UNIT 7 MATERIAL HANDLING

Structure

7.0 OBJECTIVES

By the time you have studied this unit, you should be able to:

- understand the principles and concepts of material handling;
- know various available material handling devices and their drive mechanisms; and
- understand the importance of material handling and decide the suitability of different machinery for various uses.

7.1 INTRODUCTION

Material handling is an activity that uses the right method to provide the right amount of the right material at the right place, at the right time, in the right sequence, in the right position and at the right cost. Material handling includes a number of operations that can be executed either by hand (manual) or by mechanical means or devices to convey material and to reduce the human drudgery. Mechanical handling devices aim to lighten the work of human labour. After harvesting, crops are moved, transported or conveyed from place to place. In earlier periods all these operations were manual. The crops were primary processed and bagged/boxed by human labour. Foods were transported several times through storage and processing plants, and the processed food products were conveyed manually to consumers. Thus, foods were handled too much involving increased costs and human drudgery. But in modem times, some of the mechanical devices have replaced human labour, other supplement it or in some case make possible to handle larger quantities of grains per unit human labour.

7.1.1 Material Handling Principles

Various principles involved in material handling are:

1. Thorough study the problem and identification of problem areas, constraints and goals.
2. Develop plans, which meets our basic requirements, is flexible and includes desirable features.
3. Integrate various activities such as receiving, shipping, production assembly, etc.
4. Make the unit load size as large as possible.
5. Use the cubic space as effectively as possible.
6. Where possible standardize equipment and procedures.
7. Design equipment and methods that allow effective interaction between humans and machines.
8. When evaluating handling equipment, examine energy requirement and costs.
9. To the extent possible, use methods and equipment that minimize adverse effects on the environment.
10. Where possible mechanize methods to achieve efficiency.
11. Use methods and equipments that provides the maximum flexibility.
12. Simplify, combine or if possible eliminate unnecessary moves or equipment.
13. Use gravity as much as possible to transfer material keeping in mind safety and product damage.
14. Use safe handling equipment and methods.
15. To the extent possible computerize, so as to achieve better material and information control.
16. Integrate material and information flows.
17. Evaluate each alternate layout and select the most effective and efficient one.
18. Evaluate each alternate solution and select one based on cost per unit handled.
19. Perform preventive maintenance.
20. Develop equipment replacement plan based on after-tax life cycle costs.

7.1.2 Systems Approach to Materials Handling

When establishing methods of materials handling, a systems approach covering raw materials, materials in process and finished products is needed, in order to optimize flow rates in the correct sequence throughout the production process and to avoid bottlenecks or shortages. Additionally the flow of foods through a factory should be as simple as possible to reduce costs, to avoid confusion, which could lead to the contamination of processed foods by raw foods, to improve working conditions and to attain the benefits.

7.2 MATERIAL HANDLING DEVICES

7.2.1 Conveyors

Conveyors are widely used in all food processing industries for the movement of solid materials, both within unit operations and between operations (Table 7.1). There are a large number of conveyor designs, produced to meet specific applications. Common types include the following.

1. **Belt conveyor:** This is an endless belt, which is held under tension between two rollers, one of which is driven. The belts may be stainless steel mesh or wire, synthetic rubber, or a composite of canvass, steel and polyurethane or polyester. Flat belts are used to carry packed foods, and trough-shaped belts are used for bulk materials. Belts may be inclined up to 45°, if they are fitted with cross slats to prevent the product from slipping. Metal or wooden slatted conveyors are used instead of belts for greater load bearing and a reduced risk of damage to the conveyor.

2. **Roller conveyor** and skate wheel conveyor. Free-running (unpowered) rollers or wheels are either horizontal, to allow packed foods to be pushed along, or slightly inclined for transport under gravity. Rollers are heavier and stronger than wheels and therefore able to carry heavier loads. However, they are more difficult to start and stop, and more difficult to use around corners. Steeper inclines produce greater acceleration of packages, and a fall of approximately 10 cm in 3 m is sufficient for most purposes. Powered conveyors are used horizontally, or at a maximum inclination of 10-12°.

Table 7.1: Applications of materials-handling equipment

	Conveyors	Elevators	Cranes and hoists	Trucks	Pneumatic equipment	Water flumes
Direction						
Vertical up		*	*			
Vertical down		*	*		*	
Incline up	*	*			*	
Incline up	*	*			*	*
Horizontal	*			*	*	
Frequency						
Continuous	*	*			*	*
Intermittent			*	*		
Location served						
Point	*	*			*	*
Path	*				*	*
Limited area			*			
Unlimited area				*		
Height						
Overhead	*	*	*		*	
Working height	*			*	*	*
Floor level	*		*	*		*
Underfloor	*				*	*

Materials						
Packed	*	*	*	*		
Bulk	*	*	*	*	*	
Solid	*	*	*	*	*	*
Liquid				*	*	*
Service						
Permanent	*	*	*		*	*
Temporary			*	*		

3. **Chain conveyor:** This is used to move churns, barrels, crates and similar bulk containers by placing them directly over a driven chain, with protruding lugs, located at floor level. A similar monorail conveyor is used for moving meat carcasses on an overhead track.

