MODULE – 2

Processing Techniques

Processing techniques is used in solid waste management.

The purposes of processing essentially are

1. 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.

2. Recovering material for reuse:
   Materials that have a market, when present in wastes in sufficient quantity can be recovered from solid wastes include paper, cardboard, plastic, glass, ferrous metal, aluminum and other residual metals.

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 biodigestion.
   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.

Processes used routinely to improve the efficiency of solid waste systems and to recover materials are

1. Mechanical Volume Reduction (Compaction)
2. Chemical Volume Reduction (Incineration)
3. Mechanical size reduction (Shredding)
4. Component Separation (Manual or Mechanical)

1. Mechanical Volume Reduction (Compaction)

Mechanical volume reduction is perhaps the most important factor in the development & operation of solid waste management systems. Volume reduction is nothing but the reduction of initial volume of waste by the application of force or pressure. In most cases vehicles equipped with compaction mechanism are used for the compaction of the waste.

Some of the benefits of compaction include:

- To increase the useful life of landfills, wastes are compacted.
- reduction in the quantity of materials to be handled at the disposal site;
- improved efficiency of collection and disposal of wastes

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.

Paper, cardboard, plastic, aluminum, tin cans are removed from solid waste for recycling and baled to reduce the storage, handling and shipping costs.

Equipment used for compaction based on their mobility

Stationary equipment

Movable equipment

1. **Stationary equipment**: Equipment in which wastes are brought to and loaded into either manually or mechanically. 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.
- Large stationary compactors are necessary, when wastes are to be compressed into:
  Steel containers that can be subsequently moved manually or mechanically;
  Chambers where they are compressed into a block and then released and hauled away untied; transport vehicles directly.

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

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

High pressure compaction — recently a number of high pressure compaction systems have been developed.

- In most of these systems specialized compaction equipment is used to produce compressed solid waste blocks or bales of various sizes.
- In one system the size of the completed block is about 4inc*4inc*16inch.
- In other system pulverized wastes are extracted after compaction in the form of logs approximately 9inch diameter.
- The Volume reduction achieved with this high pressure compaction systemvaries with the characteristics of waste.

Low Pressure compaction — typically low pressure compactors include those used at apartments and commercial establishment.

- Bailing equipment's is used for waste papers, cardboard while stationery compactors are used at transfer station.
- Portable stationery compactors are used increasingly by no of industries with material recovery operation.

2. Mechanical size Reduction (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.

- The objective of size reduction is to get a final product that is reasonably uniform and considerably reduced when compared to its original form. In some situations the total volume of the materials after size reduction may be greater than that of original volume.

Size Reduction Equipment

The types of equipment that can be used for reducing the size of homogenous solid waste includes small grinder, chippers, big grinder, jaw crushers, hammer mills, shredders etc..

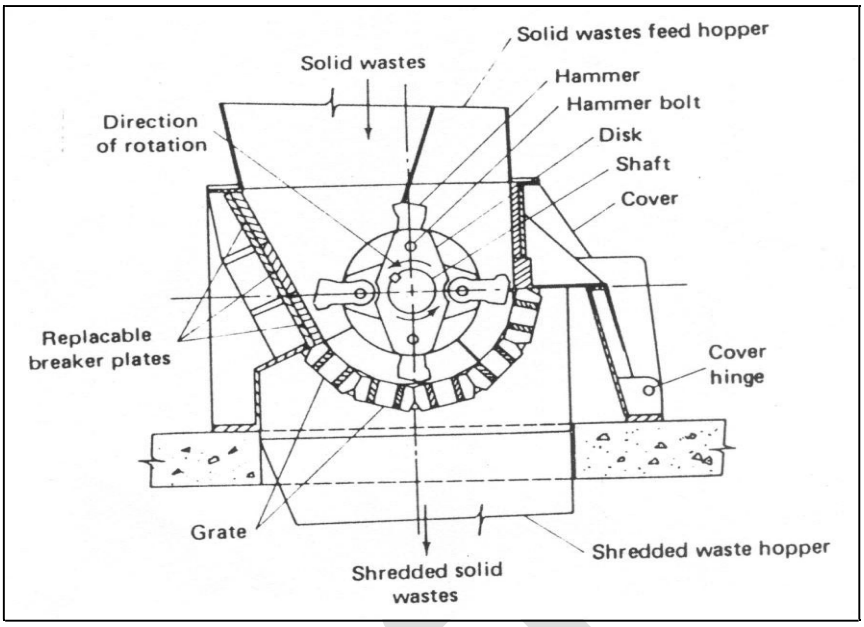
Types, mode of action and applications of equipment's used for mechanical size reduction.

