The Review of Modern Smart Manufacturing Systems

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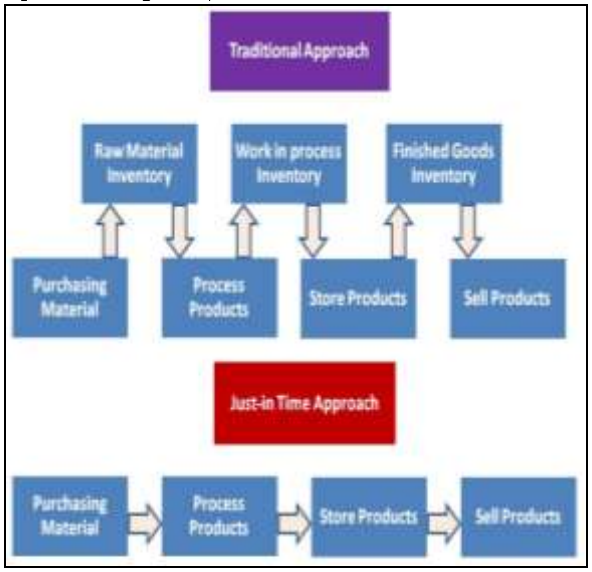
Abstract

In the world of manufacturing, there are a lot of systems to choose from, each with its ideal use and set of advantages and drawbacks. Having the appropriate manufacturing system for your product can yield a variety of benefits, including the ability to maintain the high quality of your goods, being more efficient in your production processes and saving money across the board. The right system can also help you produce higher volumes, thereby meeting your production volume targets. It is a method of organizing production. Many types of manufacturing systems are in place, including assembly lines, batch production and computer integrated manufacturing. A manufacturing system consists of the following components: production machines (plus associated tooling); a material handling system; a computer system for co-ordination and/or control; and human workers. Most manufacturing in modern-day manufacturing systems is done by machines of one form or another. Manufacturing system is of two types: Intermittent Manufacturing/Production System, Continuous Manufacturing/Production System. Types of Production System include Intermittent Production System, Continuous Production System (Production to Order) (Production to Stock), Job Production, Mass Production, Batch Production Process. A manufacturing system can be defined as the arrangement and operation of machines, tools, material, people and information to produce a value-added physical, informational or service product whose success and cost is characterized by measurable parameters. Manufacturing engineering or manufacturing process are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the product design, and materials specification from which the product is made. The following diagram shows manufacturing activities, machine cluster (Robotic Spot Welding Line).



Keywords: Manufacturing Systems

I. MANUFACTURING SYSTEMS

Manufacturing System is defined as "A collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts"

1) Equipment includes production machines and tools, Material handling and work positioning devices, Computer Systems
2) Human resources are required either full-time or periodically to keep the system running
3) Manufacturing is the process of converting raw material into finished or semi-finished part
4) Production system can be defined as a transformation system in which a saleable product or service is created by working upon a set of inputs.

5) Production is the use of man, material and machine to produce finished products.
6) Equipment includes material handling and work positioning devices, computer systems
7) Examples of applications of manufacturing systems include buses, trains, aeroplanes, helicopters etc.




The manufacturing systems are as follows:
1) Components of Manufacturing Systems
2) A Classification Scheme for Manufacturing Systems in the Production System
3) Single-Station Manufacturing Cells
4) Manual Assembly Lines
5) Automated Production Lines
6) Automated Assembly Systems
7) Cellular Manufacturing
8) Flexible Manufacturing Systems
9) Just in Time Manufacturing
10) Group Technology

II. COMPONENTS OF MANUFACTURING SYSTEMS

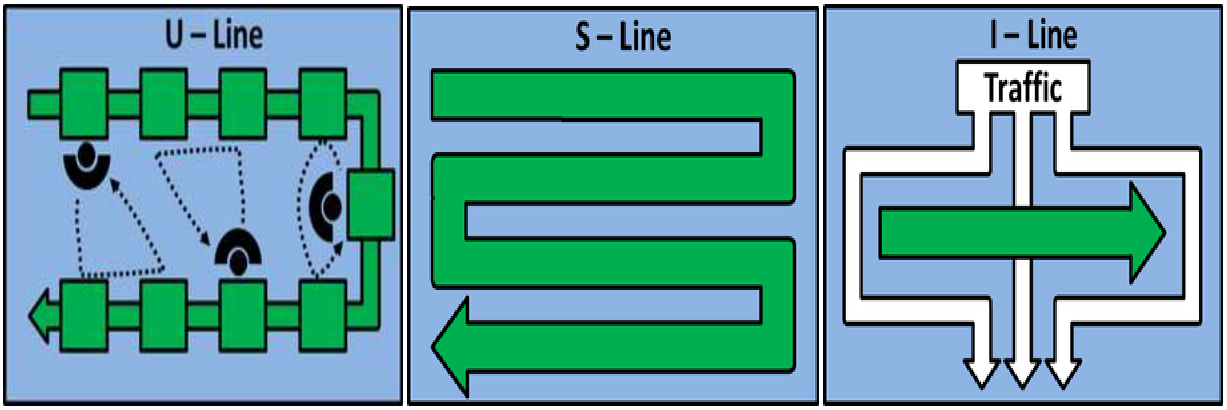
1) Production Machines
2) Material Handling System
3) Computer system to coordinate and/or control the preceding components
4) Human workers to operate and manage the system include Production Machines, In virtually all modern manufacturing systems, most of the actual processing or assembly work is accomplished by machines or with the aid of tools

A. Production Machines

1) Manually operated machines are controlled or supervised by a human worker
2) Semi-automated machines perform a portion of the work cycle under some form of program control, and a worker tends to work on the machine the rest of the cycle
3) Fully automated machines operate for extended periods of time with no human attention
4) Manually Operated Machine operates for extended periods (longer than one work cycle) with worker attention
5) Semi-Automated Machine: A semi-automated machine performs a portion of the work cycle under some form of program control, and a worker tends to the machine for the remainder of the cycle. Typical worker tasks include loading and unloading parts.

