Processing Techniques

Processing techniques- Mechanical volume and size reduction, chemical volume reduction, component separation, Drying (simple problems)

Purpose of processing

1. **Improving efficiency of SWM system:**
2. **Recovering material for reuse**
3. **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.

MECHANICAL VOLUME AND SIZE REDUCTION

- 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.
- The processes involved in **volume and size reduction** along with their **selection criteria, equipment requirement, design consideration, etc.**,

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

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

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)

Compactors

Low-pressure (less than 7kg/cm2) 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.
- Portable stationary compactors are being used increasingly by a number of industries in conjunction with material recovery options, especially for waste paper and cardboard.

Compactors

High-pressure (more than 7kg/cm2) compaction: Compact systems with a capacity up to 351.5 kg/cm2 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

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.

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.

Size reduction

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.
- **reducing moisture,** i.e., drying and dewatering of wastes

Equipment used for size reduction

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

Selection of size reduction equipment

- 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.

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.

Methods-Chemical volume reduction

- 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**.

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.
- Recovery of valuable materials for recycling;
- Preparation of solid wastes by removing certain components prior to incineration, energy recovery, composting and biogas production.

At Collection Time

STAGES OF SORTING

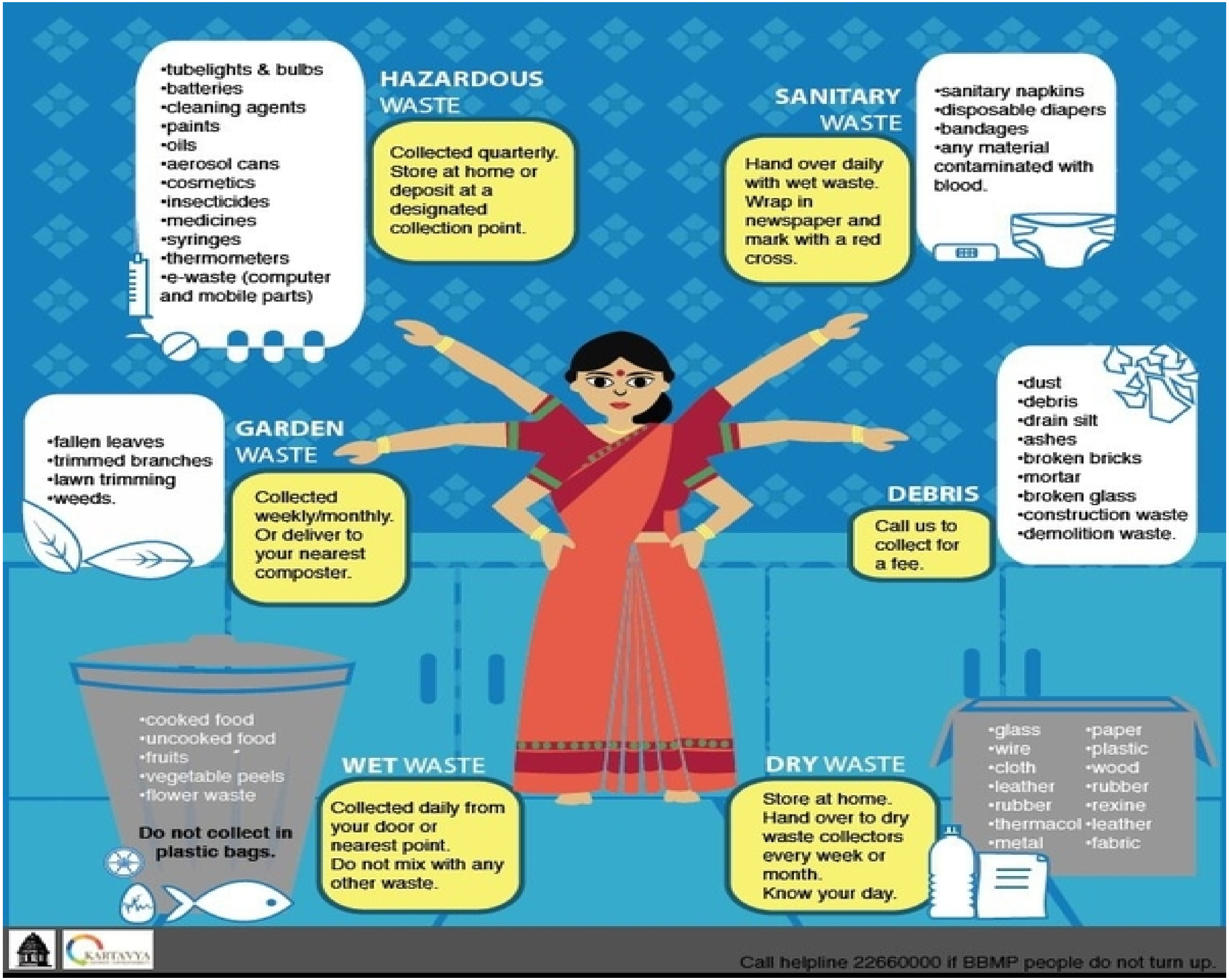
1) At the source/ household level

2) At the community bin (Municipal Bin)

