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Perspective

Chemical Incineration of Toxic Materials in Waste by Combustion Process

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DESCRIPTION

Waste incineration is the societal applications of combustion. The typical waste incineration facility includes the following operations:

- Waste storage and feed preparation;
- Combustion in a furnace, producing hot gases and a bottom ash residue for disposal;
- Gas temperature reduction, frequently involving heat recovery *via* steam generation;
- Coolant gas treatment to remove air pollutants and process residues from this process;
- Dispersion of the treated gas into the atmosphere by exhaust fans and induction chimneys.

Combustion process

Combustion is a rapid exothermic reaction between fuel and oxygen (O_2). In waste incineration applications, the fuel is primarily the waste and the source of oxygen is air. Combustion produces many same stable end products whether the fuel burned is natural gas, coal, wood, petroleum, municipal solid waste, hazardous waste, or medical waste. The flame zone of a well-designed incinerator is hot enough to decompose all organic and many inorganic molecules, allowing the reaction between the more volatile components of the waste with oxygen and nitrogen (N_2) in the air. The reactions are mainly between carbon (C) and oxygen, producing carbon dioxide (CO_2), and between hydrogen (H) and oxygen, producing water vapour (H_2O). Incomplete combustion of organic compounds in the waste stream produces carbon monoxide (CO) and carbon-containing particles. Hydrogen also reacts with organically bound chlorine to produce hydrogen chloride (HCl). In addition, many other reactions occur, producing sulfur oxides (SO_x) from sulfur compounds, nitrogen oxides (NO_x) from nitrogen compounds (and partly nitrogen from the air), metal oxides from compounds of some metals and vapours from other compounds.

The furnace is designed to produce a mixture between the combustion air and the gases and vapours from the combustion waste. However, in furnace the combustion is incomplete and combustible components of organic compounds are ignited, leaving un-burnt particles called fly ash is caught in the furnace smoke. Incineration facilities incorporate several common methods to ensure proper combustion and reduce emissions. A stable situation with no large fluctuations in the discharge rate, gas flow or other combustion conditions will promote efficient combustion. Inefficient combustion can lead to higher amounts of incomplete combustion products. Similarly, the more frequently the plant starts and stops (for maintenance or due to insufficient or variable discharge), the more uneven the combustion process and the greater the potential for increased emissions. Optimal furnace design and operation requires attention to the combustion temperature, the turbulence of the gas mixture, and the residence time of the gas at the combustion temperature. To achieve efficient combustion, each part of the gas stream must reach sufficient high temperature for sufficient amount of time, and there must be an adequate mixture of fuel and oxygen. The temperature achieved is the result of heat released from oxidation and should be kept high enough to ensure complete combustion, but not too high to damage the equipment or create too much nitrous oxide. Usually, the temperature is controlled by limiting the amount of material fed into the furnace to ensure that the heat release rate is within the desired range, then tempering the obtained conditions by varying the excess air. The disturbance is necessary to provide adequate contact between the combustible gas and oxygen through the combustion chamber (macro-scale mixing) and at molecular level (micro-scale mixing). Proper operation is indicated when there is sufficient oxygen in the furnace and the gases are strongly mixed. Cold spots may appear next to the furnace walls; where heat is first separated from combustion. These cold spots on the wall in insulated furnace are larger than the furnace with a refractory lining. Several new design features and operating techniques have been adopted to increase temperature, prolong residence time and increase turbulence in the waste incinerator to improve combustion efficiency and provide other benefits like better ash quality. These include high efficient combustion systems, waste pre-treatment methods such as shredding and mixing, and oxygen enrichment. The measurement and control of important process operating conditions is also emphasized for better control of the entirecombustion process. Furnace design is important for optimal combustion. Furnace configurations depend on what they are designed for older designs, many of them are still in use.

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