Transfer Lines

Mr. Praveenkumar B

Contents

- Fundaments
- Configurations
- Transfer mechanism
- Storage Buffers
- Control
- Applications
- Analysis of transfer lines without Storage buffers

06 hours

Fundaments

- An automated Transfer line consists of several machines or workstations which are linked together by work handling devices that transfer parts between the stations.

- The transfer of work parts occurs automatically and the workstations carry out their specialized functions automatically.

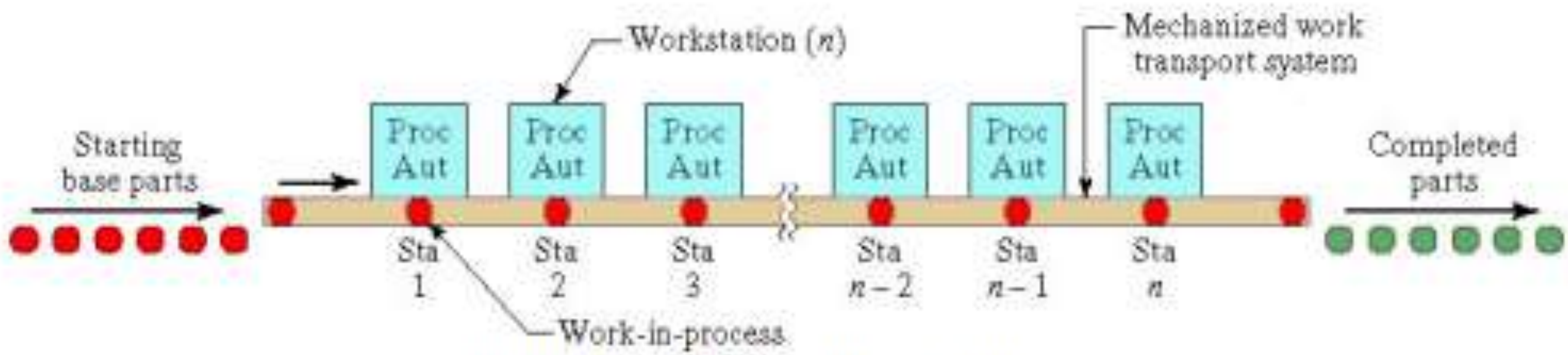
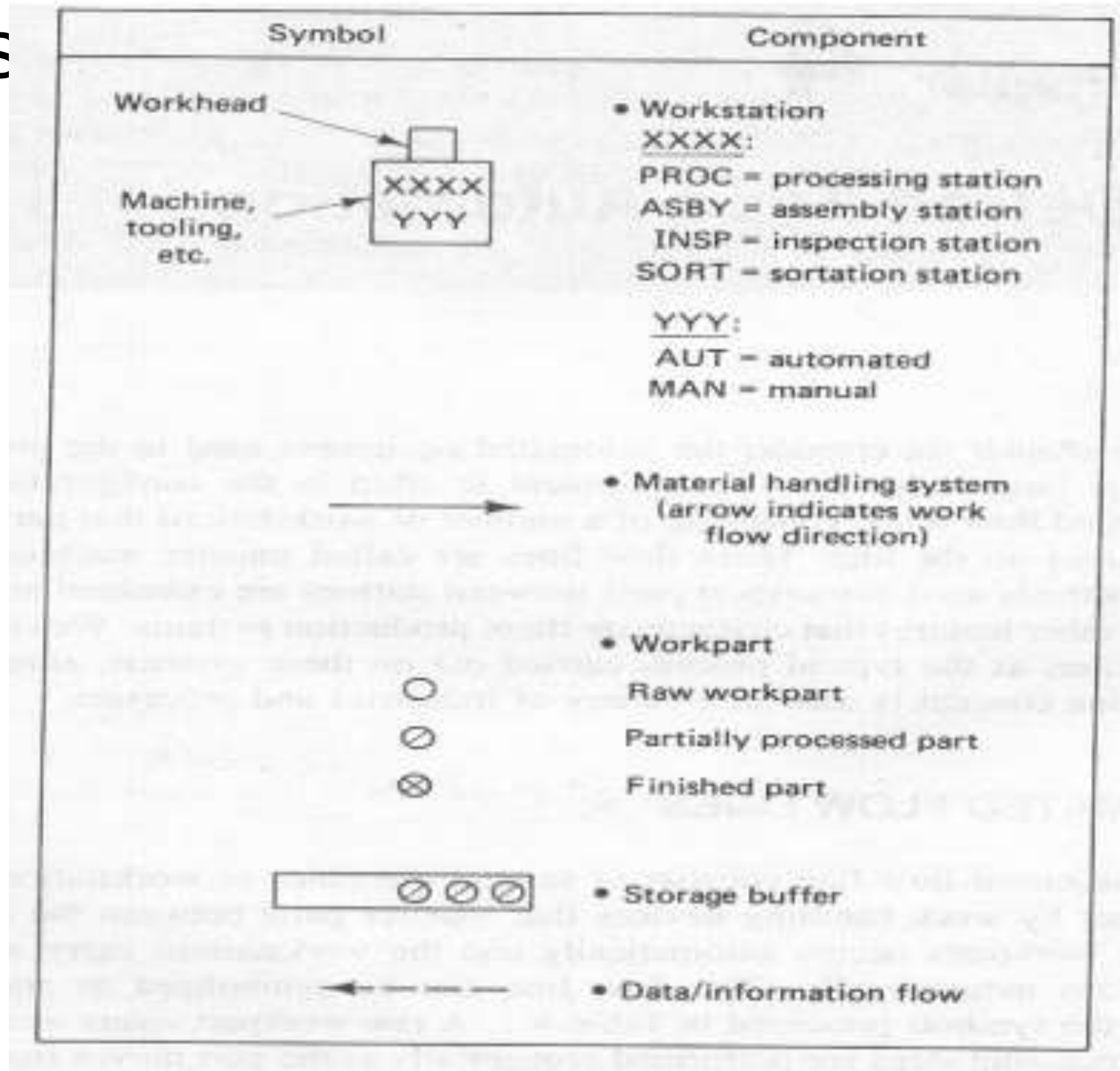


Figure 1 In-line configuration

- A raw workpart enters one end of the line and the processing steps are performed sequentially as the part moves from one station to the next.
- It is possible to incorporate buffer storage zones into the flow line, either at a single location or between every workstation.
- It is also possible to include inspection stations in the line to automatically perform intermediate checks on the quality of the workparts.
- Manual stations might also be located along the flow line to perform certain operations which are difficult or