3) At the Transfer Station or Centralized sorting facility

4) At waste processing site (
sorting and post- sorting

5) At the Landfill Site


•tubelights & bulbs
•batteries
•cleaning agents
•paints
•oils
•aerosol cans
•cosmetics
•insecticides
•medicines
•syringes
•thermometers
•e-waste (computer and mobile parts)
HAZARDOUS WASTE
Collected quarterly. Store at home or deposit at a designated collection point.
SANITARY WASTE
Hand over daily with wet waste. Wrap in newspaper and mark with a red cross.
•sanitary napkins
•disposable diapers
•bandages
•any material contaminated with blood.
•fallen leaves
•trimmed branches
•lawn trimming
•weeds.
GARDEN WASTE
Collected weekly/monthly. Or deliver to your nearest composter.
DEBRIS
Call us to collect for a fee.
•dust
•debris
•drain silt
•ashes
•broken bricks
•mortar
•broken glass
•construction waste
•demolition waste.
•cooked food
•uncooked food
•fruits
•vegetable peels
•flower waste
Do not collect in plastic bags.
WET WASTE
Collected daily from your door or nearest point. Do not mix with any other waste.
DRY WASTE
Store at home. Hand over to dry waste collectors every week or month. Know your day.
•glass
•wire
•cloth
•leather
•rubber
•thermacol
•metal
•paper
•plastic
•wood
•rubber
•rexine
•leather
•fabric
Call helpline 22660000 if BBMP people do not turn up.

Fully mechanised sorting operations comprise of

(a) unloading of waste

(b) size reduction of waste through shredders and crushers

(c) size separation of waste using screening devices

(d) density separation (air classification) of waste

(e) magnetic separation of waste

(f) compaction of waste through balers/crushers

(g) reloading of waste

Component separation Technique

In case the separation is not done prior to collection, it could be sorted out through mechanical techniques

- Air separation,
- Magnetic separation, etc., to recover the wastes
- Screening .
- Other separation techniques(other than mechanical techniques)
- Hand-sorting or previewing
- Inertial separation
- Flotation
- Optical sorting

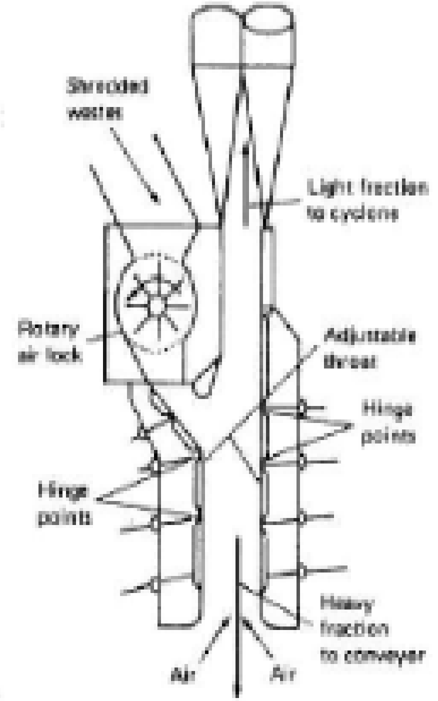
Air separation

- 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.
- 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.

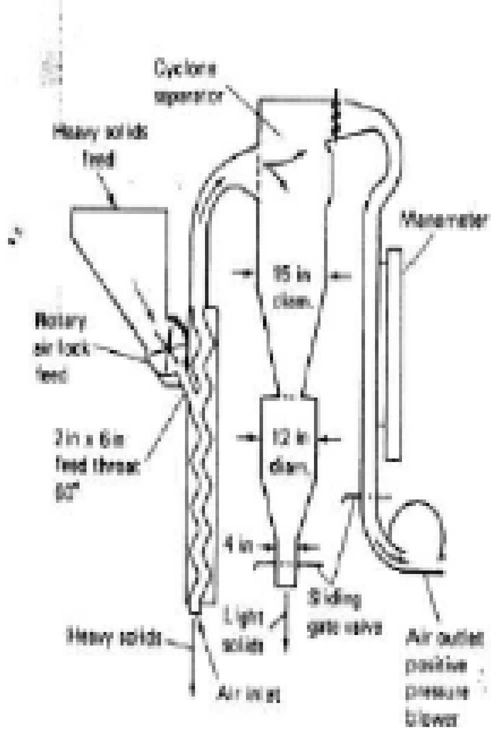
Density separation (air classification)

- Primarily used to separate lighter materials (usually organic) from heavier (usually inorganic) ones.
- Various types of air classifiers commonly used, some of which are listed below:

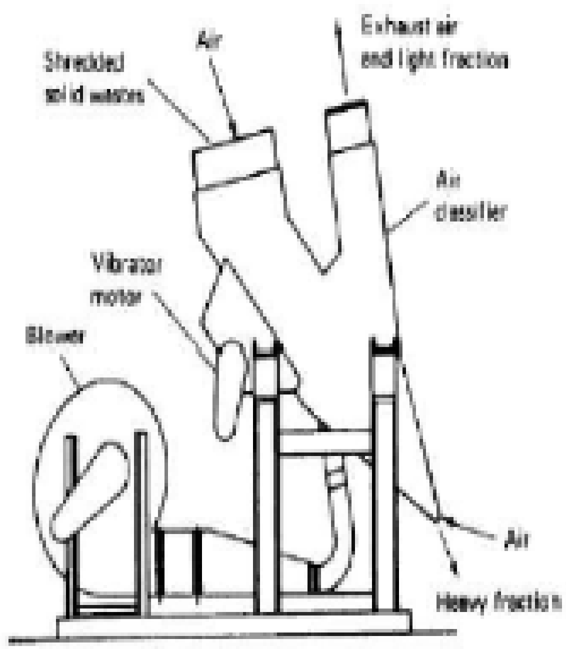
1) Conventional Chute Type



2) Zigzag Air Classifier



3) Open Inlet Vibrator

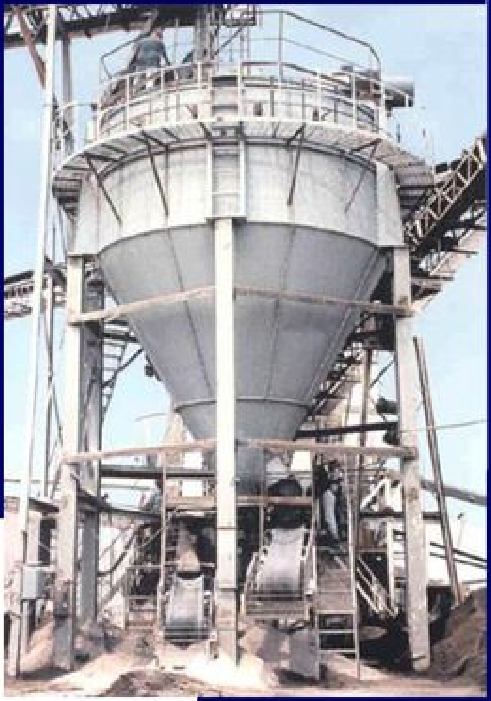


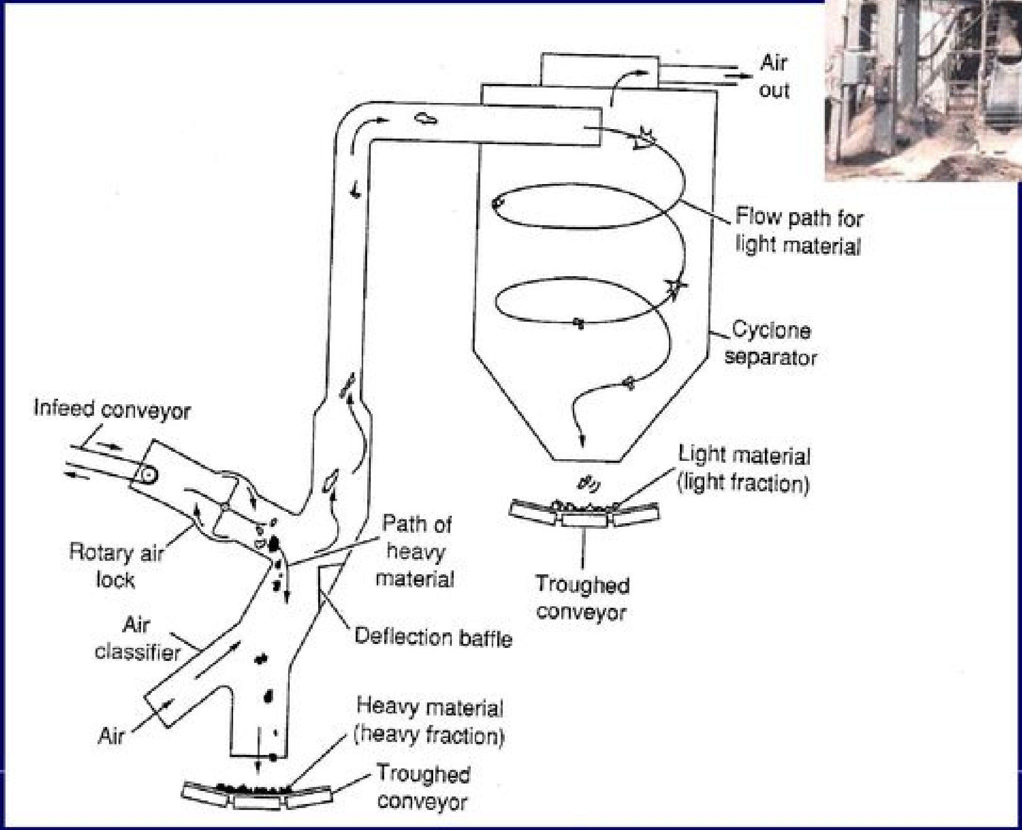
Types of air classifiers

- **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.

Air classifier (1)

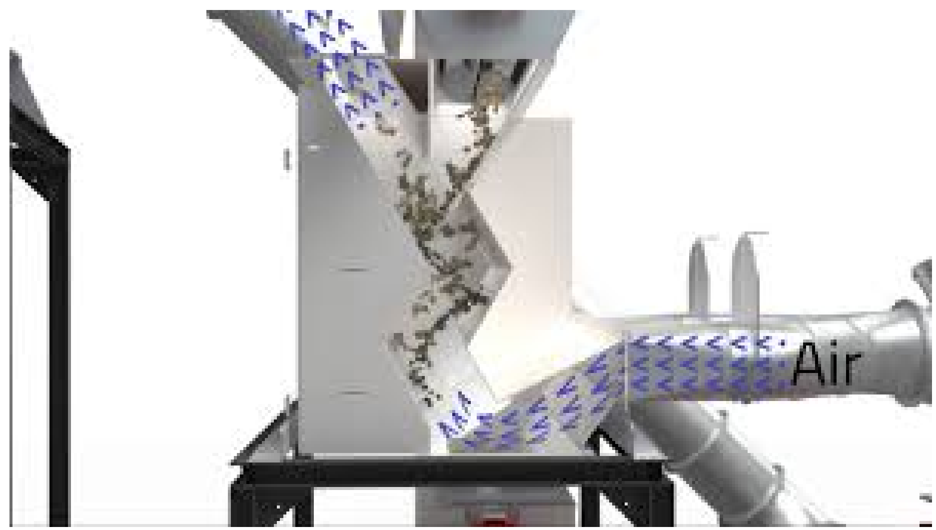
- Lighter materials transport to the top of chute by the upward airflow
- Control of the percentage split is accomplished by varying the waste loading, airflow rate, and the cross-sectional area of chute





Types of air classifiers

2. **Zigzag air classifier:** An experimental zigzag air classifier consists of a continuous vertical column with internal zigzag deflectors through which air is drawn at a high rate:



Zig zag Classifiers

- 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.