4. **Screw conveyor:** This consists of a rotating helical screw inside a metal trough. It is used to move bulk foods (for example flour and sugar) and small-particulate foods (for example peas or grains). The main advantages are the uniform, easily controlled discharge, the compact cross-section (without a return conveyor) and total enclosure to protect the product and to prevent contamination. They may be horizontal or vertically inclined but are generally limited to a maximum length of 6 m as, above this, high friction forces result in excessive power consumption.

5. **Vibratory conveyors:** These impart a vertical movement to food, to raise it a few millimetres off the conveyor, and a forward movement, to move the food along the conveyor. The amplitude of vibration is adjusted to control the speed and direction of movement. This precise control makes vibratory conveyors useful as feed mechanisms for processing equipment. They are also useful, for moving sticky or friable foods (snack foods).

6. **Flight conveyors:** Here, bulk material (for example grain or flour) is dragged through an enclosed channel by an endless chain fitted with hooks or flights. Chain speeds are low (6-10m min^{-1}) and the inclination is limited to 30°, above which the material slips back.

7.2.2 Elevators

Four common types of elevator are as follows:

1. **Bucket elevators:** consist of metal or plastic buckets fixed between two endless chains. They have a high capacity for free-flowing powders and particulate foods. The shape and spacing of the buckets, the method of discharge and the speed of the conveyor (15-100 m min^{-1}) control the flow rate of materials.

2. **Magnetic elevators:** are used for conveying cans within canneries. They have a positive action in being able to hold the cans in place and are thus able to invert empty cans for cleaning and operate at high speeds with minimal noise.

3. **Flight elevators**: are essentially inclined flight conveyors. They have flexibility in use for a wide range of free-flowing bulk foods, high capacity and good space utilization.

4. **Pneumatic elevators:** Powders or small-particulate foods are suspended in air, which is re-circulated at 1000-1700 m min^{-1} inside a system of pipes. The air velocity is critical; if it is too low, the solids settle out whereas, if it

is too high, there is abrasion damage to the pipe surfaces. Similar equipment is used to classify foods and to dry foods. A build-up of static electricity is prevented by control over the moisture content of the food and earthing the equipment. This is necessary when conveying powders to minimize the risk of dust explosions. This type of equipment has a smooth operation and cannot be overloaded. It has few moving parts; low maintenance costs and only requires a supply of compressed air at 700 kPa.

7.3 PRINCIPAL DRIVE MECHANISMS, SUITABILITY OF USE AND ENERGY REQUIREMENT FOR MATERIAL HANDLING

7.3.1 Belt Conveyors

A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers. The belt may be flat for transporting bagged material or V-shaped or some other enclosed shape for moving bulk grains. The belt conveyor consists of a belt, drive mechanism and end pulleys, idlers and loading and discharge devices (Figure 7.1). Belt conveyors have antifriction bearing, therefore, these have a high mechanical efficiency. Material carried by belt conveyor lie still on the surface of belt or there is no relative motion between the product and belt. This results in generally no damage to material. Belt can be run at higher speeds, so, large carrying capacities are possible. Horizontally the material can be transported to longer distance but there is a limit to carry the material on elevation. A properly designed and maintained belt conveyor has long service life and low operating costs. Compared to other types of horizontal conveying system, the initial cost of belt conveyor is high for short distances. But for longer distances, the initial cost of belt conveying system is competitive or low.

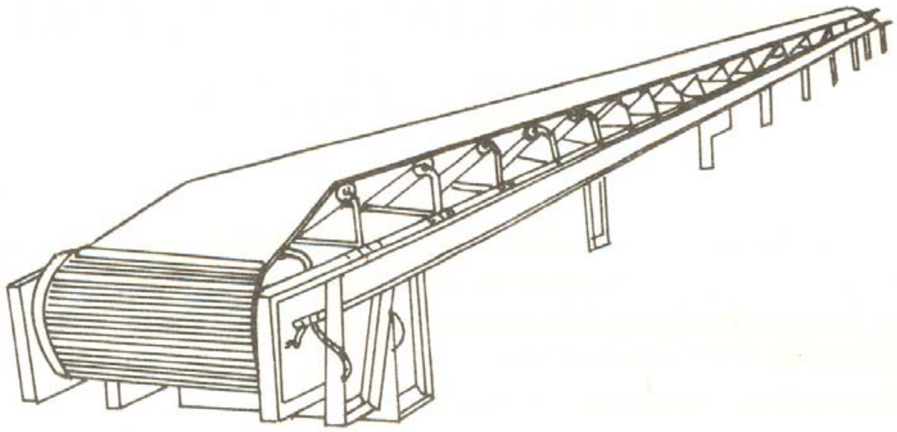

Figure 7.1: Belt conveyor

The design of belt conveyor system is based on available space, horizontal conveying length and conveying lift, characteristics of the material to be conveyed and capacity requirement. On the basis of overall requirement and information, the following will be determined to design a belt conveyor, belt width, belt speed, required horsepower, maximum belt tension and breaking strength of the belt, diameter of the pulleys and idlers and quality of belt (thickness).

The first step in the design of a belt conveyor with a specified conveying capacity is to determine the speed and width of the belt. The belt speed should be selected to minimize product spillage. The selection of belt width will depend upon the capacity requirement, speed of operation, angle of inclination of belt conveyor, trough angle and depth. The capacity of belt conveyor can be given by;

$$\text{Capacity, m}^2\text{/hr} = (\text{area of cross-section, m}^2) \times (\text{belt-speed, m/min}) \times 60 \tag{7.1}$$

The load cross sections of troughed belt is shown in Figure 7.2.

