Lecture 5

Waste Processing Techniques

STRUCTURE

OVERVIEW

In Unit 4, we discussed conventional and engineered waste disposal options, and also mentioned that through proper processing, we would be able to recover resource and energy from wastes. In Unit 5, we will explain some of the important techniques used for processing solid wastes for the recovery of materials, and their design criteria. The processing techniques we will be discussing in this Unit include mechanical and chemical volume reduction, component separation, and drying and dewatering.

LEARNING OBJECTIVES

After completing this Unit, you should be able to:

- identify the purpose of waste processing;
- explain the processing techniques for reducing the volume and size of wastes;
- carry out separation of various components;
- discuss the need for dewatering and drying of wastes;
- assess technical viability of various processing techniques.

5.1 PURPOSE OF PROCESSING

The processing of wastes helps in achieving the best possible benefit from every functional element of the solid waste management (SWM) system and, therefore, requires proper selection of techniques and equipment for every element. Accordingly, the wastes that are considered suitable for further use need to be paid special attention in terms of processing, in order that we could derive maximum economical value from them.

The purposes of processing, essentially, are (Tchobanoglous et al., 1993):

(i) **Improving efficiency of SWM system:** Various processing techniques are available to improve the efficiency of SWM system. For example, before waste papers are reused, they are usually baled to reduce transporting and storage volume requirements. In some cases, wastes are baled to reduce the haul costs at disposal site, where solid wastes are compacted to use the available land effectively. If solid wastes are to be transported hydraulically and pneumatically, some form of shredding is also required. Shredding is also used to improve the efficiency of the disposal site.

(ii) **Recovering material for reuse:** Usually, materials having a market, when present in wastes in sufficient quantity to justify their separation, are most amenable to recovery and recycling. Materials that can be recovered from solid wastes include paper, cardboard, plastic, glass, ferrous metal, aluminium and other residual metals. (We will discuss some of the recovery techniques later in Section 5.3.)

(iii) **Recovering conversion products and energy:** Combustible organic materials can be converted to intermediate products and ultimately to usable energy. This can be done either through incineration, pyrolysis, composting or bio-digestion. Initially, the combustible organic matter is separated from the other solid waste components. Once separated, further processing like shredding and drying is necessary before the waste material can be used for power generation. (We will explain these energy recovery techniques in Units 7 and 8.)

Having described the need for waste processing, we now discuss how waste processing is actually carried out.

5.2 MECHANICAL VOLUME AND SIZE REDUCTION

Mechanical volume and size reduction is an important factor in the development and operation of any SWM system. The main purpose is to reduce the volume (amount) and size of waste, as compared to its original form, and produce waste of uniform size. We will discuss the processes involved in volume and size reduction along with their selection criteria, equipment requirement, design consideration, etc., in Subsections 5.2.1 and 5.2.2.

5.2.1 Volume reduction or compaction

Volume reduction or compaction refers to densifying wastes in order to reduce their volume. Some of the benefits of compaction include:

- reduction in the quantity of materials to be handled at the disposal site;
- improved efficiency of collection and disposal of wastes;
- increased life of landfills;
- Economically viable waste management system.

However, note the following disadvantages associated with compaction:

- poor quality of recyclable materials sorted out of compaction vehicle;
- difficulty in segregation or sorting (since the various recyclable materials are mixed and compressed in lumps);
- Bio-degradable materials (e.g., leftover food, fruits and vegetables) destroy the value of paper and plastic material.

Equipment used for compaction

Based on their mobility, we can categorise the compaction equipment used in volume reduction under either of the following:

(i) **Stationary equipment:** This represents the equipment in which wastes are brought to, and loaded into, either manually or mechanically. In fact, the compaction mechanism used to compress waste in a collection vehicle, is a stationary compactor. According to their application, stationary compactors can be described as light duty (e.g., those used for residential areas), commercial or light industrial, heavy industrial and transfer station compactors. Usually, large stationary compactors are necessary, when wastes are to be compressed into:

  - steel containers that can be subsequently moved manually or mechanically;

- chambers where the compressed blocks are banded or tied by some means before being removed;
- chambers where they are compressed into a block and then released and hauled away untied;
- transport vehicles directly.

(ii) **Movable equipment:** This represents the wheeled and tracked equipment used to place and compact solid wastes, as in a sanitary landfill.

Table 5.1 below lists the types of commonly-used compaction equipment and their suitability:

Table 5.1
Types of Compaction Equipment

Location or Operation	**Type of Compactor Stationary/residential**	**Remarks**
Solid waste generation points	Vertical	Vertical compaction ram may be used; may be mechanically or hydraulically operated, usually hand-fed; wastes compacted into corrugated box containers, or paper or plastic bags; used in medium and high-rise apartments.
	Rotary	Ram mechanism used to compact waste into paper or plastic bags on rotating platform, platform rotates as containers are filled; used in medium and high-rise apartments.
	Bag or extruder	Compactor can be chute fed; either vertical or horizontal rams; single or continuous multi-bags; single bag must be replaced and continuous bags must be tied off and replaced; used in medium and high-rise apartments.

Location or Operation	**Type of Compactor Stationary/residential**	**Remarks**
	Under counter	Small compactors used in individual residences and apartment units; wastes compacted into special paper bags; after wastes are dropped through a panel door into a bag and door is closed, they are sprayed for odour control; button is pushed to activate compaction mechanism.
	Stationary/commercial	Compactor with vertical and horizontal ram; wastes compressed into steel containers; compressed wastes are manually tied and removed; used in low, medium and high-rise apartments, commercial and industrial facilities.
Collection	Stationary/packers	Collection vehicles equipped with compaction mechanism.
Transfer and/or processing station	Stationary/transfer trailer	Transfer trailer, usually enclosed, equipped with self-contained compaction mechanism.
	Stationary low pressure	Wastes are compacted into large containers.
	Stationary high pressure	Wastes are compacted into dense bales or other forms.
Disposal site	Movable wheeled or tracted equipment	Specially designed equipment to achieve maximum compaction of wastes.
	Stationary/track mounted	High-pressure movable stationary compactors used for volume reduction at a disposal site.

Source: Tchobanoglous, et al., (1993)

Let us now move on to the discussion of compactors used in the transfer station.

Compactors

According to their compaction pressure, we can divide the compactors used at transfer stations as follows:

(i) **Low-pressure (less than 7kg/cm^2) compaction:** This includes those used at apartments and commercial establishments, bailing equipment used for waste papers and cardboards and stationary compactors used at transfer stations. In low-pressure compaction, wastes are compacted in large containers. Note that portable stationary compactors are being used increasingly by a number of industries in conjunction with material recovery options, especially for waste paper and cardboard.

(ii) **High-pressure (more than 7kg/cm^2) compaction:** Compact systems with a capacity up to 351.5 kg/cm^2 or 5000 lb/in^2 come under this category. In such systems, specialised compaction equipment are used to compress solid wastes into blocks or bales of various sizes. In some cases, pulverised wastes are extruded after compaction in the form of logs. The volume reduction achieved with these high-pressure compaction systems varies with the characteristics of the waste. Typically, the reduction ranges from about 3 to 1 through 8 to 1.

