CONTINUOUS MONITORING OF THE PERFORMANCE OF MASS BURN WASTE-TO-ENERGY PLANTS

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ABSTRACT

When a public entity relies on a private contractor for efficient plant operation or pays a disposal fee based on plant throughput and energy generation, the contractor will typically guarantee certain plant performance levels conditioned upon the quality of the solid waste. The public entity will desire to verify whether these performance guarantees are met not only during initial operations, but throughout the effective plant life. This paper discusses the technical aspects of continuous monitoring of plant performance.

INTRODUCTION

A publicly owned waste-to-energy plant may be operated by a private contractor in accordance with the terms and conditions of a management agreement. In such a situation, the public owner would depend on energy sales and solid waste disposal fees to provide an adequate cash flow to pay operational expenses and debt service. It is therefore essential that the private contractor operate the plant efficiently and pay proper attention to repair and maintenance. One method of assuring efficient operation by the private contractor is to require plant performance guarantees. Even if the plant is privately owned, performance guarantees may be specified in a service agreement for solid waste disposal. This is applicable when the disposal fee calculation includes credits for the value of energy sold.

Verification that performance guarantees are being met may not always be as simple as calculating the waste processed during a specified period of time or dividing the energy generation by the amount of waste processed. Typically, the performance guarantees are contingent upon the quality of the solid waste. However, the heterogeneity and seasonal variation of the solid waste make it difficult to determine solid waste quality accurately. There has been increasing interest on the part of public entities to verify adherence to performance guarantees on a continuous basis. The intent of this paper is threefold: to describe the conditions associated with performance guarantees relating to throughput and energy generation; to explain the acceptance and performance testing procedures used; and to present a methodology for continuous monitoring of mass burn waste-to-energy facilities.

PERFORMANCE GUARANTEES

Two principal performance guarantees associated with the operation of a waste-to-energy facility are solid waste disposal capacity, or throughput, and energy generation. Satisfaction of environmental permit conditions, while also a major performance guarantee, is not discussed in this paper owing to the special testing criteria adhered to by regulatory agencies.

Private waste-to-energy contractors are willing to guarantee plant performance as long as the solid waste quality conditions on which the design is based do not vary. Typically, the throughput guarantee will be associated with a specific range of solid waste heating values, while the energy generation guarantee is referenced to a specific solid waste heating value and composition (i.e., moisture, combustibles, and inert materials).

Unless the plant experiences obvious equipment breakdowns and extended downtime, failure to meet performance guarantees may be disputed as to the cause (solid waste quality or equipment efficiency). Taking samples of the solid waste and testing for the heating value in a laboratory raises several major concerns regarding the question of whether a waste sample is representative of the entire waste stream. The number of samples required, the location of sampling (e.g., top, bottom or middle of the storage pit), individual sample size tested, and potential impacts on moisture loss during collection, storage, and sample preparation all add uncertainty in determining the heating value. Therefore, current industry practice is to use the actual combustion unit as a calorimeter for determining of the solid waste heating value.

PERFORMANCE TESTING

American Society of Mechanical Engineers (ASME) Performance Test Code 4.1-1964, reaffirmed in 1973, for Steam Generating Units (PTC 4.1) has been used, with certain modifications, to test various mass burn plants which have recently begun commercial operations in the United States. This test provides a methodology for determining the higher heating value (*HHV*) of the solid waste:

$$HHV = \frac{\text{Output} + \text{Losses} - \text{Credits}}{\text{Fuel Throughput}}$$

The output includes heat in the steam and boiler blowdown water. The credits include sensible and latent heat in the heated combustion air (if applicable). The losses include the sum of: *(a)* heat loss due to the combustibles in the total residue; *(b)* heat loss due to moisture in the flue gas; *(c)* heat loss due to the heat in the dry flue gas; *(d)* heat loss due to moisture in the air; *(e)* heat loss in the residue; and *(f)* heat loss due to radiation and convection.

