A NEW PROCESSING SYSTEM FOR THE PRODUCTION OF IMPROVED REFUSE DERIVED FUEL AND RECYCLABLES FROM MUNICIPAL SOLID WASTE

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Discussion by:

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The following are the questions and comments on the paper.

(a) An energy balance could be provided to help clarify the cost of operating the system. Drying the refuse is likely very expensive.

(b)The paper indicates that conventional RDF systems have trouble processing rugs, mattresses, wire, plastic sheets, etc.; however, the UAH system would appear to have similar difficulties with these materials.

(c) Have the melted plastic lumps been analyzed for contamination and thus marketability?

(d) One of the main advantages claimed for the process is the low plastics content, yet Fig. 2 shows 7.5% plastics in the minus 0.5-in. fraction. With 72% of all refuse as minus 0.5 in., the 7.5% amounts to 5.4% of the incoming refuse or 67% of all the plastic.

(e) On p. 285, it is stated that "woody biomass is mechanically reduced to mulch," however, on p. 286, it states that some cardboard and paper was not reduced to below 0.5 in. How can wood or branches be reduced if not all paper is reduced?

(f) When wet, dirt and other small objects have a tendency to stick to plastic, glass, metal, etc., how does this affect the quality of the recycled material? Would the 0.5–2-in. and the plus 2-in. material have to be dried just after the trommel in Fig. 1 (or all the material dried before the trommel)?

(g) Odor and particulate controls would likely be needed on a commercial scale system for the processor and the dryer. Has this been addressed?

(h) The percentages on p. 287 appear vastly different to those in Fig. 2 (and using the 5.7, 22.3, and 72% splits for the three components). The following table shows those differences:

MATERIAL	PAGE 287	FIGURE 2
Total Ferrous	7%	3.1%
Total Aluminum	2	0.86
Plus 2-in. Plastic	60	9
0.5–2-in. Plastic	40	24
Minus 0.5-in. Plastic	0.5	67
0.5–2-in. Glass	80	62
Minus 0.5-in. Glass	20	38

(i) The last complete sentence of p. 287 states ash content at 6–8%, yet Table IV shows ash at 14–21%. Why are these significantly different?

(j) On p. 289, the first two Ref. [9] conclusions need further explanation. The first conclusion implies that if the sulfates were not present, the chlorides would not be converted to hydrochloric acid. The second conclusion conflicts with the first, stating that sulfur should be added.

(k) The third conclusion on p. 289 states that corrosion will not increase when co-firing RDF with coal. It does not conclude that corrosion is reduced, yet on the same page it states that chloride corrosion is reduced significantly, implying that overall corrosion is reduced.

(l) The formula on p. 289 is not complete and it appears to be reversed. Assuming the formula is (HHV x % Ash x % Alkali)/MMBtu, the calculation to 0.75 lb/MMBtu could not be duplicated (11.39% alkali and 8% ash will back calculate to 8200 Btu/lb, which is too low).

(m) The conclusions state a more consistent moisture content and no wires or stringy material compared to conventional RDF; however, if a conventional RDF plant dried the RDF and hand sorted the stringy material, they would be comparable.

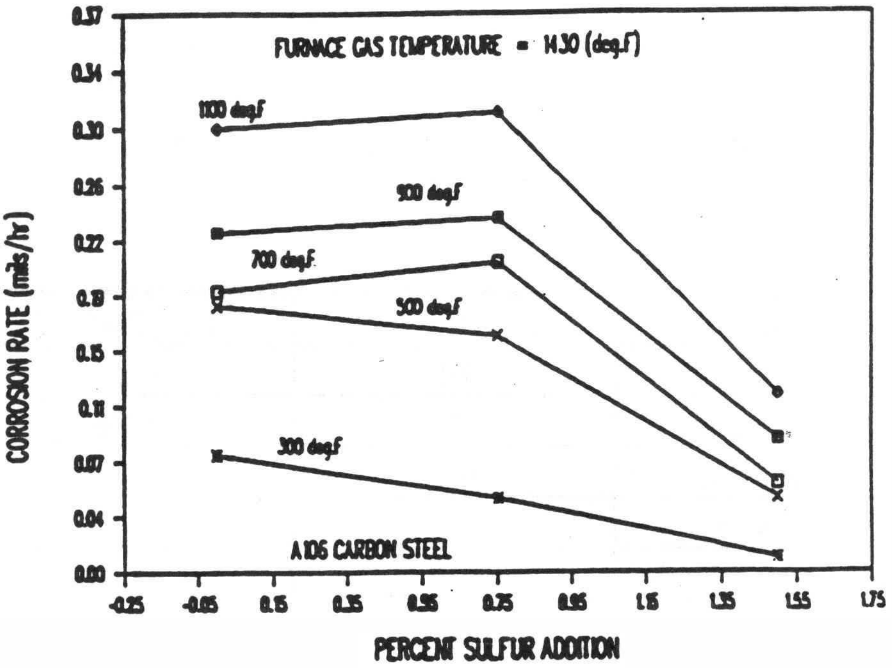
(n) Table VI was attached twice and labeled as Table VI and VII and Table VIII should have been labeled VII.

