ENVIROMENTAL EMISSIONS FROM A SUSPENSION FIRED BOILER WHILE BURNING REFUSE DERIVED FUEL AND COAL MIXTURES

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Discussion by

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The paper is quite informative and achieved its purpose with respect to the emissions of heavy metals when coal is co-burned with RDF in a suspension fired boiler.

It must be understood that, while the trends could be indicative to some extent of other RDF or MSW mass fired systems, the absolute values of emissions should not be interpreted as valid for systems using pure RDF semi-suspension or MSW mass burning systems.

With respect to other emissions, such as unburned hydrocarbons, CO and even particulates, the paper has some shortcomings which could probably be corrected by adding or rearranging some basic test data.

1. Expressing the emissions as mass concentrations in terms of total heat input, customary in constant quality fuel burning systems, is misleading when combining fuels with radically different calorific values and combustion characteristics. It is believed that the relation of emissions to the processed fuel mass or, more appropriately, to the actual gas flow, would yield better correlation of the results.

2. The conversion of the data in terms of actual gas flow is not readily possible, as there appear to be some inconsistencies in the tables. For instance, Table 5 shows two runs with 10 percent RDF @ 100 percent load, while Table 9 shows only one run. Furthermore, it is stated (under "PARTICLES") that "Some of these runs were accomplished after the location of the RDF injection point was placed below that of the coal injection nozzles in the boiler." The text goes on to state that the emissions of carbonaceous materials were substantially reduced, yet no indication is given which test runs were done under which conditions and no fly ash analysis is given to show the indicated change in carbon content.

3. Similarly, under the heading "METHANE," no indication is given which emission values correspond to the different RDF injection nozzle locations, in spite of the inference that the nozzle relocation resulted in an improved combustion efficiency. Examining Table 5, there is an apparent trend of increased stack temperatures with increasing firing of the RDF fraction, which could possibly mean better combustion conditions. While even a slight improvement in combustion conditions could result in a substantial reduction of hydrocarbon emissions, it might not materially reduce the emissions of CO. Unfortunately, CO concentrations, which yield a better combustion system characterization, are not given in any of the tables.

4. The fouling of the boiler tubes while co-firing RDF is a confirmation of European experience which showed that co-firing of MSW (with
lower ash fusion point) with coal is undesirable from an operational point of view.

In conclusion, it appears that certain clarification and addition of some basic test data could yield valuable information not readily discernable from the paper in its present form.

Discussion by

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Reading this paper, and only to get an idea of its content, takes a bit of time — to say it has "a wealth of data" is a total understatement. It has taken this writer just about a week’s worth of odd hours in review for this brief discussion, and its content is still not totally absorbed. As a reference for engineers in refuse-to-energy work, the parting words of the authors... “the results (of the test program described) should provide valuable assistance for those planning further facilities”... are again, a total understatement. This paper, without question, ranks with the most informative presented before the Eight National Solid Waste Processing Division Conferences preceding this one.

Time permits no more than stressing the highlights — the data are almost totally complete, and enable a thorough understanding of the environmental effects of suspension cofiring of RDF and coal. There is information on some of the in-plant effects as well, such as the tendency for increased slag accumulation in the boiler, and the potential benefits of a disc screen installation at the RDF preparation plant, for sand & glass fines removal upstream of the boiler.

Basic conclusions, — that emissions of particulate, chlorides, lead, copper, and zinc all increase, while emissions of NOx and SOx decrease, — are as expected. The data as to the extent of these variations, as related to varying loads on the boiler and as the varying percentages of this load being carried by RDF, comprise the real contribution to the literature which the paper provides. In addition, the detailed information on the emissions of trace elements, segregated as to the discharge stream in which they are found and the input stream by which they entered the system, provide a basis for a much better understanding of the process than many of us, perhaps, had before. One of the things, in particular, this reader gained from the paper was improved understanding as to the fate of the heavy metals, Zn, Cu, Pb, Cr, Ni, Cd and Hg. Many of us are addressing the issues of codisposal these days, where incoming concentrations of these pollutants in the sludge may be 2, 3, or more times those in the incoming refuse. The data in this paper provide a good source of information not only as to how much metal may be in the refuse stream, but also as to how much of the discharge of these metals is in the flue gas, the quench water, and in the residue. While on the subject, perhaps a repeat of the heavy metals data from Table 10 of the paper, with comparable data on New York City Sludge (average, for all treatment plants) will create useful perspective:

<table>
<thead>
<tr>
<th>Element</th>
<th>Average Concentration in Feed-PPMW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal</td>
</tr>
<tr>
<td>Zn</td>
<td>66</td>
</tr>
<tr>
<td>Pb</td>
<td>36</td>
</tr>
<tr>
<td>Cu</td>
<td>15</td>
</tr>
<tr>
<td>Cr</td>
<td>19</td>
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<tr>
<td>Ni</td>
<td>18</td>
</tr>
<tr>
<td>Cd</td>
<td>BDL</td>
</tr>
<tr>
<td>Hg</td>
<td>BDL</td>
</tr>
</tbody>
</table>

*Expressed as PPMW of the dry solids in thickened, digested sludge. Note that comparison can not be directly made, as the three fuels are not at the same moisture content, unless Table 10's basis is "dry" (this is not specified).