Symbols used in production systems diagrams



Objectives of the use of Transfer line

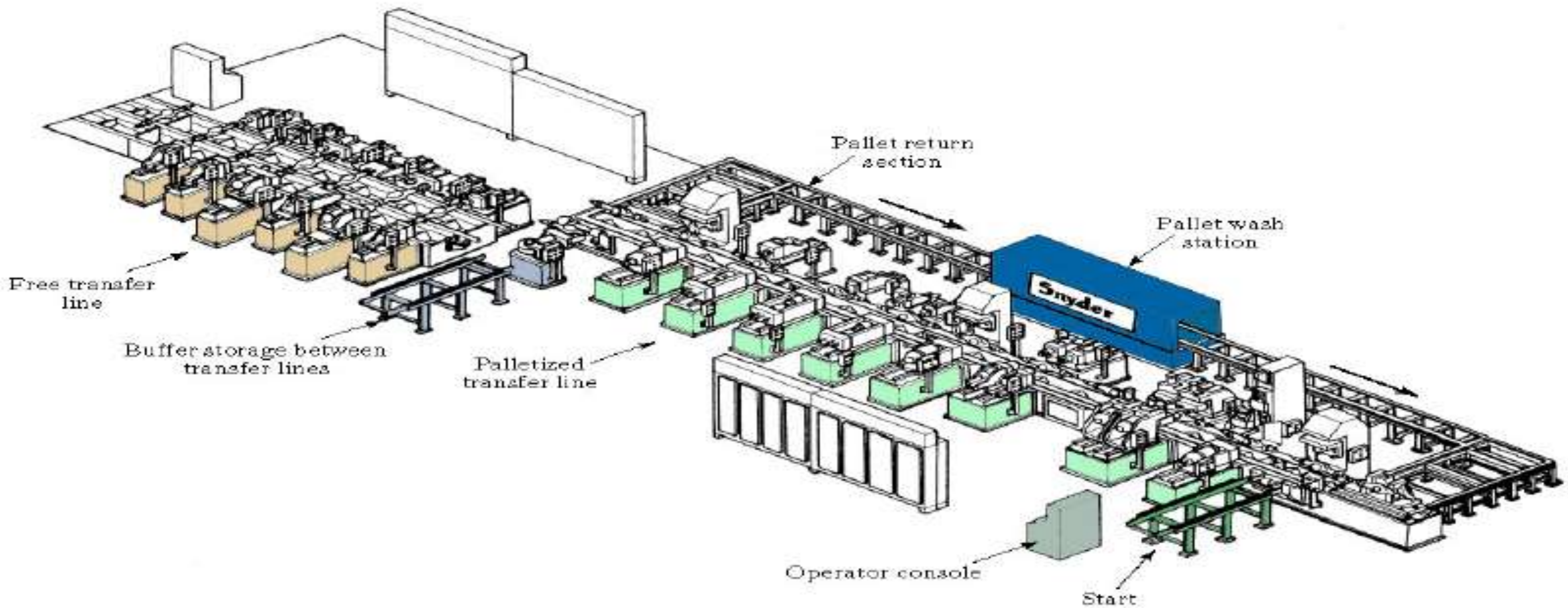
- To reduce labor costs
- To increase production rates
- To reduce work-in-process
- To minimize distances moved between operations
- To achieve specialization of operations
- To achieve integration of operations

Configurations

1. In-line type
2. Segmented In-Line Type
3. Rotary type

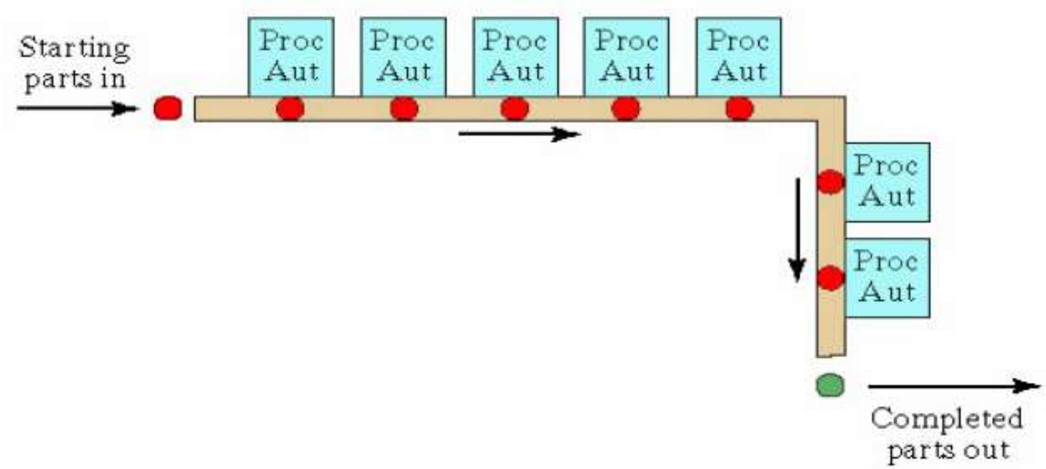
In Line type

- The *in-line configuration consists of a sequence of workstations in a more-or-less* straight-line arrangement as shown in figure 1. An example of an in-line transfer machine used for metal-cutting

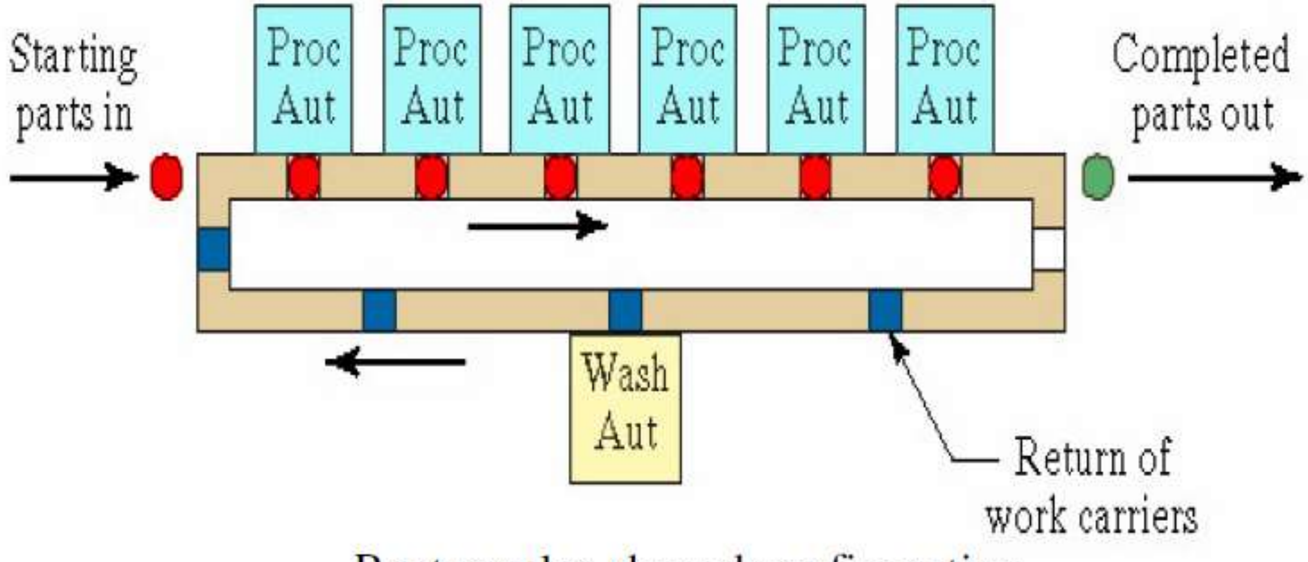


Segmented In-Line Type

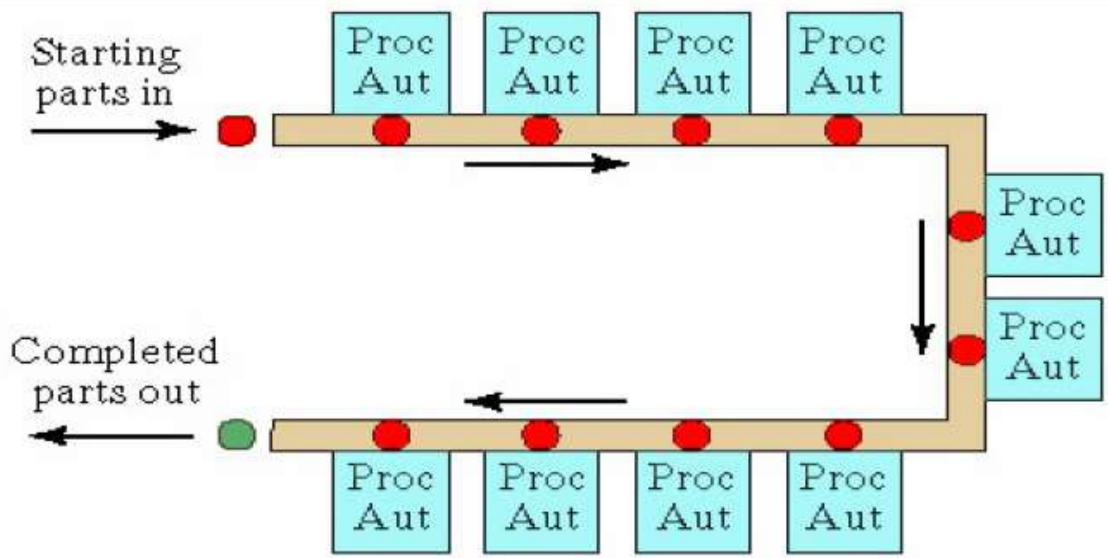
- The segmented *in-line configuration consists of two or more straight-line arrangement* which are usually perpendicular to each other with L-Shaped or U-shaped or
- The flow of work can take a few 90°
- turns, either for workpieces reorientation, factory layout limitations, qualify as a straig