When wastes are compressed, their volume is reduced, which is normally expressed in percentage and computed by equation 5.1, given below:

$$\text{Volume Reduction (\%)} = \frac{V_i - V_f}{V_i} \times 100$$ **Equation 5.1**

The compaction ratio of the waste is given in equation 5.2:

$$\text{Compaction ratio} = \frac{V_i}{V_f}$$ **Equation 5.2**

where V_i = volume of waste before compaction, m^3 and V_f = volume of waste after compaction, m^3

The relationship between the compaction ratio and percent of volume reduction is important in making a trade-off analysis between compaction ratio and cost. Other factors that must be considered are final density of waste after compaction and moisture content. The moisture content that varies with location is another variable that has a major effect on the degree of compaction achieved. In some stationary compactors, provision is made to add moisture, usually in the form of water, during the compaction process.

Selection of compaction equipment

To ensure effective processing, we need to consider the following factors, while selecting compaction equipment:

- Characteristics such as size, composition, moisture content, and bulk density of the waste to be compacted.
- Method of transferring and feeding wastes to the compactor, and handling.
- Potential uses of compacted waste materials.
- Design characteristics such as the size of loading chamber, compaction pressure, compaction ratio, etc.
- Operational characteristics such as energy requirements, routine and specialised maintenance requirement, simplicity of operation, reliability, noise output, and air and water pollution control requirement.
- Site consideration, including space and height, access, noise and related environmental limitations.

5.2.2 Size reduction or shredding

This is required to convert large sized wastes (as they are collected) into smaller pieces. Size reduction helps in obtaining the final product in a reasonably uniform and considerably reduced size in comparison to the original form. But note that size reduction does not necessarily imply volume reduction, and this must be factored into the design and operation of SWM systems as well as in the recovery of materials for reuse and conversion to energy.

In the overall process of waste treatment and disposal, size reduction is implemented ahead of:

- land filling to provide a more homogeneous product. This may require less cover material and less frequent covering than that without shredding. This can be of economic importance, where cover material is scarce or needs to be brought to the landfill site from some distance.
- recovering materials from the waste stream for recycling.
- baling the wastes – a process sometimes used ahead of long distance transport of solid wastes – to achieve a greater density.
- making the waste a better fuel for incineration waste energy recovery facilities. (The size reduction techniques, coupled with separation techniques such as screening, result in a more homogeneous mixture of relatively uniform size, moisture content and heating value, and thereby improving the steps of incineration and energy recovery. We will discuss incineration in Unit 8.)
- reducing moisture, i.e., drying and dewatering of wastes (see Section 5.4 for a discussion on drying and dewatering).

Equipment used for size reduction

Table 5.2 lists the various equipment used for size reduction:

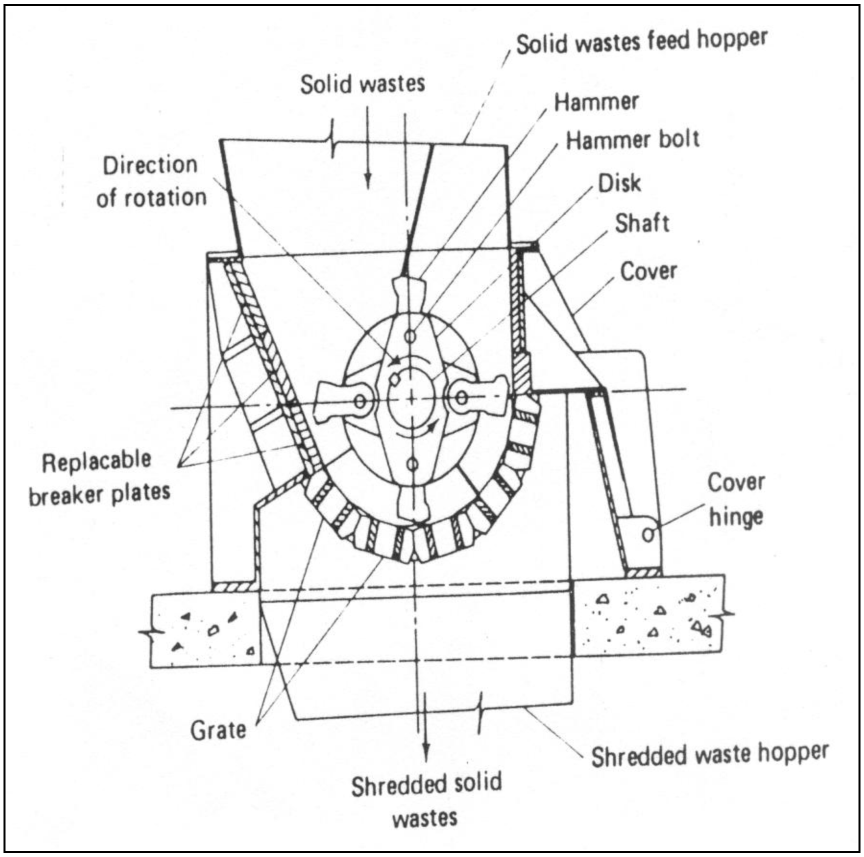
Table 5.2
Size Reduction Equipment

Type	Mode of action	Application
Small grinders	Grinding, mashing	Organic residential solid wastes
Chippers	Cutting, slicing	Paper, cardboard, tree trimmings, yard waste, wood, plastics
Large grinders	Grinding, mashing	Brittle and friable materials, used mostly in industrial operation
Jaw crushers	Crushing, breaking	Large solids
Rasp mills	Shredding, tearing	Moistened solid wastes
Shredders	Shearing, tearing	All types of municipal wastes
Cutters, Clippers	Shearing, tearing	All types of municipal wastes
Hammer mills	Breaking, tearing, cutting, crushing	All types of municipal wastes, most commonly used equipment for reducing size and homogenizing composition of wastes
Hydropulper	Shearing, tearing	Ideally suited for use with pulpable wastes, including paper, wood chips. Used primarily in the papermaking industry. Also used to destroy paper records

The most frequently used shredding equipment are the following:

(i) **Hammer mill:** These are used most often in large commercial operations for reducing the size of wastes. Hammer mill is an impact device consisting of a number of hammers, fastened flexibly to an inner disk, as shown in Figure 5.1, which rotates at a very high speed:

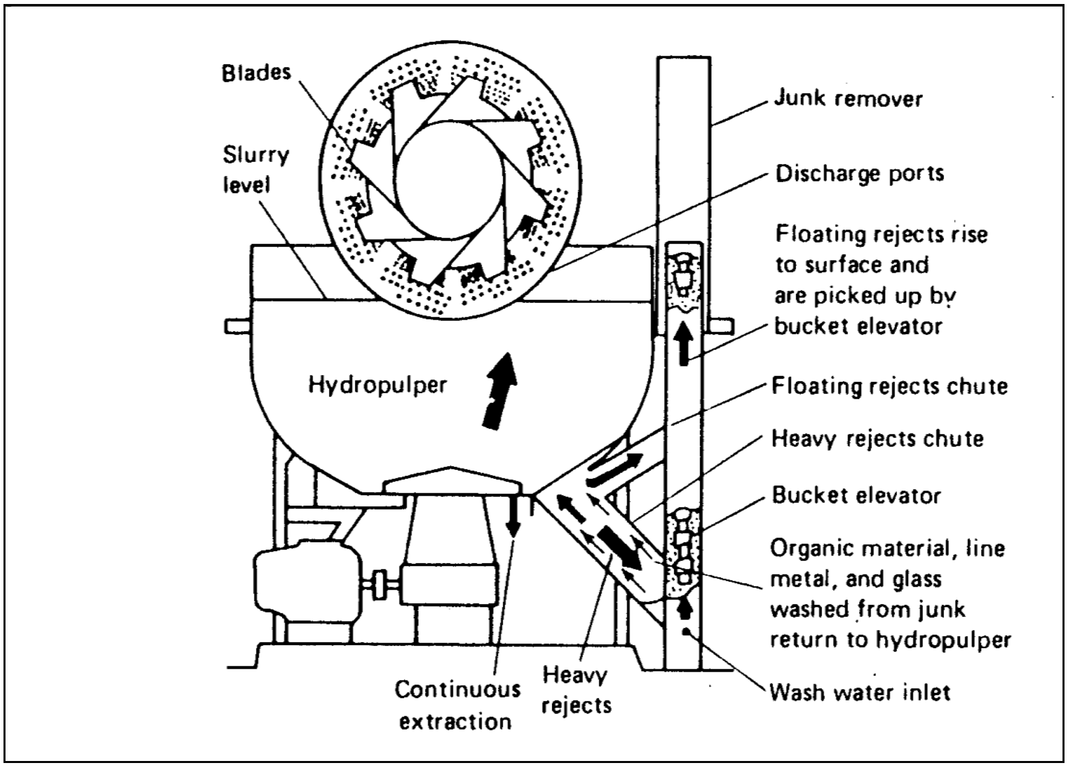
Figure 5.1
Hammer Mill: An Illustration



Solid wastes, as they enter the mill (see Figure 5.1), are hit by sufficient force, which crush or tear them with a velocity so that they do not adhere to the hammers. Wastes are further reduced in size by being struck between breaker plates and/or cutting bars fixed around the periphery of the inner chamber. This process of cutting and striking action continues, until the required size of material is achieved and after that it falls out of the bottom of the mill.

(ii) **Hydropulper:** An alternative method of size reduction involves the use of a hydropulper as shown in Figure 5.2:

Figure 5.2
Hydropulper: An Illustration



Solid wastes and recycled water are added to the hydropulper. The high-speed cutting blades, mounted on a rotor in the bottom of the unit, convert pulpable and friable materials into slurry with a solid content varying from 2.5 to 3.5%. Metal, tins, cans and other non-pulpable or non-friable materials are rejected from the side of the hydropulper tank. The rejected material passes down a chute that is connected to a bucket elevator, while the solid slurry passes out through the bottom of the pulper tank and is pumped to the next processing operation.

Selection of size reduction equipment

The factors that decide the selection of size reduction equipment include the following:

- The properties of materials before and after shredding.
- Size requirements for shredded material by component.
- Method of feeding shredders, provision of adequate shredder hood capacity (to avoid bridging) and clearance requirement between feed and transfer conveyors and shredders.
- Types of operation (continuous or intermittent).
- Operational characteristics including energy requirements, routine and specialised maintenance requirement, simplicity of operation, reliability, noise output, and air and water pollution control requirements.
- Site considerations, including space and height, access, noise and environmental limitations.
- Metal storage after size reduction for the next operation.

LEARNING ACTIVITY 5.1

Explain the difference between compaction and size reduction and their importance in SWM.

Note:
a) Write your answer in the space given below.
b) Check your answer with the one given at the end of this Unit.

Besides mechanical techniques of compaction and shredding to reduce the volume and size of wastes, there are also chemical processes through which we can reduce the volume of wastes, which we will touch upon next.

Chemical volume reduction

Chemical volume reduction is a method, wherein volume reduction occurs through chemical changes brought within the waste either through an addition of chemicals or changes in temperature. Incineration is the most common method used to reduce the volume of waste chemically, and is used both for volume reduction and power production. These other chemical methods used to reduce volume of waste chemically include *pyrolysis*, *hydrolysis* and chemical conversions. (We will discuss incineration and related issues in Unit 8.)

Note that prior to size or volume reduction, which we discussed in Section 5.2, component separation is necessary to avoid the problem of segregating or sorting recyclable materials from the mixed and compressed lumps of wastes and the poor quality of recyclable materials sorted out of compaction vehicles. We will discuss component separation in Section 5.3.

5.3 COMPONENT SEPARATION

Component separation is a necessary operation in which the waste components are identified and sorted either manually or mechanically to aid further processing. This is required for the:

- recovery of valuable materials for recycling;
- preparation of solid wastes by removing certain components prior to incineration, energy recovery, composting and biogas production. (Note that these are discussed in Units 8 and 9.)

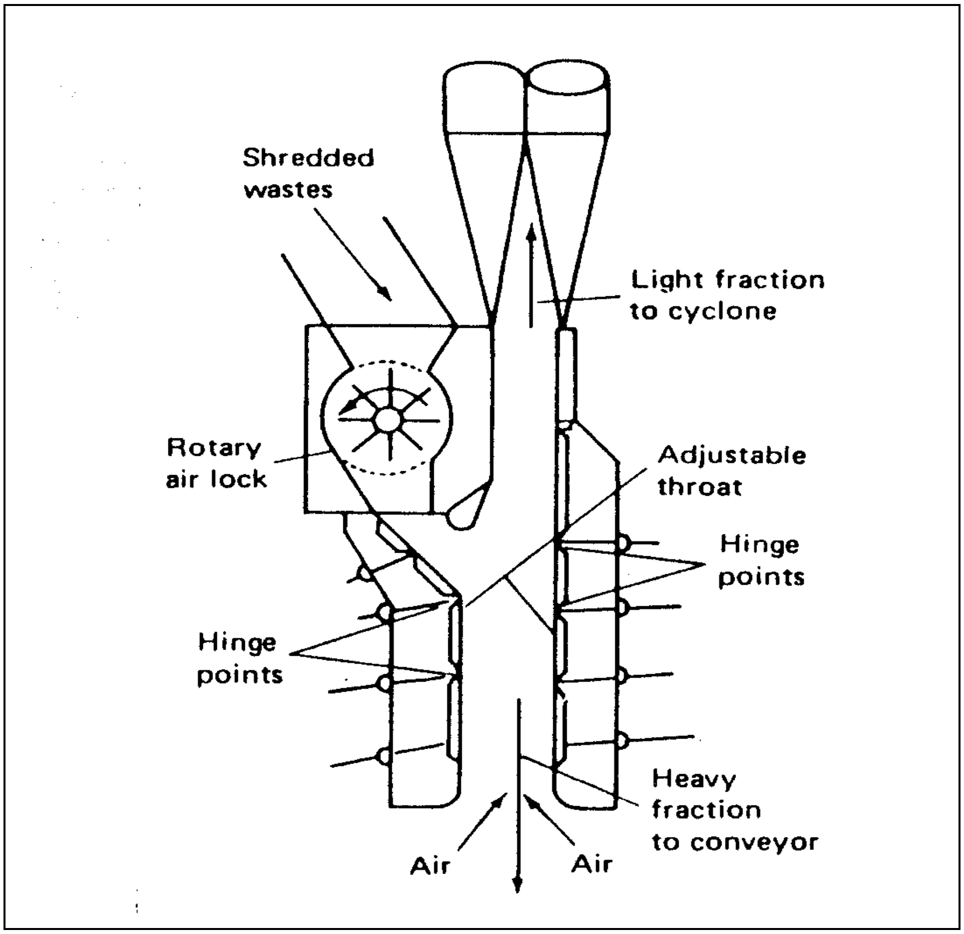
The most effective way of separation is manual sorting in households prior to collection. In many cities (e.g., Bangalore, Chennai, etc., in India), such systems are now routinely used. The municipality generally provides separate, easily identifiable containers into which the householder deposits segregated recyclable materials such as paper, glass, metals, etc. Usually, separate collections are carried out for the recyclable material. At curbside, separate areas are set aside for each of the recyclable materials for householders to deliver material – when there is no municipal collection system. In case the separation is not done prior to collection, it could be sorted out through mechanical techniques such as air separation, magnetic separation, etc., to recover the wastes. We will discuss some of these techniques in Subsections 5.3.1 to 5.3.4.