S .No	Type	Mode of action	Application
1	Small Grinder	Grinding, mashing	Organic residential solid waste
2	Chipper	Cutting & slicing	Paper, cardboard, tree trimming & plastic
3	Large grinder	Grinding, mashing	Brittle materials ,used mostly in inorganic operations
4	Jaw Crusher	Crushing & breaking	Large solids
5	Rasp mills	Shredding & tearing	Moistened solid waste most commonly used in municipal solid waste.
6	Cutters, clippers	Shredding & tearing	All types of municipal waste
7	Hammer mill	Breaking, tearing, cutting, crushing	All types of municipal waste, most common equipment for reducing size and homogenizing solid waste.
8	Hydropulper	Shearing, tearing	Ideally suited for use with pulpable waste like paper, wood chips etc used primarily in the paper industry.

The most frequently used shredding equipment are the following:

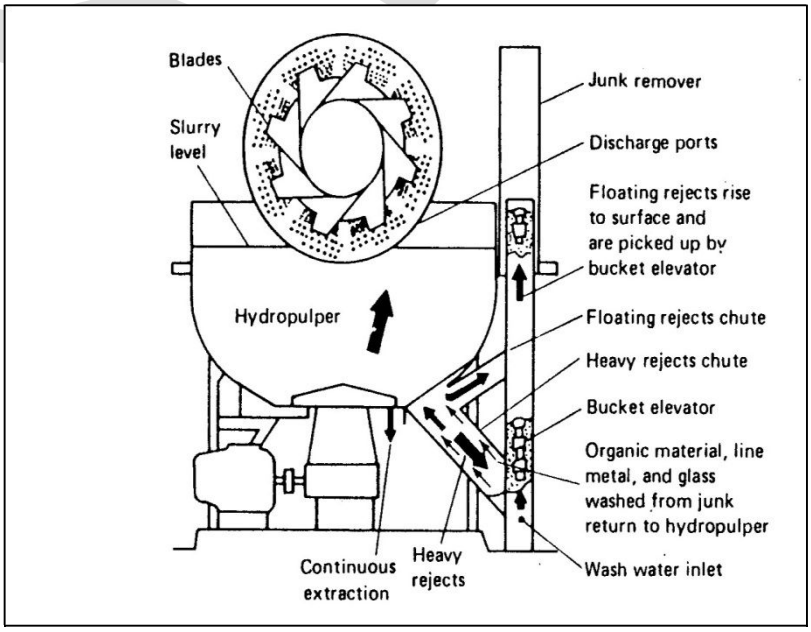
(i) **Hammer mill**:

- 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. Hydro pulper

- An alternative method of size reduction involves the use of a hydropulper
- 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 pulp able and friable materials into slurry with a solid content varying from 2.5 to 3.5%.
- Metal, tins, cans and other non-pulp able 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.



3. **Component Separation**

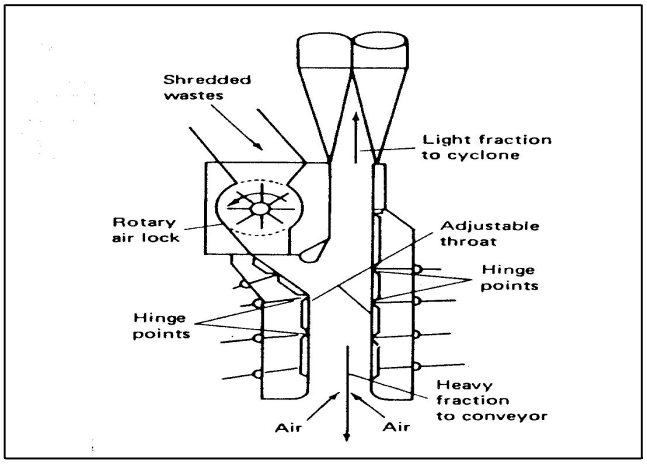
It is necessary operation in the recovery of resources from solid waste and where energy and conversion product are to be recovered from processed waste. The required separation may be accomplished manually or mechanically. When manual separation is used preprocessing of waste is not required in most techniques, however some form of size reduction is required as a first step.

