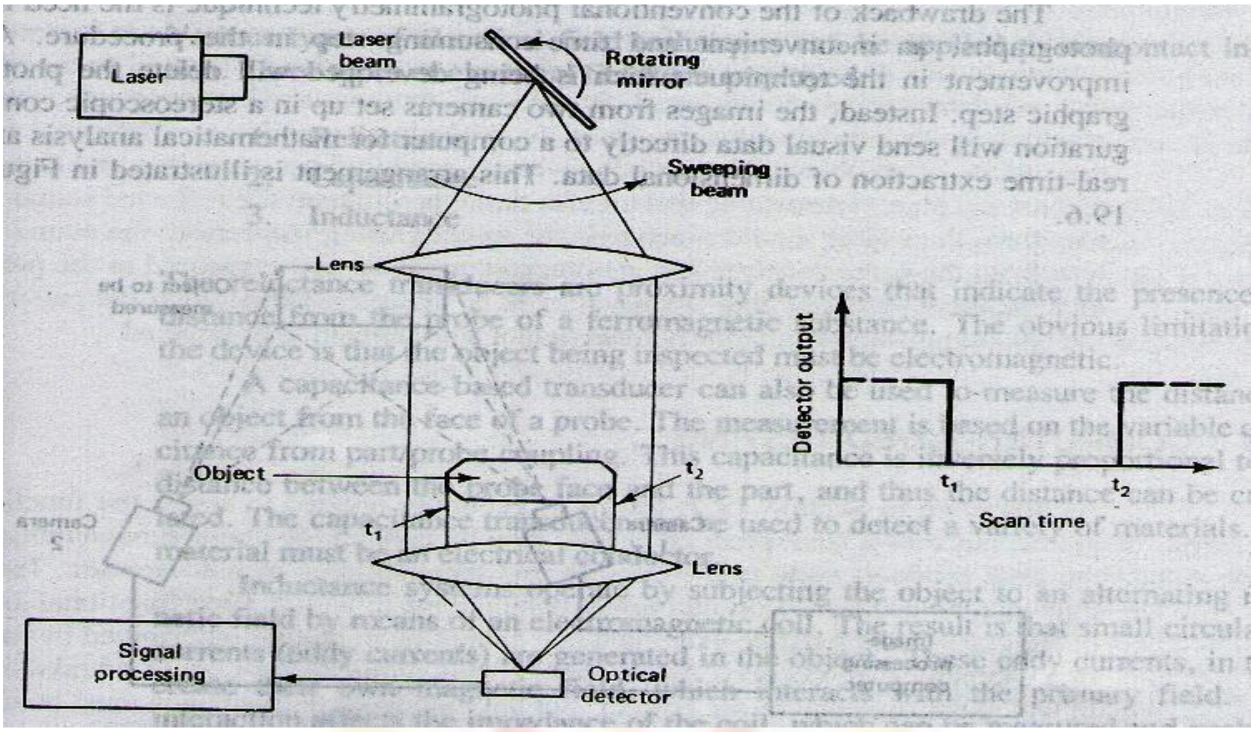
- A second limitation is that the object in front of the camera must be capable of being divided into areas of contrasting lightness and darkness.
- Third limitations is on the capability of machine vision systems recognize the object in the viewing area.

Machine vision inspection problems can be divided into two categories:

1. Noncontact gaging of dimensions - Noncontact gaging in machine vision involves the inspection of part size and other features where it is not necessary to process the image of the entire part out line, only those portions that must be examined for dimensional accuracy. During setup for an inspection, a parts-training program is used to view the workpart of interest on a TV monitor. With the image in fixed position on the screen, the operator manipulates a cursor to define the edges of interest and to apply an appropriate scale factor to establish the correct units of measure.
2. Inspection based on pattern recognition of object features - It is based on pattern recognition techniques. In this category, the attributes of the object to be inspected are typically more subjective and in some respects more complicated than part dimensions. The machine vision pattern recognition process can be conceptualized as involving a comparison of features (for example, area, perimeter, and so on) between the object being inspected and the model of the object stored in computer memory.

Scanning laser beam devices

The scanning laser beam device relies on the measurement of time rather than light, although a light sensor is required in its operation. The schematic diagram of its operation is pictured in Figure. A laser is used to project a continuous thin beam of light. A rotating mirror deflects the beam so that it sweeps across the object to be measured. The light sensor is located at the focal point of the lens system to detect the interruption of the light beam as it is blocked by the object. The time lapse corresponding to the interruption of the light beam is meas ured to determine the desired dimension of the part. Typically, a microprocessor is programmed to make the conversion of the time lapse into a dimensional value and to perform other functions, such as signaling an automatic parts-rejection mechanism to eject a defective part from the line.

