Wastewater Treatment: Sludge Incineration

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Sewage Sludge Incineration

Two main types of sewage sludge incineration (SSI) plants are used: multiple hearth and fluidized bed. Over 80 percent of the operating sludge incinerators in the USA are of the multiple hearth design and about 15 percent are fluidized bed combustors.

Multiple Hearth Furnaces

The air-cooled variation of the multiple hearth furnace (MHF) has been used to incinerate sewage sludge since the 1930s. The basic MHF is a vertically oriented cylinder. The outer shell is constructed of steel, lined with refractory, and it surrounds a series of horizontal refractory hearths. A hollow cast iron rotating shaft runs through the center of the hearths. Cooling air is introduced into the shaft and its "rabble arms," which extend above the hearths. Each arm is equipped with a number of teeth which are shaped to rake the sludge in a spiral motion.

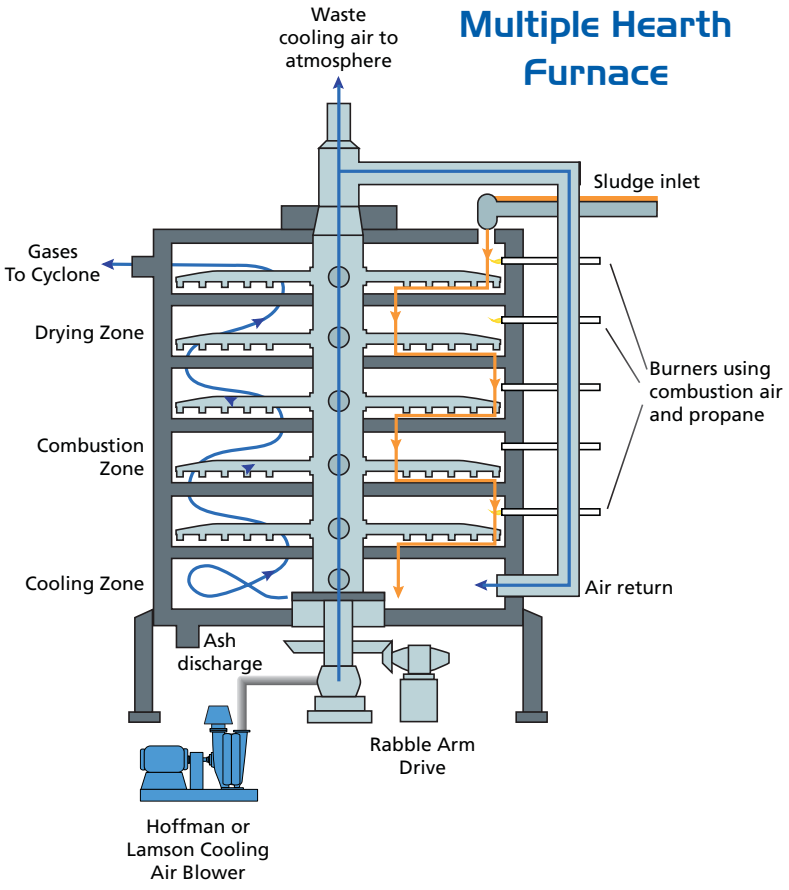
In most multiple hearth furnaces, partially dewatered sludge is fed onto the perimeter of the top hearth. The rabble arms move the sludge through the incinerator by raking the sludge toward the center shaft where it drops through holes located at the center of the hearth. In the next hearth the sludge is raked in the opposite direction. The effect of the rabble motion is to break up solid material to allow better surface contact with heat and oxygen.

Scum may also be fed to one or more hearths of the incinerator. The scum quantities are generally small compared to those of other wastewater solids.

Ambient air is first ducted through the central shaft and its associated rabble arms. A portion, or all, of this air is recirculated from the top to the bottom as preheated combustion air. The combustion air flows upward through the drop holes in the hearths, countercurrent to the flow of the sludge, before being exhausted from the top hearth. Air also enters the bottom to cool the ash. Provisions are usually made to inject ambient air directly into the middle hearths as well.

From the standpoint of the overall process, multiple hearth furnaces can be divided into three zones:

- The drying zone (upper hearths), where most of the moisture in the sludge is evaporated.



- The combustion zone (middle hearths) where the temperature is higher.
- The cooling zone (lowermost hearth), where the ash is cooled as its heat is transferred to the incoming combustion air.

Multiple hearth furnaces are sometimes operated with afterburners to further reduce odors and concentrations of unburned hydrocarbons. In afterburning, furnace exhaust gases are ducted to a chamber where they are mixed with supplemental fuel and air and completely combusted.

Under normal operating condition, 50-100% excess air must be added to an MHF in order to ensure complete combustion of the sludge. Besides enhancing contact between fuel and oxygen in the furnace, these high rates of excess air are necessary to compensate for normal variations in both the organic characteristics of the sludge feed and the rate at which it enters the incinerator.