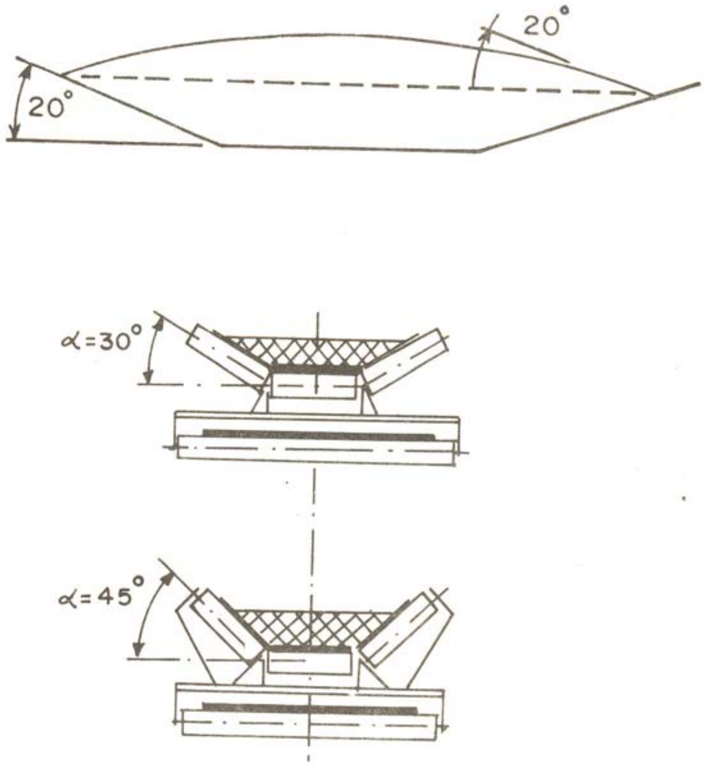

Figure 7.2: Various troughing configurations

The horsepower required for operation of belt conveyor for conveying grains can be calculated by the following equations. These equations are based on lift, friction resistance of the belt and pulleys and trippers. The values of constants are given in Table 7.2.

$$HP_1 = \frac{\text{Beltspeed, m/min.}}{0.3048} \text{x} \frac{(A+B)(3.281L)}{100} \tag{7.2}$$

$$HP_2 = \text{Capacity, t/hrX} \frac{0.48 + 0.01L}{100} \tag{7.3}$$

$$HP_3 = \frac{\text{Lift, m}}{0.3048} \text{x}1.015\text{x} \frac{\text{Capacity, t/hr}}{1000} \tag{7.4}$$

where, L = length of belt, m
A & B are constants.

Table 7.2: Values of constants A and B

Belt width, cm	Constants		Additional horsepower for tripper
	A	B	
36	0.20	0.00140	0.70
41	0.25	0.00140	0.85
46	0.30	0.00162	1.00
50	0.30	0.00187	1.40
60	0.36	0.00224	1.70
76	0.48	0.00298	2.50

The majority of belt conveyors for transporting bulk material use some type of rubberised conveyor belt made up of carcass. The pull of load is taken by the longitudinal strength of belt while the transverse strength supports the load. The belt is protected from damage by a rubber cover. The thickness of top rubber cover varies with thickness and wear resistance requirements.

7.3.2 Screw Conveyors

The screw conveyor consists of a tubular or U-shaped trough in which a shaft with spiral screw revolves. The screw shaft is supported by end and hanger bearings. The rotation of screw pushes the grain along the trough. A typical screw conveyor is shown in Figures 7.3a and b. The screw conveyor is used for conveying of products generally for short distances. Screw conveyor requires relatively high power and is more susceptible to wear than other types of conveyors. The pitch of a standard screw, which is the distance from the center of one thread to the center of the next thread, is equal to its diameter.

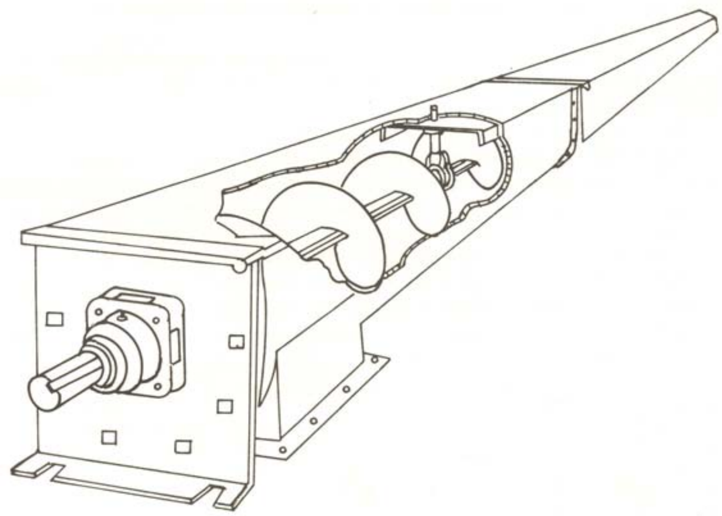

Figure 7.3a: Screw conveyor

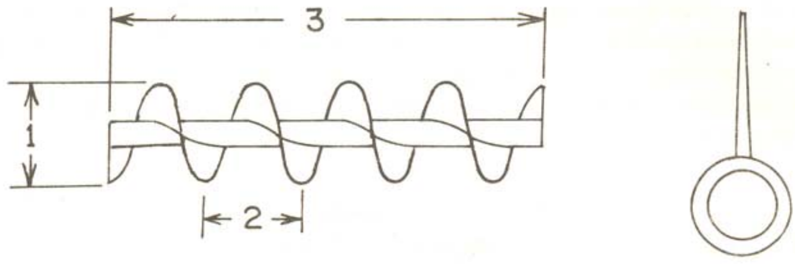

Figure 7.3b: Screw conveyor-details: 1) Screw diameter, 2) Pitch of screw, 3) Screw length