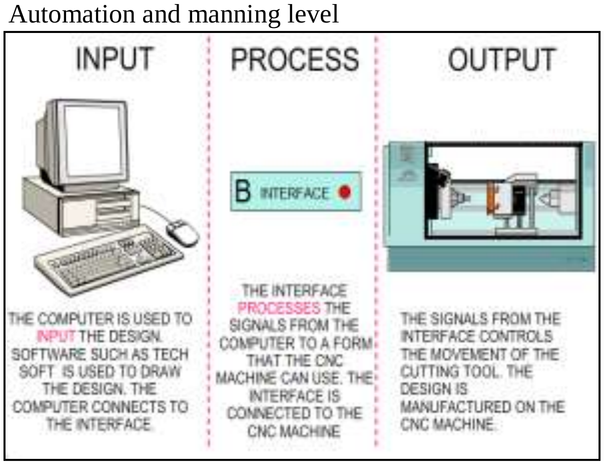
B. Material Handling System

In most manufacturing systems in the process to assemble discrete parts and products, the following material handling functions must be provided:
1) Loading work units at each station
2) Positioning work units at each station
3) Unloading work units at each station
4) Transporting work units between stations in multi-station systems
5) Temporary storage of work units
- Work Transport Between Stations
- Two general categories of work transport in multi-station manufacturing systems:
6) Fixed routing
- Work units always flow through the same sequence of workstations
- Most production lines exemplify this category
7) Variable routing
- Work units are moved through a variety of different station sequences
- Most job shops exemplify the following category production methods



C. Computer Control System

Typical computer functions in a manufacturing system:
1) Communicate instructions to workers (receive processing or assembly instructions for the specific work unit)
2) Download part programs to computer-controlled machines
3) Control material handling system
4) Schedule production
5) Failure diagnosis when malfunctions occur and preventive maintenance
6) Safety monitoring (protect both the human worker and equipment)
7) Quality control (detect and reject defective work units produced by the system)
8) Operations management (manage overall operations)
9) Factors that define and distinguish manufacturing systems:
    1) Types of operations performed
    2) Number of workstations
    3) System layout
    4) Automation and manning level



10) Part or product variety
11) Types of Operations Performed
12) 12. Processing operations on work units versus assembly operations to combine individual parts into assembled entities
13) Type(s) of materials processed
14) Size and weight of work units
15) Part or product complexity
    1) For assembled products, number of components per product
    2) For individual parts, number of distinct operations to complete processing
16) Part geometry
17) For machined parts, rotational vs. non-rotational
18) Number of Workstations
19) Convenient measure of the size of the system
20) Let n = number of workstations, Individual workstations can be identified by subscript i, where i = 1, 2,...,n

III. CLASSIFICATION OF MANUFACTURING SYSTEMS

There are four types of manufacturing systems: Custom Manufacturing, Intermittent Manufacturing, Continuous Manufacturing and Flexible Manufacturing.

A. Custom Manufacturing Systems

Custom manufacturing is by far the oldest and most popular type of manufacturing system in existence. It also happens to be associated with both the highest-quality products and the lowest-volume efficiency. In the custom manufacturing system, each item is produced by a single craftsperson, who works solely by hand or with the help of a machine. When machines are used, they tend to be highly specialized to their task and cannot produce more than one item at a time. This system will tend to have the highest unit cost for the product manufactured. As a result, custom-manufactured products are of the highest quality but are also the most expensive products in the market.

B. Intermittent Manufacturing Systems

The intermittent manufacturing system allows companies to make different types of goods using the same production line. Therefore, the manufacturing facility is designed to handle different product sizes and requirements. Generally, the goods are processed in lots to fulfill orders. This system is commonly referred to as a "job shop" due to its popularity in countries with relatively cheap labor making products for multinationals based thousands of miles away. The goods made using this manufacturing method are produced in small quantities, so they may not be suitable for stock. Customization is typically done post-purchase. This type of system is designed for production runs that happen intermittently, hence the name, or products that don't require high volumes. It uses general purpose machines and requires highly skilled labor.

C. Continuous Manufacturing Systems

Continuous manufacturing systems are designed to enable the mass production of a single product. The product goes through an assembly line with different stations where parts are added or worked on a little further. This method first arose during the Industrial Revolution and is most closely associated with the Ford Motor Company. This type of production system is ideal when a company has very high volume targets since it reduces the unit cost of the product.

D. Flexible Manufacturing Systems

Flexible manufacturing is a modern manufacturing system that has become very popular. It involves a significant investment in machinery, although it reduces labor costs by implementing robots eschewing human labor altogether. These machines can easily be reconfigured to manufacture different products in different quantities, and the whole process is automatic. This method is called flexible manufacturing due to the flexibility in the variety of high-volume goods it can produce. Due to the automated process, quality control is a lot easier, and unit costs are low.

