IAT-2 SOLUTION

SOLID WASTE MANAGEMENT(15CV651)

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

a. Reduction in the quantity of materials to be handled at the disposal site;

b. Improved efficiency of collection and disposal of wastes;

c. Increased life of landfills;

d. Economically viable waste management system.
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.

(ii)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:

(i) Low-pressure (less than 7kg/cm^2) compaction
(ii) High-pressure (more than 7kg/cm^2) compaction

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. Other chemical methods used to reduce volume of waste chemically include pyrolysis, hydrolysis and chemical conversions.

2. **Incineration**

Incineration can be defined as a controlled combustion process for burning of solid, liquid and gaseous combustible waste to gases and residue containing non combustible materials. Burning of refuse at high temperatures in furnaces are called Incinerators. Incineration is a chemical process used to reduce the volume of solid wastes. The process can also be called as chemical volume reduction. Chemical process such as pyrolysis, hydrolysis and chemical conversion are also effective in reducing the volume of wastes. Incineration process is preferred over other process because it can be used both for volume reduction and for power production. Normally only the combustible matter such as garbage, rubbish and dead animals are burnt and the incombustible matter like broken glass, china ware, metals etc are either left unburnt or are separated for recycling and reuse before burning the solid wastes. The

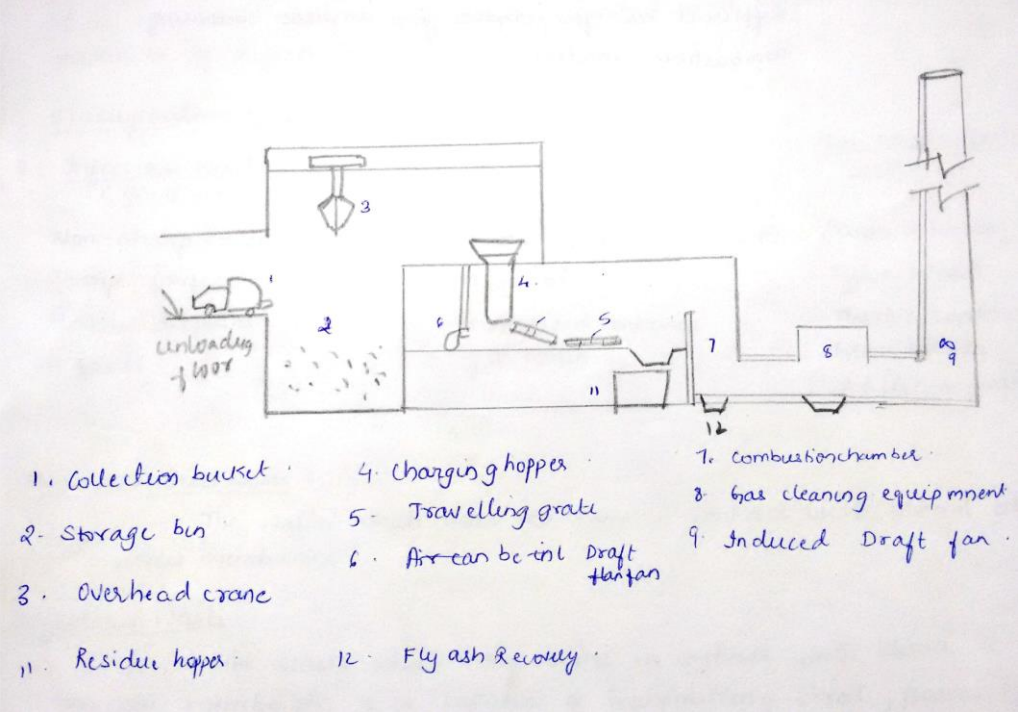
incinerators along with the non- recycled incombustible materials may, however, measure as much as 10-25% of the original waste, which in any case has to be disposed either by sanitary land filling or in some other productive manner. For example the clinkers can be used as aggregates for making low grade concrete or as road material and the ashes can be used for making bricks. The heat produced during burning of the refuse is used in the form of steam power for running turbines to generate electricity.

