Automated Assembly Systems

Definition.

•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.

When to use Automated Assembly System

•High product demand

•Stable product design

•A limited number of components in the assembly

•Product designed for automated assembly

Automated assembly system involve significant capital expenses, but it is generally less than for the automated transfer lines.

1. Work units produced on automated assembly system are usually smaller

2. 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

Fundamentals of Automated Assembly System

1. Performs as sequence of automated assembly operations Combining multiple components into a single entity

2. Single entity can be final product or a subassembly in larger product

3. Assembly is completed progressively

AUTOMATED ASSEMBLY SYSTEMS

- Design for automated assembly
- Types of automated assembly systems
- Parts feeding devices
- Analysis of multi-station assembly machines
- Analysis of a single station assembly machine

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 problems, etc

Definition of flow line.

A transfer line is a manufacturing system with a very special structure. It is a linear network of service stations or machines ($M_1, M_2, \ldots, M_n$) separated by buffer storages ($B_0, B_1, \ldots, B_n$). Material flows from outside the system to B_0, then to M_1, then to B_1, and so forth until it reaches B_n after which it leaves. Figure 1 depicts a two-machine transfer line. The squares represent machines and the triangles represent buffers.

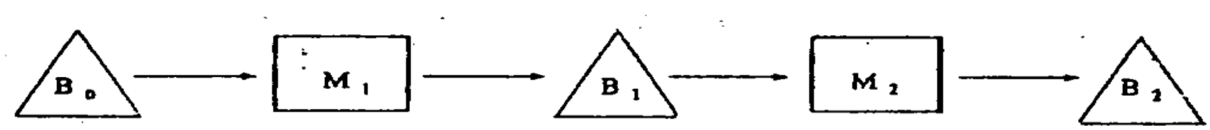


Fig.Two-machine-Transfer line with buffer system

Two-machine-one buffer-system.

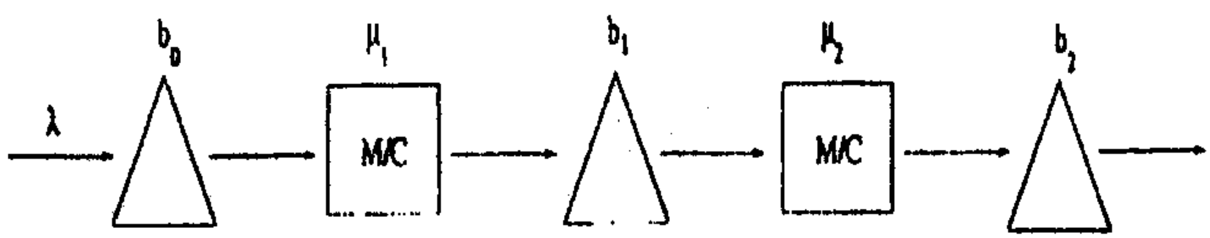


Fig. Two-machine-one buffer-system.

Now, there occurs an increase in the number of the sources of variability (T^i_λ, $T^i_{\mu_1}$, and $T^i_{\mu_2}$, $i \geqslant 1$) due to the more number of machines and buffers in the system of interest and this leads to the existence of two mutually exclusive and collectively exhaustive events that describe the behaviour of the system: (i) the part leaving M_1 finds M_2^* busy; and (ii) the part leaving M_1 finds M_2^* starved. While M_1 refers to the first machine itself, M_2^* is not considered only as the second machine of the line, but as the rest of the system consisting of the second buffer (B_1) and the second machine (M_2) of the line. In the former event, the second buffer of the line is at its full capacity and the second machine is processing a part at the time the part on the first machine is ready to leave. Hence, the system gets blocked (blocking-after-service policy). In the latter event, the part leaving the first machine enters the queue and depending on the state of the second machine (idle or busy), it is delayed in the queue for either zero or more number of units. The effect of the buffer capacity on the throughput behaviour is implicitly characterised via the consideration of this case. The two-machine transfer line will be in either of these mutually exclusive and collectively exhaustive cases at different instants during the evolution of the relevant stochastic process.

Three machine-Two-buffer systems.