L-shaped configuration

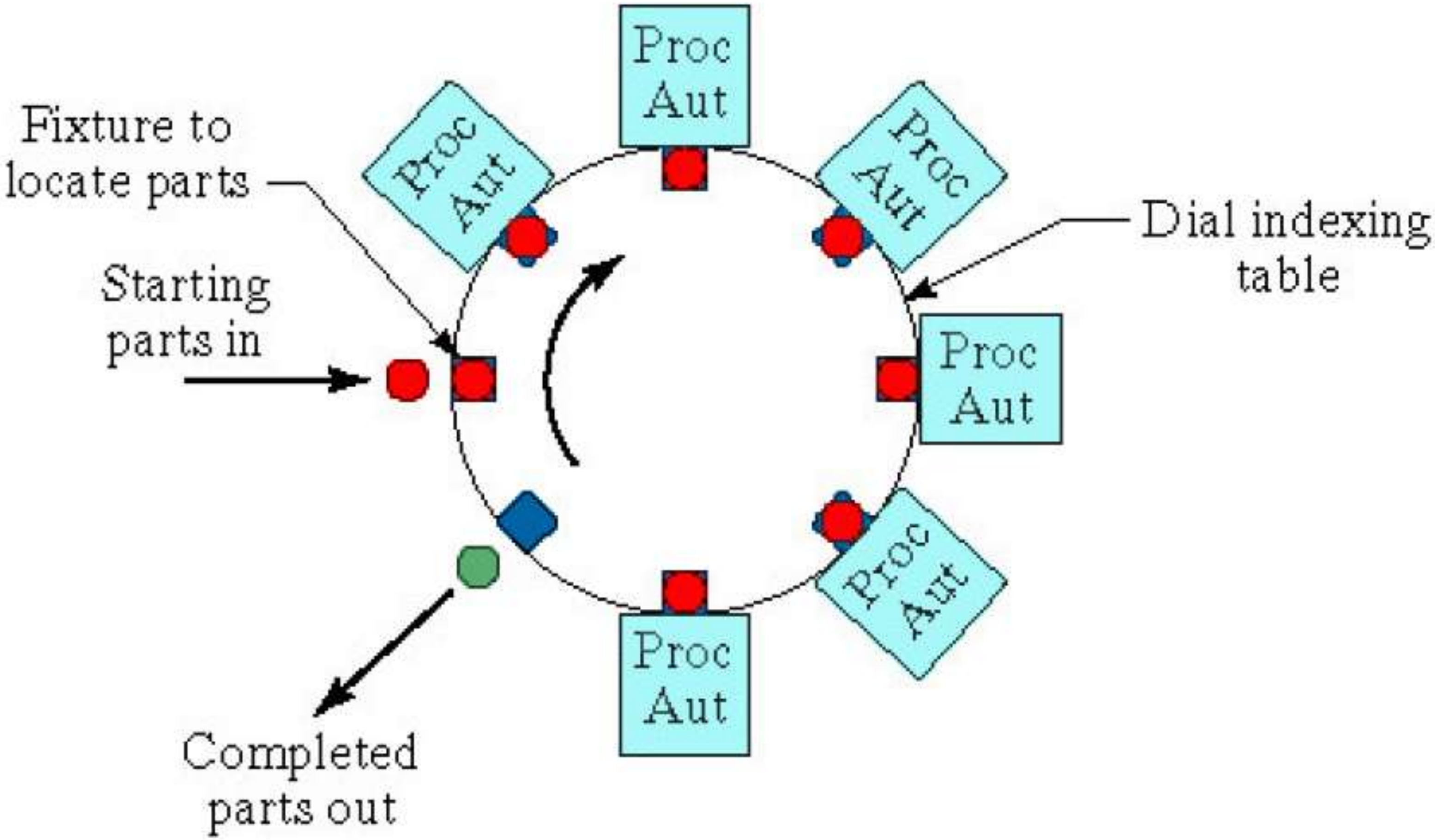


Rectangular-shaped configuration



U-shaped configuration

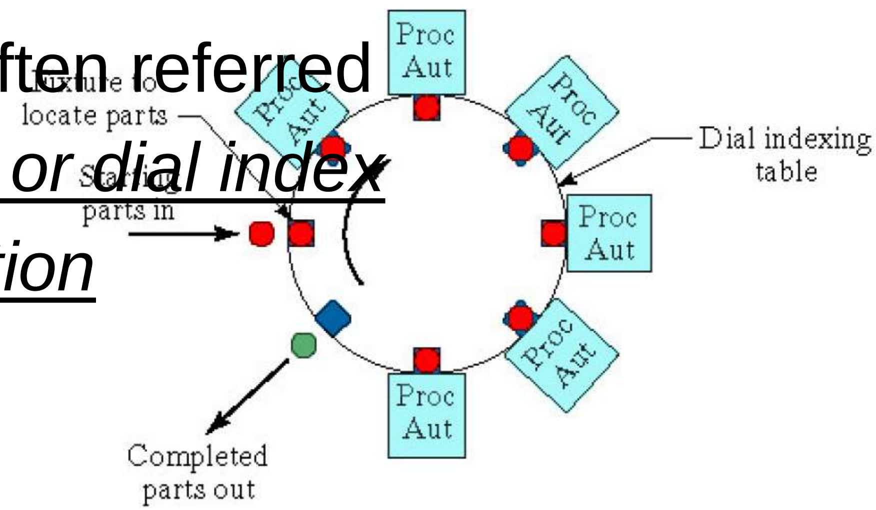
Rotary type



Rotary configuration

Rotary type

- In the *rotary configuration, the workparts are indexed around a circular table or* dial.
- The workstations are stationary and usually located around the outside periphery of the dial.
- The parts ride on the rotating table and arc registered or positioned, in turn, at each station for its processing or assembly operation.
- This type of equipment is often referred to as an *indexing machine or dial index Machine and the configuration*



Rotary configuration

6 station rotary configuration

WORKPART TRANSPORT

The transfer mechanism of the automated flow line must not only move the partially completed workparts or assemblies between adjacent stations, it must also orient and locate the parts in the correct position for processing at each station.

The general methods of transporting workpieces on flow lines can be classified into the following three categories:

1. Continuous transfer
2. Intermittent or synchronous transfer
3. Asynchronous or power-and-free

ALSO…

The most appropriate type of transport system for a given application depends on such factors as:

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

1) Continuous transfer

- The workparts are moved continuously at Constant speed.
- This requires the workheads to move during processing in order to maintain continuous registration with the workpart.
- For some types of operations, this movement of the workheads during processing is not feasible, It would be difficult for example, to use this type of system on a machining transfer line because of inertia problems due to the size and weight of the workheads.
- Examples of its use are
  - In beverage bottling operations,
  - Packaging,

2) Intermittent transfer

- As the name suggests, in this method the workpieces are transported with an intermittent or discontinuous motion.
- The workstations are fixed in position and the parts are moved between stations and then registered at the proper locations for processing.
- All workparts are transported at the same time and, for this reason, the term "synchronous transfer system" is also used to describe this method of workpart transport .

3) Asynchronous transfer

- This system of transfer, also referred to as a "power-and-free system,“
- It allows each workpart to move to the next station when processing at the current station has been completed.
- Each part moves independently of other parts. Hence, some parts are being processed on the line at the same time that others are being transported between stations.
- Asynchronous transfer systems offer the opportunity for greater flexibility than do the other two systems, and this flexibility can be a great advantage in certain circumstances.
- In-process storage of workparts can be incorporated into the asynchronous systems with relative ease.
- Parallel stations or several series stations can be used for the longer operations
- Single stations can be used for the shorter operations.
- A disadvantage of the power and-free systems is that the cycle rates are generally slower than for the other types.