(b) Incineration of Municipal wastes:

The most attractive feature of the incineration process is that it can be used to reduce the original volume of combustible solid wastes by 80 to 90%. In some of the newer incinerators designed to operate at temperatures high enough to produce a molten material before cooling it may be possible to reduce the volume to about 5% or less. Although technology of incineration has advanced in the past two decades, air pollution control remains a major problem in implementation. In addition to the use of large municipal incinerators, on site incineration is also used at individual residences apartments, stores, industries, hospitals and other institutions.

Section through a typical municipal incinerator

The basic operations involved in the incineration of solid wastes are identified in the figure. The operation begins with the unloading of solid wastes from collection trucks 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 batch load waste into the charging hopper. The crane operators can select the mix of waste to achieve a fairly even moisture content. Large or incombustible items are also removed from the wastes. Solid wastes from the charging hopper fall into the stokers where they are mass fired. Several different types of mechanical stokers are commonly used. Air may be introduced from the bottom of the grates (under fire air) by means of a forced draft fan or above the grates (over-fire air) to control burning rates and furnace temperature. The hottest part of the fire is above the burning grate various gases are driven off in the combustion process taking place in the furnace, where the temperature is about 1400^0F. These gases and small organic particles pass into a secondary chamber commonly called a “combustion chamber” and burnt at temperatures above 1600^0F. To meet local air pollution control regulations space must be provided for air cleaning equipment as well as to supply air to the incinerator itself, an induced draft fan may be needed. The end products of incineration are the cleaned gases that are discharged to the stack. Ashes and unburnt materials from the grates fall into a residue hopper 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 sluice way. Residue from the storage hopper may be taken to a sanitary landfill.



3. Pyrolysis is the thermal processing of waste in the complete absence of oxygen. Both pyrolysis and gasification systems are used to convert solid waste into gaseous, liquid and solid fractions. The principal difference between the two systems is that pyrolysis systems use an external source of heat to drive the endothermic pyrolysis reactions in an oxygen free environment, where as gasification systems are self sustaining and use air or oxygen for the partial combustion of solid waste.

Description of the pyrolysis process: Because most organic substances are thermally unstable, they can, upon heating in an oxygen free atmosphere, be split through a combination of thermal cracking and condensation reactions into gaseous, liquid and solid fractions. Pyrolysis is the term used to describe the process. In contrast to the combustion and gasification processes, which are highly exothermic, the pyrolytic process is highly endothermic, requiring an external heat source. For this reason, the term destructive distillation is often used as an alternative term for pyrolysis.

The three major component fractions resulting from the pyrolysis process are the following

1. A gas stream, containing primarily hydrogen, methane, carbon monoxide, carbon dioxide and various other gases, depending on the organic characteristics of the material being pyrolyzed.
2. A liquid fraction, consisting of a tar or oil stream containing acetic acid, acetone, methanol and complex oxygenated hydrocarbons. With additional processing the liquid fraction can be used as a synthetic fuel oil as a substitute for conventional No.6 fuel oil.
3. A char, consisting of almost pure carbon plus any inert material originally present in the solid waste.