As the screw conveyor's driving mechanism is simpler, and no tensioning device is required, the initial cost of the conveyor is lower than any other conveyor with the same length and capacity. The main parts of a screw conveyor are, screw blade, screw shaft, coupling, trough, cover, inlet and outlet gates, bearings and drive mechanism.

The screw conveyor is generally used to move grains horizontally. However, it can also be used at any angle up to *90°* from the horizontal, but the capacity correspondingly reduced as *per* the inclination of conveyance.

The screw basically consists of a shaft and the screw blade or flight. The flight is a continuous one-piece helix, shaped from a flat strip of steel welded onto the shaft. The screw shaft is usually a joint less tube with thick sides and a high tensile strength to reduce the weight. The thickness of the steel strip helix decreases from the inner edge to the outer edge. Troughs of screw conveyor have different shapes. Most common is U shaped trough. In an enlarged or *flared* trough the sidewalls become wider at the top (Figure 7..4). This type of trough is usually used *for* conveying non-easy flowing materials, which may have lumps. The tubular trough is completely closed with circular cross-section and mostly used *for* conveying materials at inclination or *for* vertical lift.

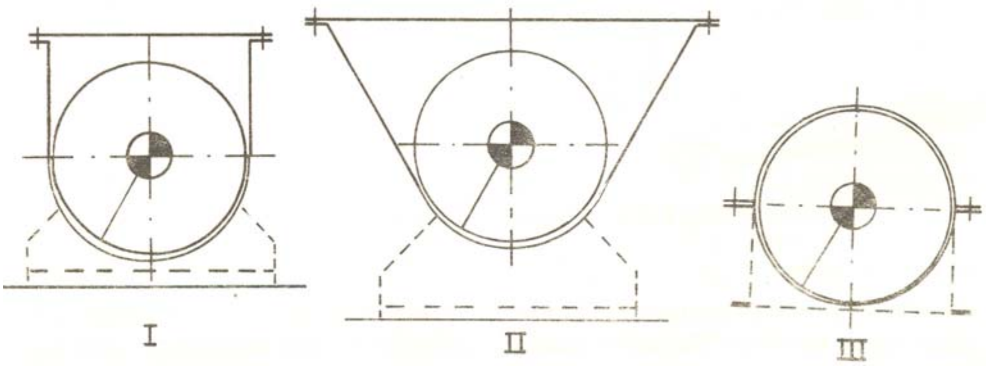

Figure 7.4: Various shapes of screw conveyor trough I) U-trough, II) Flared trough, III) Tubular trough.

For operational reasons, some gap is provided between the edge of the screw blade and the trough walls. Due to this gap it is not possible to completely empty the trough of a horizontal screw conveyor. If the screw conveyor is used to convey different materials, mixing of products is possible. Also when the food particles are pressed between the screw edge and trough walls, they can be damaged. During conveyance the kernels are also subjected to continuous friction with the trough walls. Screw conveyor may be designed for clockwise or counterclockwise rotation. The change in direction of rotation does not affect the capacity.

The capacity of screw conveyor is influenced by the screw diameter, inclination of the screw blade, speed of the blade, shaft diameter and cross-section of loading. The theoretical conveyance capacity of the screw conveyor can be given by the following equation.

$$\text{Capacity Q, m}^3\text{/hr} = 47.2\,(D^2 - d^2) \times p \times n \qquad (7.5)$$

where, D = screw diameter, m
d = shaft diameter, m
p = pitch, m
n = rpm

The theoretical capacity is more than the actual capacity because of screw housing clearance and the loading factor (Figure 7.5).

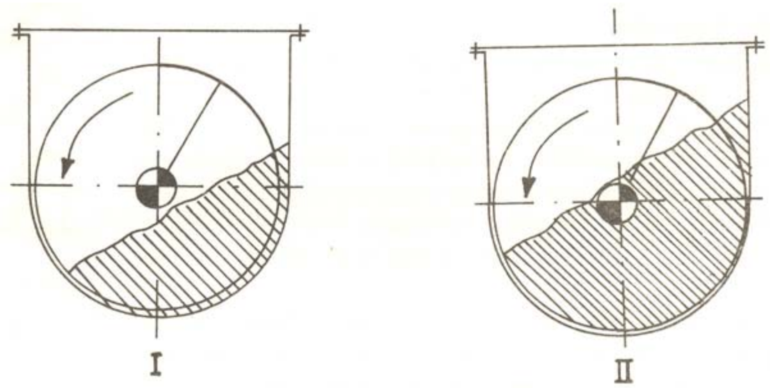

Figure 7.5: Screw conveyor loading factor I) 30% loading, II) 55% loading

The power requirement of screw conveyors for horizontal operation may be determined by the following equation:

$$\text{HorsePower} = \frac{\text{QLWF}}{4500} \qquad (7.6)$$

where, Q = conveyor capacity, m^3/min.
L = conveyor length, m
W = bulk material weight, kg/m3
F = material factor (for paddy 0.4)

If the calculated horsepower is less than 1.0, double the value.