IV. SINGLE-STATION MANUFACTURING CELLS

1) This is the most common manufacturing system in industry,
2) Operation is independent of other stations
3) Perform either processing or assembly operations
4) Can be designed for: Single model production, Batch production, Mixed model production

A. Single-Station Manned Cell

1) "One worker tending one production machine (most common model)"
2) Most widely used production method, especially in job shop and batch production

B. Reasons for Popularity:

1) Shortest time to implement
2) Requires least capital investment
3) Easiest to install and operate
4) Typically, the lowest unit cost for low production
5) Most flexible for product or part changeovers

C. Single-Station Manned Cell Examples

1) Worker operating a standard machine tool
2) Worker loads & unloads parts, operates machine
3) Machine is manually operated
4) Worker operating semi-automatic machine
5) Worker loads & unloads parts, starts semi-automatic work cycle

6) Worker attention not required continuously during entire work cycle
7) Worker using hand tools or portable power tools at one location

D. Variations of Single-Station Manned Cell

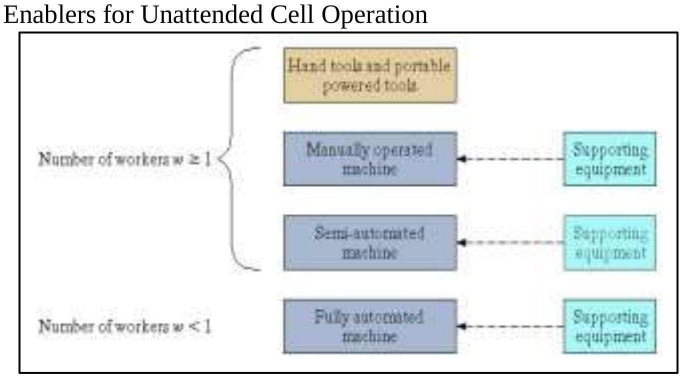
1) Two (or more) workers required to operate machine
2) Two workers required to manipulate heavy forging at forge press
3) Welder and fitter in arc welding work cell
4) One principal production machine plus support equipment
5) Drying equipment for a manually operated injection molding machine
6) Trimming shears at impression-die forge hammer to trim flash from forged part

E. Single-Station Automated Cell

"Fully automated production machine capable of operating unattended for longer than one work cycle"
Worker not required except for periodic tending

F. Reasons why it is Important:

1) Labor cost is reduced
2) Easiest and least expensive automated system to implement
3) Production rates usually higher than manned cell
4) First step in implementing an integrated multi-station automated system
5) Enablers for Unattended Cell Operation
6) For single model and batch model production:
7) Programmed operation for all steps in work cycle
8) Parts storage subsystem
9) Automatic loading, unloading, and transfer between parts storage subsystem and machine
10) Periodic attention of worker for removal of finished work units, resupply of starting work units, and other machine
11) Built-in safeguards to avoid self-destructive operation or damage to work units or unsafe to workers
12) Enablers for Unattended Cell Operation



G. For Mixed Model Production:

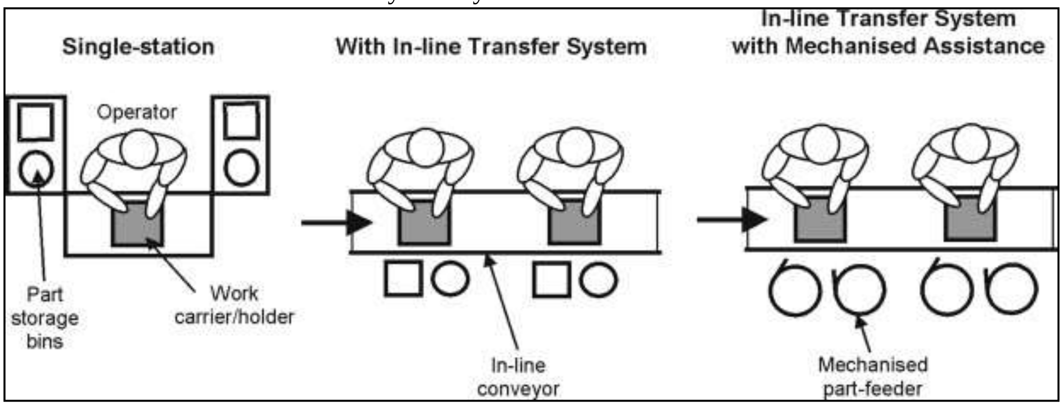
1) All of the preceding enablers, plus:
2) Work unit identification:
3) Automatic identification (e.g., bar codes) or sensors that recognize alternative features of starting units
4) If starting units are the same, work unit identification is unnecessary
5) Capability to download programs for each work unit style (programs prepared in advance)

V. MANUAL ASSEMBLY LINES

1) Manual Assembly Line consists of a production line that consists of a sequence of workstations where assembly tasks are performed by human workers. Products are assembled as they move along the line. At each station a portion of the total work content is performed on each unit. Base parts are launched onto the beginning of the line at regular intervals (cycle time) Workers add components to progressively build the product
2) Manual assembly involves the composition of previously manufactured components and/or sub-assemblies into a complete product or unit of a product, primarily performed by human operators using their inherent dexterity, skill and judgment. The operator may be at a workstation (bench) or be part of a transfer system that moves the product as it is being assembled. Manual assembly can be further assisted by mechanised or automated systems for feeding, handling, fitting and checking operations
3) Manual Assembly Lines/Work systems consisting of multiple workers organized to produce a single product or a limited range of products. Assembly workers perform tasks at workstations located along the line-of-flow of the product. Usually a powered

conveyor is used. Some of the workstations may be equipped with portable powered tools..Factors favoring the use of assembly lines include High or medium demand for product, Products are similar or identical, Total work content can be divided into work elements, To automate assembly tasks is impossible

