Departmental Elective Course

IE 473

Material Handling Systems

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Material Handling

Introduction

- **Material Handling System** is an important component of the *Facilities Planning and Design*.
- A strong relationship between the ***layout design*** and ***material handling design*** functions.
- What ever the material is being handled, many of the same principles apply.
- Wide variety of problems necessities a systematic approach to ***Material Handling Systems Design***.

Understanding Material Handling

- ***In a typical factory***, Material Handling (MH) accounts for 25% of all employees, 55% of all factory space, and 87% of production time.
- ***MH*** is estimated to represent between 15 and 70% of the total cost of a manufactured product.
- ***MH*** is one of the first place to look for ***COST REDUCTION & QUALITY IMPOROVEMENT*** **!**
- It has been estimated that 3 and 5% of all material handled becomes ***damaged***.
- **Conclusion:** In order o be competitive, ***minimize or even eliminate MH***.

Material Handling

- The ***re-design of General Electric dishwasher facility*** in Louisville, Kentucky:
  - ***Unit cost index*** reduced from 100 => 70,
  - ***Annual inventory turn-over rate*** increased from 13 => 25,
  - ***Reject rates*** reduced from 10% => 3%,
  - ***Output per employee index*** increased from 100 => 133,
  - ***# of times unit handled*** reduced from 27 to 3.
- In the summer of 1983, after this re-design study, consumer reports rated the GE dishwasher as the best value among the others. By ***simply handling less***, GE has set an admirable example for all manufacturers in industrial competitiveness.
- HOWEVER, handling less is not the ***ANSWER***.
- Material handling is a tool by which ***total manufacturing costs*** *are reduced through* **reduced inventories, improved safety, reduced pilferage, and improved material control**.
- As a result, MH is the way by which any production strategy is executed: *Not only handling* ***LESS****, but also handling* ***SMARTER*** and with an increased awareness of the vital role of MH in manufacturing and distribution is the *key to improve the firm's overall competitive edge in a global economy*.
- Any technology playing such a *vital role in the economy as MH,* deserves attention and comprehension.

Material Handling

Definition : No unique, all encompassing definition of MH. There are nine definitions on its opening page of the Material Handling Handbook: We will discuss two of them.

MH is the ***art and science*** of ***moving, storing, protecting,*** and ***controlling material***:

- ***Art*****:** Because MH problems and systems can not be explicitly solved/designed solely with scientific formulas or mathematical models. It requires an appreciation for right and wrong, that accompanies significant practical experience in the field.
- ***Science*****:** Because the engineering method (define the problem, collect and analyze data, generate alternative solutions, evaluate alternatives, select and implement preferred alternative) is an integral part of MH problem solving and system design process. Mathematical models and quantitative techniques for analysis are very valuable part of the process.
- ***Moving*****:** is required to create time and place utility. Any movement of material requires that the size, shape, weight, and condition of the material as well as the path and frequency of the move be analyzed.
- ***Storing*****:** provides a buffer between operations, facilitates the efficient use of people, and machines, and provides for efficient organization of material. The size, weight, condition, and stackability of the material, the required throughput, and building considerations such as floor loading, floor condition, column spacing, and clear height should be considered.
- ***Protecting*****:** includes both the packaging, packing and unitizing done to protect against damage and theft of material, as well as the use of safeguards on the information system to include protection against the material being mishandled, misplaced, misappropriated, and processed in the wrong sequence.

  "Inspecting quality into a product, by designing into the product": The MH System should be designed to minimize the need for inspections and costly methods of protecting the material.
- ***Controlling****:* requires physical and status material control. Physical control is control of the orientation of, sequence of, and space between material. Status control is the real-time awareness of the location, amount, destination, origin, ownership, and schedule of material.
- ***Material*****:** very broadly, including bulk material and unit loads, in any form (solid, liquid or gas). Occasionally, paperwork and information will also be considered as material.

Material Handling

From potato chips to semiconductor chips, from coin, currency, and negotiable securities to sides of beef, from sailing ships to printed circuit boards, ***the same principles and approaches are applicable*** in the *movement, storage, control, and protection of material*.

- *Material handling* means providing the ***right amount*** of the ***right material***, in the ***right condition***, at the ***right place***, at the ***right time***, in the ***right position***, in the ***right sequence***, and for the ***right cost***, by using the ***right method(s)***.