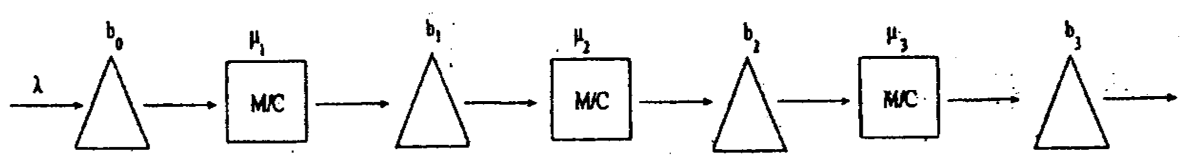


Fig. Three machine-Two-buffer systems.

In this system, there arises four mutually exclusive and collectively exhaustive events that describe the behaviour of the line: (i) the part leaving M_1 finds M_2^* busy and the part leaving M_2^* finds M_3^* busy; (ii) the part leaving M_1 finds M_2^* busy and the part leaving M_2^* finds M_3^* starved; (iii) the part leaving M_1 finds M_2^* starved and the part leaving M_2^* finds M_3^* busy; and (iv) the part leaving M_1 finds M_2^* starved and the part leaving M_2^* finds M_3^* starved. Similarly, M_2^* corresponds to the second buffer (B_1) and the second machine of the line (M_2) while M_3^* represents the third buffer (B_2) and the last machine (M_3) of the line. The behaviour of the first part of the system, which is composed of M_1 and M_2^*, implicitly describes the effects of μ_1, b_1, and μ_2 on the throughput of the line while the consideration of M_3^* helps to characterise the effects of the b_2 and μ_3 on the transient behaviour of the system behaviour. However, none of these mutually exclusive and collectively exhaustive events uniquely represent the true system behaviour by itself. Hence, an aggregate case is considered under which each condition is allowed to be valid for particular number of parts, assumed to be known in advance, in each time frame.

Product design principles.

1. *Reduce the amount of assembly required*

Combining functions within the same part

Use plastic molded parts in place of sheet metal parts

2. *Use modular design*

Design of product should be modular

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

3. *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

4. *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

5. *Limit the required directions of access*

Ideal situation is to add components vertically from above

6. *Maintain high quality in components*

Poor quality components cause jams in the feeding and assembly mechanisms

7. *Implement hopperability .*

For ease of feeding and orienting parts

Types of Automated Assembly Systems.

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

Factors that influence type of work transfer system.

- *The types of operations to be performed*
- *The number of stations on the line*
- *The weight and size of the workparts*
- *Whether manual stations are included on the line*
- *Production rate requirements*
- *Balancing the various process times on the line*

Continuous transfer system

Workparts are moved continuously at constant speed

Workhead is required to move during processing in order to maintain continuous registration with the workpart

This may pose inertia problems due to size and weight of the workheads

Relatively easy to design and fabricate and can achieve high rate of production

Example: Beverage bottling operations

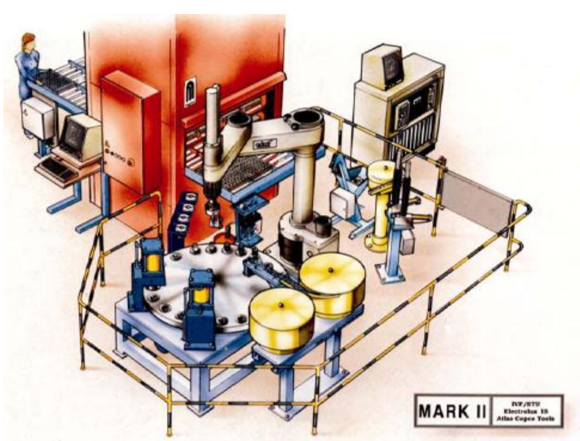
Dial type assembly machine

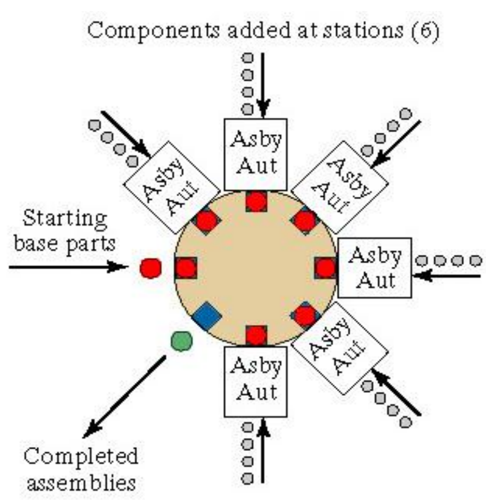
Base parts are loaded onto fixtures that are attached to a circular dial