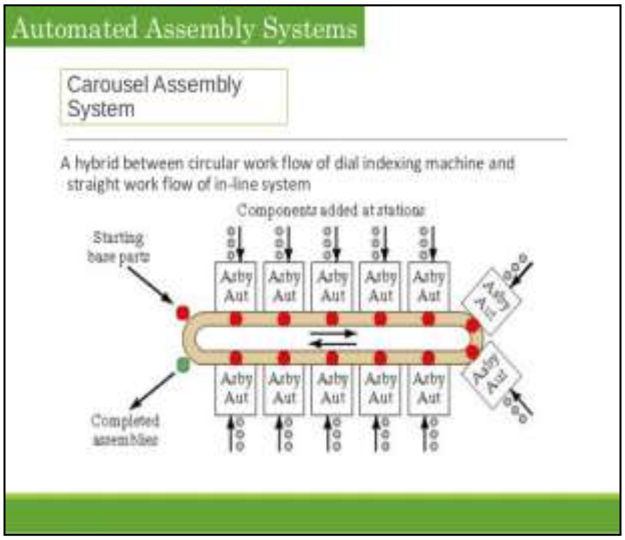
4) Assembly Lines are Productive because of specialization of labor. When a large job is divided into small tasks and each task is assigned to one worker, the worker becomes highly proficient at performing the single task (Learning curve)Interchangeable parts. Each component is manufactured to sufficiently close tolerances that any part of a certain type can be selected at random for assembly with its mating component.Thanks to interchangeable parts, assemblies do not need fitting of mating components
5) Work units are moved between stations by the workers (by hand) without powered conveyor
6) Starving of stations: The assembly operator has completed the assigned task on the current work unit, but the next unit has not yet arrived at the station.
7) Blocking of stations: The operator has completed the assigned task on the current work unit but cannot pass the unit to the downstream station because that worker is not yet ready to receive it.



8) Repositioning Losses occur on a production line because some time is required each cycle to reposition the worker, the work unit, or both. On a continuous transport line, time is required for the worker to walk from the unit just completed to the upstream unit entering the station. In conveyor systems, time is required to remove work units from the conveyor and position it at the station for worker to perform his task. Cycle Time on an Assembly Line for a worker is to be noted for each activity from starting to finished work.
9) Continuously moving conveyor operates at constant velocity. Task must be completed within a certain time limit. Otherwise the line produces incomplete units, excessive stress on the assembly worker. A work unit leaves a given station when the assigned task is completed. Work units move independently, rather than synchronously (most flexible one).Variations in worker task times may lead to small queues in front of each station.
10) To Cope with Product Variety, single model assembly line (SMAL), Batch model assembly line (BMAL), Multiple model line, If two or more different products are to be made in batches then Mixed model assembly line (MMAL) is adopted and so models can be made simultaneously with no setup time

VI. AUTOMATED PRODUCTION LINES

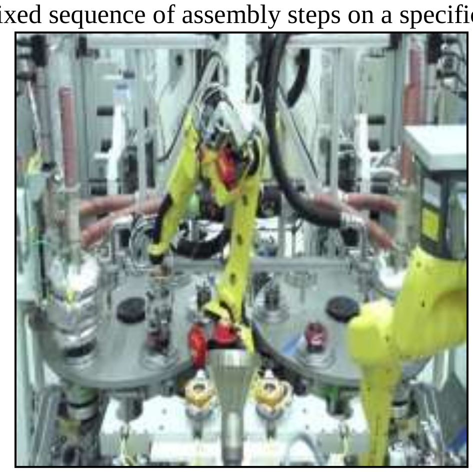
1) Automated production lines consist of distributed workstations connected by a mechanized work transport system that moves the parts from one workstation to another as they enter the system. Automated production lines are usually expensive to implement, and—as examples of fixed automation—their layout is relatively hard to change once built into the production plant's infrastructure.
2) An automated production line has multiple workstations that are automated and linked together by a work handling system that transfers parts from one station to the next. Starting—un-processed—parts enter the automated production line and undergo a system of automated processing at various workstations along the fixed production line; the parts are passed from workstation to workstation by means of a mechanized work transport system, until the completely processed parts pass out of the automated production line after the last process occurs to the part at the final workstation in the system.
3) The line may also include inspection stations to perform intermediate quality checks on parts in the system, as well as a number of manually-operated workstations that accomplish tasks that have not been automated owing to reasons of economy or difficulty. Each station performs a different operation, so all the operations are required to complete one work unit; this means that the parts' route through the production line is fixed and cannot be changed. Multiple parts are processed simultaneously, with one part undergoing processing at each workstation in the system. This means, in the simplest automated production lines, that the number of parts in the system is found to be equal to the number of workstations that the system has; however, in more complicated configurations, provision may have been made for some form of part storage, so this calculation may not be accurate where buffering is manifest.



4) In automated production un-processed parts enter the production line and undergo a system of automated processing at various workstations along the fixed production line, with parts being moved from one workstation to the next by means of a mechanized work transport system, until the last process occurs to the part at the final workstation in the system, at which point the part exits the automated production line.
5) The automated production line operates in cycles with the slowest workstation processing time setting the pace for the whole line. Each cycle consists of the processing time plus the time taken to transfer parts from one workstation to the next.

VII. AUTOMATED ASSEMBLY SYSTEMS

The use of mechanized and automated devices to perform various assembly tasks in an assembly line or cell Designed to perform fixed sequence of assembly steps on a specific product.