  Naturally, if *the right methods* are being used, then the ***MH System*** will be ***safe and damage free***.

  – ***Right amount*:** Because of JIT, production lot sizes have been reduced significantly and the amount and the cost of inventory is reduced. Contrary, in order to reduce the cost of handling, the size of the unit load should be increased. Note that the right amount is not zero.

  In determining the right amount of material to stock in a warehouse, it is often required to determine the right amount to stock in the active picking area and the right amount to provide as safety stock.

  – ***Right material*:** The two most common errors made in order picking are the picking the wrong amount and picking the wrong material. For a MH System to move, store, protect, and control the right material, an accurate identification system must be included. Automatic identification is the key to accurate identification. The proliferation of bar coding technology, the emergence and maturation of radio frequency identification, and the continued development of magnetic and other identification technologies make it possible to provide the right material consistently.

  Reduce the number of part numbers by standardization and removing obsolete parts from the database. Simplify the part numbering system at all.

Material Handling

Finally, it is important to recognize that moving, storing, protecting, and controlling the right material requires a decision as to which material to move, store, protect, and control.

Not all material has to be controlled in the same way. Infrequently used material of low value does not require the same degree of control as frequently used material of high value.

– ***Right condition*:** The first thing that comes to mind is ***top quality, and the absence of damage***. If quality is what the customer says it is, then we must identify the customers of the handling system. But, quality is not all that the right material means. We are also concerned about the status of the material (its location, the processing steps that have been performed, its physical characteristics, its availability for shipment, and the need for tests or inspections).

It is important to ascertain what each customer requires in terms of the condition of the material served by the handling system.

– ***Right place*:** When material arrives, quite often it is placed in one or more "temporary" locations or staging points before it is eventually placed in storage. Regardless of weather material has assigned or randomized storage locations, it should be placed in the right location (place).

It is also important for material locations to be entered quickly and accurately in the locator system.

When material arrives on the manufacturing floor, it tends to be stacked on the floor or placed in "buffers" awaiting further processing. The decisions should be made regarding whether central storage or distributed storage is best for a particular application.

In the design of workstation, from an ergonomics point of view, material should be placed within easy reach; hence, stooping, bending, and stretching of operator should be avoided. This also applies for the assignment of material to storage locations for an order picker.

While there might be more than one right place for material, the number of wrong places far exceeds the number of right places.

Aisle is never a right place for material to be stored, staged or queued.

Material Handling

- ***Right time***: The need for the material handling system at the right time is increasingly important due to time-based competition. Quick response systems reduce the time required to manufacture and deliver products to customers. In order for the material handling system to be able to satisfy the requirements for timely responses, excess capacity in the system is generally required.

  Cycle-time reduction is a primary target in continuous improvement programs, Total Quality Management (TQM), places considerable emphasis on reducing non-value-adding activities in the process.

  The notion of supply chain management hinges on reducing the length of the supply pipeline by reducing the time required to move, store, protect, and control the material throughout the pipeline.

  Although we advocated shorter overall system time, we did not advocate using faster equipment.

  Being to soon can be worse than being too late in material handling. Note that, the emphasis is on the right time, not the fastest time.
- ***Right position/orientation***: Machined parts are dumped into tote boxes; subsequently someone sorts out the parts and reorients them for the next operation. Physical orientation is often accommodated by changing the design of a part, by adding locator holes or pins, automatic orientation of parts might become feasible.

  Not only do parts and cases need to be oriented properly, but so do palletized loads. It is important for MH System designer to maintain the proper orientation of unit loads as they make right-angle transfers on a conveyor system.
- ***Right sequence***: Work simplification teaches that productivity can be increased by eliminating unnecessary steps in an operation and improving those that remain. Also, productivity improvement can occur by combining steps and changing the sequence of steps performed.

  The impact of the sequence of activities performed on the efficiency of an operation is very evident in material handling.

  An opportunity for systems improvements through sequence changes is often the design of the control system.

Material Handling

- ***Right cost*** **:** Remember, the objective of the firm is to maximizes the value provided to the shareholders; it is not to achieve a minimum cost of MH. The right cost is not necessarily the lowest cost.

  MH System can be a revenue enhancer, rather than a cost contributor. Today, firms compete on the basis of product functionality, product quality, service quality, time, and cost. To do so, the MH System must be both effective (does the right things) and efficient (does things right).