Types of air classifiers

3.Open inlet vibrator type

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.

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.
- It is also used for the reduction of wear and tear on processing and separation equipment, degree of product purity achieved and the required recovery efficiency.

Equipment used foe magnetic separation

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

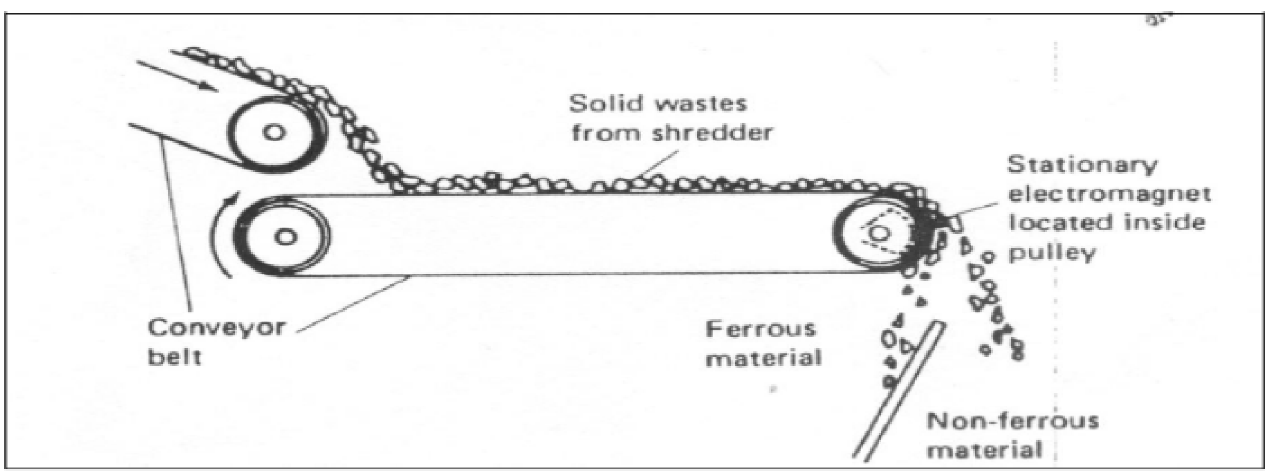
Suspended magnet: In this type of separator, a permanent magnet is used to attract the ferrous metal from the waste stream. When the attracted metal reaches the area, where there is no magnetism, it falls away freely.This ferrous metal is then collected in a container.

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.

Equipment used for magnetic separation

- 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.

Pulley Type Permanent Magnetic Separator



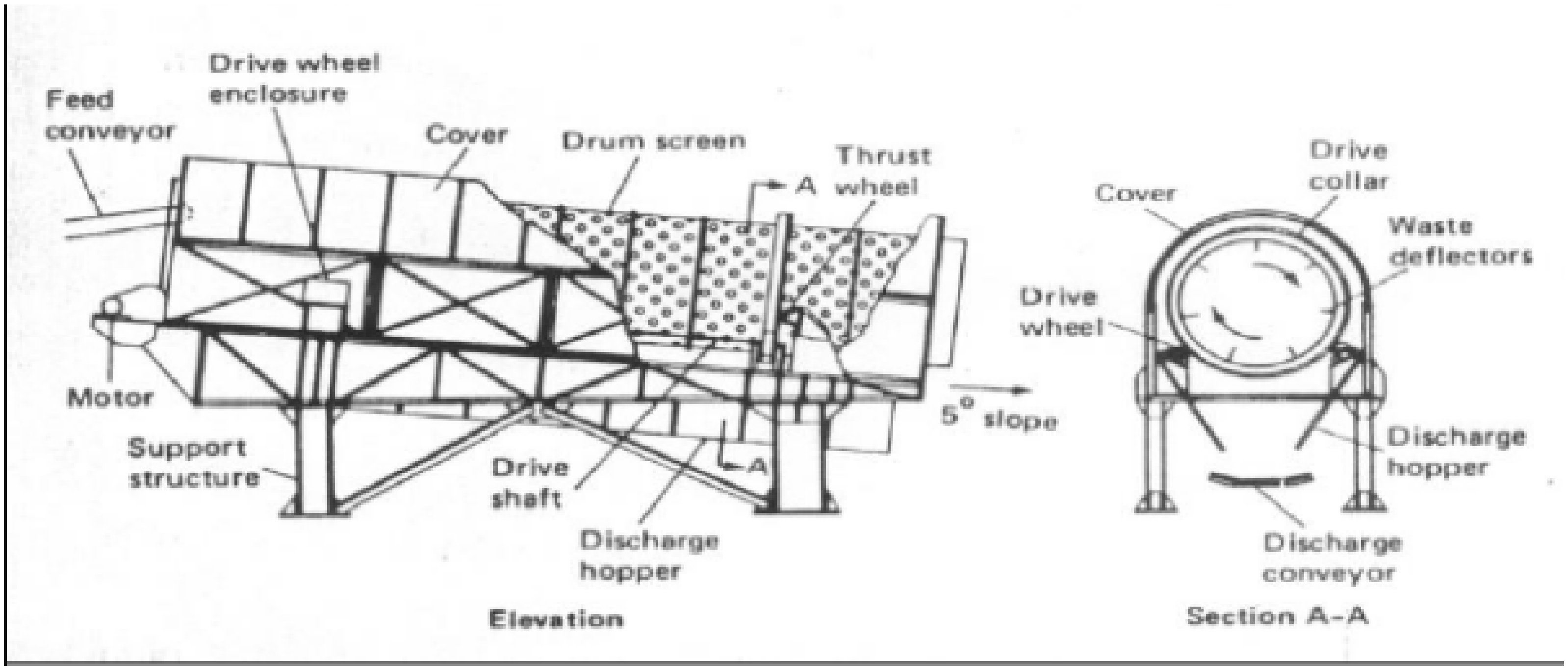
Selection of magnetic separation equipment

- **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.