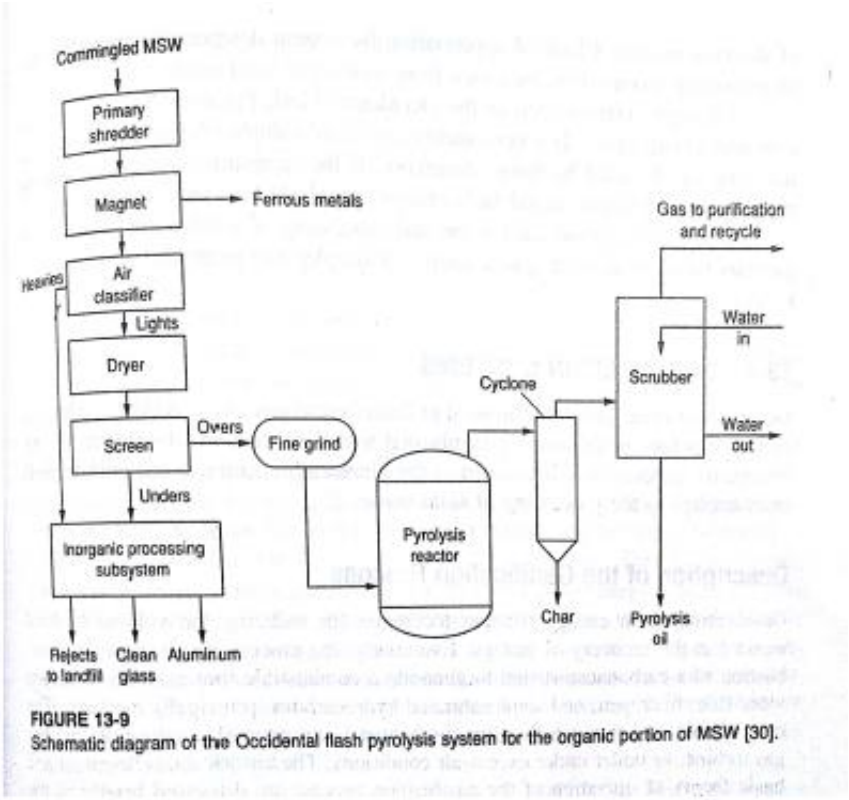


FIGURE 13-9
Schematic diagram of the Occidental flash pyrolysis system for the organic portion of MSW [30].

4.Different types of incinerators:

a.Fixed grate: The older and simpler kind of incinerator was a brick-lined cell with a fixed metal grate over a lower ash pit, with one opening in the top or side for loading and another opening in the side for removing incombustible solids called clinkers.

b.Rotary-kiln: The rotary-kiln incinerator is used by municipalities and by large industrial plants. This design of incinerator has 2 chambers: a primary chamber and secondary chamber. The primary chamber in a rotary kiln incinerator consists of an inclined refractory lined cylindrical tube. The inner refractory lining serves as sacrificial layer to protect the kiln structure. This refractory layer needs to be replaced from time to time. Movement of the cylinder on its axis facilitates movement of waste. In the primary chamber, there is conversion of solid fraction to gases, through volatilization, destructive distillation and partial combustion reactions. The secondary chamber is necessary to complete gas phase combustion reactions.

c.Fluidized bed: A strong airflow is forced through a sandbed. The air seeps through the sand until a point is reached where the sand particles separate to let the air through and mixing and churning occurs, thus a fluidized bed is created and fuel and waste can now be introduced. The sand with the pre-treated waste and/or fuel is kept suspended on pumped air currents and takes on a fluid-like character. The bed is thereby violently mixed and agitated keeping small inert particles and air in a fluid-like state. This allows all of the mass of waste, fuel and sand to be fully circulated through the furnace.

d.Moving grate: The waste is introduced by a waste crane through the "throat" at one end of the grate, from where it moves down over the descending grate to the ash pit in the other end.

5. 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.

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

(i)Land filling to provide a more homogeneous product.

(ii)Recovering materials from the waste stream for recycling.

(iii)Baling the wastes – a process sometimes used ahead of long distance transport of solid wastes – to achieve a greater density.