  Although, a significant percentages of direct labor time is devoted to material handling, generally, the majority of the material handling cost is buried in a firm's overhead costs. In measuring such costs, both costs incurred (investment and operating costs for MH technology and personnel) and costs foregone (costs of inventories, space, inspectors, expeditors, and other personnel not needed because of the installation of the MH System) should be measured.

  Reduction in losses due to damage and pilferage need to be included.
- ***Right methods***: Finally, to do all the right things right, we need to employ the right methods. But, the right method is not necessarily the most sophisticated method, the newest method, or the least expensive method.

  Simply stated, a method is right if it satisfies the requirements of providing the right amount of the right materials, in the right condition, in the right sequence, in the right orientation, at the right place, at the right time, and at the right cost.

MH is much more than simply MH. Material Handling is an art and a science, that involves the movement, storage, control, and protection of material, with the objective of providing time and place utility.

Material Handling

Material Handling Costs

- The main costs involved in designing and operating a MH System are:
  - ***Equipment cost***, which comprises the purchasing of the equipment and auxiliary components, and installations,
  - ***Operating cost***, which includes maintenance, fuel, and labor cost, consisting of both wages and injury compensation,
  - ***Unit purchase cost***, which is associated with purchasing the pallets and containers,
  - Cost due to packaging and damaged material.

Objectives

- The major objective of MH System design is reducing production cost through efficient handling or, more specifically:
  - To increase the efficiency of material flow by ensuring the availability of materials when and where they are needed.
  - To reduce material handling costs.
  - To improve facilities utilization.
  - To improve safety and working conditions.
  - To facilitate the manufacturing process.
  - To increase productivity.

Material Handling

Goals: The primary goal of material handling is to reduce overall unit costs of production.

- The following subordinate goals are a good check-list for cost reduction:
  - Maintain or improve product quality, reduce damage, and provide for protection of materials,
  - Promote safety and improve working conditions,
  - Promote productivity through;
    - Material should flow in a straight line,
    - Material should move as short a distance as possible,
    - Use gravity! It is free power,
    - Move more material at one time,
    - Mechanize material handling,
    - Automate material handling,
    - Maintain or improve material handling/production ratios,
    - Increase throughput by using automatic material handling equipment,
  - Promote increased use of facilities by;
    - Promote the use of the building cube,
    - Purchase versatile equipment,
    - Standardize material handling equipment,
    - Maximize production equipment utilization using material handling feeders,
    - Maintain, and replace as needed, all equipment and develop a preventive maintenance program,
    - Integrate all material handling equipment into a system,
  - Reduce tare (dead) weight,
  - Control inventory.

Material Handling

- OR models have been applied to the design and operations of material handling systems, involving use of mathematical programming, simulation, queuing theory, and network models.
- Examples of applications: Conveyor systems, pallet design and loading, equipment selection, dock design, equipment routing, packaging, and storage system design.
- ***The selection of material handling equipment and its assignment to departmental material-handling tasks***: after an initial screening has been performed by the designer to determine the most promising candidates, the final selection is to be made analytically.
- Each move can be performed by most or all of the candidate equipment, thus for each move, there are different values for the operating cost and time based on the equipment used.
- The problem requires selection of equipment among the candidate set and assigning them to the moves such that a move is not made by more than one item of equipment unless they are of the same type (that is, each move is assigned to only one equipment type) and all moves assigned to a piece of equipment can be performed in the available time on the equipment.
- The primary objective of the problem is cost (operating and initial) minimization. There are also some secondary objectives such as maximum utilization of equipment and minimum variation in the selected types, but they are most often compatible with the primary objective.

