"BURN-OUT BEAM" FOR THE QUANTITATIVE AND QUALITATIVE IMPROVEMENT OF MUNICIPAL COMBUSTOR ASH

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The "Introduction and Background" section to this interesting paper raises questions that are not addressed in the body of the paper. In this section, we learned that thickened and digested sewage sludge is co-fired with refuse in this plant. Questions that come to mind are:

(a) What is the solids content of the sludge cake fired?

(b) What is the percent by weight and/or by heat input of the sludge cake fired?

(c) Is there evidence that the unburned combustible in the residue was, in part, due to unburned sludge cake?

Any additional information that could be provided will be appreciated.

AUTHORS' REPLY

(a) For mechanically dewatering its anaerobically digested sludge, Bamberg uses a high solids centrifuge of the type KHD-Centripress. With the help of an organic polymer, the cake attains a solids concentration of 30-35% by weight. Its LOI averages 50-55% by dry weight.

(b) On a weight basis, the mix fired consists of 10–15% sludge cake and 85-90% mixed commercial and residential waste. In the as-fired condition, the sludge cake has an LHV = 1290–1505 Btu/lb (3000–3500 kJ/kg). For the waste mixture, an LHV = 4300–4730 Btu/lb (10,000–11,000 kJ/kg) has been observed. In order to convert the heating values to the dry condition, the following moisture concentrations can be used: approximately 68% by weight for sludge cake and approximately 26% by weight for mixed waste.

(c) Investigations over many years did not reveal that unburnt combustibles in the residue are adversely affected by the addition of sludge cake. Potentially negative effects are avoided by the mixing and pressing action in the refuse storage pit.

Discussion by:

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(a) It would have been helpful, as part of the introduction and facility background, to define furnace operating parameters and the composition of the feedstock. Specifically of interest would be the sludge, i.e., percent moisture and its mix ratio with refuse. Prior to the development of the Burnout Beam (BOB), what forensic investigation was performed to improve combustion, determine the optimum mix ratio and percent moisture of sludge, combustion air distribution, and feeding techniques?

(b) As with any sampling program, the validity of the results and conclusions drawn originate with a statistically valid sampling program. The sampling program as described should address the following:

(1) The report identifies three (3) sampling days (July 21, September 8, and October 13) selected to minimize the effects of seasonal variations. What rationale was used to discard the remaining seasons?

(2) Obviously the introduction of the sludge cake into the refuse pit and its assumed blending with the refuse by crane results in a highly variable mix ratio and distribution within the refuse bed itself. How was this variability accounted for in the sampling program?

(3) The report indicates samples were extracted from

the ash removal conveyor. Were the grate dampers open or closed? If they were open, what was the organic contribution from both the refuse and sludge?

(4) Were the one (1) hour collection samples combined on a weighted average basis as a function of hourly throughput?

(5) It is assumed the samples were dried and sized according to some acceptable standard reference. Please identify the procedure used. How was agglomeration of particles minimized?

(6) Was any attempt made to collect and analyze the suspended solids in the quench water during the testing period?

(7) What level of confidence is attributed to the test results?

(c) The conclusion that no significant changes were noted on combustion control, emission, and filter dust quantity is not obvious without comparable data with and without air classification. Likewise, boiler and ESP ash analysis should be included.

(d) The report cites BOB installation cost to be approximately $62,500. If operation and maintenance costs are also considered, what would be the payback period when compared to the sale of less than 3% LOI ash derived product?

(e) The reference material is written in German and as such is limited in its use by interested readers. Can the author provide any English references?

AUTHORS' REPLY

(a) For application of the burn-out beam (BOB) in Germany and Europe, the conditions for the combustion process are of lesser importance. This is the case because certain operating parameters are already regulated by law. For example, a minimum temperature of 1562°F (850°C), a retention time of 2 sec and a CO limit of 50 mg/Nm^3 must be maintained. The actual values for Bamberg are 1832°F (1000°C) and 10 mgCO/Nm^3. (Note: The reference conditions are 11% O_2 and dry.)

While the composition of the waste mixture, together with the sludge cake, varies continuously, total throughput is controlled by the feed rams in accordance with furnace performance requirements. Thus, the combustion process occurs to a large extent in the automatic mode. Regarding the sludge characteristics and its admixture ratio, see reply (a) to Roger S. Hecklinger.