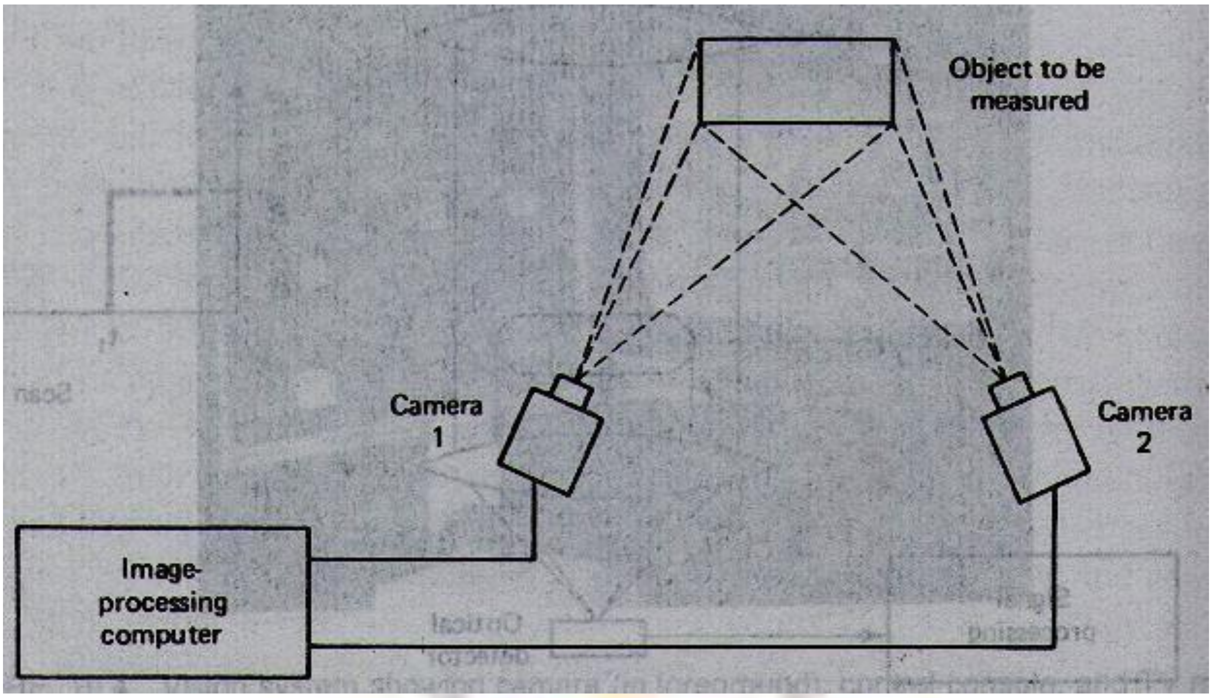


Photogrammetry

Photogrammetry involves the extraction of three-dimensional data from a pair of photographs taken at different angles. The two photographs can be combined much in the way that a stereoscope uses a pair of photographs to form a three-dimensional image for the viewer.

In the measurement process used for inspection, the two photographs are read by a device called a mono comparator to establish coordinates and positions of objects. These data are then computer-analyzed to extricate the desired information.

The drawback of the conventional photogrammetry technique is the need for photographs, an inconvenient and time-consuming step in the procedure. An improvement in the technique which is being developed will delete the photo graphic step. Instead, the images froiri two cameras set up in a stereoscopic configuration will send visual data directly to a computer for mathematical analysis and real-time extraction of dimensional data. This arrangement is illustrated in Figure.



NONCONTACT INSPECTION METHODS NONOPTICAL

In addition to noncontact inspection methods based on optical systems, nonoptical approaches can also be used. We will describe three general types which are quite representative of the current technology in this area. The three general types are:

1. Electrical field techniques
2. Radiation techniques
3. Ultrasonics

Electrical field techniques

Various types of electrical field techniques can be applied to noncontact inspection. Three types of electrical fields are employed:

1. Reluctance - The reluctance transducers are proximity devices that indicate the presence and distance from the probe of a ferromagnetic substance. The obvious limitation of the device is that the object being inspected must be electromagnetic.
2. Capacitance - A capacitance-based transducer can also be used to measure the distance of an object from the face of a probe. The measurement is based on the variable capacitance from part/probe coupling. This capacitance is inversely proportional to the distance between the probe face and the part, and thus the

distance can be calculated. The capacitance transducer can be used to detect a variety of materials. The material must be an electrical conductor

3. Inductance - Inductance systems operate by subjecting the object to an alternating magnetic field by means of an electromagnetic coil. The result is that small circulating currents (eddy currents) are generated in the object. These eddy currents, in turn, create their own magnetic field, which interacts with the primary field. This interaction affects the impedance of the coil, which an be measured andanalyzed to determine certain characteristics about the object

Radiation Techniques

X- ray radiation techniques are employed for purposes of noncontact inspection in the metals and metalworking industry. The amount of radiation absorbed by a material can be used to measure its thickness and other quality characteristics. In a typical application in a rolling mill, an X-ray scanning unit measure the thickness of the plates or strips going through the rolls so that the proper adjustments can be made in the rollers. X-ray techniques are also used to inspect weld quality in fabricated steel and aluminum pressure vessels and pipes. In this case the radiation can be used to detect flaws and voids in the weld.