5.3.1 Air separation

This technique has been in use for a number of years in industrial operations for segregating various components from dry mixture. Air separation is primarily used to separate lighter materials (usually organic) from heavier (usually inorganic) ones. The lighter material may include plastics, paper and paper products and other organic materials. Generally, there is also a need to separate the light fraction of organic material from the conveying air streams, which is usually done in a cyclone separator. In this technique, the heavy fraction is removed from the air classifier (i.e., equipment used for air separation) to the recycling stage or to land disposal, as appropriate. The light fraction may be used, with or without further size reduction, as fuel for incinerators or as compost material. There are various types of air classifiers commonly used, some of which are listed below:

(i) **Conventional chute type:** This, as shown in Figure 5.3, is one of the simplest types of air classifiers:

Figure 5.3
Conventional Chute Type

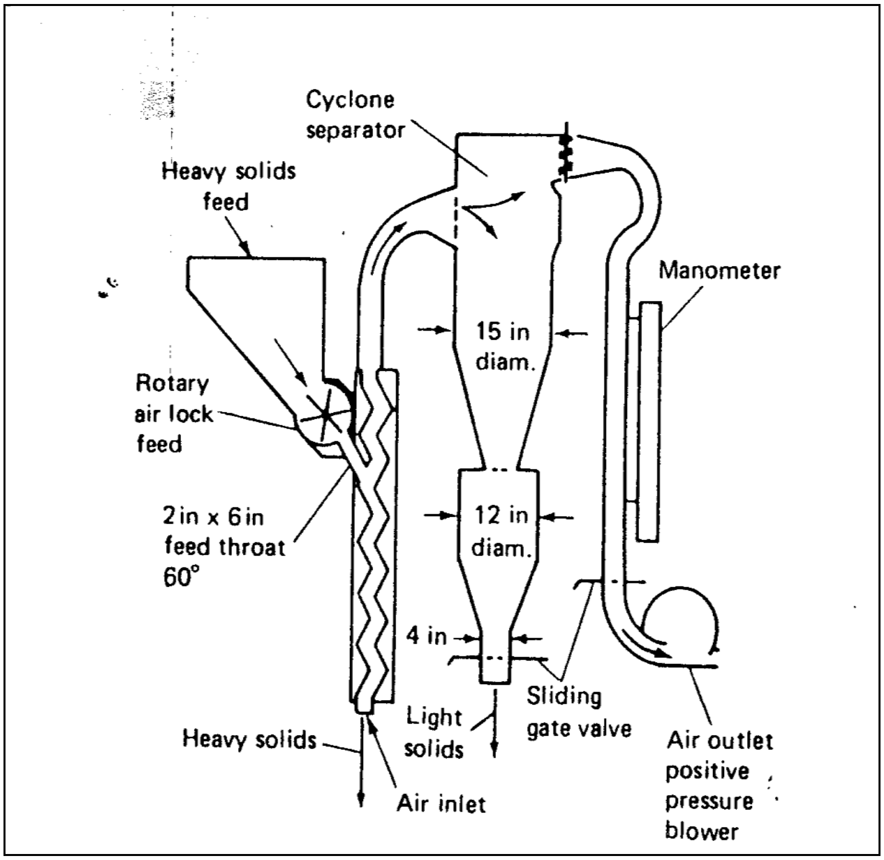


In this type, when the processed solid wastes are dropped into the vertical chute, the lighter material is carried by the airflow to the top while the heavier materials fall to the bottom of the chute. The control of the percentage split between the light and heavy fraction is accomplished by varying the waste loading rate, airflow rate and the cross section of chute. A rotary air lock feed mechanism is required to introduce the shredded wastes into the classifier.

(ii) **Zigzag air classifier:** An experimental zigzag air classifier, shown in Figure 5.4 below, consists of a continuous vertical column with internal zigzag deflectors through which air is drawn at a high rate:

Figure 5.4

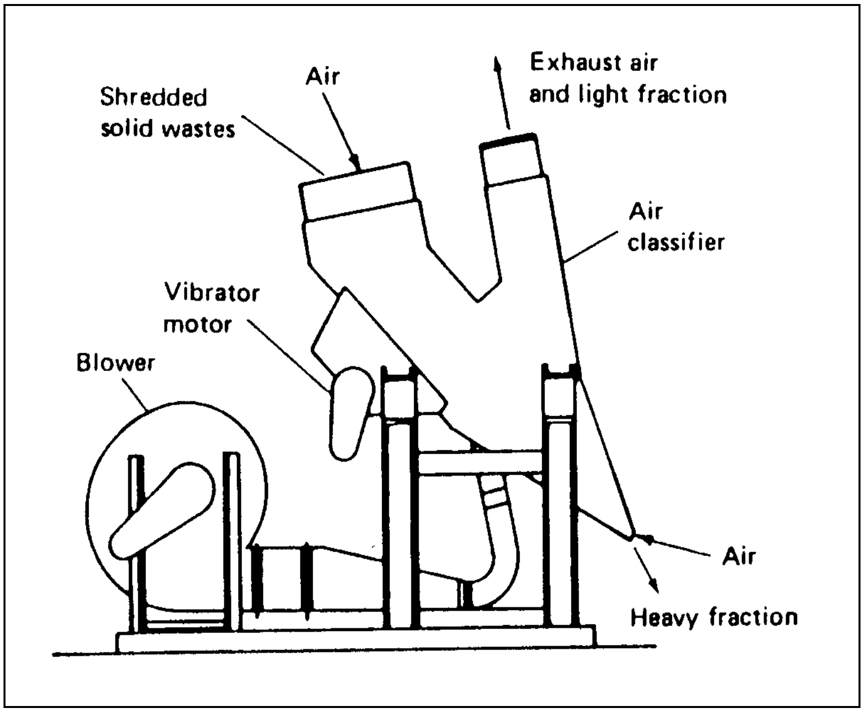
Zigzag Air Classifier



Shredded wastes are introduced at the top of the column at a controlled rate, and air is introduced at the bottom of the column. As the wastes drop into the air stream, the lighter fraction is fluidised and moves upward and out of column, while the heavy fraction falls to the bottom. Best separation can be achieved through proper design of the separation chamber, airflow rate and influent feed rate.