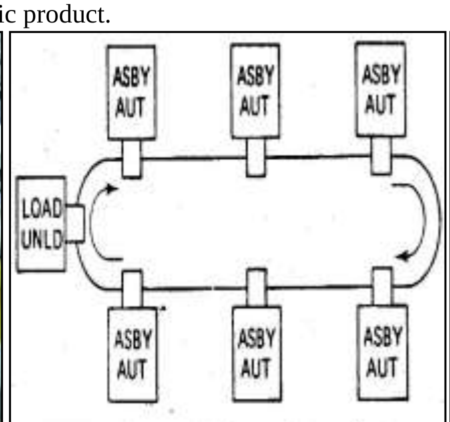
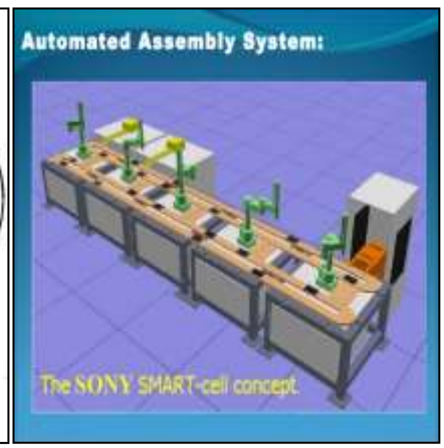


FIGURE 7.2 Configuration of a carousel assembly system.



A. *When to use Automated Assembly System*

Automated assembly system involves significant capital expenses, but it is generally less than for the automated transfer lines.
1) High product demand
2) Stable product design
3) A limited number of components in the assembly
4) Product designed for automated assembly
5) Work units produced on automated assembly system are usually smaller
6) Assembly operation do not have the large mechanical force and power requires of processing operation such as machining Automated assembly system tends to physically smaller, reduces the cost of system

B. *Fundamentals of Automated Assembly System*

1) Performs as sequence of automated assembly operations
2) Combining multiple components into a single entity
3) Single entity can be final product or a subassembly in larger product
4) Assembly is completed progressively

5) Design for automated assembly

C. Types of Automated Assembly Systems

1) Parts feeding devices
2) Analysis of multi-station assembly machines
3) Analysis of a single station assembly machine
4) Design for automated assembly

The methods traditionally used for manual assembly are not necessarily the best methods for automated assembly. Ex: The use of a screw, lock washer and a nut to fasten two sheet metal parts The position of holes through which the screw must be inserted are different for each screw. The screw holes between the two sheet metal parts have to be positioned properly for inserting the screw. The operator must juggle three separate hardware items (screw, lock washer and nut) to perform the fastening operation. A sense of touch is necessary to make sure that the nut is started properly onto the screw thread. The methods traditionally used for manual assembly are not necessarily the best methods for automated assembly. For assembly automation to be achieved, fastening procedures must be devised and specified during product design that do not require all of these human capabilities.. It is difficult to design assembly machines which have human like capabilities such as, intelligence, dexterity, manipulating multiple tasks and problem solving, etc.

D. Product Design Principles:

1) Reduce the amount of assembly parts required
2) Combining functions within the same part
3) Use plastic molded parts in place of sheet metal parts
4) Use modular design. Each module requiring around 10 to 12 parts to be assembled on a single assembly system. Subassembly should be designed around a base part to which other components are added
5) Reduce the number of fasteners required. Design the fastening mechanism using snap fits and similar features Design such that several components are fastened simultaneously rather than each component fastened separately
6) Reduce the need for multiple components to be handled at once separate the operations at different stations rather than to handle and fasten multiple components simultaneously at the same workstation
7) Limit the required directions of access, Ideal situation is to add components vertically from above
8) Maintain high quality in components
9) Poor quality components cause jams in the feeding and assembly mechanisms
10) Implement hopper ability. for ease of feeding and orienting parts

E. Types of Automated Assembly Systems

1) Based on the type of work transfer system:
   - Continuous transfer system
   - Synchronous transfer system
   - Asynchronous transfer system
   - Stationery base part system
2) Based on physical configuration:
   - Dial type assembly machine
   - In-line assembly machine
   - Carousel assembly system
   - Single-station assembly machine

F. Factors That Influence Type of Work Transfer System Include

1) The types of operations to be performed
2) The number of stations on the line
3) The weight and size of the workparts
4) Whether manual stations are included on the line
5) Production rate requirements
6) Balancing the various process times on the line

G. Continuous Transfer System

1) Workparts are moved continuously at constant speed.
2) Workhead is required to move during processing in order to maintain continuous registration with the workpart
3) This may pose inertia problems due to size and weight of the workheads
4) Relatively easy to design and fabricate and can achieve high rate of production
5) Example: Beverage bottling operations,

H. Dial type assembly machine

1) Base parts are loaded onto fixtures that are attached to a circular dial Components are added and/or fastened at various workstations located around the periphery of the dial
2) The dial indexing machine is the most common system in this category
3) It operates with a synchronous or intermittent motion In-line assembly machine Consists of a series of automatic workstations located along an in-line transfer system
4) Continuous, synchronous or asynchronous transfer systems can be used with the in-line configuration. For synchronous transfer of work between stations, the ideal cycle time equals the operation time at the slowest station plus the transfer time between stations

I. Carousel Assembly System

It represents a hybrid between the dial assembly system and In-line system. It can be operated with continuous, synchronous or asynchronous transfer mechanisms.