Ultrasonics

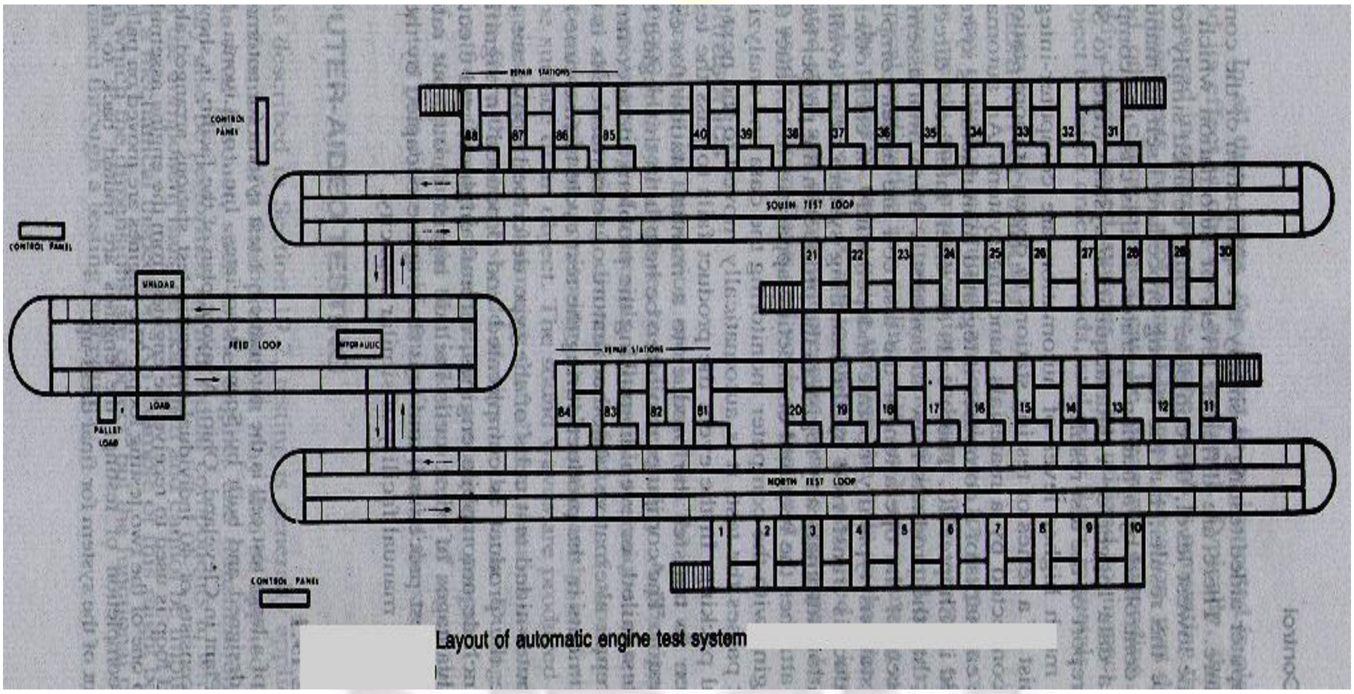
Ultrasonics in inspection work involves the use of very high frequency (above 20,000 Hz) sound waves to indicate quality. A principal application is in nondes tructive testing of materials. Ultrasonic techniques can also be applied to the problem of determining dimensional features of workparts. One approach, called acoustical phase monitoring, involves the analysis of sound waves reflected from the surface of an object. The sound waves are produced by an emitter and directed against the object. Assuming that all else remains constant, the reflected sound pattern from the object should always be the same. During inspection, the sound pattern from the part is analyzed by a computer program and compared to the pattern of a standard part, one that is known to be of acceptable quality. If the pattern of the test part differs significantly from that of the standard, it is rejected.

COMPUTER-AIDED TESTING

Testing is generally applied to assess the functional performance of a final product. It may also be applied for major subassemblies of the final product, such as the engines and transmissions of automobiles. Testing may also be performed on individual components in which some functional aspect of the component must be examined and cannot be implicitly determined by means of a mechanical inspection. An example of this might be the case of a brake lining in which the dimensions are correct, but the functional performance must be determined through a testing procedure.