One of the factors not clear when beginning to read the paper is the basis of reporting the amount of RDF being fired. These are expressed as percentages of total boiler heat input, and unless I missed it, this is clear only when one reaches Fig. 5, eleven pages into the text! Measurements of fly ash resistivity and bulk density are not included, and these would have been useful additions for those specifying precipitators at future plants. Another question arising during reading is as to the experience with increased slagging — how difficult was removal compared with coal-only firing, and were the parts of the boiler affected the same, or different?

This paper is worth much more study than this writer has been able to accomplish prior to writing this short discussion, — which ends with a "many thanks" to the authors, who have added a great deal to our knowledge in publishing their work.
Discussion by

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On Table 3 of this timely and important paper, we are informed of the sampling and analytic procedures to determine organics (pCB, POM, etc.). The results of these sampling and analytic procedures appear to be missing from the paper. Can the authors elucidate?

AUTHORS' REPLY

The authors would like to thank the discussors for their efforts and constructive comments concerning our paper on “Emissions From a Suspension Fired Boiler While Burning Refuse Derived Fuel and Coal Mixtures.” Had the comments been presented to the authors prior to the actual presentation, comment could have been made before the audience in attendance to clarify some of the points.

Additional data obtained during the study described in this paper was not able to be presented because of space limitation. For example, extensive data concerning fly ash resistivity and operation of the electrostatic precipitator was not presented in the paper, but a short summary was given during the oral presentation of the paper. This data is currently being prepared for publication.

The original version of the paper contained information concerning sampling and results to determine organics (PCB, POM, etc.) in the stack effluent gas and the fly ash. These items were removed from the paper not only to shorten its length, but also at the request of Dr. Velmer Fassel of the Ames Laboratory, Department of Energy. These items will be combined with additional data and presented by researchers of the Ames Laboratory, Department of Energy. These items will be combined with additional data and presented by researchers of the Ames Laboratory, Department of Energy, at an appropriate time in the near future.

The data presented in the various graphs and tables of the text have been converted to an “as fired” basis except for the “bottom” and “fly ash” values, which are presented on a “dry” basis.

More extensive data on trace element emissions is available, but there simply was not sufficient space to present more than the summaries provided. Furthermore, the variability in the trace element emissions data did not warrant further detail or breakdown of the information in the opinion of these authors. Thus, the trace element data for all loads and values of RDF have been averaged to yield a representative value of each trace element emission. In addition, the maximum value of each trace element emission is given along with the average and standard deviation in the various tables containing the trace element data. Presentation of the data in this manner should be sufficient to allow appropriate predictions.

The trace element emission data is presented in the paper both in terms of parts per million as well as amount per Joule of energy content of the fuel. Data presented in Tables 5, 6, and 9 allow emissions of interest (particulates, SO₂, NOₓ, chlorides, etc. [see Table 9]) to be converted from the pounds per million Btu basis as tabulated to a basis involving either fuel input mass or actual gas flow as desired by Mr. Dvirka. Space limitations prevented presenting the data in all possible desirable formats.

The number of experimental runs at each load and percent RDF is specifically given in Table 2. The data tabulated in tables following Table 2 are the data averages for the runs at each load and percent RDF. Thus, the data of Table 5 contains rows of entries for the multiple runs of each combination of load and percent RDF listed in Table 2. The average (X) and standard deviation (σ) given in each row of Table 5 should also make it clear that each entry in a given row of Table 5 is not for a single experimental run but for the multiple runs shown in each entry of Table 2. Furthermore, the data of Table 9 is also the average and standard deviation of selected emissions from multiple runs corresponding to the loads and percent RDF presented in Table 2. A careful examination of Tables 2, 5, and 9 will reveal that there are indeed no inconsistencies as implied by Mr. Dvirka.

The particulate data obtained for the case when the RDF injection point was placed below the coal nozzles was data obtained during compliance testing of the city of Ames suspension fired unit. These compliance runs performed for the city of Ames were not part of this EPA/DOE supported study. These compliance runs were performed several weeks after the EPA/DOE runs were finished. (During this several week interim citizens complaints concerning “black,” “flaky,” “sticky” residue emitted from the stack prompted the relocation of the RDF injection point.) Unfortunately, resources were not made available to sample and analyze any data other than “particulates” for
these compliance runs. Thus, the only additional data available following the relocation of the RDF injection point is for the particulate emissions. That is the reason for its inclusion only in the "PARTICULATES" section of the paper. The authors are grateful to the city of Ames, Iowa for allowing the compliance particulate data to be included with the EPA/DOE particulate data so that the comparison could be included in the paper. Hopefully, undue confusion has not been generated by its inclusion and the authors apologize if an impression was conveyed that additional emissions) was available for the boiler operation with the relocated RDF injection point.

The only CO measurements performed in this study was from Orsat measurements performed in both the stack and before the particulate collector. CO was not detected in most of the runs and was generally at the resolving level (or below) of the Orsat technique when it (CO) appeared to be detected. Thus, the results of trying to obtain CO values by this technique were not reliable or effective. However, the values given for "methane" emission in the paper would include the C₁ hydrocarbons detected by chromatographic techniques from a sample of stack gas. From this data it can be observed that the levels of C₁ hydrocarbons are very low, confirming our observations from the Orsat measurements.

In conclusion, more data is available than can possibly be presented in the space allowed. Much of this data will be available through EPA publication in the near future. However, the data selected for presentation will hopefully allow appropriate predictions of emissions to be performed for the case of cofiring RDF and coal mixtures.