AUTHOR'S REPLY

(a) This point has been made to the authors on numerous occasions, and with the variability of the MSW composition, and particularly the variable moisture content, an accurate balance may not be possible. However, we have measured the steam consumption for a number of runs and found that only about 0.2–0.3 kg steam/kg MSW (about 700 kJ/kg) is required for processing. Of this, about one third can be condensed and recovered during depressurization.

As far as drying is concerned, it should be noted that the biomass has been exposed to 50 psig steam in the processor, which corresponds to a saturation temperature of 298°F. Upon release of pressure, a large portion of the water will immediately flash to vapor and the heat capacity of the solid material will serve as a heat source for additional evaporation. It is speculated that sufficient drying could be achieved without additional heat, provided adequate airflow and mixing is assured in the materials separation steps which follow the steam processing. This could be accomplished, for example, by using a trommel equipped with a fan or an air classifier as the first step in the materials recovery process.

(b) It is true that the UAH system, like conventional RDF systems, would have difficulty with mattresses, carpeting, and other such large bulky items, and these would



probably be removed prior to processing in either system. Wire, which does often create a problem in shredders, does not interfere with the UAH system during processing, but it does sometimes entangle with textiles, making it difficult to later separate the textiles for recycling. Plastic sheeting and plastic milk bottles that apparently cause problems with shredding do not cause any problems in the UAH system because these components are melted and are later recovered as densified aggregates of plastic.

(c) The melted plastic lumps have not been analyzed, but based on the success of Rutgers University and some commercial facilities with producing extruded or molded products from mixed plastics, we believe that the same may be true for the mixed plastic aggregates from the UAH process.

(d) The percentage of materials shown in the minus 0.5-in. fraction in Fig. 2 only shows the percentages in each size fraction on the first processing with no other steps. The data in Fig. 2 does not include the separation with the stoner, and most of the plastic and glass in the 0.5-in. fraction from the screener is removed by the stoner. After stoner treatment, the RDF only contains about 1% plastic on a dry weight basis.

(e) In the description of the recovered materials for recycling, we included woody biomass as a recoverable material. It may not have been clear that this recovered wood waste from the process unit would be mechanically reduced with a grinder and that the mechanical reduction does not take place inside the process unit.

Later, when we are describing the resultant screen fractions, it was pointed out that the pulp and paper materials found in the >1/2-in. fractions are, in fact, heavy grades of paper and the like that are not completely broken down for lack of sufficient absorbed moisture and time during processing.

(f) Apparently there is a misconception about the "wetness" of the processed materials. MSW typically has a moisture content of 20–25% by weight, and our product RDF typically has a moisture content of about 50% by weight. Even at 50% moisture, it is very difficult to squeeze any free water out of the material. It is important to recognize that the RDF has the capacity to absorb much more moisture before reaching saturation. Therefore, the non-biomass materials, such as metals, glass, and plastics are not wet, because free moisture is absorbed quickly by the RDF which is in continuous contact with the non-biomass during processing by the constant agitation. Thus, dirt does not adhere to the materials and the quality of the recyclables is not affected. The non-biomass materials >1/2 in. are not wet, and drying is not necessary, with the exception of textiles and residual paper. The residual paper is removed by reprocessing to the <1/2-in. size. The damp textiles would have to be washed and dried before recycling.