Computer-aided testing is simply the application of the computer in the testing procedure. There are different levels of automation which can be found CAT. At the lowest level, the computer would be used simply to monitor the test and analyze the results, but the testing procedure itself is manually set up, initiated, and controlled by a human operator. In this case the computer receives the data from a data logger or a data acquisition system and prepares a report of the test results

Computer-aided test cells are applied in situations where the product is complicated andproduced in significant quantities, Examples include automobile engines, aircraft engines,and electronic integrated circuits. Advantages of these cells include higher throughput rates,greater consistency in the test procedure, and less floor space occupied by the automated cell As compared to a manual facility of similar capacity.



Layout of automatic engine test system

INTEGRATION OF CAQC WITH CAD/CAM

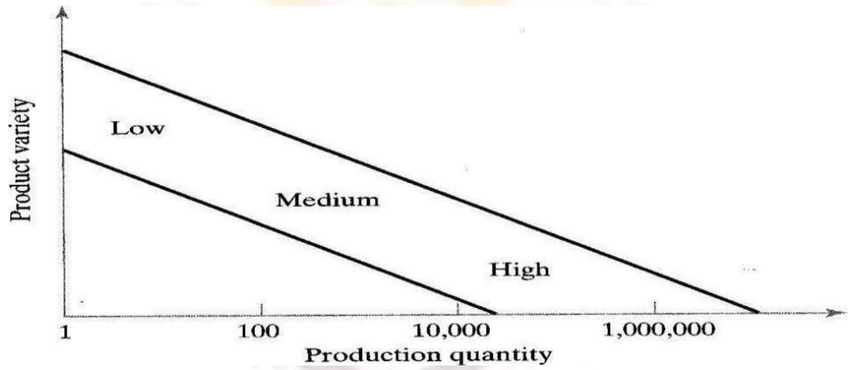
Although many important benefits result from the use of computer-aided quality control,additional benefits can be obtained by integrating CAQC with CAD/CAM.

- The design department creates the product definition and the manufacturing department makes use of and supplements this definition to develop the manufacturing plan. It is important to add the QC connection to the CAD/CAM framework.

- The quality control department must use the same CAD/CAM data base to perform its function. These quality standards are all contained in the CAD/CAM data base, available for QC to use.
- One way in which the data base can be used is to develop the NC programs to operate the tape-controlled or computer-controlled coordinate measuring machines. Theseprograms can be generated automatically.
- These programs would then be down loaded to the CMM through a DNC link from the central computer to the controller unit for the CMM. The same sort of downloading process is possible for some of the noncontact inspection methods.
- Another way in which a common data base is helpful to QC is when engineering changes are made to the product. It is helpful for any changes to be recorded in a common data file for all departments, including QC, to use.
- Another area where CAD/CAM benefits the QC function is in computer production monitoring. The types of production records that are generated during computer monitoring are sometimes useful to the quality control department in tracing the causeof poor quality in a particular production lot.

FLEXIBLE MANUFACTURING SYSTEM (FMS)

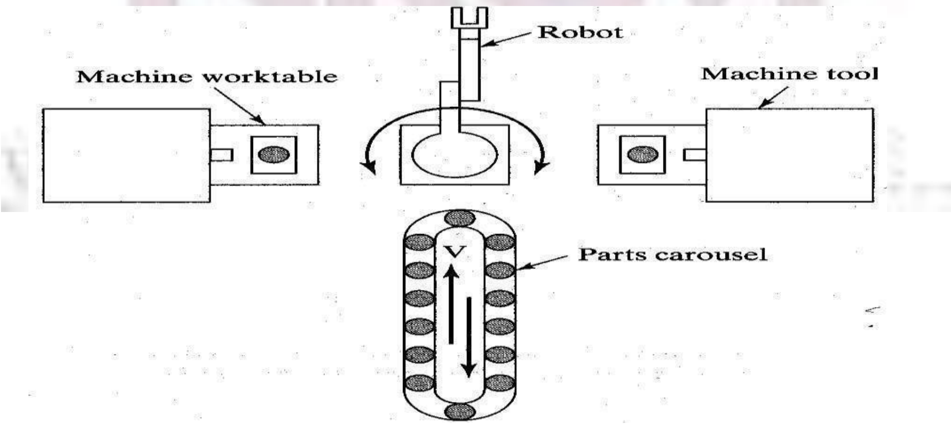
- ***A flexible manufacturing system (FMS)*** is a highly automated GT machine cell, consisting of a group or processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.
- The reason the FMS 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.
- The FMS is most suited for the mid-variety, mid-volume production range



What Make It Flexible?

Three capabilities that a manufacturing system must possess to be a flexible.

1. The ability to identify and distinguish among the different part styles processed by thesystem.
1. Quick changeover of operating instructions, and
2. Quick changeover of physical setup.



