STORAGE SYSTEMS

The function of a material storage system is to store materials for a period of time and to permit access to those materials when required.

Types of materials See Table 11.1

Product (Raw material, purchased parts, Work-in-Process, Finished product, Rework & scrap)

Process (Refuse, Tooling, Spare parts)

Overall support for factory operations (Office supplies, plant records)

Different categories of materials require different storage methods and controls.

- Manual: Inefficient use of human resources, factory floor space and material control.
- Automated: To improve the efficiency of the storage function.

STORAGE SYSTEM PERFORMANCE:

- system must be sufficient to justify its investment and operating costs.

Performance measures of a storage system

- Storage capacity
  - Total Volumetric space available
  - Total number of storage compartments
- Storage Density
- Accessibility
- Throughput
- Availability
- Utilization (Mechanized/Automated)

Materials are stored in unit loads (standard sized containers: pallets, tote pans, ...)

"handled, stored, transported"

Storage capacity is ~~conventionally~~ measured as the number of unit loads.

The physical capacity of the storage system should be greater than the maximum number of loads anticipated to be stored, in order to provide available empty spaces for materials being entered into / retrieved from the system.

Storage Density is defined as the volumetric space available for actual storage relative to the total volumetric space in the storage facility.

Aisle space and wasted overhead space account for more than the volume available for actual storage.

Sometimes floor area is used, since it is convenient to measure on a floor plan of the facility. However, volumetric density is usually more appropriate than area density.

For efficient use, the facility should achieve a high density.

Note that; as storage density is increased, accessibility is adversely affected.

↓

refers to the capability to access any item stored in the system.

There is a trade off between density and accessibility.

System throughput is defined as the hourly rate at which the storage system:

- receives and puts loads into the storage,
- retrieves and delivers loads to the output station,

The storage system must be designed for the maximum throughput required.

System throughput is limited by the time to perform storage/retrieval cycles

Single-command cycles

A typical storage transaction:
- pickup load at the input station,
- travel to storage location,
- place load into the storage location,
- travel back to the input station.

A typical retrieval transaction:
- travel to the storage location,
- pick the item from the storage location,

- travel to output station,
- unload the item at the output station.

Dual-command cycle:

Throughput can sometimes be increased by combining storage and retrieval transactions in one cycle, by reducing travel time.

In manual systems, time is lost often looking up the storage location of the item being stored / retrieved. There is a lack of control, since there are variations in elemental times and motivations of human workers.

Single vs. Dual depends on demand and scheduling capability.

If in some periods only storage and in some periods only retrieval operations demanded, then it is not possible to combine the transactions in one cycle. If both transaction types are required in the same period, then greater throughput will be achieved by scheduling dual command cycles. This is more readily achieved in automated syste

Throughput is also limited by the capability of the material handling system that is interfaced to the storage system.

If the maximum rate at which loads can be delivered to the storage system or removed from it by the handling system is less than the S/R cycle rate of the storage system, then throughput will be adversely affected.

Additional performance measures for mechanized/automated storage systems:

Utilization, is defined as the proportion of time that the system is actually being used for performing S/R operations compared with the time that is available. May vary throughout the day.

Desired range of utilization: 80 - 90%

If utilization is too low, it is overdesigned.
If utilization is too high, there is no allowance for rush periods or system breakdown.

Availability, (a measure of system reliability) is defined as the proportion of time that the system is capable of operating (not broken down) compared with the normally scheduled shift hours.

{Malfunctions / Failures} ≡ {Down Time} = { - Computer failures; - Mechanical breakdowns; - Load jams; - improper maintenance; - incorrect procedures } can be improved by good preventive maintenance procedures and by having repair parts on hand for critical components.

∴ Back-up procedures should be devised to overcome the adverse affects of system downtime.

STORAGE LOCATION STRATEGIES:

Basic strategies

Randomized Storage

Note that; each item type stored in a Warehouse is known as a SKU. (stock-keeping-unit)

Items are stored in any available location in the storage system. "incoming items are placed into storage in the nearest available open location." Retrieval FIFO!

Dedicated Storage

SKU's are assigned to specific locations in the storage system. The number of storage locations for each SKU must be sufficient to accomodate its maximum inventory level.

Retrieval FIFO!

Basis for specifying the storage locations:
- items are stored in part number or product number sequence,
- items are stored according to activity level, the more active SKU's being located closer to the input/output station.
- items are stored according to their activity-to-space ratios, the higher ratios being located closer to the input/output station.

∴ Less total space is required in a storage system that uses RANDOMIZED STORAGE, but higher throughput rates can usually be achieved when a DEDICATED STORAGE STRATEGY is implemented based on activity level.

Example 11.1:

A total of 50 SKUs must be stored.

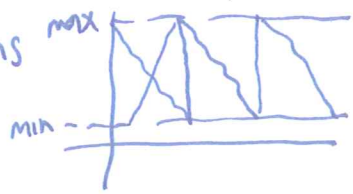
For each SKU: average order quantity = 100 cartons/order
average depletion rate = 2 cartons/day
safety stock = 10 cartons

Assume: 1 carton ≡ 1 storage space

An inventory cycle of 50 days: It is scheduled that a different SKU arrives each day.

Determine the number of storage locations required in the system under two alternative strategies: Randomized vs. Dedicated.

Maximum inventory level = 100 + 10 = 110 cartons
Minimum inventory level = 10 cartons
Average inventory level = $\frac{(110 + 10)}{2}$ = 60 cartons



Randomized storage strategy:

Number of locations = (50 SKUs)(60 cartons/SKU) = 3000 cartons
= 3000 locations

Dedicated storage strategy:

Number of locations = (50 SKUs)(110 cartons/SKU) = 5500 cartons
= 5500 locations

∴ CLASS-BASED DEDICATED STORAGE ALLOCATION:

The storage system is divided into several classes according to activity level, and a randomized storage strategy is used within each class. The classes containing more active SKUs are located closer to the input/output point of the storage system for increased throughput, and the randomized locations within the classes reduce the total number of storage compartments required.

