Health Care Without Harm

Update on Pyrolysis – a non-traditional thermal treatment technology

HCWH prepared this update to correct the impression that HCWH supports or promotes pyrolysis, gasification, and plasma arc technologies and to provide additional information on these controversial technologies. Inclusion of medium and high-heat thermal technologies into HCWH's "Non-incineration medical waste treatment technologies" does not mean support for these technologies as alternatives to incineration. This update provides more information and reinforces HCWH's concern about the release of pollutants, including dioxins and furans, from these technologies, as well as the potential for toxic liquid and solid residues. In some places, including the European Union and in U.S. hazardous waste laws, pyrolysis and gasification are legally classified as incineration

Thermal treatment of wastes has a long and controversial history. The simplest and most polluting approach is to burn wastes in an open pit or barrel. Such uncontrolled combustion provides no containment or treatment of the gases, ashes and other residues of combustion and associated pollutant releases.

Medical waste incinerators are designed to provide greater control of the combustion process. However, since chlorine-containing materials are typically included in medical waste, toxic products of incomplete combustion (PICs), such as dioxins and furans, are inevitably formed and released in the stack gases and other residues. The fact that oxygen is integral to the molecular structure of dioxins and furans suggests that the formation of these particular PICs may be reduced or avoided by minimizing or completely excluding oxygen from thermal waste treatment.

Thermal waste treatment technologies fall into two broad categories: 1) those in which wastes are combusted – burned in the presence of oxygen, i.e., incineration technologies; and 2) those in which wastes are heated in the presence of little or no oxygen so that there is no direct combustion , i.e., pyrolysis (sometimes referred to as thermolysis) and gasification.

When oxygen levels in an incinerator are reduced to levels below the optimum for combustion, the incinerator is said to operate in a "starved air", or "pyrolytic" mode. Pyrolysis, also sometimes referred to as thermolysis, is defined as the thermal degradation of a substance in the absence or with a limited supply of oxygen. However, with medical wastes and similar materials a complete absence of oxygen is unachievable. As a result, some oxidation will occur during pyrolysis so that dioxins and related products of incomplete combustion are formed.

Pyrolysis is typically carried out in a temperature range of 400-800 °C. At these temperatures, waste materials are transformed into gases, liquids and a solid residue called `char'. The relative proportions of gases, liquids and char depend on the composition of the wastes, temperature and the time that the temperature is applied. Short exposure to high temperatures is termed "flash" pyrolysis, which maximises the amount of liquids generated. If lower temperatures are applied for longer periods of time, chars predominate.

While many proponents of modern waste treatment systems refer to pyrolysis as being a new technology, UNDP (1999), this is not the case. For centuries pyrolysis has been used in the manufacture of charcoal, FAO (1994), and it is also used extensively in the petroleum and chemical industries. Of particular interest, many current medical waste incinerator designs operate via a two-stage process: a pyrolysis chamber followed by an afterburner, or combustion chamber (e.g., Compact Power (2002) and Statewide Medical Services (2002)).

Another not-so-modern pyrolytic treatment technology is "gasification", which is defined as the conversion of a solid or liquid substance into a gaseous mixture by partial oxidation with the application of heat. Partial oxidation is usually achieved by restricting the level of oxygen (or air) in the combustion chamber (pyrolysis). The process is optimized to generate the maximum amount of gaseous breakdown products, typically carbon monoxide, carbon dioxide, hydrogen, methane, water, nitrogen and small amounts of higher hydrocarbons.

If the oxidant used is air, the gas produced is called "producer gas" and usually has a calorific value that is no more than 25 percent that of natural gas. If the oxidant used in the system is oxygen or oxygen-enriched air, the resultant "synthesis gas" has a higher calorific value due to the absence of nitrogen, typically 25-40 percent that of natural gas.

While gasification is a pyrolytic process that is optimized for the maximum yield of gases, it still generates solid and liquid by-products, which may contain high levels of toxic contaminants. The degree of contamination will depend on the waste being treated, the type of technology used and how it is operated.

The heat required for pyrolysis is generated by the combustion of traditional fuels (natural gas, oil, etc), or by the use of electricity to create high temperature plasmas. In plasma-based systems the primary source of heat is a plasma torch or arc that may achieve temperatures ranging from 3000 to 20 000 degrees. Plasmas are normally generated in a high-energy electrical discharge or arc, and as such require considerable amounts of electrical energy to operate.

While pyrolysis systems differ in some respects from conventional incineration, they are sufficiently similar to incinerators to be legally classified as such by the European Union. Also, the US federal government defines systems which use plasma consisting of a high intensity electrical discharge or arc followed by an afterburner as incineration (40 CFR 260.10).

Many proponents of pyrolytic systems maintain that they are not incinerators and do not generate hazardous by-products, such as dioxins. However, they have not provided detailed information demonstrating this in full-scale systems treating medical or other wastes. In fact, limited data from full-scale systems have shown that

dioxins, furans and other products of incomplete combustion are formed in these systems.

A recent review of pyrolysis systems by the UK research group, CADDET(1998), raises concerns about residues from these processes;

> *"The various gasification and pyrolysis technologies have the potential for solid and liquid residues from several process stages. Many developers claim these materials are not residues requiring disposal but are products which can be used. However in many cases such claims remain to be substantiated and any comparison of various waste treatment options should consider releases to air, water and land."*

CADDET (1998) also paid particular attention to liquid residues:

> *"The sources of liquid residues from [mass burn combustion] plant are boiler blow-down and wet scrubbing systems, when used for flue gas cleaning. Whilst these sources remain for gasification and pyrolysis systems using steam cycles or wet scrubbers, these technologies can also produce liquid residues as a result of the reduction of organic matter. Such residues have the potential to be highly toxic and so require treatment. Any releases of liquid residues into the environment should therefore be carefully considered."*

In their examination of a commercial scale German municipal waste gasification system operating under pyrolysis conditions, Mohr et al. (1997) found that dioxins and furans were formed in the process with particularly high levels in liquid residues from the process. Weber and Sakurai (2001) recently examined the formation of dioxins and furans under pyrolysis conditions and concluded that they were definitely formed from wastes containing chlorine and copper. Several other researchers have found similar results for a range of common wastes, clearly demonstrating that dioxins, furans and potentially other persistent organic pollutants may be formed in pyrolysis/gasification systems.

It therefore appears that pyrolysis and gasification systems, while being promoted as clean non-incineration alternatives, are still capable of generating dioxins, furans and other pollutants of concern, despite marketing and promotional claims to the contrary.

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