OPERATING PARAMETERS
Reliable Means to Continuously Monitor Facility Performance

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ABSTRACT

The monitoring of specific parameters that bear directly on operating performance to ensure that a modern mass-burn waste-to-energy facility is continuously operated at the highest efficiency requires the monitoring of the refuse higher heating value. Monitoring of operating parameters only, assures that the plant will be operating at its best efficiency point for a fixed fuel HHV. Variations in municipal solid waste HHVs, however, will give variations in plant power output far greater than the variation due to tolerances in the monitored operating parameters.

The monitoring of fuel HHV is the only way to establish power output, data and assess penalties for operator inefficiency or nonperformance.

INTRODUCTION

The paper "Operating Parameters—Reliable Means to Continuously Monitor Facility Performance" by Richard Scherrer makes the point that monitoring a select group of plant operating parameters and assuring that these parameters are maintained within tolerance provides a "just means to establish penalties for operator inefficiency or nonperformance." This statement is proposed based on the supposition that "monitoring of specific parameters that bear directly on operating performance will ensure that the facility is continuously operated at the highest achievable efficiency for any fuel composition."

COMMENTS ON SUBJECT PAPER

A review of the subject paper indicating several inadequacies and points of difference follows:

(a) Excess air rates for waste-to-energy boilers are in the range of 80–100%. There is a trend to using the lowest excess air percentage that will assure efficient and complete combustion of the refuse since boiler efficiency is inversely related to excess air percentage. (The lower the excess air the higher the boiler efficiency.)

(b) An additional impact on the overall thermal cycle of the facility due to operator negligence, other than the inefficient operation of the condensing system, is the influence the operator has on fuel HHV. The fuel (municipal solid waste-MSW) is typically deposited in a pit by the refuse collectors. The plant operators (crane operators) take the MSW and stock piles it in

the pit, since the delivery rate of MSW to the plant is over a relatively short period, while the MSW is burned continuously over a 24 hr period. The MSW is not only stockpiled, but mixed and blended during this stockpiling period and large non-combustible items such as refrigerators, stoves, hot water heaters, etc. (white goods), that will cause uneven burning on the grate, are removed. This is done to try to increase the homogeneity of the fuel, and therefore decrease the range of fluctuations in the boiler heat output and thus the plant energy output.

(c) The parameters the author indicates as requiring monitoring are good. It is suggested, in the light of recent requests for proposals, however, that greater emphasis on the influence of air cooled condensers on turbine backpressure be given. Recent RFPs have all indicated that air cooled condensers be used for turbine exhaust steam condensing. This, of course, will influence the tolerance level for maintenance of condenser vacuum and turbine exhaust pressure.

(d) The impact of tolerance levels assigned to each of the subject paper's parameters is open to discussion. The percent difference in energy output (kWh/T) has been reviewed with the following comments:

(1) Economizer Exit Gas Temperature—For a 75°F rise in exit gas temperature the drop in kWh/T should be nearer to 20 kWh/T based on an average loss in boiler efficiency of 0.32%/10°F increase in economizer exit gas temperature. This gives a percent change in energy output of 3.6% rather than 5.1% indicated.

(2) Condenser Vacuum—For a 0.5 in. HgA difference in condenser vacuum, the percent differential in kWh/T will be 1.5% only for an increase in vacuum from 2.5 in HgA to 3.0 in HgA. The correction curves for turbine power output, however, are not straight lines and therefore this percent difference in kWh/T will vary depending on turbine (plant) load and actual condensing pressure. This variation can be seen in the following tables:

(a) At maximum & 100% turbine load

Turbine Exhaust Pressure-in. HgA	Plant Energy Output kWh/T	% Differential
1.50	607.7	3.0
1.75	604.2	2.4
2.00	599.4	1.6
2.25	594.7	0.8
2.50	590.0	0.0
2.75	585.9	−0.7
3.00	581.2	−1.5
3.25	577.0	−2.2
3.50	573.5	−2.8

(b) At 80% turbine load

Turbine Exhaust Pressure-in. HgA	Plant Energy Output kWh/T	% Differential
1.50	610.7	3.5
1.75	606.5	2.8
2.00	601.8	2.0
2.25	595.9	1.0
2.50	590.0	0.0
2.75	584.1	−1.0
3.00	578.8	−1.9
3.25	574.1	−2.7
3.50	572.3	−3.0

Therefore, the influence on plant energy output (kWh/T) is probably greater than 1.5% and more nearly on the average 1.7%.

(e) Cooling Water Temperature—For a 5°F change in cooling water temperature, it is suggested that the plant energy output will change only 5 kWh/T for a percent difference of only 1.0% rather than 1.7%. This also is influenced by the turbine back pressure correction curves which will change this percentage difference to 1.3% when operating at a plant load of 80% or an average of 1.1%. It should be noted that the condenser vacuum tolerance influence is of greater magnitude; and since condenser vacuum depends primarily on cooling water temperature, the tolerance for condenser vacuum only should be used in this analysis.