Components are added and/or fastened at various workstations located around the periphery of the dial

The dial indexing machine is the most common system in this category

It operates with a synchronous or intermittent motion



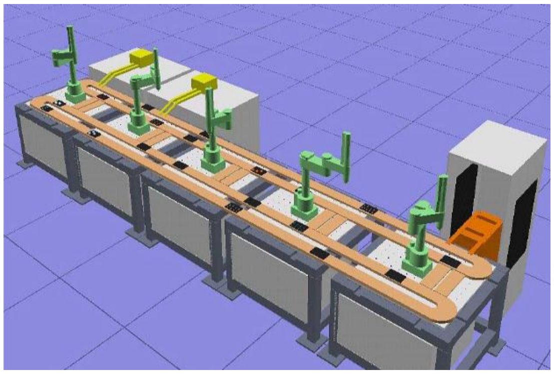


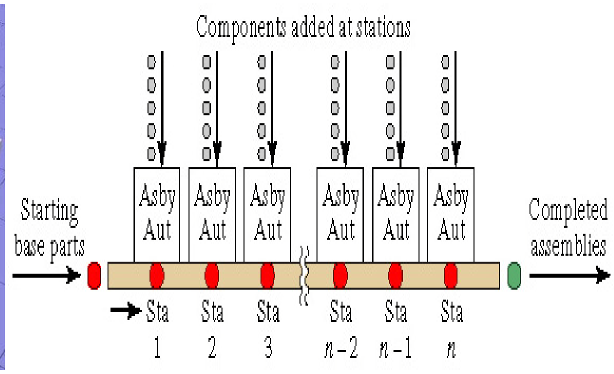
In-line assembly machine

Consists of a series of automatic workstations located along an in-line transfer system

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

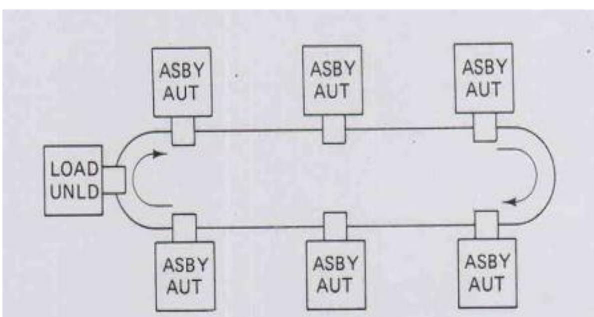


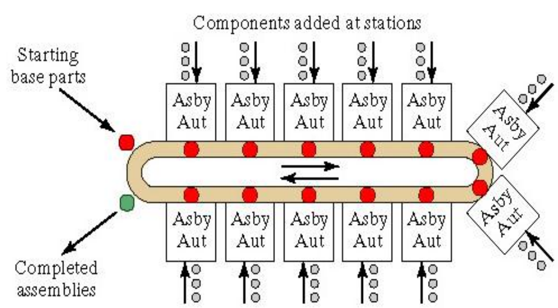


Carousel assembly system.

It represents a hybrid between the dial assembly system and In-line system

It can be operated with continuous, synchronous or asynchronous transfer mechanisms





Single-station assembly machine

Assembly operations are performed at a single location

First, a base part is placed at the workstation where components are added to the base

Components are delivered to the station by feeding mechanisms

One or more workheads perform the various assembly and fastening operations

Typically uses robotic assembly

Once all the components have been assembled onto the base part, the base part leaves the system.

Inherently slower than the other three system configurations, as only one base part is processed at a time.