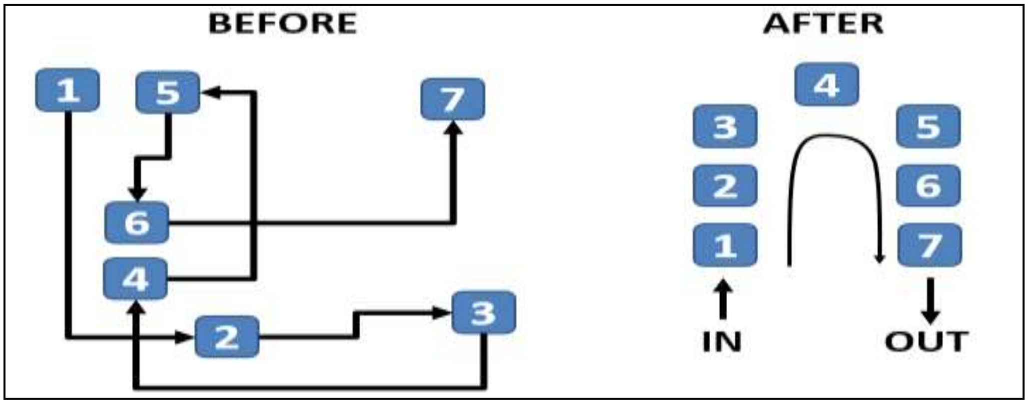
J. Single-Station Assembly Machine

1) Assembly operations are performed at a single location
2) First, a base part is placed at the workstation where components are added to the base
3) Components are delivered to the station by feeding mechanisms
4) One or more work heads perform the various assembly and fastening operations
5) Typically uses robotic assembly
6) Once all the components have been assembled onto the base part, the base part leaves the system.
7) Inherently slower than the other three system configurations, as only one base part is processed at a time.

VIII. CELLULAR MANUFACTURING

Organizing the production equipment into machine cells, where each cell specializes in the production of a part family is called cellular manufacturing. Cellular manufacturing can be implemented by manual or automated methods. It is an application of group technology in manufacturing. Cellular layout is also known as product- process layout. This layout is suitable for medium variety and medium volume environment. It provides flexibility to produce variety of low demand products. This approach facilitates continuous flow of production.

Cellular Manufacturing is a lean manufacturing approach encompassing group technology that helps companies build a variety of products for their customers with as little waste as possible. In cellular manufacturing, equipment and workstations are arranged in a sequence that supports a smooth flow of materials and components through the process, with minimal transport or delay. The goal of cellular manufacturing is to move as quickly as possible, make a wide variety of similar products, while making as little waste as possible.



One piece flow is a condition that exists when products move through a manufacturing process one unit at a time, at a rate determined by the needs of the customer. The opposite of one piece flow is mass production with batches and queues. One piece flow focuses on flow efficiency rather than on resource efficiency.

Applying one piece flow allows to:

1) Minimize stocks and thereby reduce transport and inventory wastes
2) Deliver quicker
3) Minimize damage, deterioration and obsolescence.

A. How to operate in a U-shaped Cell?

Reduce travel distance by arranging equipment and workstations closer together. The beginning of the process must be close to the end of the process. The goal is to minimize the travel distance between each steps and cycles.

B. What do you need in order to implement Cellular Manufacturing?

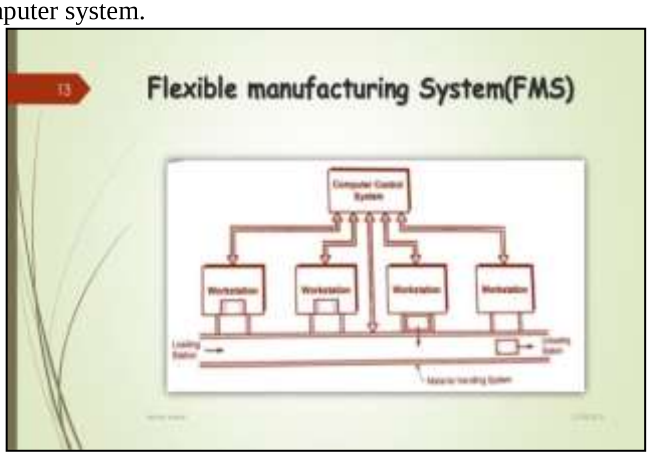
1) Organize your operations and equipment in a logic and validated U-Shaped Cell
2) Empower your operators and set multi-machine and multi-skilled operators as a standard
3) Favor small, flexible machines
4) Using autonomation (Jidoka) to eliminate machine watching

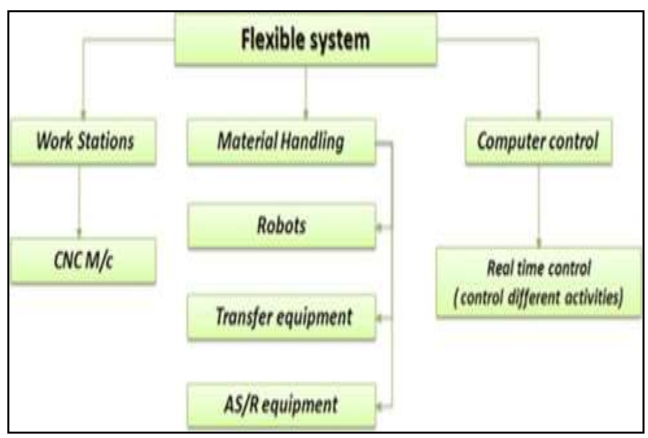
C. How to Design Cells for Cellular Manufacturing?