CONVENTIONAL STORAGE METHODS & EQUIPMENTS:

See Table 11.1.

The choice of method/equipment depends largely on the material to be stored, the operating philosophy, and budgetary limitations.

Bulk storage, refers to the storage of stock in an open floor area. Generally, unit loads on pallets/containers, stacked on top of each other and next to each other to increase storage density. To achieve accessibility, loads can be organized into rows and blocks, so that natural aisles are created between loads. Block widths can be designed to provide an appropriate balance between density and accessibility.

Depending on the shape and physical support provided, there may be a restriction on how high the unit loads can be stacked. Even in some cases loads can not be stacked on top of each other.
The inability to stack loads in bulk storage reduces storage density. (This removes one of its principal benefits).

Bulk storage is characterized by the absence of specific storage equipment
↙
Industrial Trucks
(pallet truck/powered fork lifts)

Rack systems, provide a method of stacking unit loads vertically without the need for the loads themselves to provide support. (Pallet rack) consisting of a frame that includes horizontal load supporting beams.

- Cantilever racks "elimination of vertical beams" rods, bars, pipes
- Portable racks "box frames"
- Drive-through racks "open from both ends" "supporting rails"
  ↘ open at one end "drive-in rack"
- Flow-through racks "FIFO" one directional access for fork lifts!
  "Loaded from one-side and unloaded from the other side"

Shelving and bins, A shelf is a horizontal platform, supported by a wall or frame.

0.8 to 1.2 meters in the aisle direction,
0.3 to 0.6 meters wide,
upto 3 meters tall,

Bins are containers or boxes that hold loose items.

Drawer storage, Modular drawer storage cabinets are available in various dimensions.

Widely used for tools and maintenance items.

AUTOMATED STORAGE SYSTEMS: AS/RS systems, Carousel storage systems.

In the previous sections, a human element is required to access the item in the storage. So, the system itself is static.

Mechanization or Automation is used to reduce or even eliminate the amount of human intervention.

Level of Automation:
- less-automated — "Operator is required in each storage/retrieval transaction
- highly-automated — "loads are entered or retrieved under computer control, with no human participation."

- Increased storage capacity,
- Increased storage density,
- Improve security and reduce pilferage,
- Reduce labour cost,
- Increase labour productivity,
- Recover factory floor space (presently used for WIP)
- Improve safety,
- Improve control over inventories,
- Improve stock rotation,
- Improve customer service,
- Increase throughput.

Automated Storage/Retrieval Systems: It performs storage and retrieval operations with speed and accuracy under a defined degree of automation.

Wide range of automation:
- On one extreme: the operations are totally automated, computer controlled and fully integrated with factory and/or warehouse operations.
- On the other extreme; human workers control the equipment and perform the storage/retrieval transactions.

	AS/R SYSTEM	COROUSEL SYSTEM
STORAGE STRUCTURE	RACK SYSTEM	BASKETS SUSPENDED FROM AN OVERHEAD CONVEYOR
MOTIONS	LINEAR MOTIONS OF S/R MACHINE	REVOLUTION OF OVERHEAD CONVEYOR TROLLEY
S/R OPERATION	S/R MACHINE (CRANES) TRAVELS TO COMPARTMENTS IN RACK STRUCTURE	CONVEYOR REVOLVES TO BRING BASKETS TO UNLOAD/LOAD STATION
REPLICATION	MULTIPLE AISLES EACH ONE CONSISTING OF RACK STRUCTURE + S/R MACHINE EACH AISLE MAY HAVE ONE OR MORE INPUT/OUTPUT STATIONS PICKUP-AND-DEPOSIT (P&D) STATIONS can be manual or interfaced to some form of automated handling system (such as CONVEYOR, AGVs).	MULTIPLE CAROUSELS EACH CONSISTING OF OVAL TRACK AND SUSPENDED BINS.

AS/R System Types:

Horizontal Aisles

- Unit load AS/RS: "pallet or standard containers" Computer controlled S/R Machine capable of handling unit loads.
- Deep-lane AS/RS: "high-density" large quantities with small SKU types Ten or more loads in a single rack. "Flow Through Racks" (input on one side and output the other side)
- Miniload AS/RS: capable of handling small loads (individual parts) contained in bins or drawers. Bins & drawers moved to P/D station. Then returned. Smaller in size!
- Man-on-Board AS/RS: A human operator rides on the carriage of the S/R Machine. P/d at storage location.
- Automated Item Retrieval System: items are stored in lanes. Required item is pushed from the lanes, drops onto a conveyor for P/D station.

Vertical Aisle

- Vertical lift storage modules: Vertical Lift AS/R System.

Reasons for AS/RS for WIP:

- Buffer storage in production,
- Support just-in-time-delivery,
- Kitting of parts for assembly,
  tote box = Kit
- Compatible with automatic identification systems,
- Computer control and tracking of materials,
- Support for factory-wide automation.

Components and Operating Features of AS/RS:

- Storage structure,
- S/R Machine,
- Storage modules,
- One or more pickup-and-deposit stations.

Operating Features:

- positioning the S/R machine,
- determination of storage locations,

Carroussel Storage Systems:

consists of a series bins or baskets suspended from an overhead chain conveyor that revolves around a long rail system.

- horizontal
- vertical

Applications:
- storage/retrieval operation,
- transport and accumulation,
- Work in process,
- Unique applications.