Transfer mechanisms-

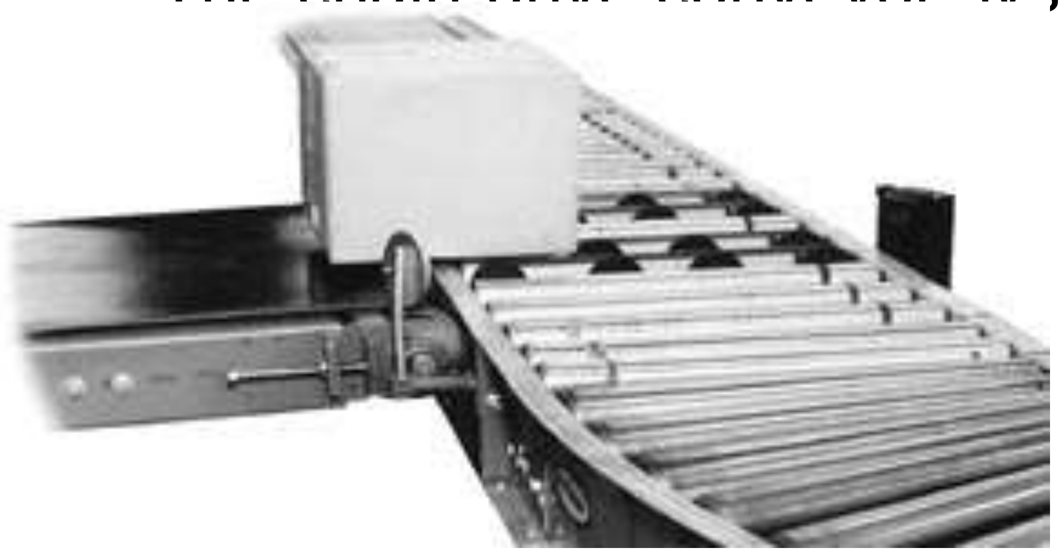
- There are various types of transfer mechanisms used to move parts between stations.
- These mechanisms can be grouped into two types: # Linear travel for in-line machines, # Rotary motion for dial indexing machines.

Linear transfer System

- We will explain the operation of three of the typical mechanisms;   The walking beam transfer bar system

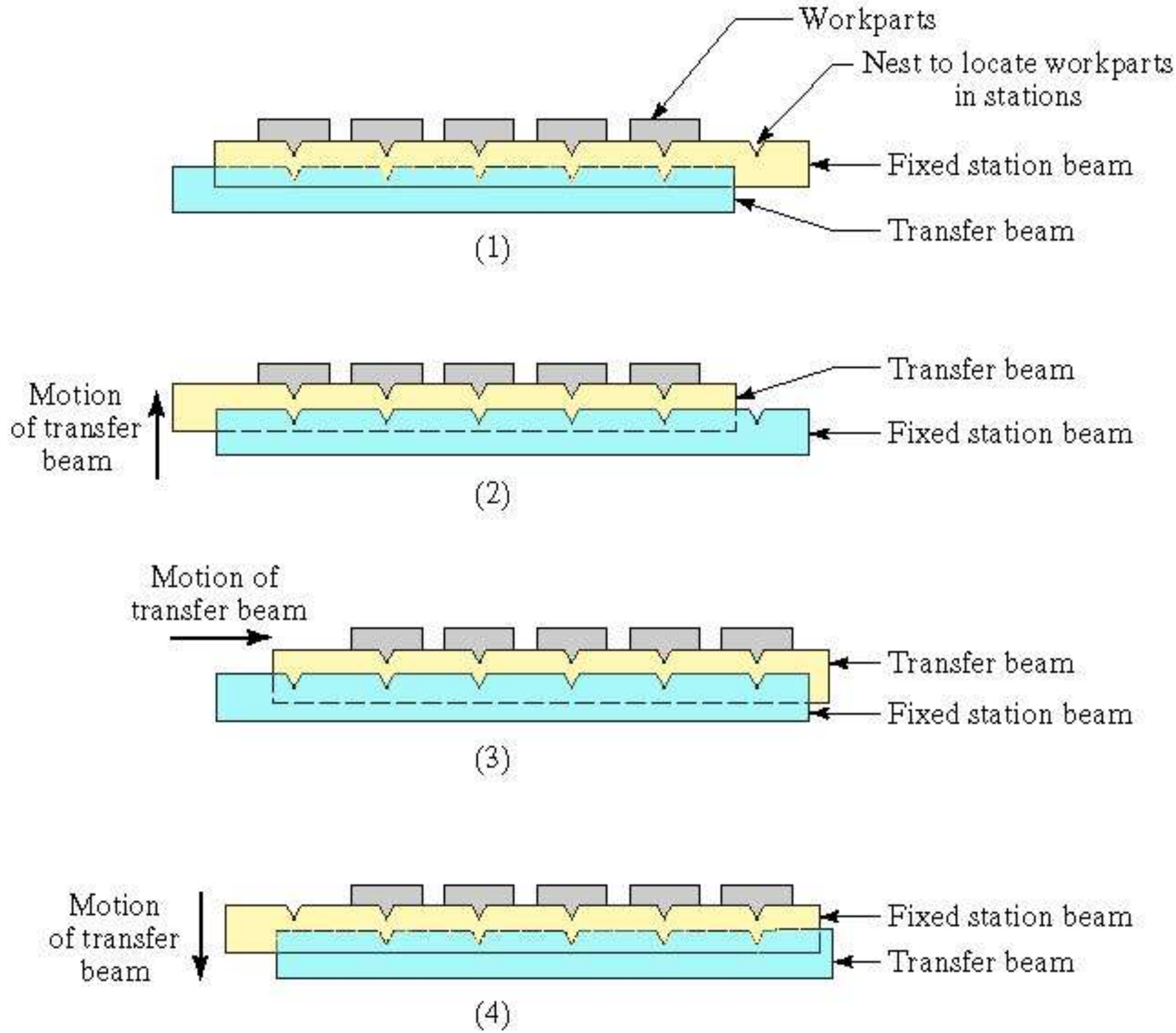
  The powered roller conveyor system, and

  The chain-drive conveyor system.



The walking beam transfer bar system

- The work-parts are lifted up from their workstation locations by a transfer bar and moved one position ahead, to the next station.
- The transfer bar then lowers the pans into nests which position them more accurately for processing.
- For speed and accuracy, the motion of the beam is most often generated by a rotating camshaft powered by an electric motor or a roller movement in a profile p



Workparts
Nest to locate workparts in stations
Fixed station beam
Transfer beam
(1)
Motion of transfer beam
Transfer beam
Fixed station beam
(2)
Motion of transfer beam
Transfer beam
Fixed station beam
(3)
Motion of transfer beam
Fixed station beam
Transfer beam
(4)

[redacted]

Powered roller conveyor system

- This type of system is used in general stock handling systems as well as in automated flow lines.
- The conveyor can be used to move pans or pallets possessing flat riding surfaces.
- The rollers can be powered by either of two mechanisms.