Horsepower	=	1 to 2	multiply the value by 1.5
Horsepower	=	2 to 4	multiply the value by 1.25
Horsepower	=	4 to 5	multiply the value by 1.1

For horsepower values of more than 5, no correction is required.

Screw conveyors can be operated in an inclined position. In this case, the material will be conveyed upward. The capacity of inclined screw conveyor decreases than the horizontal operation. A screw conveyor inclined 15 degrees will carry about 75% of the rated horizontal capacity. At an inclination of 25 degrees, it will carry about 50% of the rated horizontal capacity.

7.3.3 Pneumatic Elevator

The pneumatic conveyor moves granular materials in a closed duct by a high velocity air stream. Pneumatic conveying is a continuous and flexible transportation method. The material is carried in pipelines either by suction or blowing pressure of air stream. The granular materials because of high air pressure are conveyed in dispersed condition. For dispersion of bulk material, air velocities in the range of 15-30 m/s is necessary. The pneumatic conveying system needs a source of air blowing or suction, means of feeding the product into the conveyor, and a cyclone or receiving hopper for collection of products. There are three basic systems of pneumatic conveying. These are pressure or blowing system, suction or vacuum system, and combined push-pull or suck-blow system.

In blowing or positive pressure systems, the product is conveyed by using air pressures greater than the atmospheric pressure. This system consists of a fan or blower, an air-lock feeder for introducing the product into the system, ducts and suitable air and product separating device. The product is fed into the pneumatic conveying system from the bottom of a hopper.

The feeder should be able to feed product at a specified rate in a pneumatic conveying system from the supply hopper at one pressure to the conveying pipeline at another pressure. The most common type of feeder is rotary feeder (Figure 7.6). It consists of a bladed rotor with pockets at the inlet port. When the rotor moves, the products are dropped to outlet port and to the conveying pipeline. The advantage of rotary feeder is that it meters the supply of products into the conveying pipeline. It also affects the air lock, which is necessary for the operation of the system.

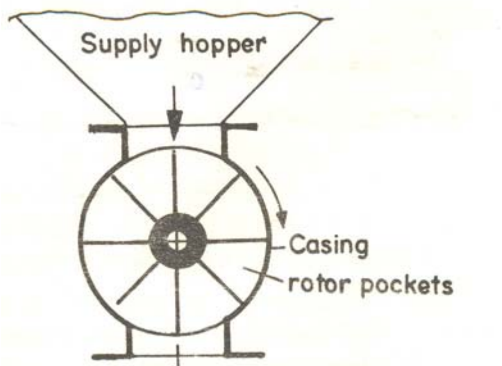

Figure 7.6: Rotary feeder for pneumatic conveyor

The selection of air mover is the most important aspect of the design of a pneumatic conveying system. In design, the two factors, (1) supply air pressure and (2) the volumetric flow rate of air should be considered. .

The supply pressure's value depends upon the working pressure drop required for the length of conveying line and across the filter. The magnitude of air pressure depends on the conveying length and the properties of the product to be conveyed. The volumetric flow rate of air depends on the necessary air velocity and pipe or duct size used in the system. In pneumatic conveying systems, fans and blowers with high volumetric flow rates and low pressures to positive displacement compressors producing high pressures are used. .

For separation of product particles from air, air-product separators are used. Cyclones are mostly used to collect the particles. Cyclone is a device, which removes the bulk of the product particle from the conveying air stream by centrifugal force. In some cyclone, a fabric filter is attached to remove residual dust and fine product particles from the air stream (Fig. 7.7). The conveying air is first passed through the cyclone and then it goes to the fabric filter for secondary separation of finer particles.

Limitations of Pneumatic Conveying

1. Erosion of solid surfaces and equipment surfaces by solid particles with conveying air stream. The rate of erosion of solid surfaces increased remarkably with conveying of abrasive products.
2. In case of bends or misaligned sections, the erosion problem becomes severe. In industrial installations, the erosion of duct system poses major problem in the operation of pneumatic conveying system.
3. In a pneumatic conveying system, chances of repeated impacts between the particles and the solid surfaces are high. Due to such impacts, product degradation results, because of this changes take place in the product size distribution and consequently the market value diminishes.

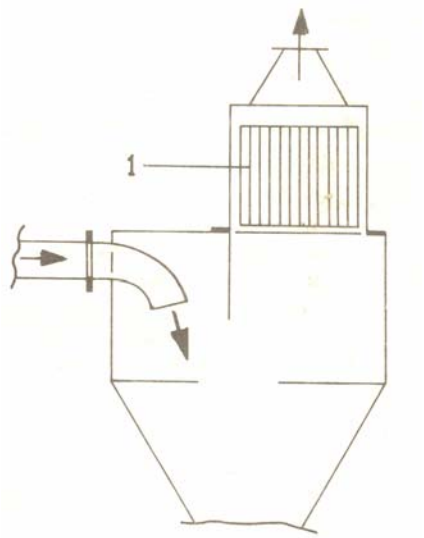

Figure 7.7: Separation of product particles from air by means of fabric filter

7.3.4 Bucket Elevator

A bucket elevator consists of buckets attached to a chain or belt that revolves around two pulleys one at top and the other at bottom. The vertical lift of the elevator may range between few meters to more than 50 m. Capacities of bucket elevators may vary from 2 to 1000 t/hr. Bucket elevators are broadly classified into two general types, 1) spaced bucket elevators and 2) continuous bucket elevators. The above two types are further subdivided into various classes.