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

Rotary Drum Screen



Selection of screening equipment

- **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.

Other separation techniques

- **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.

Other separation techniques

- **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.

1. Ballistic Inertial Separator
2. Inclined Conveyor Separator

Other separation techniques

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.

Other separation techniques

- **Optical sorting**: Optical sorting is used mostly to separate glass from the waste stream.
- 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

Drying and Dewatering

- 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.
- **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.

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.

Selection of a drying equipment

- **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.

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.

Dewatering

- 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.

MODULE 4

PROCESSING TECHNIQUES

Processing techniques are used in solid waste management systems to improve the efficiency of operations, to recover resources and to recover conversion products and energy.

i. **Improving efficiency of solid waste management systems**

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.

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.

MECHANICAL VOLUME 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.

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.

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.

Compactors used at transfer stations may further be divided according to the compaction pressure:

Low pressure, less than 100 lb/in^2

High pressure, more 100 lb/in^2

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.

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.
	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	Stationary/transfer trailer	Transfer trailer, usually enclosed, equipped with self-contained compaction mechanism.

station	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.

When wastes are compressed, their volume is reduced, which is normally expressed in percentage

$$\text{Volume Reduction (\%)} = \{(V_i - V_f)/V_i\}100$$

$$\text{Compaction ratio} = V_i / V_f$$

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

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.

MECHANICAL SIZE REDUCTION

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:

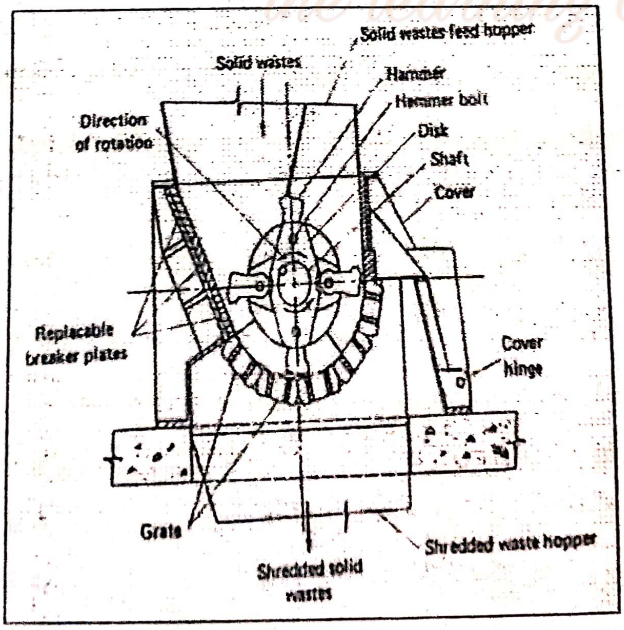
- Land filling to provide a more homogeneous product. This may require less cover material and less frequent covering than that without shredding. This can be of economic importance, where cover material is scarce or needs to be brought to the landfill site from some distance.
- Recovering materials 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.
- Reducing moisture, i.e., drying and dewatering of wastes

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

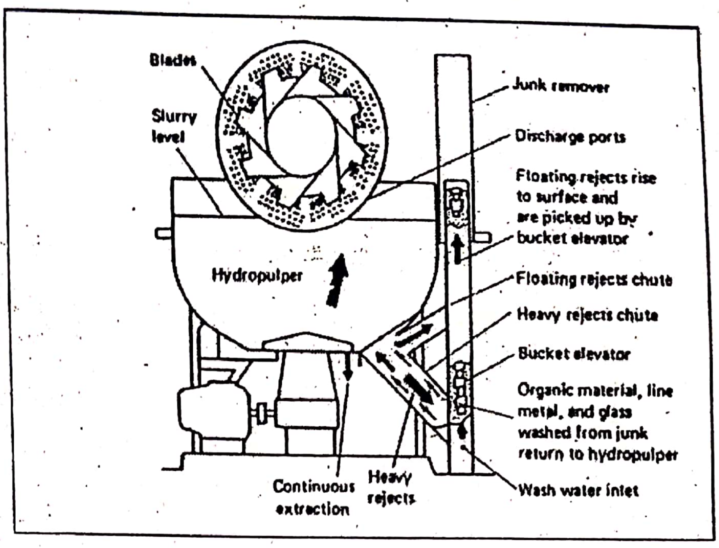
Cutters, Clippers	Shearing, tearing	All types of municipal wastes
Hammer mills	Breaking, tearing, cutting, crushing	All types of municipal wastes, most commonly used equipment for reducing size and homogenizing composition of wastes
Hydropulper	Shearing, tearing	Ideally suited for use with pulpable wastes, 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, which rotates at a very high speed. Solid wastes, as they enter the mill, 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. Solid wastes and recycled water are added to the hydropulper. The highspeed 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.

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.