(iii) **Open inlet vibrator type:** Figure 5.5 below illustrates this type of air classifier:

Figure 5.5
Open Inlet Vibrator



In this type of air classifier, the separation is accomplished by a combination of the following actions:

- **Vibration:** This helps to stratify the material fed to the separator into heavy and light components. Due to this agitation, the heavier particles tend to settle at the bottom as the shredded waste is conveyed down the length of the separator.
- **Inertial force:** In this action, the air pulled in through the feed inlet imparts an initial acceleration to the lighter particle, while the wastes travel down the separator as they are being agitated.
- **Air pressure:** This action refers to the injection of fluidising air in two or more high velocity and low mass flow curtains across the bed. A final stripping of light particles is accomplished at the point where the heavy fraction discharges from the elutriators. It has been reported that the resulting separation is less sensitive to particle size than a conventional vertical air classifier, be it of straight or zigzag design. An advantage of

this classifier is that an air lock feed mechanism is not required and wastes are fed by gravity directly into the separator inlet.

Selection of air separation equipment

The factors that are to be considered for selecting air separation equipment include the following:

- Characteristics of the material produced by shredding equipment including particle size, shape, moisture content and fibre content.
- Material specification for light fraction.
- Methods of transferring wastes from the shredders to the air separation units and feeding wastes into the air separator.
- Characteristics of separator design including solids-to-air ratio, fluidising velocities, unit capacity, total airflow and pressure drop.
- Operational characteristics including energy requirement, maintenance requirement, simplicity of operation, proved performance and reliability, noise output, and air and water pollution control requirements.
- Site considerations including space and height access, noise and environmental limitations.

So far, we have studied the separation of solid waste components by air separation. We will next learn about the separation of wastes based on their magnetic properties.

5.3.2 Magnetic separation

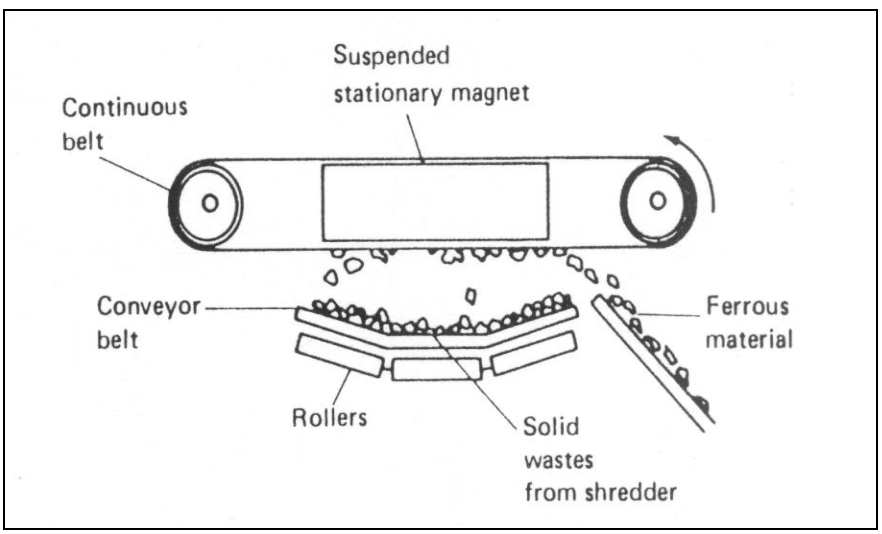
The most common method of recovering ferrous scrap from shredded solid wastes involves the use of magnetic recovery systems. Ferrous materials are usually recovered either after shredding or before air classification. When wastes are mass-fired in incinerators, the magnetic separator is used to remove the ferrous material from the incinerator residue. Magnetic recovery systems have also been used at landfill disposal sites. The specific locations, where ferrous materials are recovered will depend on the objectives to be achieved, such as reduction of wear and tear on processing and separation equipment, degree of product purity achieved and the required recovery efficiency.

Equipment used for magnetic separation

Various types of equipment are in use for the magnetic separation of ferrous materials. The most common types are the following:

(i) **Suspended magnet:** In this type of separator, a permanent magnet is used to attract the ferrous metal from the waste stream. When the attracted metal reaches the area, where there is no magnetism, it falls away freely. This ferrous metal is then collected in a container. Figure 5.6 shows a typical suspended magnet:

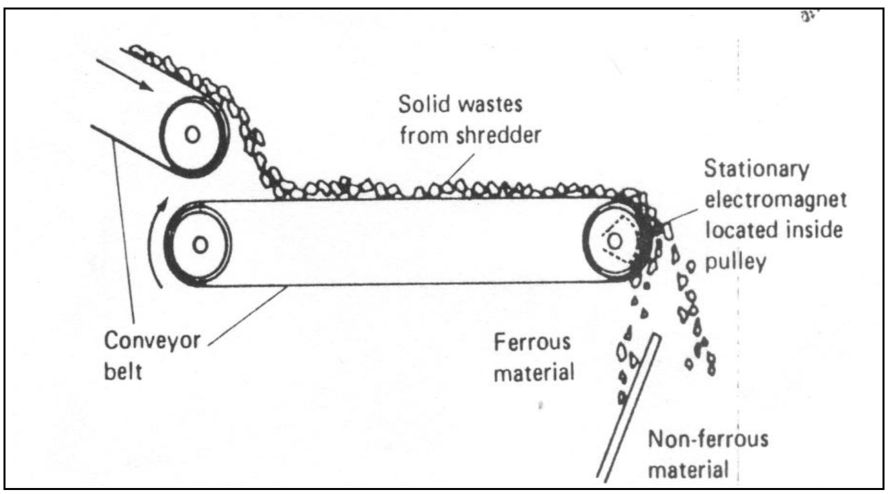
Figure 5.6
Suspended Type Permanent Magnetic Separator



This type of separation device is suitable for processing raw refuse, where separators can remove large pieces of ferrous metal easily from the waste stream.

(ii) **Magnetic pulley:** This consists of a drum type device containing permanent magnets or electromagnets over which a conveyor or a similar transfer mechanism carries the waste stream. The conveyor belt conforms to the rounded shape of the magnetic drum and the magnetic force pulls the ferrous material away from the falling stream of solid waste. Figure 5.7 illustrates this type of magnetic separator:

Figure 5.7
Pulley Type Permanent Magnetic Separator



Selection of magnetic separation equipment

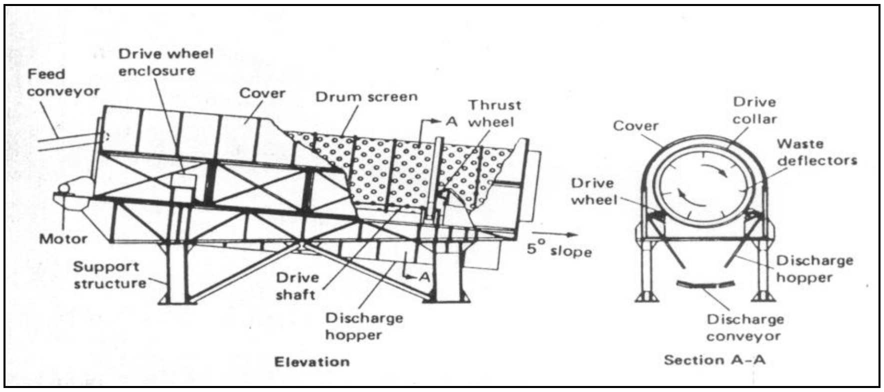
We must consider the following factors in the selection of magnetic separation equipment:

- Characteristics of waste from which ferrous materials are to be separated (i.e., the amount of ferrous material, the tendency of the wastes to stick to each other, size, moisture content, etc.)
- Equipment used for feeding wastes to separator and removing the separated waste streams.
- Characteristics of the separator system engineering design, including loading rate, magnet strength, conveyor speed, material of construction, etc.
- Operational characteristics, including energy requirements, routine and specialised maintenance requirements, simplicity of operation, reliability, noise output, and air and water pollution control requirements.
- Locations where ferrous materials are to be recovered from solid wastes.
- Site consideration, including space and height, access, noise and environmental limitations.