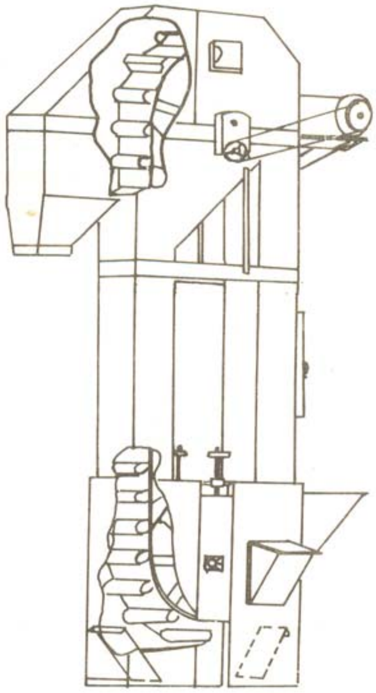

Figure 7.8: Bucket elevator

The spaced bucket elevators are further classified as, 1) centrifugal discharge elevators, 2) positive-discharge elevators, 3) marine leg elevators and 4) high-speed elevators. The continuous bucket elevators are classified as 1) super capacity bucket elevators, and 2) internal-discharge bucket elevators.

The spaced-bucket centrifugal discharge type is most commonly used for elevating the grains. A centrifugal discharge bucket elevator is shown is Figure 7.8. The bucket elevator is a very efficient device for the vertical conveyance of bulk grains. Bucket elevators with belts are employed in food industries for vertical conveyance of grains, derivatives and flours. Bucket elevators are usually mounted at a fixed location, but they can also be mounted in a mobile frame. Bucket elevators have high capacities and it is a fairly cheap means of vertical conveyance.

It requires limited horizontal space and the operation of conveying is enclosed in housing, thus it is dust free and fairly quite. The bucket elevator has limited wear problem since the product is enclosed in buckets. In a bucket elevator, the conveyor belt with buckets runs over pulleys at the upper and lower ends. The top pulley is driven pulley while the lower pulley is return and tension pulley. Buckets are usually made of steel or plastic and are bolted onto the belt. The buckets may be enclosed in a single housing called leg, or two legs may be used. The return leg may be located at some distance from the elevator leg. The houSing or legs are also made of steel, are welded or bolted together, and are dust tight. The curved hood is designed for proper centrifugal discharge of the grains. The boot can be loaded from the front or back or both (Figure 7.9). The various discharge types of bucket elevators are shown in Figure 7.10. The product flow is discharged either by means of gravity or centrifugal force.

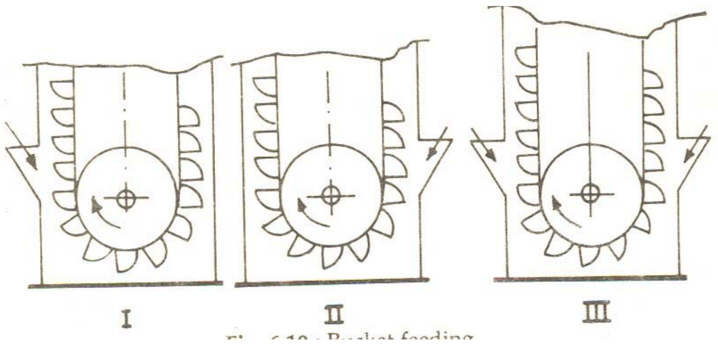

Figure 7.9: Bucket feeding I) Front feed, II) Back feed, III) Combined feed.

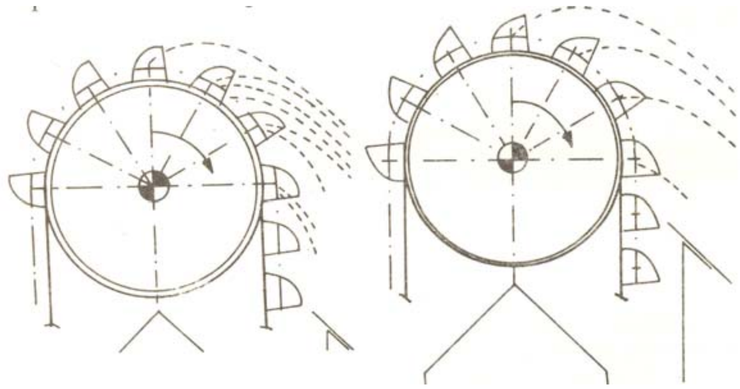

Figure 7.10: Bucket elevator's discharge methods: 1) Low speed gravitational discharge, 2) high speed centrifugal discharge.