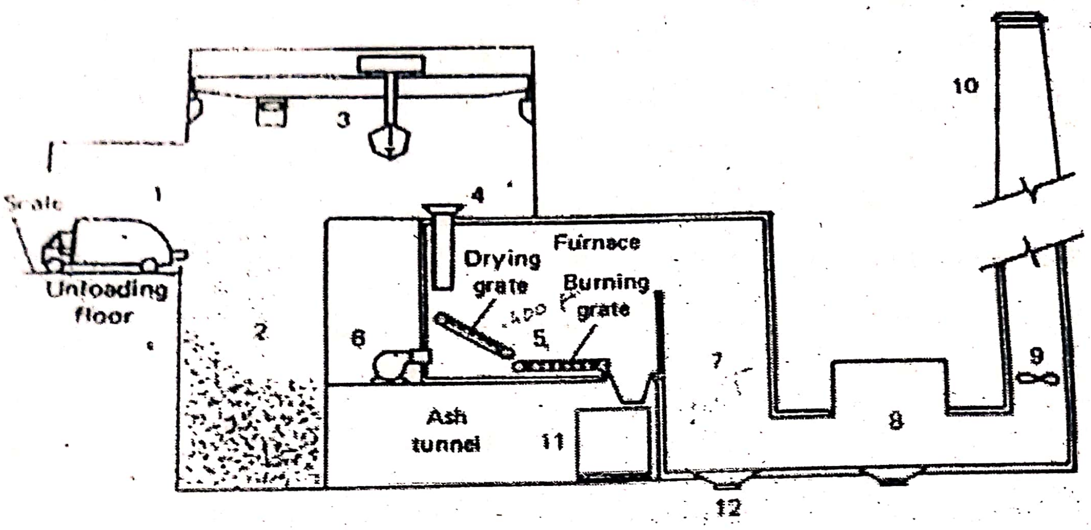
Description of incineration process

The operation begins with the unloading of solid wastes from collection trucks (1) into storage bin (2). The length of the unloading platform and storage bin is a function of the number of trucks that must unload simultaneously. The depth and width of the storage bin are determined by both the rate at which waste loads are received and the rate of burning. Storage capacity usually averages about the volume of 1 day. The overhead crane (3) is used to batch load wastes into the charging hopper (4). The crane operator can select the mix of wastes to achieve fairly even moisture content in the charge. Large or incombustible items are also removed from the wastes. Solid wastes from the charging hopper fall onto the stokers (5) where they are commonly used.

Air may introduce from the bottom of the grates by means of a forced-draft fan (6) or above the grates to control burning grates and furnace temperature. The hottest part of the fire is above the burning grates. The heated air rises over the incoming high-moisture wastes at the top of the drying grate and thus drives off the moisture to permit burning as the wastes travel down the grate. Because most organic wastes are thermally unstable, various gases are driven off in the combustion process taking place in the furnace, where the temperature is about 1400°F. These gases and small organic particles pass into a secondary chamber, commonly called combustion chamber (7). And burn at temperatures in excess of 1600°F. odor-producing compounds usually are destroyed at temperature above about 1400 to 1600 °F.

Some fly ash and other particulates may be carried through the combustion chamber. To meet local air pollution control regulations, space must be provided for air – cleaning equipment (8). To secure adequate air flows to provide for head losses through air cleaning equipment as well as to supply air to the incinerator itself, an induced fan (9) may be needed. Ti may also be done with forced draft fan.

The end products of incineration are the cleaned gases that are discharged to the stack (10). Ashes and unburned materials from the grates fall into a residue hopper (11) located below the grates where they are quenched with water. Fly ash which settles in the combustion chamber is removed by means of a fly ash sluiceway (12). Residue from the storage hopper may be taken to a sanitary landfill or to a resource recovery plant. Fly ash from the sluiceway and wastes from the air-cleaning equipments are taken to a sanitary landfill.



1. Collection truck
2. Storage bin
3. Overhead crane
4. Charging hopper
5. Traveling grate stokers
6. Forced draft fan
7. Combustion chamber
8. Gas cleaning equipment
9. Induced draft fan
10. Stack
11. Residue hopper
12. Flyash sluiceway

FIG. 8-8 Section through a typical continuous-feed mass-fired municipal incinerator.

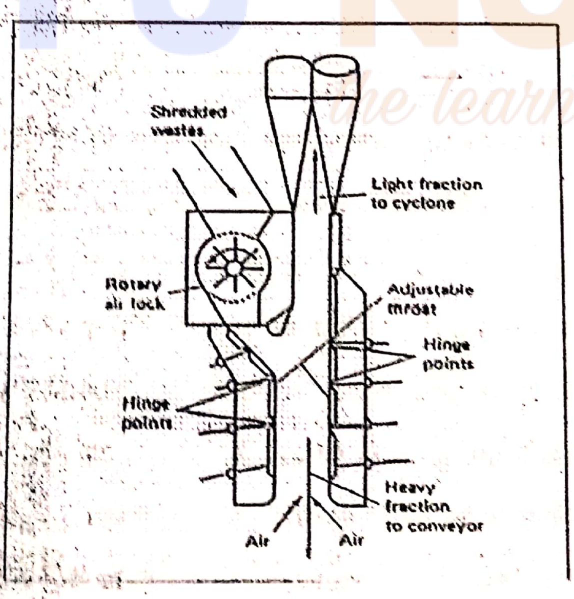
COMPONENT SEPARATION

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. 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.

