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Project Summary

Densification of Refuse-Derived Fuels: Preparation, Properties and Systems for Small Communities

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Densified refuse-derived fuel (d-RDF) is produced by compacting refuse derived fuel (RDF) into agglomerated pieces sufficiently cohesive to sustain storage and handling. The use of this d-RDF product as a substitute for coal in spreader-stoker boilers is a developing resource recovery alternative.

The study summarized here investigated the operation, performance, and product characteristics of a waste shredding and densification subsystem for producing d-RDF from the air-classified light fraction of municipal solid waste. The study also provided a technical and economic evaluation of d-RDF facilities for small communities.

During the investigation, a pellet mill was used to produce nearly 1300 Mg (megagram) (1442 tons) of pellets that were later test burned. Treated in the project report are the performance and effects on densification of modifications to the feed preparation equipment, particularly the secondary shredder. Densifier operation and maintenance are discussed as they are affected by feedstock properties, feedrate control, equipment wear on pellet production and properties. Physical properties of pellets analyzed over the 1300-Mg (1442-ton) production period are summarized. Observations on handling and storage are discussed and recommendations are made on minimizing potential problems.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

The U.S. Environmental Protection Agency (EPA) assigned the Municipal Environmental Research Laboratory (MERL) in Cincinnati, Ohio, major responsibility for research and development in the field of recovery and use of municipal solid waste. One concept investigated involves the recovery of energy from solid waste. Refuse is combusted either directly for steam recovery or in combination with fossil fuels for power generation. The latter involves processing the refuse to remove the combustibles for use in a modified power generation boiler, usually in combination with coal. The processed refuse is usually referred to as refuse derived fuel (RDF).

The RDF concept in the United States has generally been limited to power generating facilities that burn pulverized coal. The use of RDF need not be limited to large users, however; in fact, RDF may be more valuable to small power generating facilities. Small industrial and institutional boiler owners may find RDF an attractive and cheaper alternative to fossil fuels, for which they receive no quantity discounts, as do the large users. In addition, small users may have increased flexibility in negotiating contracts for RDF (especially with regard to length of commitment). Many small power generators are economically marginal because their boiler facilities are older, coal-burning models that require costly air pollution equipment. The use of RDF may help such facilities absorb the cost for such controls.

RDF prepared for large utility boilers is typically the light fraction of shredded refuse that has been air-classified, screened, or otherwise processed to remove the noncombustibles. In this fluffy form, it can be pneumatically fed into the suspension utility boiler. Smaller industrial and institutional stoker-fired boilers, in the range of 11,000 to 90,000 kg (25,000 to 200,000 lb) of steam per hour, are particularly attractive for smaller communities. To maintain storage and feed system capacities and to ensure proper distribution and burning on the grates, an RDF product with a range of properties comparable to conventional stoker (particle) coal is necessary. Rather than a low-density fluff RDF, a densified form of refuse-derived fuel (d-RDF) would be more suitable.

This d-RDF may approximate the physical characteristics of the stoker coal fed to the boiler. RDF in this form offers increased flexibility in transport, handling, and storage, and it can be mixed directly with the coal and fed to the boiler with few, if any, modifications.

Although considerable experience was available for cofiring RDF and coal, little information was available on the production and burning of d-RDF. EPA therefore implemented parallel programs to (1) determine the engineering and economic aspects of preparing d-RDF and (2) assess the technical and environmental implications of using d-RDF as a coal substitute.

In addition to the report summarized here, the following reports have been prepared as part of these programs: (1) "Coal:d-RDF Demonstration Tests in an Industrial Spreader Stoker Boiler," (2) "Fundamental Considerations for Preparing Densified Refuse Derived Fuels," and (3) "A Field Test Using Coal:d-RDF Blends in Spreader Stoker-Fired Boilers," EPA-600/2-80-095.

Materials and Methods

The work described in this report was conducted at NCRR's Equipment Test and Evaluation Facility (ETEF) located in what was the oversize, bulky, waste-processing area of the District of Columbia's Solid Waste Reduction Unit No. 1, a large, operating incinerator. Packer trucks, containing municipal solid waste (MSW), were diverted from the incinerator tipping floor and dumped at the test site to provide feedstock for investigations.