1) Analyse & document the process today (ASIS Situation)
2) Define the product family that the cell will produce and calculate the TAKT Time for the cell
3) Balance the work to create flow between work-stations that meets demand constraints
4) Design the cell for ergonomics/safety, quality, cost reduction and production improvement
5) Implement, test and improve the cell through continuous improvement

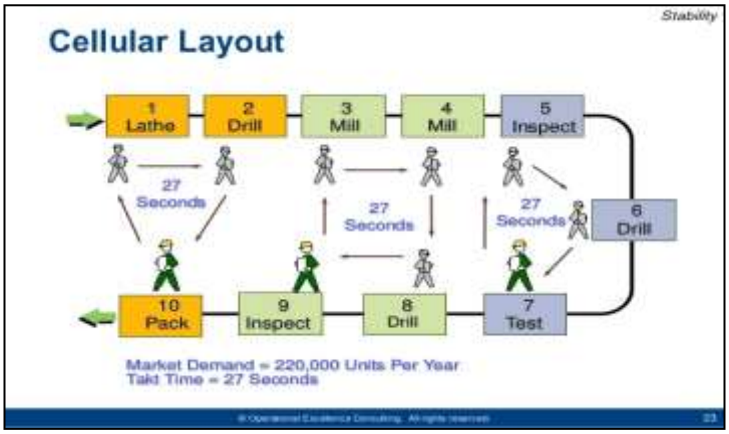
IX. FLEXIBLE MANUFACTURING SYSTEMS

A flexible manufacturing system (FMS) is a highly automated OT machine cell. Consisting of a group of processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.

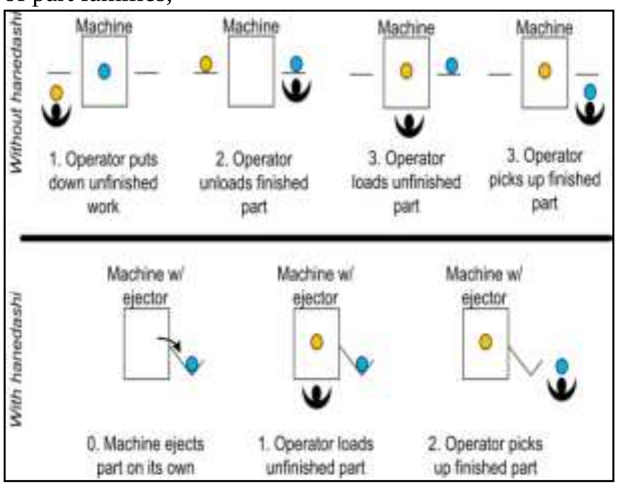


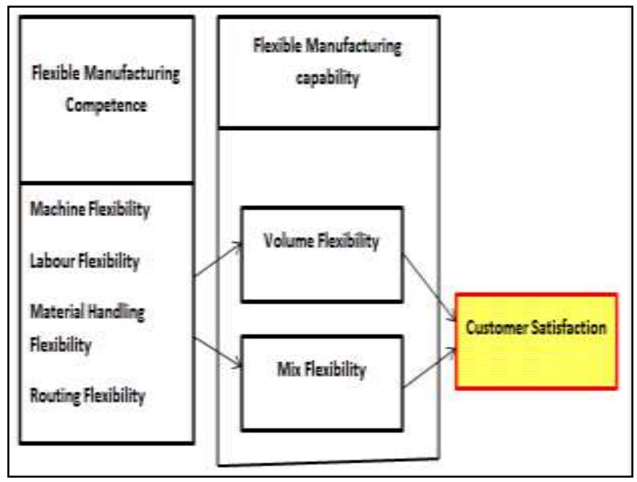


The reason the FMS is called flexible is that it is capable of processing a variety of different part styles simultaneously at the various workstations, and the mix of part styles and quantities of production can be adjusted in response to changing demand patterns. The FMS is most suited for the mid-variety, mid-volume production range. The initials FMS are sometimes used to denote the term flexible machining system. The machining process is presently the largest application area for FMS technology.



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





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

A. Number of Machines

Flexible manufacturing systems can be distinguished according to the number of machines in the system. The following are typical categories: single machine cell (type I A), flexible manufacturing cell (usually type II A, sometimes type III A) . The following table shows the type of flexibility:

S.No	*Flexibility Type*	*Definition*	*Depends on Factors Such As*
1	*Machine Flexibility*	*Capability to adopt to a given machine (work station) in the system to a wide range of production operations and part styles*	*Set up or changeover time, T ool storage capacity of machines, Skill and versatility of workers in the system*
2	*Production Flexibility*	*The range of universe of part styles that can be produced on the system*	*Machine flexibility of individual stations, Range of machine flexibility of all stations in the system*
3	*Mix Flexibility*	*Ability to change product mix while manufacturing the same total oroduction quantity that is producing same parts in different proportions*	*Similarity of parts in the mix, Relative work content of parts produced, Machine flexibility*
4	*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, Offline part programme presentation, Machine flexibility*

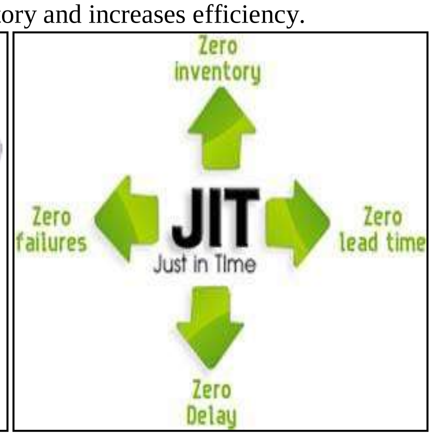
5	*Routing Flexibility*	*Capacity to produce parts through alternative workstation sequences in tool failures, and other interruptions at individual stations*	*Similarity of parts in the mix, Similarity of workstations, Duplication of workstations, Cross training of manual workers, Common tooling*
6	*Volume Flexibility*	*Ability to economically produce parts in high and low quantities of production, given the fixed investment in the system*	*Similarity of parts in the mix, Similarity of workstations, Duplication of workstations, Crosstraining of manual workers, Common Tooling*
7	*Expansion Flexibility*	*Ease with which the system can be expanded to increase total production quantities*	*Ease 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*