Tests of Flexibility

To qualify as being flexible, a manufacturing system should satisfy several criteria. Thefollowing are four reasonable tests of flexibility in an automated manufacturing system:

- *Part variety test.* Can the system process different part styles in a nonbatch mode?
- *Schedule change test.* Can the system readily accept changes in production schedule,and changes in either part mix or production quantity.
- *Error recovery test.* Can the system recover quickly from equipment breakdowns, sothat the production is not completely disrupted?
- New *part test.* Can new part designs be introduced into the existing product mix withrelative ease.

If the answer to all of these quest ions is –YES‖ for a given manufacturing system, then thesystem can be considered flexible.

Types of Flexibility in Manufacturing

Flexibility Type	*Definition*	*Depends on Factors Such As:*
Machine flexibility	Capability to adapt a given machine (workstation) in the system to a wide range of production operations and part styles. The greater the range of operations and part styles, the greater the machine flexibility.	Setup or changeover time. Ease of machine reprogramming (ease with which part programs can be downloaded to machines). Tool storage capacity of machines. Skill and versatility of workers in the system.
Production flexibility	The range or universe of part styles that can be produced on the system.	Machine flexibility of individual stations. Range of machine flexibilities of all stations in the system.
Mix flexibility	Ability to change the product mix while maintaining the same total production quantity; that is, producing the same parts only in different proportions.	Similarity of parts in the mix. Relative work content times of parts produced. Machine flexibility.
Product flexibility	Ease with which design changes can be accommodated. Ease with which new products can be introduced.	How closely the new part design matches the existing part family. Off-line part program preparation. Machine flexibility.
Routing flexibility	Capacity to produce parts through alternative workstation sequences in response to equipment breakdowns, tool failures, and other interruptions at individual stations.	Similarity of parts in the mix. Similarity of workstations. Duplication of workstations. Cross-training of manual workers. Common tooling.
Volume flexibility	Ability to economically produce parts in high and low total quantities of production, given the fixed investment in the system.	Level of manual labor performing production. Amount invested in capital equipment.
Expansion flexibility	Ease with which the system can be expanded to increase total production quantities.	Expense of adding workstations. Ease with which layout can be expanded. Type of part handling system used. Ease with which properly trained workers can be added.

Comparison of Four Criteria of Flexibility in a Manufacturing System and the Seven

Flexibility Tests or Criteria	*Type of Flexibility (Table 16.1)*
1. ***Part variety test.*** Can the system process different part styles in a non–batch mode?	Machine flexibility Production flexibility
2. ***Schedule change test.*** Can the system readily accept changes in production schedule, changes in either part mix or production quantities?	Mix flexibility Volume flexibility Expansion flexibility
3. ***Error recovery test.*** Can the system recover gracefully from equipment malfunctions and breakdowns, so that production is not completely disrupted?	Routing flexibility
4. ***New part test.*** Can new part designs be introduced into the existing product mix with relative ease?	Product flexibility

Types of Flexibility

COMPONENTS OF FMS

There are several basic components of an FMS:

1. Workstations.
2. Material handling and storage systems.
3. Computer control system.

WORKSTATIONS

• Following are the types of workstations typically found in an FMS:

1. Load/Unload Stations.
2. Machining Stations.
3. Other processing Stations. (punching, shearing, welding, etc.)
4. Assembly Station.
5. Other Stations and Equipment. (Inspection, Vision, etc)

Material Handling and Storage System

Functions of the Handling System

1. Independent movement of work parts between stations.
2. Handle a variety of work part configurations.
3. Temporary storage.
4. Convenient access for loading and unloading work parts.
5. Compatible with computer control.

Material Handling Equipment

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

1. Primary handling system establishes the basic layout of the FMS and is responsiblefor moving work parts between stations in the system. (Conveyor)
2. Secondary handling system consists of transfer devices, automatic pallet changing, and similar mechanisms located at the workstations in the FMS.

The function of the secondary handling system is to transfer work from the primary system to the machine tool or other processing station and to position the parts with sufficient accuracy and repeatability to perform the process or assembly operation.

Computer Control System

The FMS includes a distributed computer system that is interfaced to

- ❖ Workstations,
- ❖ Material handling system, and
- ❖ Other hardware components.

A typical FMS computer system consists of a central computer and microcomputers.

- ❖ Microcomputers controlling the individual machines and othercomponents.
- ❖ The central computer coordinates the activities of the components toachieve smooth overall operation of the system

Production control—management of the mix and rate at which various parts are launched into the system is important; alongside data input of a number of essential metrics, such as: daily desired production rates, number of raw work parts available, work-in-progress etc.