Process Description

Densified refuse derived fuel (d-RDF) is formed by the mechanical compaction of a processed waste fraction into particles. Equipment to compact or densify the waste includes pelletizers, cubers, extruders, and briquetters. In this study, processing of the refuse before densification included primary shredding, screening, air classification, and secondary shredding. Primary shredding of the refuse was done in a 750 Kw (1000 hp) horizontal hammermill located at the NCRR test facility.

After primary shredding, two process configurations were used to produce the d-RDF. The first configuration included a screen, a Heil-Tollemache* shredder (secondary size reduction), the densifier (California Pellet Mill), and auxiliary equipment such as a cyclone, conveyors, and feeders. This first configuration was later modified to include a vibratory feeder to the air classifier and a screen deck added to the feeder to remove inorganic particulate materials. This configuration (Figure 1) permitted investigating different air classifiers and other means to improve the d-RDF product.

The air classified light fraction was de-entrained in a cyclone, reintroduced through a rotary air lock into a pneumatic conveyor, and then discharged onto the 5 mm (3/16 inch) screen or into the Heil-Tollemache shredder (configuration 2). After the secondary shredder further reduced the size, the material was conveyed to the live-bottom bin. The live-bottom bin helps control surges and meters the material through two screw feeders to the densifier. The d-RDF product was discharged by conveyor to containers.

These processes were used to investigate the production of d-RDF and to produce the d-RDF for combustion tests conducted at other facilities. Investigations conducted included evaluating screening, air classification, secondary shredding, pellet mill operation and maintenance, and product characteristics.

Observations

The investigations of screening and air classification were part of a concurrent EPA program. Only results applicable to d-RDF production are presented.

Screening

After primary shredding, the particle size of 30.4 percent of the refuse was less than 6.4 mm (1/4 inch). The significance of this fraction is that it contains primarily inorganic particulate material that is likely to "fly" with the light fraction when air-classified. These removable inorganics fines (RIF) will add to the ash, or noncombustible, portion of the fuel and lead to increased abrasion and wear on the secondary shredder and densifier.

The use of vibrating screens to remove the noncombustible shredded waste and the air-classified light fraction was studied. Flat screening of municipal solid waste (MSW) cannot be recommended; a better method was found to be rotary screening.

Air Classification

Two different air classifiers were used at ETEF: a Triple/S Vibrolutriator™ and a vertical zig-zag-type classifier. Factors studied included separating air velocity, light/heavy split, and recovery of specific seed materials. Both produced the same light fraction yield, but the zig-zag classifier required a lower air velocity, indicating that the carryover of RIF would be lower than with the Vibrolutriator™.

Secondary Shredding

To decrease wear on the densifier die and roller assemblies and reduce size and milling action, the primary-shredded, air-classified, light fraction must be shredded a second time. The secondary shredder was a vertical-shaft, reversible, Heil-Tollemache hammermill. When first operated, large pieces of textiles and plastics passed through the shredder and jammed the densifier or wrapped around the augers. A number of changes were made in hammer styles and configurations. Fixed stater bars, which created a scissor action with the

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*Mention of trade names or commercial products does not constitute endorsement or recommendation for use

