EFFECT OF WASTE COMPOSITION AND CHARGING CYCLE ON COMBUSTION EFFICIENCY OF MEDICAL AND OTHER SOLID WASTE COMBUSTORS

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Mr. Hasselriis presents an interesting and thought-provoking paper. To help me understand what he has done, however, I would appreciate answers to a few questions:

(a) Regarding Fig. 11, while the low temperature CO levels seem to exceed the high temperature levels, is this phenomena related to inherent system chemistry, or is it an artifact on Enercon type units which use a mixing "orifice" between the primary and secondary chambers? The mixing efficiency of flow restrictions is a function of the velocity.

(b) Why are the dioxin and furan guidelines plotted as shown? The low temperature total is in the range of the high temperature repeated runs. Why isn't the left-hand side of this curve happenstance and a simple horizontal band appropriate?

(c) Figures 13–15 show parabolic guidelines. Is there a theoretical explanation for such curvature, or do the curves simply connect contaminated data points? Absent a theoretical justification, there may be no trend in the data at all, just noise.

AUTHOR'S REPLY

(a) Regarding Fig. 11, you ask whether the increase in CO at high temperature levels is related to inherent system chemistry, or is it an artifact of the Enercon type waste combustors.

The Enercon system does use a mixing "orifice" between the primary and secondary chambers, as you point out. The Pittsfield research specifically addressed the degree of mixing in the secondary chamber by making temperature traverses at the inlet and outlet regions.

The question we must ask is: Would the phenomenon of the CO "jump" at high temperatures found in other combustors, or is it an artifact of the Enercon system?

I have analysed data from other combustors and have found that similar trends can be seen. Figure 13 shows CO jumps occurred at temperatures above 1850°F for a two-chamber starved-air combustor with secondary air injection at the throat. As I have pointed out in describing Fig. 8, these jumps are related to excessively low oxygen concentrations, which in turn result from overloading the primary chamber.

If you look closely at Fig. 14, you can see that the specific points of high CO correspond with low oxygen and high temperature. When there is sufficient oxygen, high temperatures represent low CO.

I included Fig. 3 in order to display the variations in oxygen concentration which result from rapid combustion of each charge which is fed to the combustor. Note that the oxygen scale of Fig. 3 reflects oxygen in the boiler outlet, including tramp air, not the actual oxygen leaving the furnace. Figure 6 shows how much lower the secondary chamber oxygen may be after a large charge is fed to the furnace.

The Pittsfield combustors inject all of the secondary air in the primary chamber, before entering the orifice. The actual flame temperatures before secondary air mixing are therefore higher than those measured in the secondary chamber. I have calculated that the flame temperatures are about 150–200°F higher. Therefore the 1700°F minimum in Fig. 11 reflects a flame temperature of 1850-1900°F. This corresponds well with the jumping point shown in Fig. 13.

An important factor related to the design of the incinerator chambers is the degree of mixing achieved. With perfect mixing and assurance of sufficient oxygen, the CO spikes would not take place.

I have plotted dioxins and furans on the same graph as CO to show that they follow similar patterns, and that when the CO spikes at low oxygen, the total dioxins also spike. In fact, we find that the furans increase, not the dioxins. This is logical when you consider that furans have one oxygen link, reflecting a shortage of oxygen.

In order to confirm or at least support the universality of the Pittsfield data, I have plotted other data on the same graphs. The other data is too sparse, but it does fall within the same, although wide, envelope.

In conclusion, I believe that this data shows clearly that in order to eliminate CO spikes and corresponding high dioxin and furan levels, it is necessary that oxygen levels never fall below about 7–8% and that effective mixing takes place so that no pockets develop which have much lower levels of oxygen.

In my opinion, the provision of oxygen controls is the key to assurance of good combustion. The oxygen controls can be used to assure that sufficient oxygen is always provided. In addition, they can be used to correct conditions leading to low oxygen, such as overloading of the primary chamber. If the charge is too large, or burns too rapidly, the oxygen controls can act to reduce primary air, thus slowing the rate of volatilization of the waste, so that the air supplied in the secondary chamber is still sufficient to maintain the needed excess oxygen. A low oxygen signal can also be used to delay the next charge, allowing more time for the excessive charge to burn down more.

(b) You ask whether there are theoretical explanations for the parabolic curves in Figs. 13–15. In one sense the drop-offs are noise, in that occasional feed batches upset the combustion more than others. The probability that good combustion and low CO will result is enhanced when oxygen is in the range of 8% to 9%, and the secondary chamber outlet temperature is between 1650°F and 1850°F for this conventional refractory starved-air combustor. When furnaces are water-cooled, and the range of injection of secondary air is more diffuse, the ideal oxygen and temperature ranges can be expected to be somewhat different.