5.3.3 Screening

Screening is the most common form of separating solid wastes, depending on their size by the use of one or more screening surfaces. Screening has a number of applications in solid waste resource and energy recovery systems. Screens can be used before or after shredding and after air separation of wastes in various applications dealing with both light and heavy fraction materials. The most commonly used screens are rotary drum screens and various forms of vibrating screens. Figures 5.8 shows a typical rotary drum screen:

Figure 5.8
Rotary Drum Screen



Source: Tchobanoglous, et al., (1977)

Note that rotating wire screens with relatively large openings are used for separation of cardboard and paper products, while vibrating screens and rotating drum screens are typically used for the removal of glass and related materials from the shredded solid wastes.

Selection of screening equipment

The various factors that affect the selection of screens include the following:

- Material specification for screened component.
- Location where screening is to be applied and characteristics of waste material to be screened, including particle size, shape, bulk, density and moisture content.
- Separation and overall efficiency.
- Characteristics screen design, including materials of construction, size of screen openings, total surface screening area, oscillating rate for vibrating screens, speed for rotary drum screens, loading rates and length.
- Operational characteristics, including energy requirements, maintenance requirements, simplicity of operation, reliability, noise output and air and water pollution control requirements.

- Site considerations such as space and height access, noise and related environmental limitations.

The efficiency of screen can be evaluated in terms of the percentage recovery of the material in the feed stream by using Equation 5.3:

$$\text{Recovery } (\%) = \frac{U \times W_u}{F \times W_f} \times 100 \qquad \textbf{Equation 5.3}$$

$$W_f = \frac{\text{Weight of sample}}{\text{Weight of material fed to the screen}} \qquad \textbf{Equation 5.4}$$

$$W_u = \frac{\text{Weight of sample in underflow}}{\text{Total weight of material in underflow}} \qquad \textbf{Equation 5.5}$$

where U = weight of material passing through screen (underflow) kg/h; F = weight of material fed to the screen, kg/h; W_u = weight fraction of material desired size in underflow; W_f = weight fraction of material of desired size in feed.

The effectiveness of the screening operation can be determined by:

Effectiveness = recovery $\times$ rejection

where, rejection = 1 – recovery of undesired material

$$= 1 - \frac{U(1 - W_u)}{F(1 - W_f)}$$

Therefore, the effectiveness of screen is:

$$\text{Effectiveness} = \frac{U \times W_u}{F \times W_f} \times \left[1 - \frac{U(1 - W_u)}{F(1 - W_f)}\right]$$

LEARNING ACTIVITY 5.2

Given that 100 tonne/h of solid waste is applied to a rotary screen for the removal of glass prior to shredding, determine the recovery efficiency and effectiveness of the screen, based on the following experimental data:

The percentage of glass in solid waste = 8 %
Total weight of material in under flow = 10 tonne/h
Weight of glass in screen underflow = 7.2 tonne/h

Note:
a) Write your answer in the space given below.
b) Check your answer with the one given at the end of this Unit.

5.3.4 Other separation techniques

Besides the mechanical techniques we studied earlier for segregating wastes, there are others. A description of some of these other separation techniques is given below:

(i) **Hand-sorting or previewing:** Previewing of the waste stream and manual removal of large sized materials is necessary, prior to most types of separation or size reduction techniques. This is done to prevent damage or stoppage of equipment such as shredders or screens, due to items such as rugs, pillows, mattresses, large metallic or plastic objects, wood or other construction materials, paint cans, etc.

(ii) **Inertial separation:** Inertial methods rely on ballistic or gravity separation principles to separate shredded solid wastes into light (i.e., organic) and heavy (i.e., inorganic) particles. Figures 5.9 and 5.10 illustrate the modes of operation of two different types of inertial separators:

Figure 5.9
Ballistic Inertial Separator

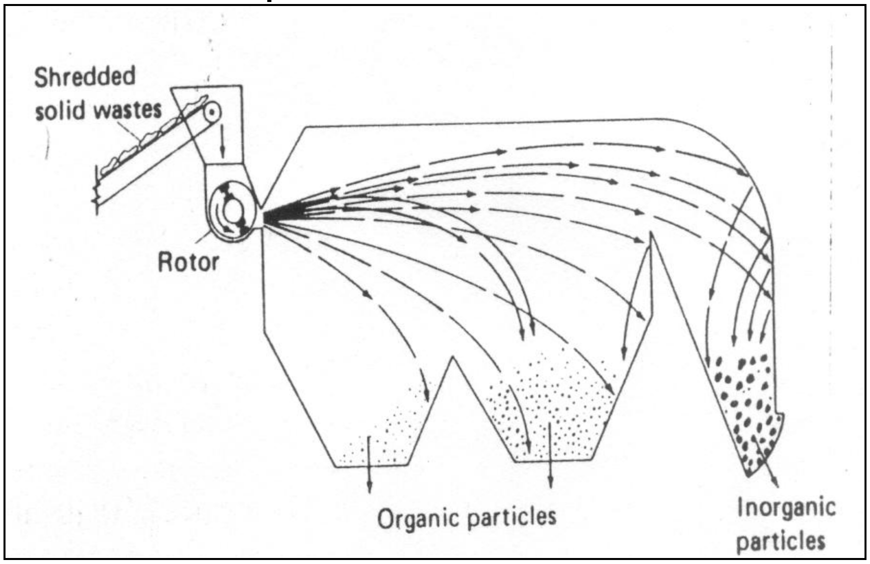
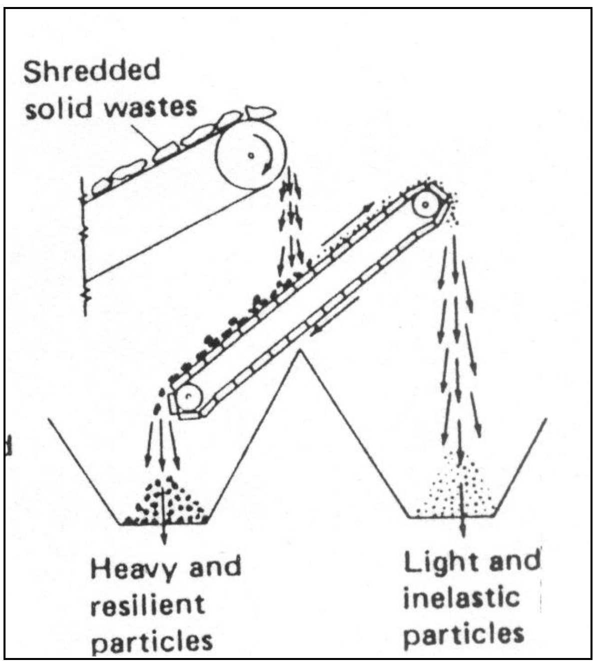