(iv)Making the waste a better fuel for incineration

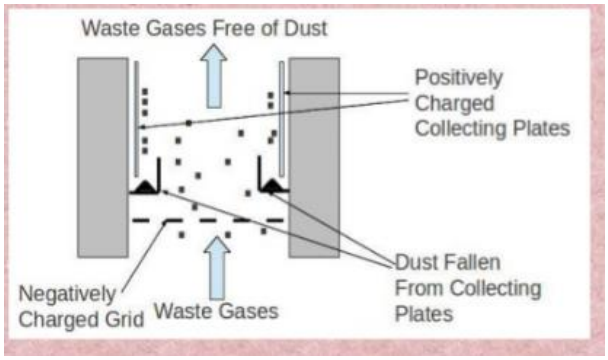
(v)Reducing moisture, i.e., drying and dewatering of wastes

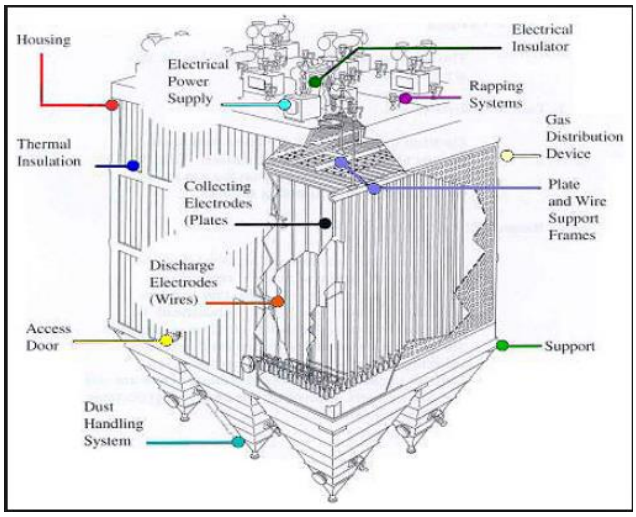
The most frequently used shredding equipment are the following:

(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. 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

6. Electrostatic precipitator: The electrostatic precipitator (ESP) operate on the principle of electrostatic attraction. A high negative voltage , 20,000 to 100,000 volts, applied to the discharge electrodes, produces a strong electric field between the discharge and collector electrodes. Particles in the gas stream acquire a negative charge as they pass through the electrical field. Because of their charge, the particles are then attracted to collector electrode. The efficiency of an ESP is a function of the flue gas characteristics (especially temperature and moisture) and the electrical resistivity of the particles.





ELECTROSTATIC PRECIPITATOR : Consists of six major components,

i) A source of high voltage
ii) Discharge electrodes and collecting electrodes
iii) Inlet and outlet for the gas
iv) An electric cleaning system
v) 'Hopper' for collection and disposal of particulates
vi) An outer casing [called shell] to form an enclosure around the electrodes.

APPLICATIONS

1) Cement factories : Cleaning of flue gas from cement kilns, recovery of cement dust from kilns.
2) Pulp and paper : Soda-Fume recovery in kraft pulp mills.
3) Steel plants : Cleaning blast furnace gas, cleaning open hearth and electric furnace gases.
4) Chemical Industries – Collection of SO_x, Phosphoric Acid mist, cleaning various types of gases i.e., hydrogen, CO_2, SO_2, Removing dust from elemental phosphorus in the vapor state.
5) Petroleum industry:- Recovery of catalyst.
6) Carbon black industry :- Agglomeration and collection of carbon black.
7) Thermal Power plants:- Collecting Fly ash from coal fired boilers.

Fabric filter: The fabric filter has become the technology of choice on most recently constructed MSW combustion systems in the United States. The fabric filter, or bag house as

it is sometimes referred to, is an intrinsically simple device. A number of filter bags are connected in parallel in a housing. Particles in the flue gas are trapped on a dust bed that gradually builds upon the surface of the fabric. The dust bed allows the fabric to filter particles as small as 0.1μm, much smaller than the 50 to 75μm. As particles build up on the surface of the fabric, the pressure drop across the fabric filter gradually increases. The particles are removed from the filter bags by several techniques, including mechanical shaking, reverse air flow and pulse-jet. A Typical fabric filter installation is illustrated in figure. The major design parameters for fabric filter are filter area, material and method of cleaning. Felted glass and Teflon have been used as fabric filters with some success in MSW combustion applications.