(f) For an air-cooled condenser, it is suggested that a number of ± 1% is not inordinary for the variation (tolerance) level in operation. This tolerance level will result in plant energy outputs of 574 kWh/T as back pressure rises 1 in HgA for a 2.8% difference and an output of 608 kWh/T as back pressure drops 1 in HgA for a 3.0% difference. These percentages apply only at plant 100% load, so therefore it is reasonable to assume that the percentage on the average will vary similarly to those for a water cooled condenser on approximately 3.1%.

The above points of difference will result in a worst case scenario (all operating parameters at extreme tolerance level) as follows:

		(water cooled)	(air cooled)
O_2	9%–10.5%	2.5	2.5
CO	200 ppm–200 ppm	0	0
Econ. Exit Gas Temp	430°F–505°F	3.6	3.6
Condenser Vacuum (water cooled)	0.5 in. HgA difference	1.7	—
Condenser Vacuum (air cooled)	1.0 in. HgA difference	—	3.1
Total % Difference		7.8	9.2
kWh/T		544.0	535.7

This is an average drop of 9.1% in energy output or expressed as a range from the average energy output: 563 ± 27 kWh/ton (± 4.8%).

DISCUSSION

All of the above assumes that refuse with a higher heating value of 5000 Btu per pound (2778 kcal/kg) is being processed.

As can be seen, there is a slight difference in average energy output between the above calculations and that arrived at by the author of the subject paper. However, the following must be taken into account. On the average, although the operator can, on a day to day basis, attempt to mix and blend the fuel (MSW) to attain some degree of homogeneity, the fuel HHV will vary over the full range of HHVs from lowest to highest. For fuel HHV ranges of 3500 btu/lb to 6000 btu/lb with a design HHV of 4750 btu/lb the plant energy output will vary (with no tolerance in operating parameters) ± 26%. The addition of operating parameter tolerance to this plant energy output variation will give a maximum swing of ± 31% and a minimum swing of ± 21%.

Using only adherence to operating parameter tolerances to assure efficient operation of the plant is therefore impossible unless the HHV of the fuel can be held constant. In a plant where a variation in plant energy output of only ± 4.8% is imposed energy output variations of ± 21% are possible and still be operating the plant efficiently. It is doubtful that any service agreement will allow a variation of ± 21 to ± 31% in plant energy output with no penalty. The only sensible thing that can be proposed is that a variation of ± 4.8% be allowed without penalty, but that this be based upon the expected plant energy output as adjusted for fuel HHV which must be monitored.

The subject of monitoring fuel HHV is a complicated one that has not been adequately addressed. However, use of the boiler as a calorimeter is one possible way to monitor gross changes in fuel HHV.

AUTHOR'S REPLY

The discussion by A. J. Licata and C. R. Goettinger addresses specific numerical as well as philosophical aspects of the paper. Points 1–3 need no further discussion. To Point 4, it should be noted that small differences in the percentage change of facility efficiency are dependent on the inherent characteristics of the equipment and will therefore not be exactly the same for all facilities. The conclusion in Point 5 that only condenser vacuum should be used to analyze turbine performance misses the fact, that the operator can influence the temperature of the cooling water by operating more or less fans or in some cases changing the fan speed. Cooling water temperature should therefore be a monitored parameter and be compared to ambient temperature and cooling tower efficiency curves.

Although the conclusion in Point 6 regarding an air cooled condenser is correct for a given design of the air cooled condenser, the case must be made, that sizing of the air cooled condenser is always based on overall economics. If predicted energy revenues warrant it, a larger and more efficient condenser will be installed.

The general discussion seems to miss the intent and purpose of the paper completely. It is not contemplated that using the operating parameter principle will account for changes in fuel heating value. Quite to the contrary, a change in fuel heating value will directly cause a change in energy output of the facility expressed in kW/ton. Operating parameters are only a means to check if the operator operates the plant efficiently. In all fairness, it cannot be expected that the operator assumes the risk of a fuel HHV that is beyond his control. It is common practice to guarantee to deliver to the operator a minimum quantity of refuse fuel each year which he guarantees to process. He also guarantees to process fuel with a widely varying HHV. However, it is impossible to recover constant amounts of energy from different HHV fuels.

Although using the boiler as calorimeter is done during testing to determine fuel HHV, to do so on a continuous basis is too complicated and expensive if an acceptable accuracy is desired. Still, even if the fuel HHV is obtained this way and energy efficient operation is monitored based on fuel HHV versus energy output, any variation in fuel HHV will nevertheless cause a change in energy output.

To minimize the problem altogether, a good energy revenue sharing arrangement is still the best way to ensure optimal operator performance.

On a general note, it should not be overlooked that with the large number of operating plants that will be in service in the near future, built and operated by reputable companies that are in this business to stay, most of the anxieties of the present in respect to how well plants are operated will diminish. This should reduce the problem to generally acceptable contract terms to achieve a mutually beneficial relationship of trust between communities and their consultants on one side and the builders and operators of the facilities on the other.

I wish to thank the authors of the written discussion and the many who discussed the paper verbally after its presentation for their well formulated and extensive arguments.