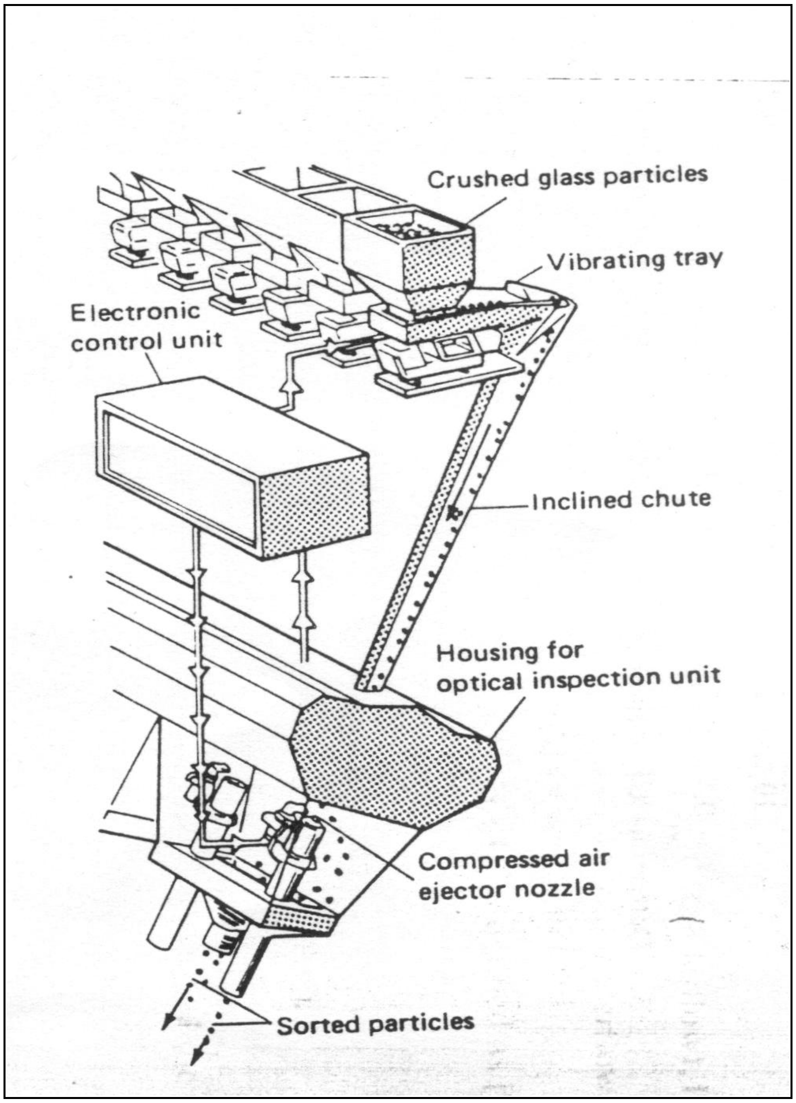
Figure 5.10
Inclined Conveyor Separator



(iii) **Flotation:** In the flotation process, glass-rich feedstock, which is produced by screening the heavy fraction of the air-classified wastes after ferrous metal separation, is immersed in water in a soluble tank. Glass chips, rocks, bricks, bones and dense plastic materials that sink to the bottom are removed with belt scrappers for further processing. Light organic and other materials that float are skimmed from the surface. These materials are taken to landfill sites or to incinerators for energy recovery. Chemical adhesives (flocculants) are also used to improve the capture of light organic and fine inorganic materials.

(iv) **Optical sorting:** Optical sorting is used mostly to separate glass from the waste stream, and this can be accomplished by identification of the transparent properties of glass to sort it from opaque materials (e.g., stones, ceramics, bottle caps, corks, etc.) in the waste stream. Optical sorting involves a compressed air blast that removes or separates the glasses – plain or coloured. An optical sorting machinery is, however, complex and expensive. Consider Figure 5.11 shows a simplified scheme of electronic sorter for glass:

Figure 5.11
Simplified Scheme of Electronic Sorter



Source: Tchobanoglous, et al., (1993)

So far, we discussed component separation through air classifiers, magnetic separators, screens, and hand sorting, flotation, optical sorting and inertial separators. In case, however, the waste consists of moisture, we need to remove it for efficient management. It is in this regard that drying and dewatering are considered the most appropriate means of removal of moisture. We will study this next.

5.4 DRYING AND DEWATERING

Drying and dewatering operations are used primarily for incineration systems, with or without energy recovery systems. These are also used for drying of sludges in wastewater treatment plants, prior to their incineration or transport to land disposal. The purpose of drying and dewatering operation is to remove moisture from wastes and thereby make it a better fuel. Sometimes, the light fraction is *pelletised* after drying to make the fuel easier to transport and store, prior to use in an incinerator or energy recovery facility.

Table 5.3 shows the range of moisture content for municipal solid waste components:

Table 5.3
Moisture Content of
Municipal Solid Waste Components

Component	**Moisture (in percent)**	
	Range	**Typical**
Food wastes	50 – 80	70
Paper	4 – 10	6
Cardboard	4 – 8	5
Plastics	1 – 4	2
Textiles	6 – 15	10
Rubber	1 – 4	2
Leather	8 – 12	10
Garden trimmings	30 – 80	60
Wood	15 – 40	20
Glass	1 – 4	2
Tin cans	2 – 4	3
Nonferrous metals	2 – 4	2
Ferrous metals	2 – 6	3
Dirt, ashes, brick, etc.	6 – 12	8
Municipal solid wastes	15 – 40	20

Source: Tchobanoglous, et al., (1993)

5.4.1 Drying

The following three methods are used to apply the heat required for drying the wastes:

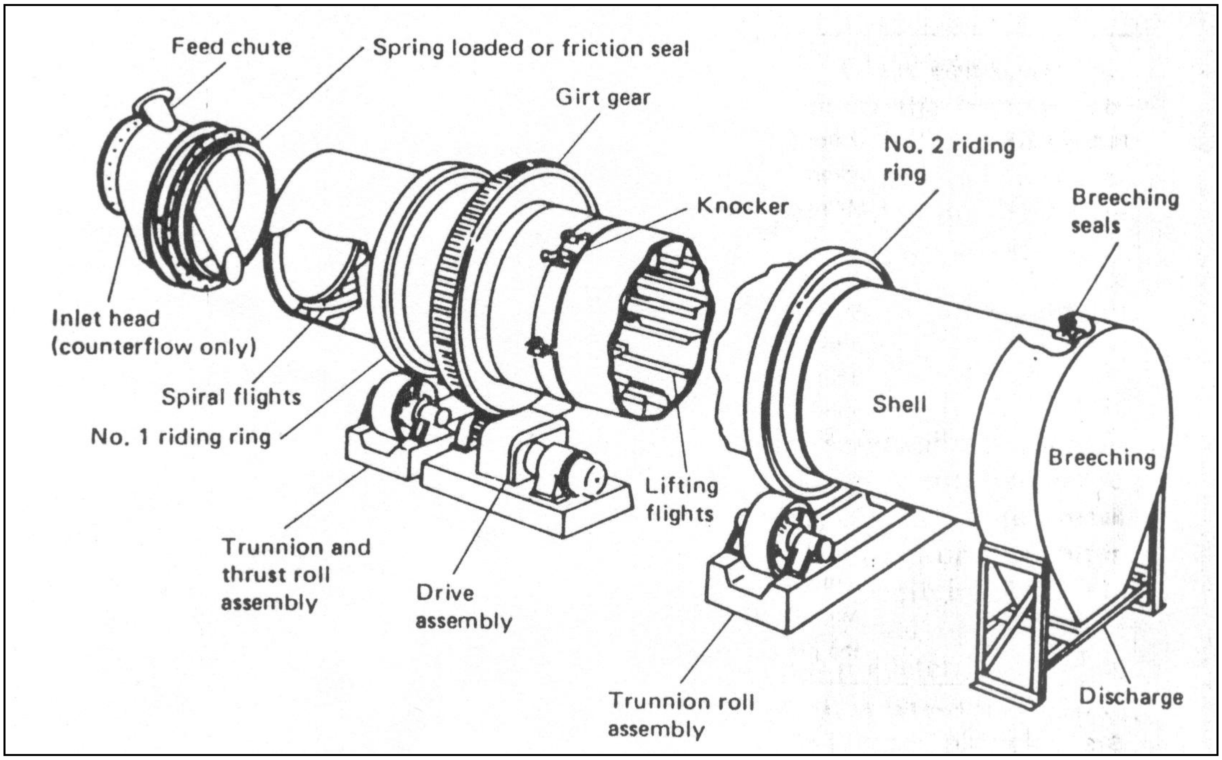
(i) **Convection drying:** In this method, hot air is in direct contact with the wet solid waste stream.

(ii) **Conduction drying:** In this method, the wet solid waste stream is in contact with a heated surface.

(iii) **Radiation drying:** In this method, heat is transmitted directly to the wet solid waste stream by radiation from the heated body.

Of these three methods, convection drying is used most commonly. Figure 5.12 illustrates a rotary drum dryer used in the cement industry:

Figure 5.12
Countercurrent Direct-Heat Rotary Drum Dryer
(Bartlett-Snow)



Source: Tchobanoglous, et al., (1977)

As Figure 5.12 illustrates, a rotary drum dryer is composed of a rotating cylinder, slightly inclined from the horizontal through which the material to be dried and the drying gas are passed simultaneously. The drying of material in a direct rotary dryer occurs in the following stages:

- Heating the wet material and its moisture content to the constant-rate drying temperature.
- Drying the material substantially at this temperature.
- Heating of material to its discharge temperature and evaporation of moisture remaining at the end of the stage.

The retention time in the rotary drum is about 30 – 45 minutes. The required energy input will depend on the moisture content, and the required energy input can be estimated by using a value of about 715 KJ/kg (or 1850 Btu/1b) of water evaporated. Some of the factors, we need to consider in the selection of a drying equipment that include the following:

- Properties of material to be dried.
- Drying characteristics of the materials, including moisture content, maximum material temperature and anticipated drying time.
- Specification of final product, including moisture content.
- Nature of operation, whether continuous or intermittent.
- Operational characteristics, including energy requirements, maintenance requirements, simplicity of operation, reliability, noise output and air and water pollution control requirements.
- Site considerations such as space and height access, noise and environmental limitations.

5.4.2 Dewatering

Dewatering is more applicable to the problem of sludge disposal from wastewater treatment of plants, but may also be applicable in some cases to municipal/industrial waste problems. When drying beds, lagoons or spreading on land are not feasible, other mechanical means of dewatering are used. The emphasis in the dewatering operation is often on reducing the liquid volume. Once dewatered, the sludge can be mixed with other solid waste, and the resulting mixture can be:

- incinerated to reduce volume;
- used for the production of recoverable by-products;
- used for production of compost;
- buried in a landfill.

Centrifugation and filtration are the two common methods for the dewatering of sludge. Sludges with solid content of a few percent can be thickened to about 10 – 15% in centrifugation and about 20 – 30% in pressure filtration or vacuum filtration.

LEARNING ACTIVITY 5.3

List the methods of drying.

Note:
a) Write your answer in the space given below.
b) Check your answer with the one given at this end of this Unit.

SUMMARY

In this Unit, we discussed various processing techniques that are used in SWM system to improve the efficiency of operation, recovery of resources, i.e., usable materials, and recovery of conversion product and energy. We began our discussion with the importance of processing techniques and the nature of equipment involved for the purpose. Subsequently, we discussed mechanical volume and size reduction techniques and touched upon chemical volume reduction. We also explained some component separation techniques (air separation, magnetic separation, screening, etc.). We closed the Unit with a discussion on drying and dewatering, i.e., the processing techniques used for removing varying amounts of moisture present in solid wastes.

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Lecture 5

Model Answers to Learning Activities

LEARNING ACTIVITY 5.1

Compaction of wastes is the method in which waste is densified so as to reduce its volume. This is done to improve the efficiency of collection and disposal of wastes. Compaction is done to increase the useful life of landfills and to reduce the quantity of material handled at the disposal site. It also brings down the cost involved in waste management.

Size reduction refers to the conversion of solid wastes into smaller portions. This helps to obtain the final product in reasonably uniform and considerably reduced size in comparison to the original form. It is important in the recovery of materials for reuse and for conversion to energy. In order to make a better fuel for incineration waste energy recovery facilities, size reduction is practised. It is also used prior to moisture reduction, drying and dewatering.

LEARNING ACTIVITY 5.2

1 tonne = 1000 kg

The weight fraction of the glass in the feed is given by the equation:

$$W_f = \frac{\text{Weight of sample}}{\text{Weight of material fed to the screen}}$$

$$= \frac{100 \times 1000 \times 0.08 \text{ kg}}{100 \times 1000 \text{ kg}}$$

$$= 0.08$$

Weight fraction of glass in screen underflow is given by:

$$W_u = \frac{\text{Weight of sample in underflow}}{\text{Total weight of material in underflow}}$$

$$= \frac{7.2 \times 1000 \text{ kg}}{10 \times 1000}$$

$$= 0.72$$

Recovery efficiency is given by the equation:

$$Recovery\ (\%) = \frac{Uw_u}{Fw_u}$$

$$= \frac{10 \times 1000 \times 0.72 \times 100}{100 \times 1000 \times 0.08}$$

$$= 90\%$$

Effectiveness is given by the equation:

Effectiveness = recovery $\times$ rejection

$$= \frac{U \times W_u}{F \times W_f} \times 1 - \frac{U(1 - W_u)}{F(1 - W_f)}$$

$$= \frac{(10 \times 1000)(0.72)}{(100 \times 1000 \times 0.08)} \times 1 - \frac{10 \times 1000(1 - 0.72)}{100 \times 1000(1 - 0.08)}$$

$$= 0.87$$

LEARNING ACTIVITY 5.3

The heat required for drying can be applied by the following methods:

(i) Convection drying in which hot air is in direct contact with the wet solid waste stream.

(ii) Conduction drying in which wet solid waste stream is in contact with a heated surface.

(iii) Radiation drying in which heat is transmitted directly to the wet solid waste stream by radiation from the heated body.