The combustion technology and control of the furnace grates are operated as efficiently as possible. This means that besides the furnace feed rate, specific combustion parameters as mentioned above are also maintained.

Of course, the combustion technology is influenced by grate selection and furnace geometry (parallel–, middle– and counter-current flow furnace). In spite of all attempts to optimize, some LOI will always remain in the residue. Testing, not only in Germany, but also in the European community, indicated that LOIs of over 10% have been encountered.

The distribution of combustion air is controlled by the feed rams which follow the steam demand. Not only in Bamberg, but also in the majority of the German refuse incinerators, the ratio is 75% primary air to 25% secondary/tertiary air by volume. Typically, the specific air requirement is 5 Nm^3/kg waste as fired.

(b)(1) In Bamberg, the results of ash quality testing without the BOB have been collected over a period of several years. They fall into the same order of magnitude as those taken more recently when the BOB was switched off. Therefore, a general statement can be made on the burn-out of ash obtained without the BOB in operation. By making direct comparisons with and without the BOB, the improvements discussed in the paper were proven.

The first installation of the BOB took place in Bamberg over two years ago. The initial test results were confirmed during subsequent routine operations. Improvement of the LOI by this rather simple method was clearly demonstrated.

(2) The addition of sludge cake was previously commented on under (a) above. In principle, there are two sequential steps practiced. First, and this is most important, the ballistic spreader sprinkles the sludge cake over a large surface area in the refuse storage pit. This relatively uniform distribution causes homogenization of the refuse and its associated heating value. Second, by means of picking, resetting and/or feeding, the pit crane makes further mixing possible. In case an uneven distribution of sludge in the refuse is observed, a day-long visual test is conducted in order to remedy the situation.

(3) Generally, the quench tank is closed. This is to ensure a negative pressure in the furnace chamber.

(4) The hourly probes were weighed out and related to hourly furnace throughput. In this connection, it should be noted that average throughput per furnace ranged between 5.84 and 6.28 stph (5.30–5.70 Mg/h), depending on fluctuations in the heating value.

(5) In accordance with German regulations, LOI determinations followed DIN procedure 38414–S3.

(6) Separate collection and analysis of suspended solids in the quench water was not possible because they are removed together in the ash with the slag. However, they are included in the test results.

(7) The confidence limit of the test results exceeded 90%. Its significance remains undecided because no scientific research was intended. Instead, a practical and simple way was to be demonstrated for improving ash quality.

(c) Important emissions are measured in the stack, allowing quantification of any effects attributable to the BOB

Evidently, this presumes that these emissions can be related to the furnace chamber without the influence of the flue gas cleaning system. In Bamberg, only the CO concentration is continuously measured immediately after the furnace chamber. No visible changes in CO due to the BOB were detected. The same applies to the O_2 concentration. This should not come as a surprise, because the air requirement of the BOB represents less than 3% of total air required for combustion. Furthermore, this 3% falls below the accuracy of the instrumentation for which a deviation of 3% of full-scale deflection is normally permitted.

The accumulation of boiler ash, filter ash, and neutralized scrubber sludge was tracked separately from bottom ash. No increases in weight were registered. Also, the cement-gray appearance of boiler and filter ash did not change, which leads to the visual conclusion that their LOI did not change, either.

The potential impact of the flue gas cleaning system is further diminished by the fact that German law regards all residues which result from flue gas cleaning as special waste. Even if they are to be beneficially used in mine shafts, as has been suggested in some quarters, minor changes do not matter. The BOB has not influenced the make-up of these residues in any discernible way, which makes this matter more one of scientific interest than practical value.

(d) The reporting of investment costs of about DM100,000 ($62,500) was intended to show that an installation inclusive of piping, switches, valves, etc., is a reasonable expenditure. Likewise, O&M costs can be described as very low. In order to be more specific, the U.S. costs for compressed air at 43.5 psig (3 bar), use and disposal of cooling water with a permissible temperature rise from 64 to 104°F (18–40°C), 0.1 man-hours per day, etc., would have to be known. After two operating years with the same BOB, no wear was observed. This suggests, with a measure of certainty, that a useful equipment life in excess of 10 years can be used for amortization. Regular maintenance is estimated at 2–3% of the initial investment.