The bucket elevator's capacity mainly depends on bucket size, conveying speed, bucket design and spacing, the way of loading and unloading, the bucket and the characteristic of bulk material. Belt speed is the first critical factor to consider. Bucket elevators with a belt carrier can be used at fairly high speeds of 2.5 to 4 m/ s. The speed of the belt depends on the head pulley speed. If the belt speed is too low, the discharge of the grains becomes more difficult, with too high speed the buckets are not fed well. A properly designed bucket elevator driven at the correct speed will make a clean discharge.

The gravitational discharge occurs with non-adhesive bulk material elevated at low speed and by means of buckets mounted closely together. In such discharge, the contents of a bucket flow over the rear side of the previous bucket. With purely centrifugal discharge, complete contents of a bucket are projected towards the discharge chute. Such type of discharge is obtainable with high belt speeds and smaller diameter drive pulleys. In elevating of grains the discharge from bucket elevators is a combination of centrifugal and gravitational discharge. Part of the bucket contents is projected by the centrifugal force, the rest flows out by gravity.

When a product mass turns around a pulley, it is influenced by two forces, (1) gravitational force, which is oriented downwards and (2) centrifugal force. The magnitude of the centrifugal force which is oriented outward can be given by

$$c_f = \frac{WV^2}{gr} \qquad (7.7)$$

where, W = weight of grain
V = velocity of product mass
g = acceleration due to gravity .
r = radius of the wheel plus one-half of the projection of the bucket

For optimum centrifugal discharge, and calculation of the speed of head pulley, the resultant force is zero, it means that the centrifugal force is equal to the force of gravity, or, $c_f = W$

Hence, $W = \frac{WV^2}{gr}$ or, $V = \sqrt{gr}$

Since velocity, $V = \frac{2\pi nr}{60}$ (n = rpm) (7.8)

$$\frac{2\pi nr}{60} = \sqrt{gr} \quad \text{or,} \quad n = \frac{60\sqrt{g}\sqrt{r}}{2\pi\sqrt{r}\sqrt{r}} = \frac{29.9}{\sqrt{r}} \qquad (7.9)$$

The bucket elevator's capacity may be calculated by the following equation.

Elevator capacity, *m³/hr* = bucket capacity, *m³* x number of bucket per meter of belt x belt speed, m/min. × 60 (7.10)

$$Capacity, t/hr = \frac{Capacity, m^3/hr \times material density, kg/m^3}{1000} \qquad (7.11)$$

Drive mechanism

The drive mechanism of a bucket elevator is located near the elevator head. At the elevator head, the belt is turned around the drive pulley. Drive motor with gearbox and couplings are mounted on a rigid and separate frame. For serving the elevator head section, the drive mechanism, a working platform is provided. Usually a ladder is provided for access to this platform.

The theoretical horsepower requirement for the bucket elevator can be calculated by the following equation.

$$hp = \frac{QHF}{4500} \qquad (7.12)$$

where, Q = capacity of bucket elevator, kg/min
H = lift of elevator, m
F = factor; 1.5 for elevators loaded on the up side and 1.2 for elevators loaded on the bottom side

The theoretical horsepower should be increased 10-15% to provide for friction and power requirements for loading, power transmission and drive losses.

7.4 INTERACTION BETWEEN MATERIAL AND HANDLING DEVICES

Interaction between the material and the handling device is one of the important considerations for the selection of a suitable material handling device. The suitability of the different material handling devices for food products have been already discussed in section 7.2 and 7.3.

7.5 SELECTION OF MATERIAL HANDLING DEVICES

The selection of proper conveying system is important for ease in operation and getting desired capacity for a particular product. Before selecting a conveying system, the following principles should be taken into account.

1. The conveying device has to be selected according to the characteristics of the products being conveyed
2. The stability of the conveyor must be ensured under all normal working and climatic conditions.
3. The capacity of conveying and speed rating should be maintained at specified limits.
4. The dead load of the conveyor should be low in relation to the weight of transported product.
5. In a conveying system possibility of use of gravity should be taken into consideration.
6. The capacity of handling/conveying equipment should match with the capacity of processing unit or units.
7. Spillage of conveyed products should be avoided. Pollution of the environment due to noise or dust by the conveying system should also be avoided.

The four basic issues (Figure 7.11) relating to integration of material handling (MH) equipment into a manufacturing environment are (1) extraction to extract information about individual material handling tasks, (2) filtering and matching of individual tasks with individual resources, without regard to system performance and economy, (3) aggregation of tasks into sets that are then matched with technologies and (4) system selection and specification.