  A **belt drive**

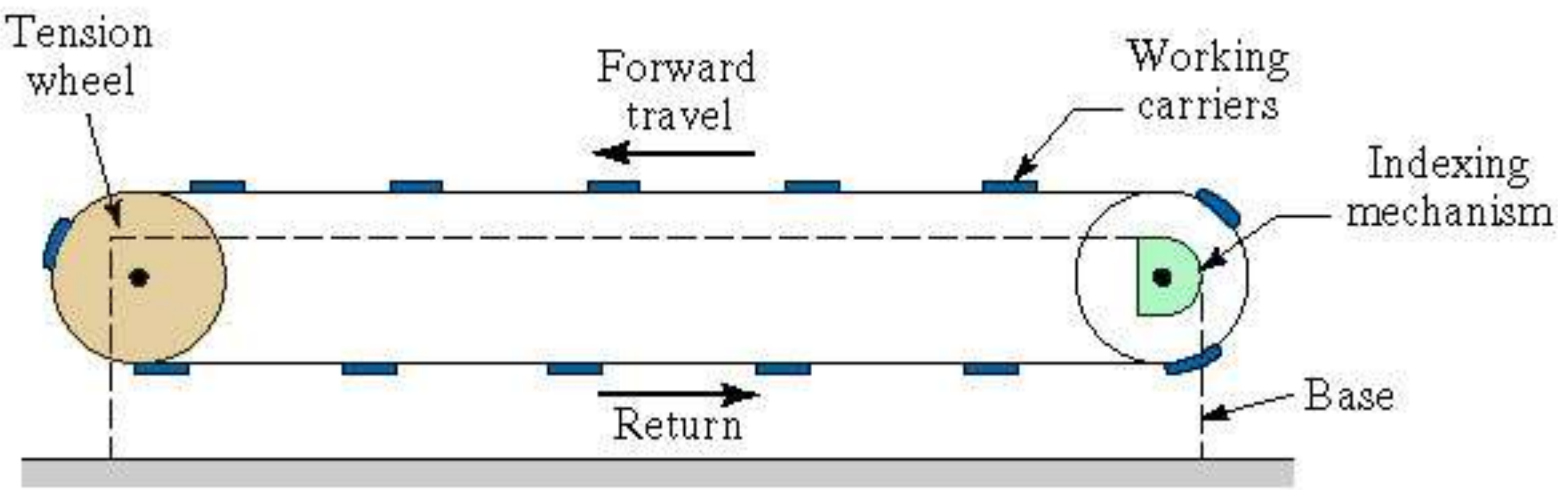
  A **chain drive**

- Powered roller conveyors are versatile transfer systems

  because they can be used to divert work

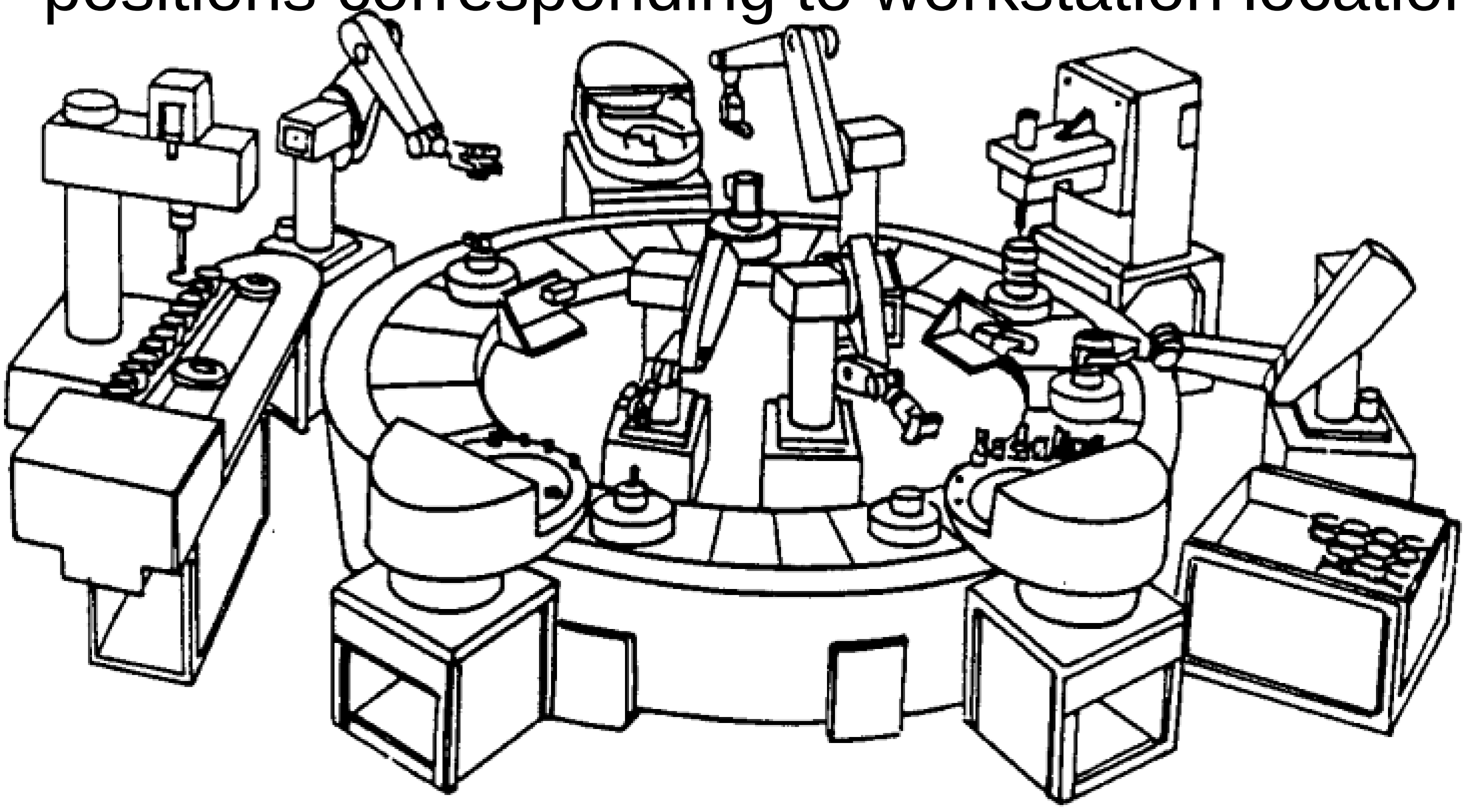
Chain-drive conveyor system

- Either a chain or a flexible steel belt is used to transport the work carriers.
- The chain is driven by pulleys in either an “over-and-under“ config, in which the pulleys turn about a horizontal axis, or an “around-the-corner“ configuration, in which the pulleys rotate about a vertical axis.



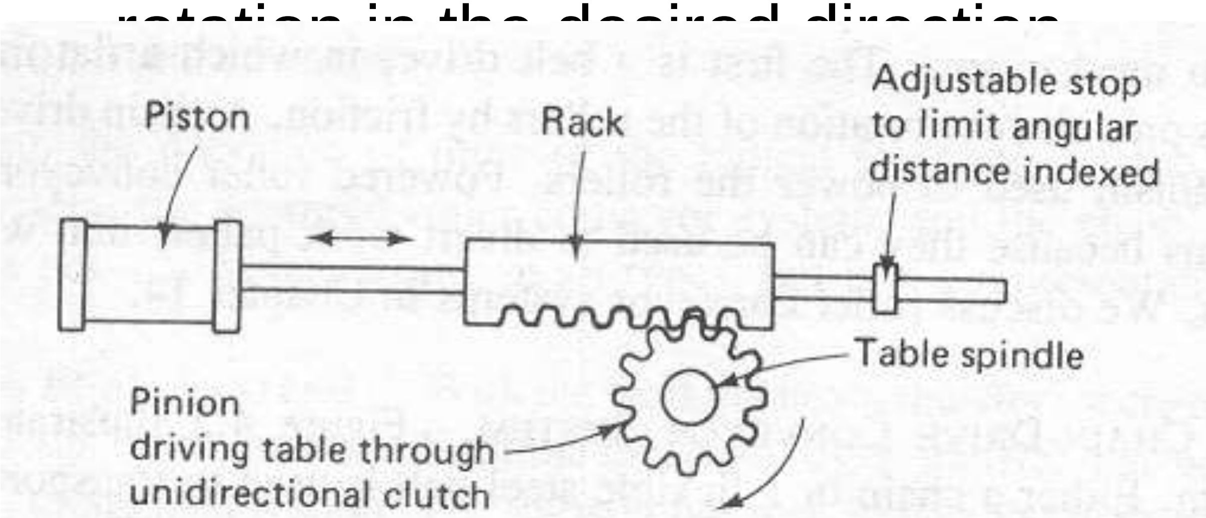
Rotary transfer mechanisms

- There are several methods used to index a circular table or dial at various equal angular positions corresponding to workstation locations.