Fluidized Bed Incinerators

Fluidized bed combustors (FBCs) consist of a vertically oriented outer shell constructed of steel and lined with refractory. Tuyeres (nozzles designed to deliver blasts of air) are located at the base of the furnace within a refractory-lined grid. A bed of sand, approximately 0.75 meters (2.5 feet) thick, rests upon the grid.

There are two general configurations:

- In the "hot windbox" design the combustion air is first preheated by passing through a heat exchanger.
- Alternatively, ambient air can be injected directly into the furnace from a cold windbox.

Partially dewatered sludge is fed into the lower portion of the furnace. Air injected through the tuyeres, at pressures of from 20 to 35 kilopascals (3 to 5 psi gauge), simultaneously fluidizes the bed of hot sand and the incoming sludge. As the sludge burns, fine ash particles (and some sand) are carried out the top of the furnace.

Combustion of the sludge occurs in two zones:

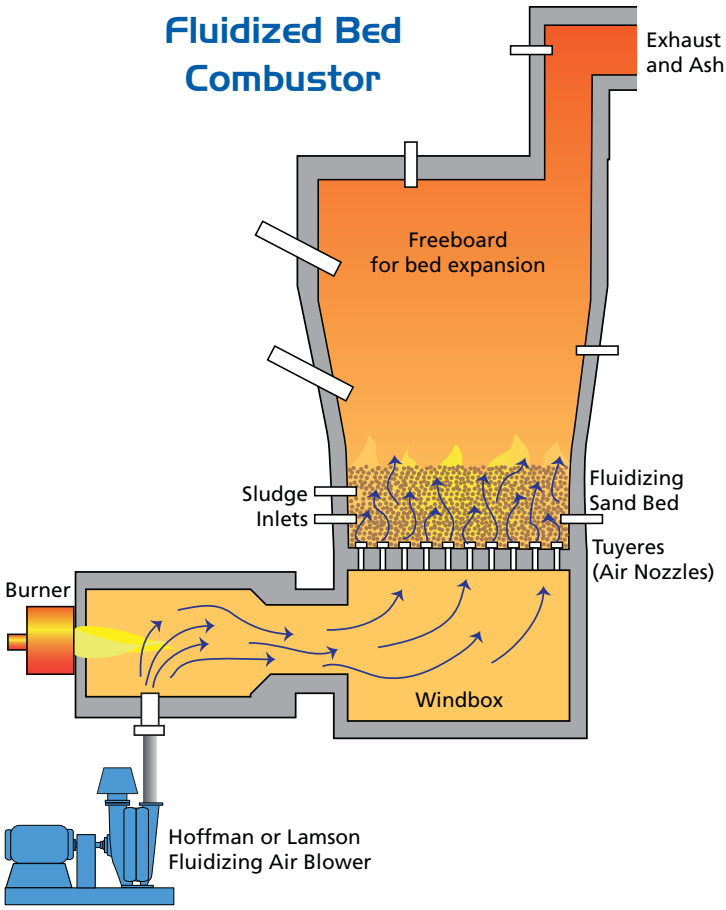
- Within the sand bed itself - evaporation of the water and pyrolysis of the organic materials occur nearly simultaneously as the temperature of the sludge is rapidly raised.
- In the freeboard area - the remaining free carbon and combustible gases are burned. This zone essentially functions as an afterburner.

Fluidization achieves nearly ideal mixing between the sludge and the combustion air; and the turbulence facilitates the transfer of heat from the hot sand to the sludge. Smaller amount of excess air are required for complete combustion of the sludge. Typically, FBCs can achieve complete combustion with 20-50% excess air, about half of that required by multiple hearth furnaces.

Other Technologies

Electric infrared incinerators consist of a horizontally oriented, insulated furnace. A woven wire belt conveyor extends the length of the furnace and infrared heating elements are located in the roof above the conveyor belt. Combustion air is preheated by the flue gases and injected into the discharge end of the furnace.

The cyclonic reactors are designed for small capacity applications. Preheated combustion air is introduced into the vertical cylindrical chamber at high velocity. The sludge is sprayed radially toward the hot refractory walls. Combustion is rapid: The residence time of the sludge in the chamber is on the order of 10 seconds.



Rotary kilns are also used for small capacity applications. The kiln is inclined slightly from the horizontal plane, with the upper end receiving both the sludge feed and the combustion air. A burner is located at the lower end of the kiln. The circumference of the kiln rotates at a speed of about 15 centimeters per second (6 inches per second).

The wet oxidation process is not strictly incineration; it utilizes oxidation at elevated temperature and pressure in the presence of water (flameless combustion). Thickened sludge is first ground and mixed with compressed air. The slurry is then pressurized and the mixture is circulated through a series of heat exchangers before entering a pressurized reactor.

Co-incineration and Co-firing

Virtually any material that can be burned can be combined with sludge in a co-incineration process. Common materials for co-combustion are coal, municipal solid waste (MSW), wood waste and agriculture waste. Refuse co-fired with sludge is limited to multiple hearth incinerators only.

Info from epa.gov

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