Material Handling

Parameters to be used*:*

- q = total number of moves to be assigned,
- p = number of candidate equipment types,
- a_{ij} = {0/1} binary parameter; 1 if equipment type i can perform move j, or 0 otherwise,
- W_{ij} = total operating cost of performing move j by equipment type i in the pre-determined time period,
- K_i = capital cost of one unit of equipment type i in the pre-determined time period,
- h_{ij} = total operating time required by equipment type i to perform move j,
- H_i = available operating time of one unit of equipment type i in the pre-determined time period,
- i = index to be used for equipment types, $i = 1, .., p$,
- j = index to be used for moves, $j = 1, .., q$,

Decision variables:

- λ_i = number of units of equipment of a selected equipment type i that are required,
- X_{ij} = {0/1} binary decision variable; 1 if equipment type i is assigned to move j, *or* 0 otherwise,

Material Handling

Minimizing $z = \sum_{i=1}^{p}\sum_{j=1}^{q} W_{ij} X_{ij} + \sum_{i=1}^{p} \lambda_i K_i$

Subject to

$$\sum_{i=1}^{p} a_{ij} X_{ij} = 1 \qquad j = 1, \quad \ldots \quad , q$$

$$\sum_{j=1}^{q} h_{ij} X_{ij} \leq \lambda_i H_i \qquad i = 1, \quad \ldots \quad , p$$

$X_{ij} = \{0/1\}$ binary for all *i j*

$\lambda_j \geq 0$ and integer for all *i j*

Material Handling

The scope:

- The *first*, and narrowest, the "***conventional*** " interpretation;
  - here the primary emphasis is on the movement of materials from one location to another, usually within the same plant. Very little attention is given to the inter-relationships of the individual handling tasks. Unfortunately, this is very common interpretation of the scope of material handling.
- A *second* interpretation is the "***contemporary***" point of view,
  - in which attention centers on the overall flow of materials in a plant or warehouse; inter-relationships between handling tasks are analyzed, and an effort is made to develop an integrated material handling plan.
- A *third* interpretation, the broadest, is the "***progressive***" interpretation;
  - this is the systems perspective, defining material handling as all activities involved in handling material from all suppliers, handling material within the manufacturing or distribution facility, and distributing finished goods to customers.

Material Handling

The principles:

- In 1966 the College-Industry Council on Material Handling Education adopted 20 principles of material handling. They were revised in 1981 to reflect changes in industrial operations in the years since they were first adopted.
- The material handling principles provide concise statements of the fundamentals of material handling practice. They provide guidance and perspective to material handling system designers.
- The applicability of the principles depends on the conditions that exist; due to the many different conditions that might exist, it is unlikely that any principle will always be applicable.
- Rather than being design axioms, the principles serve as rough guides or rules of thumb for material handling systems design.
- Based on the principles, a number of checklists have been developed to facilitate the identification of improvement opportunities for existing systems.
- Checklists can serve a useful purpose in designing new and improved systems and can make a valuable contribution to the design process.
- These principles can also be compiled slightly differently to suggest how the objectives are to be achieved.
- These principles are compatible with each other.

Material Handling

The principles:

- ***Orientation***: Identify existing methods and problems, physical and economic constraints.
- ***Planning*****:** Establish a plan to include basic requirements, desirable options, and the considerations of contingencies for all material handling and storing activities.
- ***Systems***: Integrate those handling and storage activities that are economically viable into a coordinated system of operations, including receiving, inspection, storage, production, assembly, packaging,, warehousing, shipping , and transportation.
- ***Unit Load*****:** Handle product in as large a unit load as practical.
- ***Space Utilization***: Make effective utilization of all cubic space.
- ***Standardization*****:** Standardize handling methods and equipment wherever possible.
- ***Ergonomic*****:** Recognize human capabilities and limitations by designing material handling equipment and procedures for effective interaction with the people using the system.
- ***Energy*****:** Include energy consumption of the material handling systems and procedures when making comparisons or preparing economic justifications.
- ***Ecology*****:** Use material handling equipment and procedures that minimize adverse effects on the environment.
- ***Mechanization*****:** Mechanize the handling process where feasible to increase efficiency and economy in handling of materials.