Rack and pinion

- This mechanism is simple but is not considered especially suited to the high-speed operation often associated with indexing machines.
- It uses a piston to drive the rack, which causes the pinion gear and attached indexing table to rotate, A clutch or other device is used to provide rotation in the desired direction.

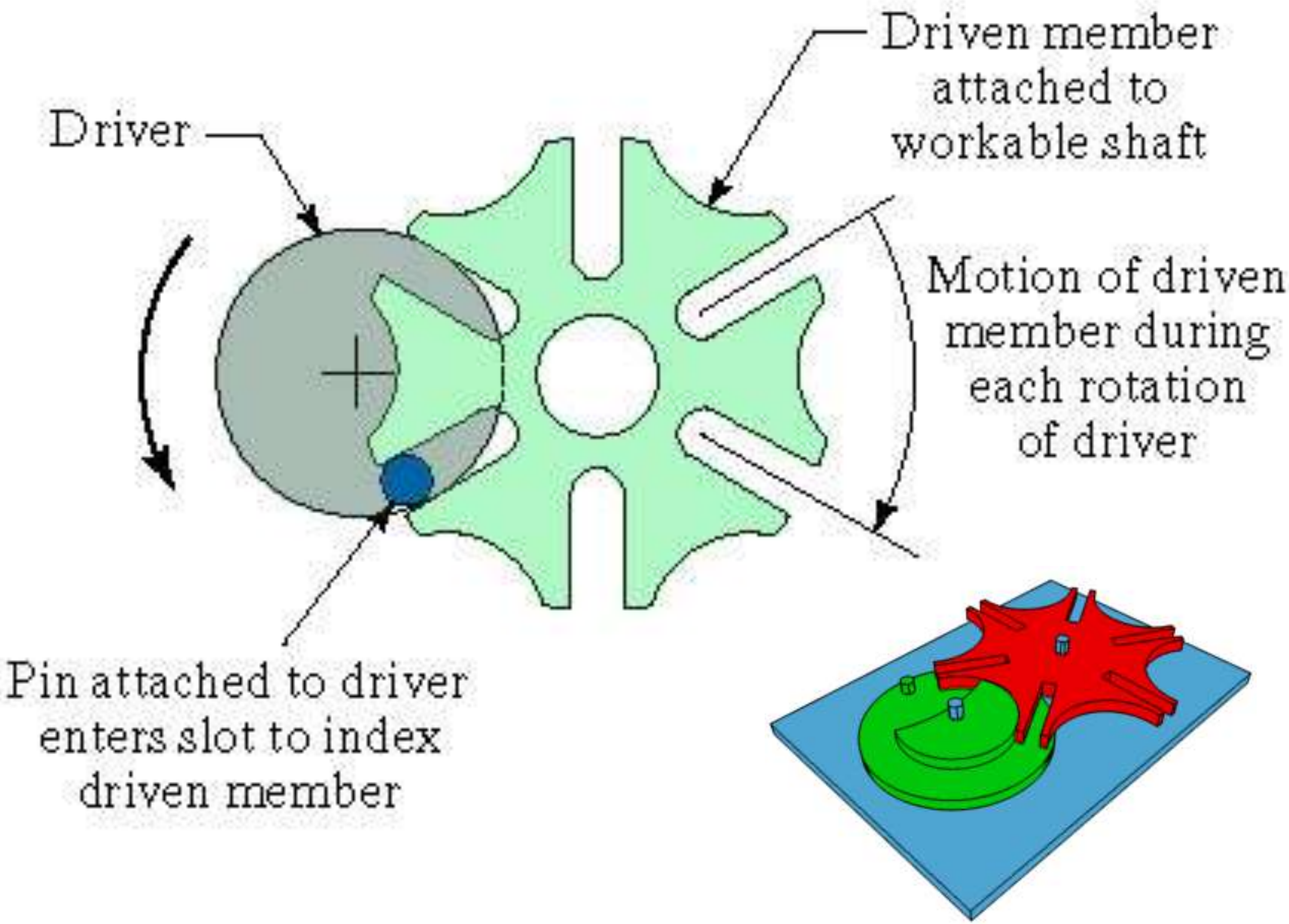


Ratchet and pawl:

- A ratchet is a device that allows linear or rotary motion in only one direction, while preventing motion in the opposite direction.
- Ratchets consist of a gearwheel and a pivoting spring loaded finger called a pawl that engages the teeth.
- Either the teeth, or the pawl, are slanted at an angle, so that when the teeth are moving in one direction, the pawl slides up and over each tooth in turn, with the spring forcing it back with a 'click' into the depression before the next tooth.
- When the teeth are moving in the other direction, the angle of the pawl causes it to catch against a tooth and stop further motion in that direction.

Geneva mechanism:

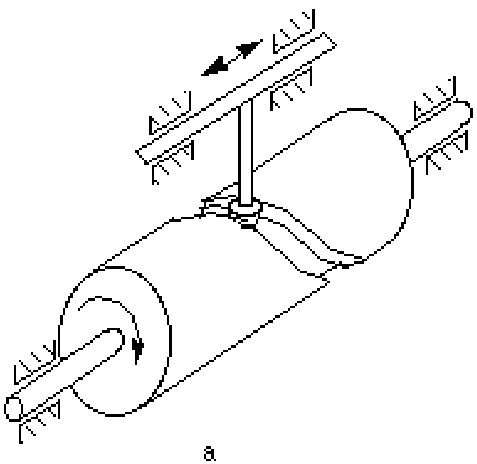
- The Geneva mechanism uses a continuously rotating driver to index the table,
- If the driven member has six slots for a six-station dial indexing machine, each turn of the driver will cause the table to advance one-sixth of a turn.
- The driver only causes movement of the table through a portion of its rotation.
- For a six-slotted driven member, 120° of a complete rotation of the driver is used to index the table. The other 240° is dwell. For a four-slotted driven member, the ratio would be 90° for index and 270° for dwell. The usual number of indexings per revolution of the table is four, five, six, and eight.

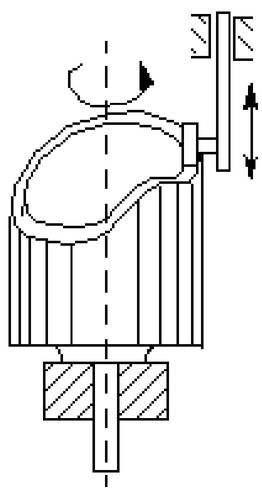


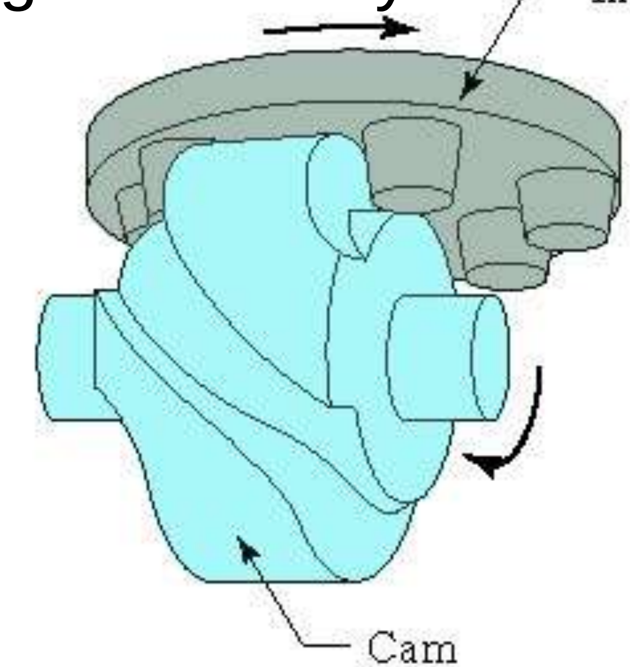
Driver
Driven member attached to workable shaft
Motion of driven member during each rotation of driver
Pin attached to driver enters slot to index driven member

CAM Mechanisms

- CAM Mechanism provide probably the most accurate and reliable method of indexing the dial.
- They are in widespread use in industry despite the fact that the cost is relatively high compared to alternative mechanisms.
- The cam can be designed to give a variety of velocity and dwell characteristics.