(g) Odor from the processor would be controlled by condensing the vapors during depressurization of the unit and any subsequent evaporation/cooling step. Once cooled, the UAH RDF has little odor, certainly nothing comparable to MSW or conventional RDF. Most noncondensibles would be directed to the intake air of the boiler combustion chamber and thus destroyed by combustion. Odors from a dryer would also be collected and combusted.

(h) Most of the confusion over the different percentages of materials in typical residential MSW (Table 1), the description of the splits of materials on the vibratory screen, and the data shown in Fig. 2 come from differences in moisture content. The typical composition of residential MSW provided in Table 1 includes 20% moisture by weight, and that composition is based on an accumulation of information from a variety of sources. The data presented in Fig. 2 is based on actual test data from a total of nine runs, and reflects the distribution of components between the three screened fraction after processing. No attempt was made to reconcile the differences in composition of "typical" residential MSW in Table 1 and the actual data from our test runs in Fig. 2. The data in Fig. 2 is also presented on a dry weight basis for each of the three screened fractions, and therefore does not take into account the differences in moisture content of these three fractions. The moisture content of the >2-in. fraction was 38% by weight, the moisture content of the midsize fraction was 48% by weight, and the <1/2-in. fraction had a moisture content of 65% for the particular test runs included. Thus, when the description of the splits in the text are given, we were including the moisture, but the data in Fig. 2 is dry weight. We also described the properties of the recyclables recovered in relation to their percentages in the original waste stream.

(i) During the period in which this research was completed, we made many changes in the pilot plant, and some of the data were obtained at various times when changes may have affected the data. We also have included information concerning the expectations for a commercial scale operation which may not always agree with the data in a particular instance. The higher ash content in Table IV of 14-21% was obtained from samples prepared during a time frame when we had included a screw conveyor to transfer the <1/2-in. fraction to the stoner which actually ground the glass to a fine sand, thus making it much more difficult to remove it from the damp cellulosics in the stoner. When the screw conveyor is not used, the lower ash content is found.

(j) The three conclusions regarding chloride corrosion were obtained from Ref. [9], and attempts to resolve the contradiction were not entirely successful Reference [9] had referenced "an extensive study ..." of chloride corrosion of both RDF and MSW cofired with high sulfur coal (Vaughan, D. A., Krause, H. H., and Boyd, W. K., "Chloride Corrosion and Its Inhibition in Refuse Firing," *Proceedings of the International Conference on Ash Deposits and Corrosion from Impurities in Combustion Gases*, New England

College, Henniker, New Hampshire, June 26–July 1, 1977, The American Society of Mechanical Engineers, pp. 473–493). A copy of this paper could not be obtained to determine if the first inclusion was mis-worded from that original source. A chemist asked to review the statement could not establish the reactions implied to in the first conclusion.

The second and third conclusion are based on experimental data provided by Ref. [9] from the original source. These data showed significantly decreased corrosion rate (0.30 mils/hr to 0.10 at 1100°F) as the percent sulfur increased from 0 to 1.55. This figure is presented below to illustrate the effects of sulfur content corrosion rates at other gas temperature.

(k) See reply to comment 12.

(l) The equation is difficult to understand as presented in Ref. [10] and provided in the paper. A clearer statement would be:

$$\text{Pounds of alkali/MMBtu} = \frac{10^6 \text{ x Fraction of Ash in Fuel x Fraction of Alkali in Ash}}{\text{HHV}}$$

(m) The suggestion that a conventional RDF plant dry their product and hand sort stringy material to make their RDF comparable to ours may have some validity, but we do not hand sort anything out of the fuel fraction to attain the consistency in particle size. Dry conventional RDF would appear to have merit, but our material can be dried more easily due to the latent heat already available immediately after processing, thus eliminating the necessity to provide additional heat for drying. Just by the very nature of the two methods of preparation, we believe it would be difficult to shred commingled waste and end up with the same product that we produce without shredding.

(n) Delete Table VII and renumber Table VIII as VII.