Traffic control—management of the primary handling system is essential so that parts arrive at the right location at the right time and in the right condition

Shuttle control—management of the secondary handling system is also important, to ensure the correct delivery of the work part to the station's work head

Work piece monitoring—the computer must monitor the status of each cart or pallet in the primary and secondary handling systems, to ensure that we know the location of every element in the system

Tool control—this is concerned with managing tool location (keeping track of the different tools used at different workstations, which can be a determinant on where a part can be processed), and tool life (keeping track on how much usage the tool has gone through, so as to determine when it should be replaced)

Performance monitoring and reporting—the computer must have collected data on the various operations on-going in the FMS and present performance findings based on this

Diagnostics—the computer must be able to diagnose, to a high degree of accuracy, where a problem may be occurring in the FMS

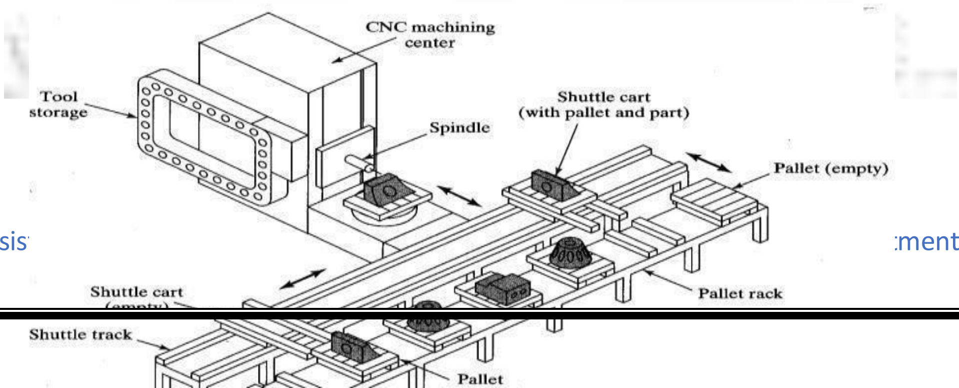
TYPES OF FMS SYSTEMS

Flexible manufacturing systems can be distinguished according to the number of machinesin the system. The following are typical categories:

- Single machine cell (Type I A)
- Flexible manufacturing cell (usually type II A, sometimes type III A)
- Flexible manufacturing system (usually Type II A, sometimes type III A)

Single Machine Cell (SMC)

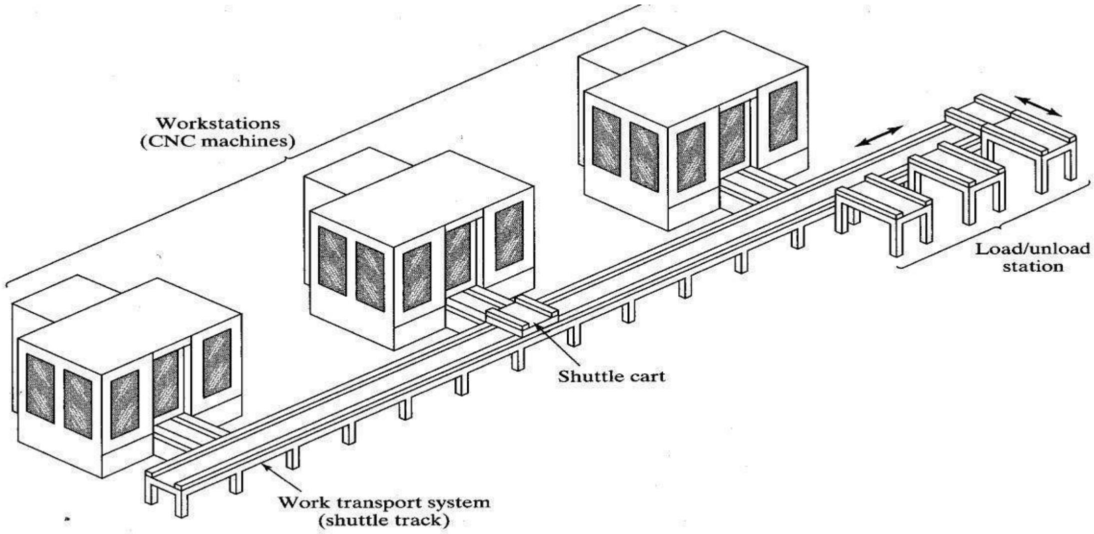
A single machine cell consists of one CNC machining center combined with a parts storage system for unattended operation. Completed parts are periodically unloaded from the parts storage unit, and raw work parts are loaded into it



Flexible Manufacturing Cell (FMC)