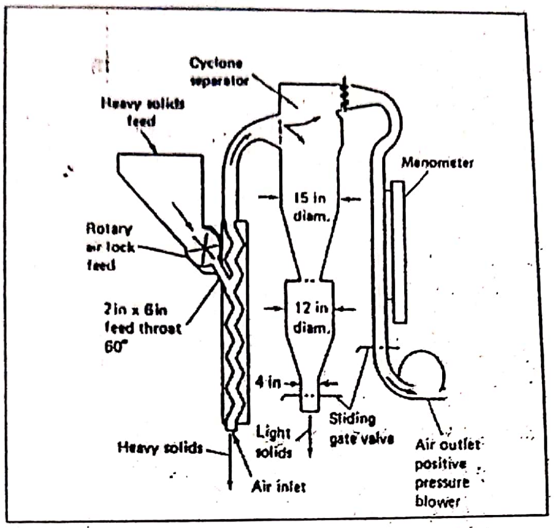
i. Air separation

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:

Conventional chute type: It is one of the simplest types of air classifiers. 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.



Zigzag air classifier: An experimental zigzag air classifier, consists of a continuous vertical column with internal zigzag deflectors through which air is drawn at a high rate. 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.

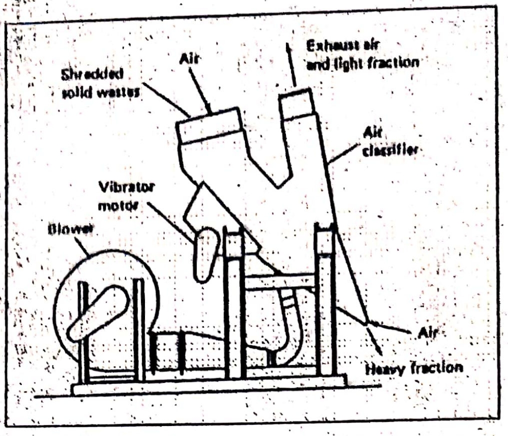


Open inlet vibrator type: In this type of air classifier, the separation is accomplished by a combination of the following actions:

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.

ii. Magnetic separation

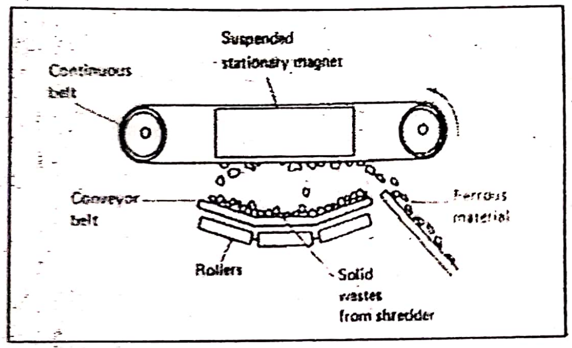
The most common method of recovering ferrous scrap from shredded solid wastes involves the use of magnetic recovery systems. Ferrous materials are usually recovered either after shredding or before air classification. When wastes are mass-fired in incinerators, the magnetic separator is used to remove 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:

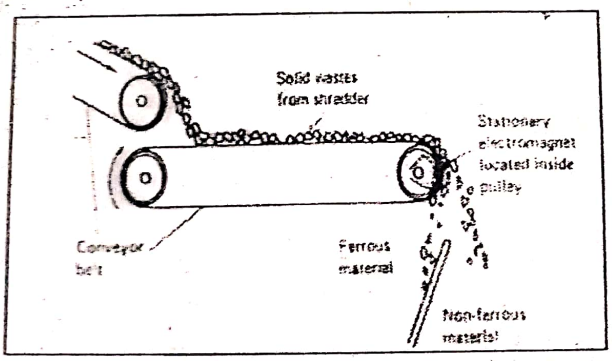
(i) Suspended magnet:

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. 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.



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.

Other separation techniques

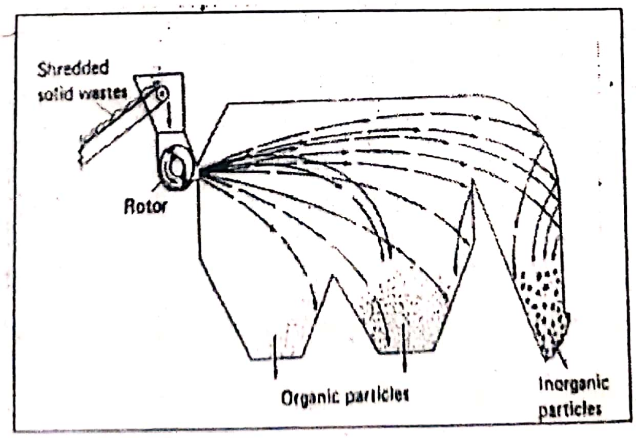
Besides the mechanical techniques we studied earlier for segregating wastes, there are others. A description of some of these other separation techniques is given below:

(i) **Hand-sorting or previewing:**

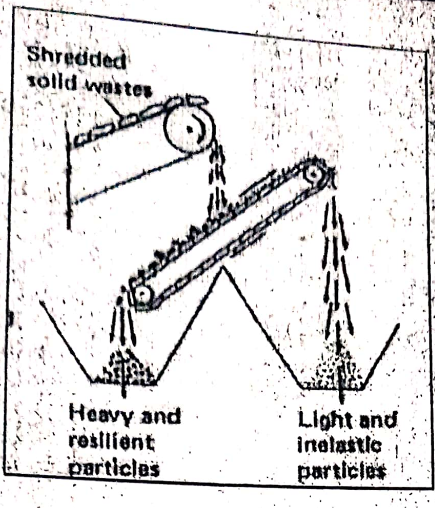
Previewing of the waste stream and manual removal of large sized materials is necessary, prior to most types of separation or size reduction techniques. This is done to prevent damage or stoppage of equipment such as shredders or screens, due to items such as rugs, pillows, mattresses, large metallic 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.