CONTROL FUNCTIONS

- Controlling an automated flow line is a complex problem, owing to the sheer number of sequential steps that must be carried out. There are three main functions that are utilized to control the operation of an automatic transfer system.
- The first of there is an operational requirement, the second is a safety requirement, and the third is dedicated to improving quality.

Sequence control.

Safety monitoring

Quality monitoring

Instantaneous control

Memory control

- ***Sequence control.***

  The purpose of this function is to coordinate the sequence of actions of the transfer system and its workstations. The various activities of the automated flow line must be carried out with split-second timing and accuracy. Sequence control is basic to the operation of the flow line

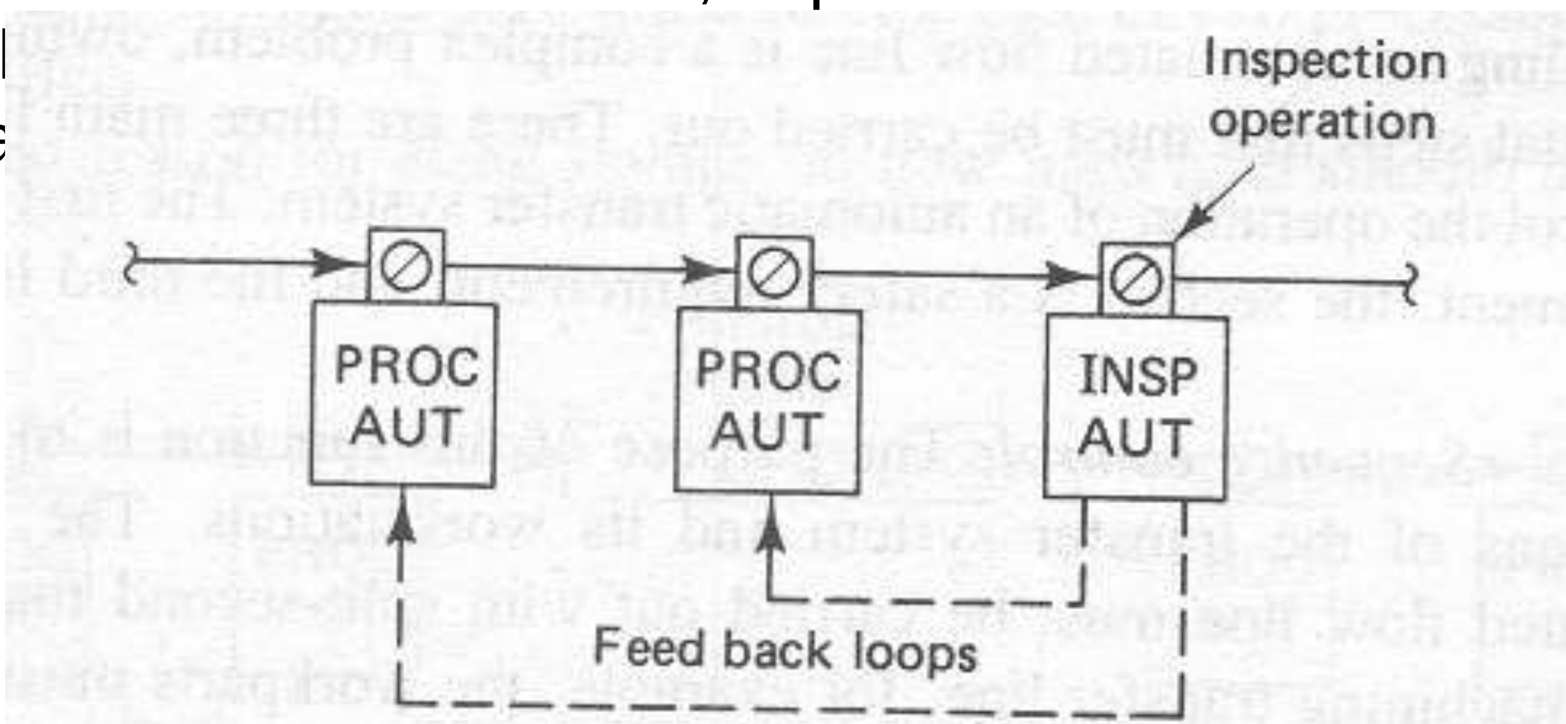
- ***Safety monitoring:***

  This function ensures that the transfer system does not operate in an unsafe or hazardous condition. Sensing devices may be added to make certain that the cutting tool status is satisfactory to continue to process the workpart in the case of a machining-type transfer line. Other checks might include monitoring certain critical steps in the sequence control function to make sure that these steps have all been performed and in the correct order. Hydraulic or air pressures might also be checked if

- ***Quality monitoring:***

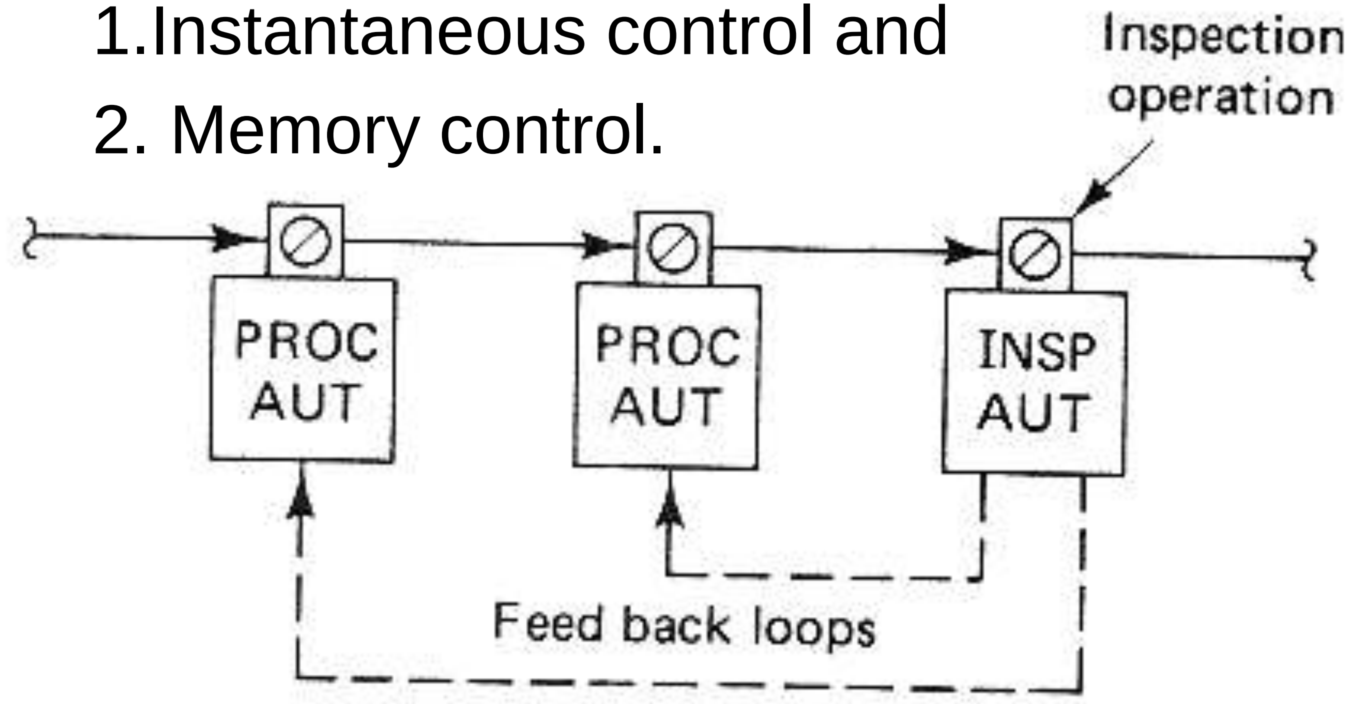
The third control function is to monitor certain quality attributes of the workpart. Its purpose is to identify and possibly reject defective workparts and assemblies. The inspection devices required to perform quality monitoring are sometimes incorporated into existing processing stations. In other cases, separate stations are included in tl kpart

a



Conventional thinking on the control of the line has been to stop operation when a malfunction occurred. While there are certain malfunctions representing unsafe conditions that demand shutdown of the line, there are other situations where stoppage of the line is not required and perhaps not even desirable. There are alternative control strategies