A. 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:

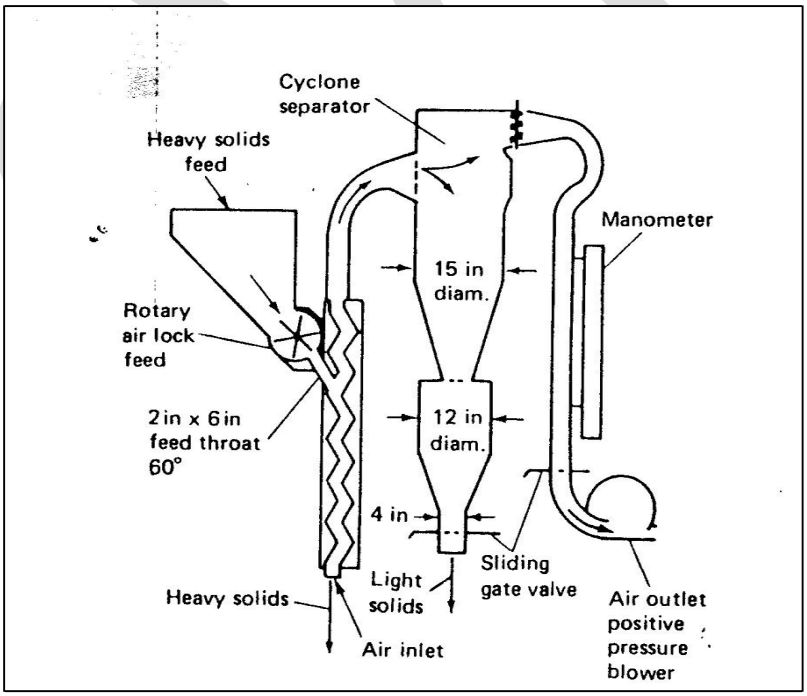
1. Conventional chute type

- 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.



2. 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 fluidized 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.



B. Magnetic separation

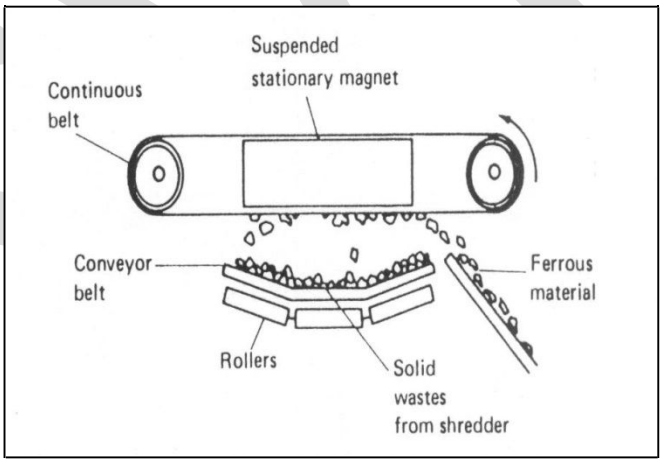
The most common method of recovering ferrous scrap from shredded solid wastes involves the use of magnetic recovery systems.

- 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.

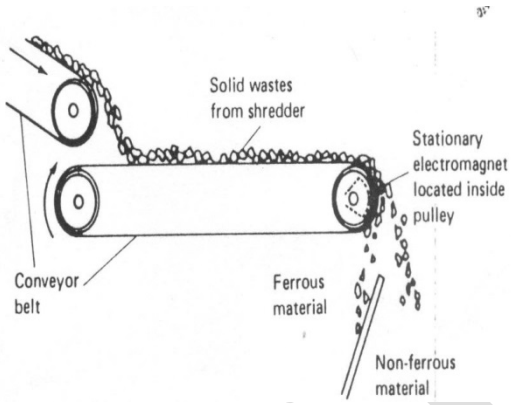
Equipment used for magnetic separation

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

a) **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.



b) **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.



C. 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.
- 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.

D. Heavy Media Separation — Although the removal of aluminum can be accomplished in a number of different ways. Heavy media separation is the best process for which the, greatest operating experience exists principally in the automobile recovery industry.

- In this process the feedstock i.e. rich in aluminum such .as air classified solid waste where in ferrous metals and glass has been removed, is dumped into a liquid which has a high specific gravity.
- The specific gravity is maintained at higher level that will permit aluminum to float and other materials remain submerged.
- At present the major disadvantage of this process is that the optimum size plant requires about 2000 — 3000 tons per day of feed stock

E. **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

F. **Hand Sorting-** The manual separation of solid waste components are accomplished at a source where solid waste is generated or at the disposal site.
   - The number and types of components sorted depend on the location and the resale market.
   - Typically the components include newspaper, aluminum, and glass from residential sources, cardboard, & high quality paper, metals, wood from commercial & industrial source, metals, wood & bulky items of value from transfer station & disposal site.
   - 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.