The payback period was not calculated simply because refuse incinerators are obligated to keep the LOI under 5%. In case of a violation, the permit is revoked. Consequently, the purpose of the BOB is not to earn money but to improve quality of bottom ash to the point where the LOI is guaranteed not to exceed the legal limit. Yet bottom ash with an LOI of under 3% is eligible for beneficial use, which would accrue about DM30/Mg ($17.00/ST) in expenses. In the case of decentralized facilities, transportation costs would have to be added, too.

Beneficial use of bottom ash is officially encouraged in Germany, although usually no revenues are generated. Still, beneficial use is a bargain. If bottom ash achieves an LOI of only >3% and <5%, it must be put into a Class II landfill at a current cost of DM50–100/Mg ($28–$57/ST). New estimates suggest that future landfill disposal costs will climb to DM250–350/Mg ($142–$199/ST). It follows that beneficial use is preferred not only from the regulatory point of view, but also because it makes good economic sense. In contrast, boiler and filter ash are considered to be hazardous waste which will have to go to a landfill specially permitted for this category. Disposal costs are estimated to be in the order of DM500–1000/Mg ($284–$567/ST).

(e) The BOB was invented in Germany in fairly recent years, and no foreign installations can be referenced at the present time. Whatever deals with the basics of combustion is internationally known, as evidenced by other German and English language publications. Therefore, they are not repeated here. However, the references given in the paper add to the specifics of the Bamberg experiences. A brief translation follows:

(1) Beneficial use of refuse incinerator ash.

(2) Characteristics of refuse incinerator ash.

(3) Grate combustion systems for waste disposal.

(4) Thermal waste reduction within the context of modern waste disposal concepts.

Two additional references may be useful to the reader who wishes to broaden his understanding of cofiring:

(5) Reimann, D. O. "Thermal Treatment of Sewage Sludge," European Seminar on Energy Efficient Options for the Treatment of Sewage Sludge, EOLAS, Dublin, Ireland, 1993.

(6) Reimann, D. O. "Situation of Sewage Sludge Treatment and Incineration in Germany," *ISWA Times*, Volume 2, page 5ff, 1993.

In essence, the Bamberg combustion philosophy follows the theorem: "Keep the temperature as high as possible without using the auxiliary burners. On the other hand, stay below the ash melting temperature, i.e., <2012°F (<1100°C)."

AUTHORS' CLOSURE

The authors wish to thank both discussors for their probing questions. However, it needs to be pointed out that for application of the BOB it is not absolutely necessary to know the Bamberg combustion parameters in detail. The principle of the BOB will work with nearly all wastes, regardless of their composition.

After the first installation of the BOB in Bamberg, two other German facilities were provided with this equipment, i.e., Essen-Karnap II and Ingolstadt. The first of these performed demonstration tests during which the LOI was reduced by 1–2 percentage points. (Note: Essen-Karnap II features counter-flow furnaces with roller grate systems from DBA.) Ingolstadt is another coincineration facility.

(Note: Ingolstadt was equipped with an early installation of the horizontal combustion grate from W+E.)

In Bamberg, the sludge addition is of secondary importance, given the success of the sludge cofiring methodology developed there. Additional data concerning this particular aspect may be found in the EOLAS article, which is mentioned here as a new reference, i.e. [Ref. 5].

The main thrust of the BOB is to improve ash quality in a dependable fashion which can facilitate beneficial use. German laws, especially the Waste Disposal and Recycling Act, generally prescribe that materials like ash must first be tested and evaluated with regard to beneficial use before they can be landfilled. Towards this end, criteria have been set forth which limit the LOI to 3% by dry weight.

Based on the experience gathered to date, the BOB is simple and amenable to fully automatic operation. It lends itself to convenient retrofit with minimal disruption of ongoing operations. The BOB leads to a measurable improvement in ash quality which is not exclusively limited to the LOI. For example, problem items such as compacted dirty newspapers and parts of books are picked up by the upper air currents. They are transported back into the depth of the furnace where they can be burnt.

Because of their basic contribution to the ash disposal problem, additional BOB installations are expected in the coming years. It is hoped that the paper and its subsequent discussions will encourage consideration of the BOB for U.S. applications.