The four criteria of Flexibility in a Manufacturing System include the following:

S.No	*Flexibility Tests or Criteria*	*Summary*	*Type of Flexibility*
1	*Parts 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 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 design be introduced into the existing product mix with relative ease*	*Product Flexibility*

X. JUST IN TIME MANUFACTURING

In manufacturing, speed to market and costs of production can make or break a company. Just in time (JIT) manufacturing is a workflow methodology aimed at reducing flow times within production systems, as well as response times from suppliers and to customers. JIT manufacturing helps organizations control variability in their processes, allowing them to increase productivity while lowering costs. JIT manufacturing is very similar to Lean manufacturing, and the terms are often used synonymously. The just-in-time (JIT) inventory system is a management strategy that minimizes inventory and increases efficiency.



The following methods are included in a true JIT system:
1) Housekeeping -- physical organization and discipline
2) Elimination of defects
3) Setup reduction and flexible changeover approaches
4) Small lot sizes
5) Uniform plant load -- leveling as a control mechanism
6) Balanced flow -- actively managing flow by limiting batch sizes
7) Skill diversification -- multi-functional workers
8) Control by visibility -- using visual tools to improve communication
9) Designing for process
10) Streamlining the movement of materials
11) Cellular manufacturing
12) Pull system

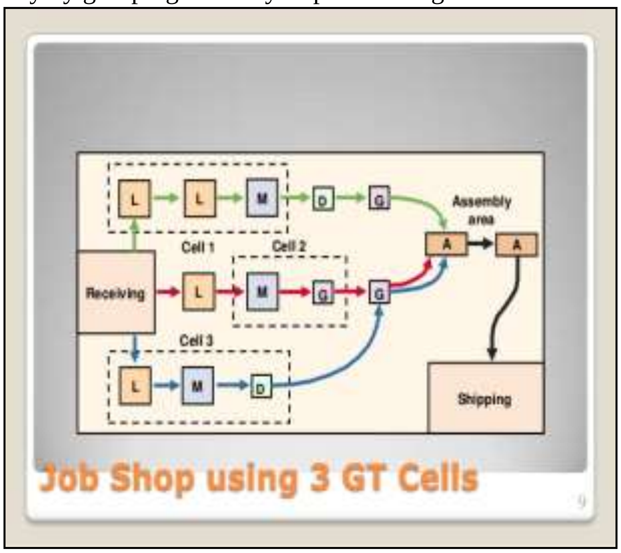
13) Kanban

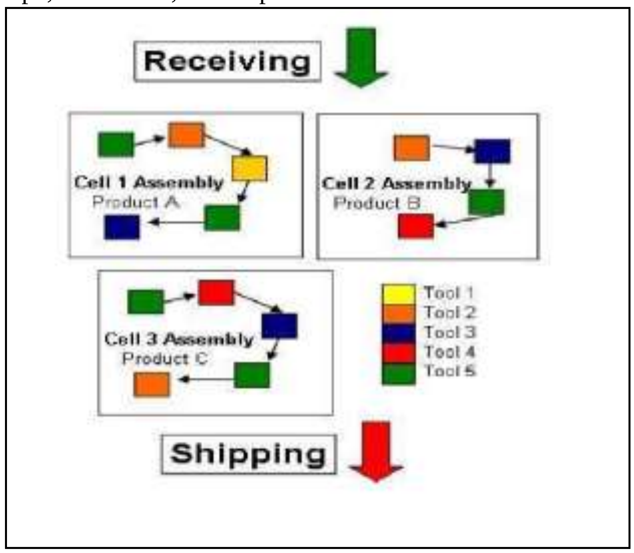
A. *Benefits of JIT experienced by Manufacturers Worldwide*

1) Reduction in inventory
2) Reduction in labor costs
3) Reduction in space needed to operate
4) Reduction in WIP (work in process)
5) Increase in production
6) Improvements in product quality (lower rates of defects)
7) Reduction of throughput time
8) Reduction of standard hours
9) Increase in number of shipments

XI. GROUP TECHNOLOGY (GT)

Group Technology may be defined as a manufacturing philosophy that justifies batch production by capitalizing on design and/or manufacturing similarities among component parts. Thus in GT, similar parts are identified and grouped together to take advantages of their similarities in design and production. 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.





In many plants where GT has been implemented, the production equipment is arranged into 'machine groups' (also known as 'cells') to facilitate work flow and parts handling. Efficiencies are due to reduced setup times, lower in- process inventories, better scheduling, streamlined material flow, improved quality, improved tool control, and the use of standardized process plans. This grouping philosophy results in increased manufacturing efficiencies. For example, a plant producing many parts (say, 5000 different parts) may be grouped into several distinct (say, 20 to 25 part families).Each family possesses similar design and manufacturing characteristics.

XII. ADVANTAGES OF MANUFACTURING SYSTEMS

1) Businesses can adapt their base product to differing consumer needs with the help of flexible manufacturing systems.
2) Reduced manufacturing cost.
3) Lower cost per unit produced,
4) Greater labor productivity,
5) Greater machine efficiency,
6) Improved quality,
7) Increased system reliability,
8) Reduced parts inventories,
9) Adaptability to CAD/CAM operations.
10) Decrease in Human Error
11) Reduction in Overall Production Time

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