1. Instantaneous control and
2. Memory control.



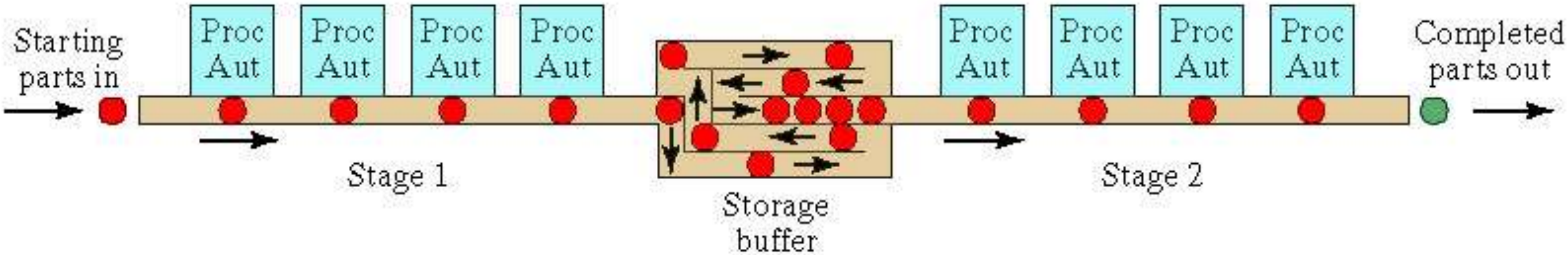
- ***Instantaneous control:***

  This mode of control stops the operation of the flow line immediately when a malfunction is detected. It is relatively simple, inexpensive, and trouble-free. Diagnostic features are often added to the system to aid in identifying the location and cause of the trouble to the operator so that repairs can be quickly made. However, stopping the machine results in loss of production from the entire line, and this is the system's biggest drawback.

- ***Memory control:***

  In contrast to instantaneous control, the memory system is designed to keep the machine operating. It works to control quality and/or protect the machine by preventing subsequent stations from processing the particular workpart and by segregating the part as defective at the end of the line. The premise upon which memory-type control is based is that the failures which occur at the stations will be random and infrequent. If, however, the station failures result from cause and tend to repeat, the memory system will not improve production but, rather, degrade it. The flow line will continue to operate, with the consequence that bad parts will continue to be produced. For this reason, a counter is sometimes used so

Buffer Storage



- It is not uncommon for production flow lines to include storage zones for collecting banks of workparts along the line.
- One example of the use of storage zones would be two intermittent transfer systems, each without any storage capacity, linked together with a workpart inventory area.
- It is possible to connect three, four, or even more lines in this manner. Another example of workpart storage on flow lines is the asynchronous transfer line.
- With this system, it is possible to provide a bank of workparts for every station on the line.

- There are two principal reasons for the use of buffer storage zones.
- The first is to i. reduce the effect of individual station breakdowns on the line operation.
- The continuous or intermittent transfer system acts as a single integrated machine. When breakdowns occur at the individual stations or when preventive maintenance is applied to the machine, production must be halted.

<u>Some of the common reasons for line stoppages are:</u>

Tool failures or tool adjustments at individual processing stations Scheduled tool changes

Defective workparts or components at assembly stations, which Require that the Feed mechanism be cleared

Feed hopper needs to be replenished at an

[redacted]

Analysis of Transfer Lines

There are a few assumptions that we will have to make about

the operation of the Transfer line & rotary indexing machines

- The workstations perform operations such as machining & not assembly.
- Processing times at each station are constant though they may not be equal.
- There is synchronous transfer of parts.
- No internal storage of buffers.

- In the operation of an automated production line, parts are introduced into the first workstation & are processed and transported at regular intervals to the succeeding stations.
- This interval defines the ideal cycle time, *Tc* of the production line. *Tc* is the processing time for the slowes ne; i.e. :

$$T_c = \max\,(T_{si}) + T_r \text{ ---------------- } (1)$$

Tc = Ideal cycle on the line (min)

Tsi = Processing time at station (min)

Tr = Repositioning time, called the transfer time (min)

In above eq. we use the max (Tsi) because the longest service time establishes the pace of the production line. The remaining stations with smaller service times will have to

- In the operation of a transfer line, random breakdowns & planned stoppages cause downtime on the line.

Common reasons for downtime on an Automated Production line:

1. Tool failures at workstations.
2. Tool adjustments at workstations
3. Scheduled tool charges
4. Limit switch or other electrical malfunctions.
5. Mechanical failure of a workstation.
6. Mechanical failure of a transfer line.
7. Stock outs of starting work parts.
8. Insufficient space for completed parts.
9. Preventive maintenance on the line worker breaks.

- The frequency of the breakdowns & line stoppages can be measured even though they occur randomly when the line stops, it is down for a certain average time for each downtime occurrence.
- These downtime occurrences cause the actual average production cycle time of the line to be longer than the ideal cycle time.

The actual average production time T_p:

$$T_p = T_c + FT_d \text{ ---------------------- } 2$$

F = downtime frequency, line stops / cycle

Td = downtime per line stop in minutes

The downtime Td includes the time for the repair crew to swing back into action, diagnose the cause of failure, fix it & restart the drive.

FT_d = downtime averaged on a per cycle basis

Production can be computed as a reciprocal of Tp

$$R_p = \frac{1}{T_p} \text{ -------------------------- } 3$$

Where, R_p = actual average production rate (pc / min)

T_p = the actual average production time

The ideal production rate is given by

$$R_c = \frac{1}{T_c} \text{ --------------------------- } 4$$

Where R_c = ideal production rate (pc / min)

Production rates must be expressed on an hourly basis on automated production lines.

- Line efficiency refers to the proportion of uptime on the line & is a measure of reliability more than efficiency.
- Line efficiency can be calculated as follows:

$$E = \frac{T_c}{T_p} = \frac{T_c}{T_c} + FT_d \text{ ---------------- } 5$$

Where
E = the proportion of uptime on the production line.

An alternative measure of the performance is the proportion of downtime on the line which is given by:

$$D = \frac{FT_d}{T_p} = \frac{FTd}{Tc} + FT_d \text{ ---------------- } 6$$

Where D = proportion of downtime on the line

$$E + D = 1.0$$

An important economic measure of the performance of an automated production line is the cost of the unit produced. The cost of 1 piece includes the cost of the starting blank that is to processed, the cost of time on the production line & the cost of the tool consumed. The cost per unit can be expressed as the sum of three factors:

$$Cpc = Cm + CoTp + Ct \text{ ---------------------- } 7$$

Where Cpc = cost per piece (Rs / pc)

Cm = cost per minute to operate the time (Rs / min)

Tp = average production time per piece (min / pc)

Ct = cost of tooling per piece (Rs / pc)

Co = the allocation of capital cost of the equipment over the service life, labour to operate the line, applicable overheads, maintenance, & other relevant costs all reduced to cost per min.

Problem on Transfer line performance:

A 30 station Transfer line is being proposed to machine a certain component currently produced by conventional methods. The proposal received from the machine tool builder states that the line will operate at a production rate of 100 pc / hr at 100% efficiency. From a similar transfer line it is estimated that breakdowns of all types will occur at a frequency of F = 0.20 breakdowns per cycle & that the average downtime per line stop will be 8.0 minutes. The starting blank that is machined on the line costs Rs. 5.00 per part. The line operates at a cost for 100 parts each & the average cost per tool = Rs. 20 per cutting edge. Compute the following:

1. Production rate
2. Line efficiency
3. Cost per unit piece produced on the line

- End of Chapter