G. **Electro Static Separation** - High voltage electro static fields can be used to separate glass from the heavy fraction of air classified waste.
   A vibrating feedometer feeds waste to a negatively charged rotating drum. Positive electrode near the drum and the feeder induces a charge in the waste particles.
   Nonconductors such as glass and clay retain the charge where as crystalline materials such as rock loose it rapidly.
   The drum holds nonconductor and the remaining materials drops off.

CHEMICAL VOLUME REDUCTION (INCINERATION)

Incineration can be defined as the controlled combustion process for burning of solid, liquid waste to residue containing non-combustible materials.

Incineration is one of the chemical process used to reduce the volume of the solid waste This process is also called as chemical volume reduction.

Incineration is a chemical reaction in which carbon, hydrogen and other elements in the waste mix with oxygen in the combustion zone and generates heat.

At present it is one of the common method used to reduce the volume of waste chemically, chemical process such as pyrolysis, hydrolysis and chemical conversion are also effective in reducing the volume of waste.

Normally all the combustible matters such as garbage rubbish and dead animals are burnt and the incombustible matters like chinaware, glass, metals etc. are left unburnt or separated out for recycling and reuse before the burning of solid wastes.

The air requirements for combustion of solid wastes are considerable. For example, approximately 5000 kg of air is required for each ton of solid wastes burned. Usually, excess air is supplied to the incinerator to ensure complete mixing and combustion and to regulate operating temperature and control emissions. Excess air requirements, however, differ with moisture content of waste, heating values and the type of combustion technology employed. The principal gas products of combustion are carbon dioxide, carbon monoxide, water, oxygen and oxides of nitrogen.

Many incinerators are designed to operate in the combustion zone of 900°C – 1100°C. This temperature is selected to ensure good combustion, complete elimination of odors and protection of the walls of the incinerator. Incinerator systems are designed to maximize waste burn out and heat output, while minimizing emissions by balancing the oxygen (air) and the three "Ts", i.e., time, temperature and turbulence. Complete incineration of solid wastes produces virtually an inert residue, which constitutes about 10% of the initial weight and perhaps a larger reduction in volume. The residue is generally landfilled.

Advantages of Incineration

- It is the only practical method of disposing of certain wastes such as unwanted chemicals and contaminated material which cannot go to landfill. If incineration is not available locally such material has to be exported.
- Significantly reduces the quantity of material that must go to landfill and associated pollution risks.

- Produces useful energy from waste, reducing fossil fuel consumption and resulting greenhouse gas (GHG) emission.
- The costs, energy usage and GHG emissions can be lower than those in the collection, transport and processing involved in recycling.
- Building incinerators in or close to urban areas reduces the cost of and emissions from waste transport and means the waste is treated where it is generated.

Disadvantages of Incineration

- If incorrectly operated can lead to the release of harmful levels of pollutants. Even in proper operation small amounts of fine particles and pollutants are released. As the technology has matured emission levels have reduced dramatically – in Germany in 2000 dioxin emissions were ~1/1000th of the 1990 levels.
- Incineration of MSW produces relatively large amounts of fly ash (approximately 4% of original waste weight) which must be dumped in secure landfills.
- Incineration could reduce the incentive to recycle. The energy content of waste with all recyclable components removed is much less than unsegregated waste. Incineration plants could compete with recycling for some materials.
- Incineration plants have a large initial capital cost and require long term contracts to be viable. This could hamper the deployment of future more efficient waste treatment technology.

3T'S of Incineration process

- **Time**
- **Temperature**
- **Turbulence**

Time: some wastes are exposed for sufficient time to atmosphere for complete combustion.Sufficient residence time must be allowed to achieve efficiency as well as to assure conversion of products of incomplete combustion to desirable incinerator product.

Temperature: In any combustion process the temperature is the most significant factor in ensuring proper *disposal* of the hazardous waste.

- The temperature that will ensure the destruction of was e & at the same time will allow for cost effective operation.

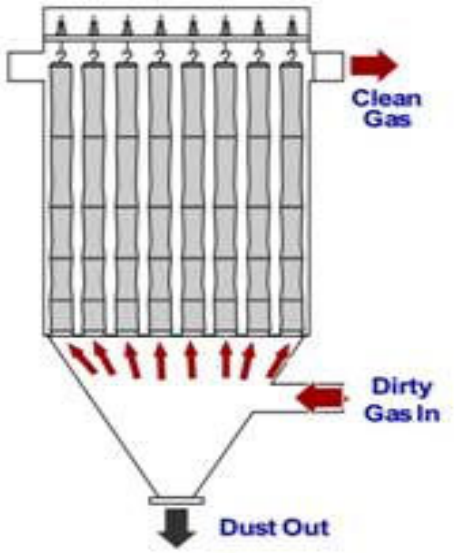
- The temperature for incineration process varies from 550 1000°c. Temperature range is controlled to be above 750°c to ensure adequate combustion and below 1000°c to prevent ash melting and clogging the grate.
- The temperature is controlled by the addition of diluted air to the furnace as required.