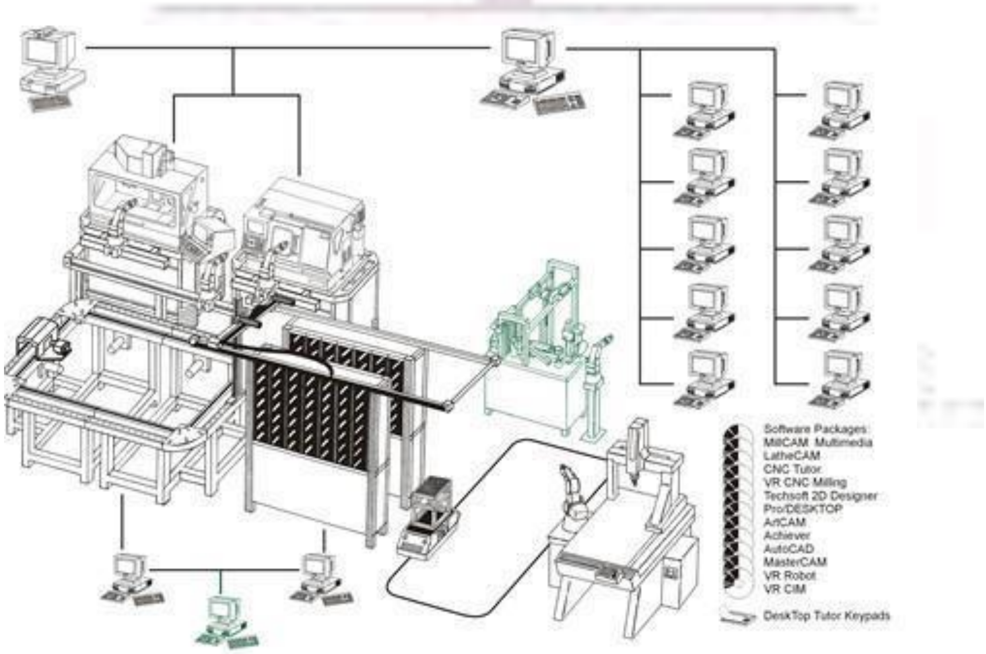
❖ A flexible manufacturing cell consists of two or three processing workstations (typically CNC machining centers) plus a part handling system.

❖ The part handling system is connected to a load/unload station.



Flexible Manufacturing System (FMS)

A flexible manufacturing system has four or more processing workstations connected mechanicallyby a common part handling system and electronically by a distributed computer system.



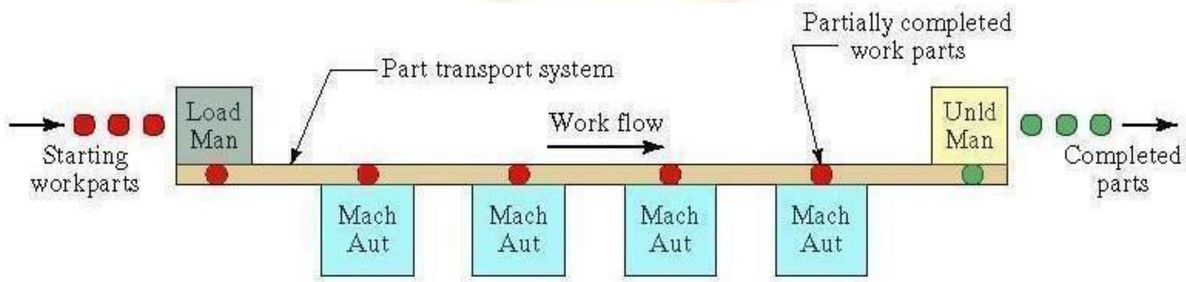
FMS LAYOUTS

The material handling system establishes the FMS layout. Most layout configurationsfound in today's FMS are:

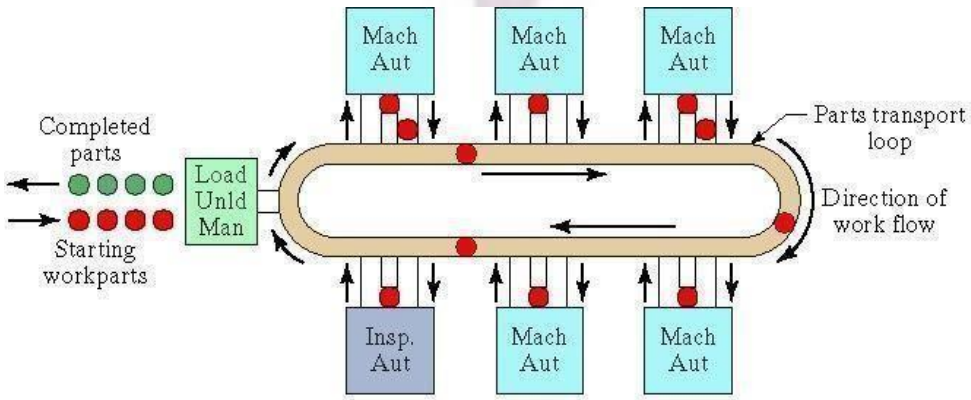
In-line Layout:

All the machine tools are kept along a straight line as shown in Figure. This is the simplest form and is generally used for smaller number of machines in a system. The parts move inwell-defined sequences and the workflow is generally in both the directions. The Part handling at the individual workstations is performed by the transport vehicle, which will havethe necessary pallet changer. Often The machine tools used in such a system are identical, sothat the part routing will not be a problem.