During testing, all necessary data are taken to determine the higher heating value of the waste. Adjustments are made to the actual data, as required, to result in a solid waste composition comparable to that used to verify the performance guarantees. If after initial acceptance testing of the plant a dispute arises over the performance, either party may have the option of asking for a retest of the plant in order to check performance. Retesting is a very time consuming and expensive process. Furthermore, by the time the test is actually run, the waste in question will already have been burned or the problem with the plant may have already been fixed, so that the retest will not have accomplished its purpose.

As an alternative to this, the lower heating value (*LHV*) of the waste can be used to reference performance guarantees. Lower heating value is the higher heating value less the heat loss from the moisture in the flue gas resulting from the moisture in the solid waste and the moisture from burning hydrogen in the solid waste. During initial acceptance testing, all the necessary data are taken to determine the higher heating value of the waste, including moisture in the stack which is not required for lower heating value calculation but is required for the environmental testing. From this data, the lower heating value is calculated and adjusted for comparison to the quality of the reference composition waste. Using in-plant instrumentation and some basic assumptions, as discussed below, the lower heating value of the solid waste can be calculated at any time after initial acceptance testing by reading the appropriate data and making the required calculations. Also, if the plant uses a distributed control system with a computer, this calculation could be programmed on the computer and done continuously to check future performance.

CONTINUOUS MONITORING

The continuous performance monitoring as proposed in this paper would require only a nominal amount of data to make the lower heating value calculation. The following is a list of the minimum amount of data which would be required to be taken periodically:

(a) waste feed rate

(b) superheated steam outlet rates (net after soot blowing), temperatures, and pressures

(c) feedwater rates, temperatures, and pressures

(d) boiler drum pressures

(e) boiler blowdown rates

(f) turbine generator throttle flow, temperature, and pressure

(g) flue gas flows and temperatures at the economizer outlet

(h) CO_2, O_2, CO in the flue gas at the economizer outlet

(i) bottom ash, siftings, and fly ash quantities

(j) barometric pressure

(k) ambient wet/dry bulb temperatures

(l) gross and net power output

(m) turbine exhaust pressure

In addition, some basic assumptions must be made if continuous monitoring is to work on a day-to-day basis. These assumptions include: *(a)* the amount of moisture in the residue; *(b)* unburned combustible content in the residue; and *(c)* unaccountable and radiation losses. The unaccountable losses can be set at the value that was originally agreed upon during initial acceptance testing; radiation losses can be determined from ASME PTC 4.1, Steam Generating Units—Power Test Codes. The information pertaining to residue requires laboratory analysis, which cannot be done on a continuous basis without adding unnecessary cost. Therefore, residue data can be assumed, based on results obtained during initial acceptance testing, and periodically updated by random residue analysis during commercial operation.

Plant performance can be continuously monitored by keeping a running average of the calculated lower heating value, the solid waste throughput, and the energy output. This information can be compared with the results obtained during the initial acceptance tests and with the performance guarantees. By this comparison, any decline in energy output or waste throughput can be attributed to either the equipment in the plant or the variations in waste quality. For example, if the energy output falls during a given period, but the lower heating value of the waste remains nearly the same as it was during initial acceptance testing, this may indicate a problem in the plant equipment as opposed to a degradation of the solid waste quality.

CONCLUSION

The method of continuous monitoring as discussed herein, because several assumptions are included, is intended to be an approximate method of indicating performance problems which may result in a dispute between contract parties and eventually lead to retesting of the plant. However, contract parties may agree to use this method to adjust the operating service fee paid in future years of commercial operation. In such a case, the assumptions would need further refining, and performance guanantees would have to be referenced in terms of lower heating values. The method has been proposed for use in this capacity in the Hennepin County, Minnesota, waste-to-energy project, which is currently scheduled to be tested and commercially operational in 1989.

REFERENCES

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