Turbulence- Turbulence ensure the mixing of each volume of gas with sufficient air **for** complete burning of combustible matter and suspended particulates The degree of turbulence may be used effectively to attain desirable efficiency and decrease the operating temperature and time requirement.

AIR POLLUTION CONTROL EQUIPMENTS

Fabric Filters
Electrostatic Precipitator

Fabric Filters



Filtration is one of the most reliable, efficient & economic method by which the particulate matter can be removed. from the gas.

- The most common type of fabric collector is the tabular type consisting of tabular bags or bag filter.
- A no of filter bags are connected in parallel in housing.

- The gas entering through the inlet pipe strikes a baffle wall which causes the large particles to fall into a hooper due to gravity.
- The carrier as then flows upwards into the tube and then outward through the fabric leaving the particulate matter inside the bags.
- The dust becomes the actual filtering medium. The bags in effect act primarily as a matrix to support the dust.
- Filter bags can be cleaned by shaking or vibration or by reverse air flow causing the filter to be loosened and to fall into the hopper below.

Advantages

- High collection efficiencies for all particle size.
- Simple construction & operation.
- Normal power usage
- Dry disposal of collected material.

Disadvantages

- Large size of equipment.
- Problems in handling dust which may corrode the filter cloth.
- High maintenance & fabric replacement cost.
- Temperature of flue gas has to be cooled to a temperature of 100 — 400'c, so that the fabric filters are stable.

Electrostatic Precipitator [ESP]

The electrostatic precipitator was the first particle control device used for MSW combustor that was capable of removing fine particle of size lesser than 10pm upto an extent of 0.1 pm.

- They operate on principle of electrostatic attraction.
- In electrostatic precipitators, the gas stream is passed between two electrodes, across which the high potential difference is maintained. Out of that one is collecting electrode and other one is discharging electrode.
- Because of high potential difference and discharge system, a powerful ionizing field is formed. Potentials as high as 100KV are used.
- As the particulates in the carrier gas pass through this field, they get charged and migrate the oppositely charged collecting electrode.
- The particles once deposited on the collecting electrode, lose their charge and are removed by vibration to a hopper below.

Thus, the four steps in this process are

- Particulate matters are charged.
- The particles migrate to the collector
- Neutralize the charge at the collector
- Remove the collected particles

Advantages

- High collection efficiency.
- Low maintains & operation cost
- Treatment time is negligible.
- Cleaning is easy by removing units, in the precipitators.
- Particles are as small as 0.1μ can be removed.

Disadvantages

- Initial cost is high.
- Space requirement is more because of large size equipment.
- Possible explosion hazards during collection of combustible gases.
- Precautions are necessary to maintain for safety during operation. Proper gas flow distribution, gas resistivity, particulate conductivity must be maintained carefully.
- Poisonous gases are produced by the —ve charge discharge electrode during ionization.

CONVENTIONAL MUNICIPAL INCINERATOR

The solid waste reaching the incinerator plant is generally quite wet *& it* is necessary to dry them before burning- of these wastes.

- The operation begins with unloading of solid waste from collection tanks into a storage bin.
- The length of the unloading platform and storage bin is a function of the number of trucks that must unload simultaneously.
- The over head crane is used to load the wastes into the charging hooper.
- From the Charging Hooper falls into the stoker where they are mass fired.
- Air may be introduced from the bottom of the grates to control furnace temperature.
- The gases are driven off into the combustion chamber taking place in the furnace where the temperature is about 1400°F.

- To meet the air pollution control regulations space must be provided for air cleaning equipments' as well as to supply air to incinerator itself by induced draft fan.

The end products of incineration are the cleaned gases that are discharged to the stock. Ashes& un burnt materials from the grates fall into a the ash tunnel located below the grates where they are quenched with water, fly ash particle settles in the combustion chamber which is removed by means of fly ash sluice way residue from the storage hopper may be taken to a sanitary landfill or to a resource recovery plant. Flash from the sluice way & the wastes from the air cleaning equipment are to a sanitary landfills.

Merits

1. This is the most important method of was e disposal and ensures complete destruction of pathogenic bacteria.
2. There is no odour trouble or dust nuisance.
3. The disposal site can be conveniently located within the city.
4. It requires less space for refuse disposal.

Demerits

- It is very costly method.
- Transport vehicle are required in slightly large numbers.
- Solid waste to be burnt should have calorific value.