Loop Layout:



Workstations are organized in a loop that is served by a looped parts handling system. In Figure parts usually flow in one direction around the loop with the capability to stop and be transferred to any station. Each station has secondary handling equipment so that part can be brought-to and transferred-from the station work head to the material handling loop. Load/unload stations are usually located at one end of the loop.

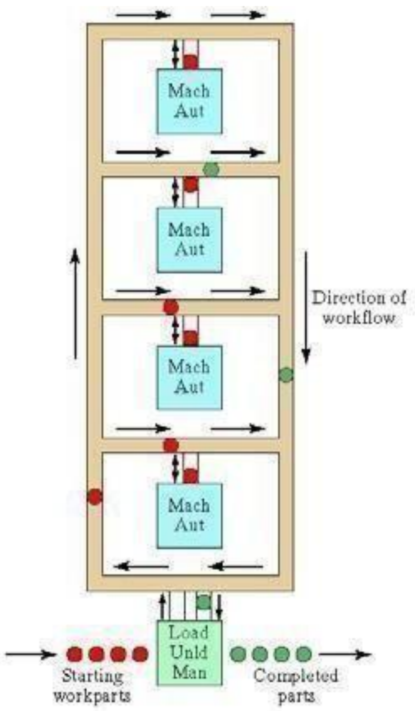


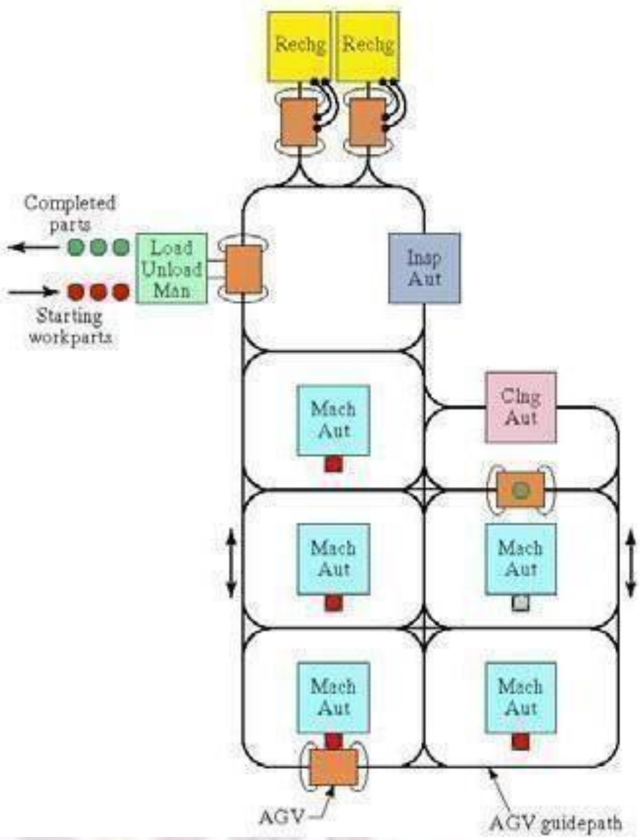
Ladder Layout:

This consists of a loop with rungs upon which workstations are located. The rungs increase the number of possible ways of getting from one machine to the next, and obviates the need for a secondary material handling system. It reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between stations.

Open Field Layout:

Consists of multiple loops and ladders, and may include sidings also. This layout is generally used to process a large family of parts, although the number of different machine types may be limited, and parts are usually routed to different workstations–depending on which one becomes available first.





HUMAN RESOURCES

Human are needed to manage the operations of the FMS. Functions typically performedby human includes:

- Loading raw work parts into the system
- Unloading finished parts (or assemblies) from the system,
- Changing and setting tools,
- Equipment maintenance and repair,
- NC part programming in a machining system, and
- Programming and operation the computer system.

ADVANTAGES OF FMS

1. Flexible manufacturing systems are regarded as one of the most efficient methods to employ in reducing or eliminating problems in manufacturing industries.
2. FMS brings flexibility and responsiveness to the manufacturing floor.
3. FMS enables manufacturing to machine a wide variety of work places on few machines with low staffing levels, productively reliably and predictably.
4. FMS shortens the manufacturing process through improved operational control round the clock availability of automated equipment, increases machines utilization and responsiveness, and reduction of human intervention.
5. Better competitive advantage.
6. Lower work in process inventories.
7. Reduced through put time and its variability.
8. Improved manufacturing control.
9. Improved quality and reduced scrap rate.
10. Reduction of floor space used.
11. Better status monitor of machines tools and material handling devices.

DISADVANTAGES OF FMS

1. FMS is a complex system.
2. Requires highly skilled technicians.
3. Needs high level of planning.
4. Demands high initial investment.

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