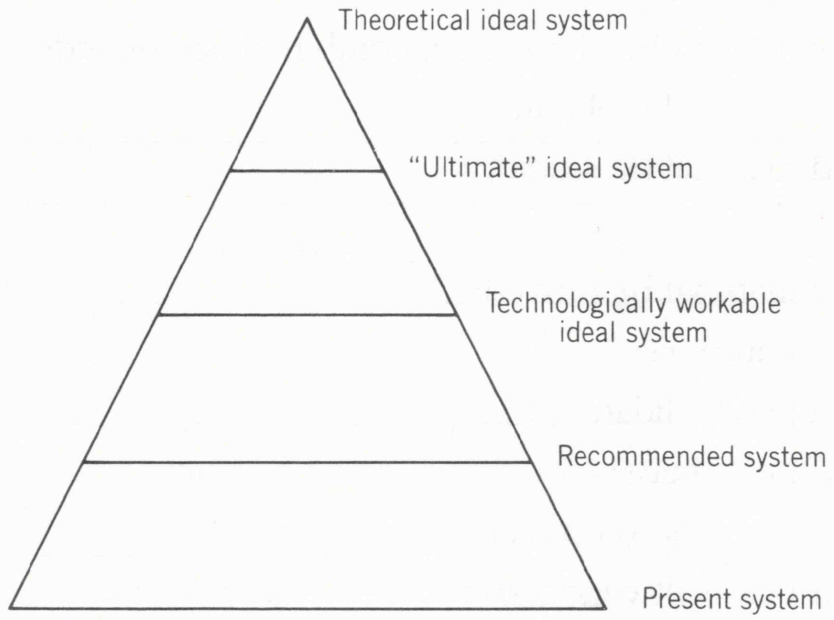
Material Handling

- ***Flexibility***: Use methods and equipments that can perform a variety of tasks under a variety of operating conditions.
- ***Simplification***: Simplify handling by eliminating, reducing, or combining unnecessary movements and/or equipment.
- ***Gravity***: Utilize gravity to move material wherever possible, while respecting limitations concerning safety, product damage, and loss.
- ***Safety***: Provide safe material handling equipment and methods that follow existing safety codes, and regulations in addition to accrued experience.
- ***Computerization***: Consider computerization in material handling and storage systems, when circumstances warrant, for improved material and information control.
- ***System Flow***: Integrate data flow with physical material flow in handling and storage.
- ***Layout***: Prepare an operation sequence and equipment layout for all viable system solutions, then select the alternative system which best integrates efficiency and effectiveness.
- ***Cost***: Compare the economic justification of alternative solutions in equipment and methods on the basis of economic effectiveness as measured by expense per unit handled.
- ***Maintenance***: Prepare a plan for preventive maintenance and scheduled repairs on all material handling equipment.
- ***Obsolescence***: Prepare a long-range and economically sound policy for replacement of obsolete equipment and methods with special consideration to after-tax life cycle costs.

Material Handling Systems Design

- ***In designing new or improving an existing material handling system, the six-phased engineering design process should be used:***
  - Define the objectives and scope for material handling system,
  - Analyze the requirements for moving, storing, protecting, and controlling material,
  - Generate alternative designs for meeting material handling system requirements,
  - Evaluate alternative material handling system designs,
  - Select the preferred design for moving, storing, protecting, and controlling material,
  - Implement the preferred design, including the selection of supplies, training of personnel, installation, debug and start-up of equipment, and periodic audits of system performance.
- ***To stimulate the developers of alternative system designs, the "ideal systems approach" should be considered. As proposed by Nadler:***
  - **AIM for the theoretical ideal system,**
    - It is a perfect system with zero cost, perfect quality, no safety hazards, no wasted space, and no management inefficiencies,
  - **CONCEPTUALIZE the ultimate ideal system,**
    - It is a system that probably would be achievable at some point in the future, but is not achievable at the present time because of a lack of available technology,
  - **DESIGN the technologically workable ideal system,**
    - It is a system for which the required technology is available; however, costs or other conditions may prevent some components from being installed now,
  - **INSTALL the recommended system,**
    - It is a cost-effective system that will work now without obstacles to its successful implementation.

Material Handling Systems Design



The ideal systems approach.

Material Handling Systems Design

- ***Relationship between Material Handling and Plant Layout:***
  - The relationship between the two involves the data required for designing each activity, their common objectives, the effect on space, and the flow pattern.
  - Specifically, plant layout problems require knowledge of the equipment operating cost in order to locate the departments in a manner that will minimize the total material-handling cost.
  - At the same time, in designing a material handling system the layout should be known in order to have the move length, move time, source and destination of the move.
  - Because of this dependency, the only feasible way is to start with one problem, use its solution for solving the other, then go back and modify the first problem on the basis of the new information obtained from the second, and so on until a satisfactory design is obtained.
  - Plant layout and material handling have the common objective of cost minimization. The material handling cost can be minimized by arranging closely related departments such that the material moves only short distances.