Ballistic



Inclined conveyor

(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.

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.

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.

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.

Type of dryer	Method of operation
Rotary tray	Material to be dried is spread on the top of a series of stacked trays and raked to lower trays as it dries.
Endless belt	Material to be dried is spread at the feed end of the dryer on a continuous perforated wire mesh belt or conveyor bands which are used to move the material through the dryer.
Rotary drum	Slow rotating cylindrical shell, slightly inclined from the horizontal is provided with a means for continuously feeding material to be dried.
Fluid bed	Material to be dried is maintained in fluidized condition. Fluid bed dryers are usually in the form of vertical cylindrical columns.
Spray	Material to be dried is sprayed into a drying chamber. Movement of feedstock and the drying medium can be concurrent, countercurrent or

	combination of both.
Flash	Material to be dries is entrained in the drying medium and is conveyed in the process of drying

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

8/4/19

PROCESSING TECHNIQUES & EQUIPMENTS (PPT)

Purpose of processing - in order that we could derive max. economical value from them

1) Improving efficiency of SWM
   - Eg: wastes are baled to reduce volume.
     Shredding.

2) Recovering materials for reuse
   Eg: Paper, Cardboard, glass, Ferrous metals etc.

3) Recovering coversion products & energy
   - Combustible organic materials can be converted to energy.
   - Incineration, Pyrolisis

MECHANICAL VOLUME & SIZE REDUCTION

- Main purpose to reduce size & volume compared to its original form
- Vol. reduction or compaction.
  - Densifying wastes
  - Reduction in the quantity of materials to be handled at disposal site.
  - Improved efficiency of collection and disposal of wastes.
  - Increased life of landfills
  - Economically viable waste management system.

- Disadvantages
  Difficulty in seggregation or sorting
  Biodegradable materials destroy the value of paper & plastic material.

EQUIPMENTS USED FOR COMPACTION

1) Stationary equipment
   - light duty (residential)
   - commercial or industrial
   - heavy industrial
2) Movable equipment

TYPES OF COMPACTORS

Based on compaction Pressure

1) Low-pressure - less than 7 kg/cm²
2) High-pressure - greater than 7 kg/cm²
   Capacity - 851 kg/cm²

$$\text{Volume Reduction (\%)} = \frac{V_i - V_F}{V_i} \times 100$$

$$\text{Compaction Ratio} = \frac{V_i}{V_F}$$

Selection of Compaction Equipment

Considering Factors

- Size, composition, moisture content, bulk density of wast
- Potential uses of compacted waste
- Design characteristics
- operational characterics
- Site considerations.

9/4/19

SIZE REDUCTION OR SHREDDING

- convert large size particles to smaller pieces.
- obtain Final product in uniform size.

SHREDDING EQUIPMENTS

The most frequently used shredding equipments are:

1) Hammer mill
2) Hydropulper

1) HAMMER MILL

These are mostly used in large commercial operations for reducing the size of waste. It is an impact device consisting of no. of hammers attached to an inner disk. Solid waste as they enter the mill are hit by sufficient force which crush or tear them with a velocity, so that they do not ~~~~ adhere to the hammer. Waste are further reduced in size by being strucked between breaker plates or cutting bars fixed around the periphary of the inner chamber. The process of cutting & striking action continuous until the required size of materials is achieved & after that it falls out of the bottom of the mill.

Selection of Size Reduction Equipments

Factors considered:

1) Properties of material
2) size requirements.
3) Method of feeding
4) Type of operation (Continous & intermitant)
5) operational characteristics
6) site considerations.

CHEMICAL VOLUME REDUCTION

chemical changes by adding chemicals & change in temp.

COMPONENT SEPERATION.

⇒ For recovery of valuable materials.
⇒ Most effective way of seperation is manual sorting

10/4/19

AIR SEPARATION.

- For seperation of lighter materials from heavier materials. From dry mixture
- cyclone seperator

(i) Convention type
(ii) zigzag air classifier

zig zag deflector is used.

(iii) open inlet vibrator type

Seperation acomplished by

- vibration
- Inertial Force
- Air pressure

In this type only micron sized particles are blow through air

Selection of Air separation Equipment

- characteristics of material
- Material specification For light Fraction
- Method of transferring
- characteristics of seperator
- site characteristics
- operational characteristics.

MAGNETIC SEPERATION

- For recovery of Ferrous scrap From shredded solid waste.
- Types of magnet
  1) suspended magnet
  2) Magnetic puley

SCREENING

- seperating solid wastes depending on their sizes by use of screening surface.
- can be used befor or after ~~shee~~shredding & after air seperation of wastes.
- Most commonly used screens are rotary drum screens & various Forms of vibrating screens.
- Wire screens with large opening - seperation of cardboard & paper product.
- Rotating drum - removal of glass.

Selection of screening Equipment

Other seperation Technique.

(i) Hand - sorting or previewing.

Previewing of the waste stream & manual removal of large sized materal Prior to size reduction.

Done to prevent damage of machines.

(ii) Inertial seperation

1) Ballistic inertial seperator. } (just mention names)
2) Inclined conveyor seperator

(iii) Floatation

- To seperate glass particles after ferrous metal separation.
- Glass chips, rocks, bricks, bones & dense plastic materials

(iv) optical sorting

DRYING & DEWATERING

- used primarily for incineration systems.
- Remove moisture from wastes & there by make it a better fuel

Drying

1) Convection drying

Hot air is in direct contact with wet solid waste

2) Conduction.

wet solid waste stream is in contacted with heated surface.

3) Radiation

Factors considered to select drying equipment

Dewatering.

10/4/19