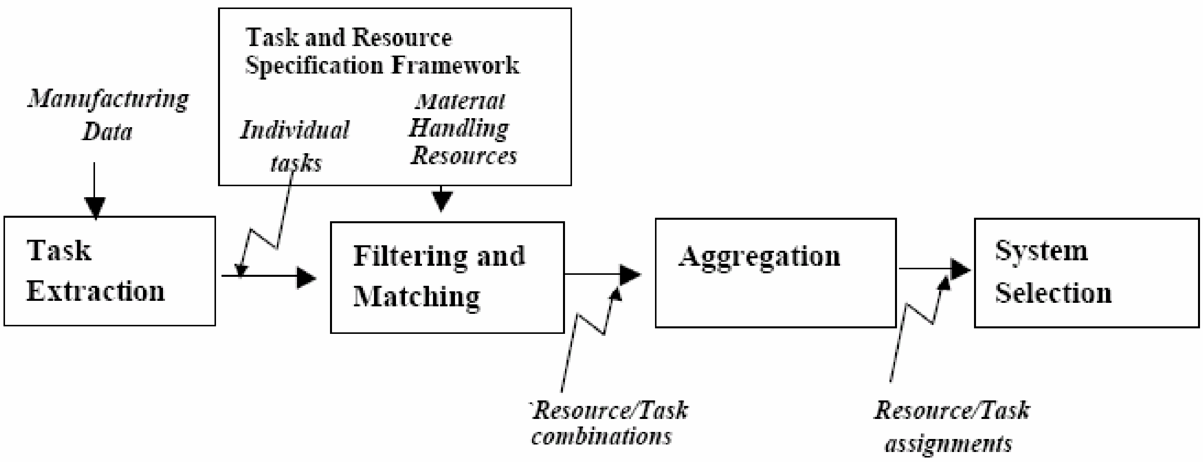

Figure 7.11: Major steps of procedure for selecting and specifying material handling equipment for manufacturing.

7.6 COST OF MATERIAL HANDLING

The cost of material handling will depend on (i) material to be carried, (ii) distance over which the material is to be carried, (iii) height of material elevation, (iv) efficiency of the material handling device, (v) maintenance cost of the material handling device, (vi) cost of the device, (vii) life span of the material handling device, (viii) method of loading and unloading of the material onto and from the device, etc.

There is no thumb rule as to which material handling device would be economical for a particular operation. It has to be therefore, decided keeping in mind the actual activity to be undertaken.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.
c) Use separate sheets where no space is provided.

1. Write a short note on the importance of material handling in food industry.

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2. Enlist any five principles of material handling.

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3. Write short notes on the following:

i) Belt conveyor
ii) Screw conveyor
iii) Bucket elevator

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4. Differentiate between conveyors and elevators.

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5. A belt conveyor carrying 1 $m^3$of material having a bulk density of 600 kg/m^3 per meter length of belt is moving at 2.5 m/min. The length and width of the belt is 100 m and 60 cm respectively. Calculate the capacity and horsepower requirement of the conveyor.

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6. A screw conveyor having shaft and screw diameters as 15 and 25 cm respectively rotates at 500 rpm. Considering the pitch of the screw to be equal to its shaft diameter, calculate the capacity of the conveyor. If the conveyor length is 10 m, bulk density of the material is 500 kg/m^3, calculate the horsepower requirement of the conveyor assuming the material factor as 0.5.

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7. A bucket elevator having 100 buckets of 0.2 m^3 capacity is running at a speed of 1 m/s. The length of the elevator is 10 m and material bulk density is 700 kg/m^3. Calculate the capacity and horsepower requirement of the bucket elevator.

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7.7 LET US SUM UP

Conveyors and elevators are the two much important classes of material handling equipment. Once we know the characteristics of the material to be handled and other critical requirements, one could select an appropriate conveyor/elevator. These conveyors/elevators could be chain, belt, bucket, screw, pneumatic, magnetic, vibratory types. Proper selection and design of capacity and power units leads to the minimization of the cost of material handling.

7.8 KEY WORDS

Material handling : It is a method of carrying the material from one place to another either horizontally or vertically.

Selection of material handling equipment : It is a method of adoption of the most appropriate handling device to suite ones own requirement.

Elevators : Used for transfer of materials in horizontal direction where the angle of lift is very steep.

Power requirement : It is the amount of energy required per unit time to operate any system.

Capacity : It is the total material that any given system can carry for a given time and energy utilized.

7.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Importance of material handling in food industry:
2. Five principles of material handling are:
   - Thoroughly study the problem and identify problem areas, constraints and goals.
   - Develop plans, which meets our basic requirement, is flexible and includes desirable features.
   - Integrate various activities such as receiving, shipping, production assembly, etc.
   - Make the unit load size as large as possible.
   - Use the cubic space as effectively as possible.
3. i) A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers. The belt may be flat for transporting bagged material or V-shaped or some other enclosed shape for moving bulk grains.

   ii) The screw conveyor consists of a tubular or U-shaped trough in which a shaft with spiral screw revolves. The screw shaft is supported by end and hanger bearings. The rotation of screw pushes the grain along the trough.

iii) A bucket elevator consists of buckets attached to a chain or belt that revolves around two pulleys one at top and the other at bottom. The vertical lift of the elevator may range between few meters to more than 50 m. Capacities of bucket elevators may vary from 2 to 1000 t/hr.

4. Conveyors are mainly used for horizontal or inclined transmission of materials. The inclination is limited to the material transported, whereas, elevators can be used to lift materials vertically irrespective of the material they carry.

5. i) Calculate capacity by using equation 7.1.
   ii) Hp = Hp1 (Equation 7.2) + Hp2 (Equation 7.3) + Hp required for tripper (Table 7.2)

6. i) Calculate capacity by using equation 7.5.
   ii) Calculate horse power by using equation 7.6.

7. i) Calculate capacity by using equation 7.11.
   ii) Calculate horse power by using equation 7.12.

7.10 SOME USEFUL BOOKS

1. Henderson, S.M. and Perry, R.L. (1976) Agricultural Process Engineering. AVI Publishing Co. West Port Connecticut.

2. McCabe, W.L., Smith, J.C. and Harriott, P. (1993) Unit Operations of Chemical Engineering. McGraw Hill, New York.