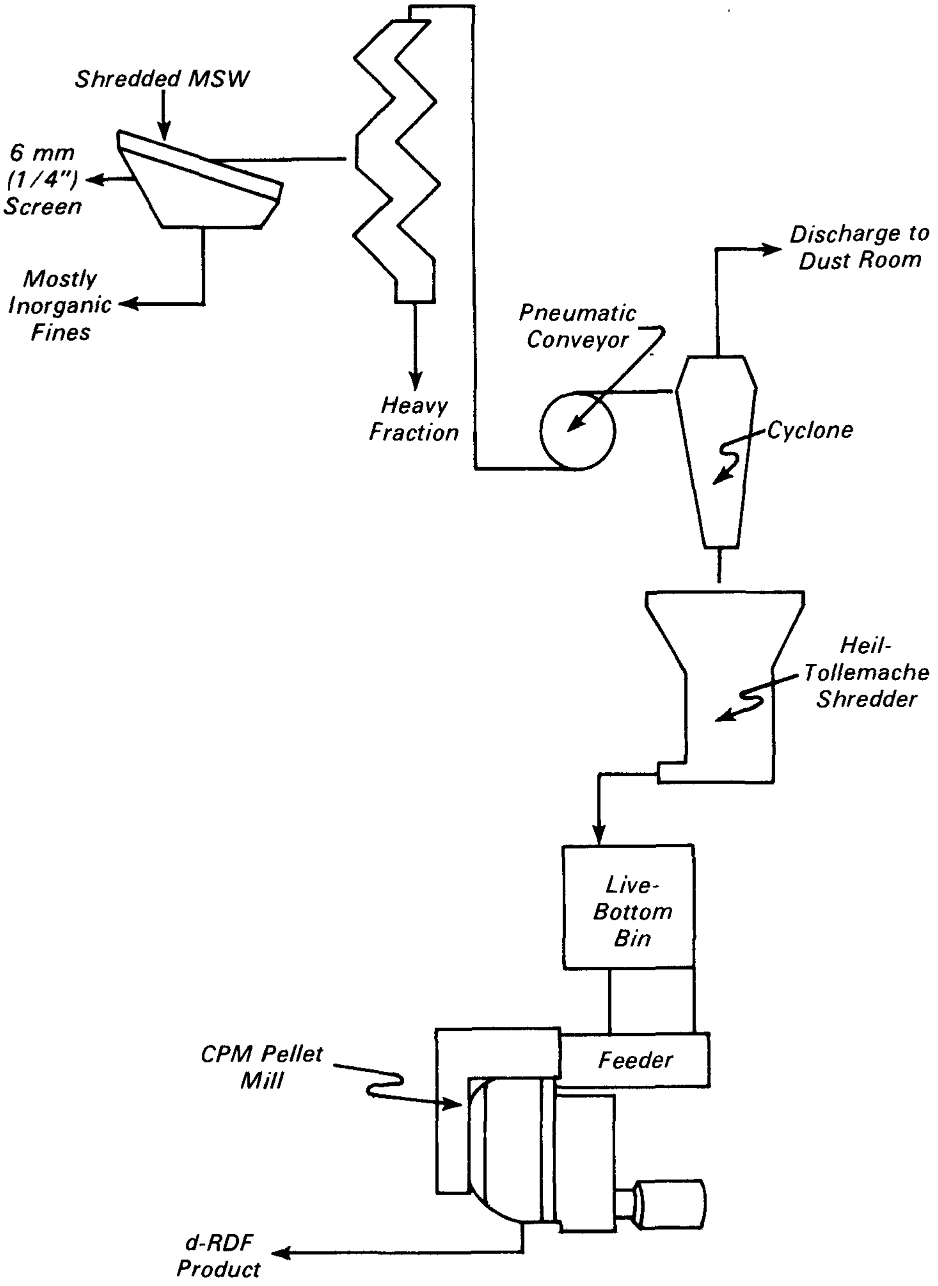

Figure 1. *Portion of Equipment Test and Evaluation Facility for preparation of d-RDF, configuration 2.*

hammers, were also added at various locations in the grinding section. Five trials varying hammer number (up to 72) and length were made, and the particle size of paper and plastics was significantly reduced. Textile size reduction did not follow this trend, however.

An alternative to hammermills for secondary shredding is a rotary-knife shredder. Although such a device does offer the benefits of pure shearing action as well as grates to control particle size, it is susceptible to damage from tramp metal (tools and hardware) and high wear from abrasive feedstocks. In the test, a model 24 Knife Granulator was used. A single test comparison of product size from the knife shredder and hammermill is difficult because of the effect of throughput and wear and the natural variability of such test results. Knife shredders do, however, clearly limit the larger particles.

Densification

In these investigations, a California Pellet Mill (CPM) Model B162 ring extrusion type densifier was used. Auxiliary equipment included a live-bottom bin and a screw feed mixer and conditioner. As material is fed into the densifier die cavity, it is flattened against the die by the rollers. Layer after layer builds up until the material is forced radially through the die holes. A tapered hole inlet provides some lateral compaction, while the resistance from the taper further compacts the pellet along its axis.

The pellets are extruded from the outside of the die and break in random lengths, either from the centrifugal force of the die, by contact with other pellets, or by striking the pellet bar.

Pellet production rates of 7 to 9 Mg per hour (7.8 to 9.9 tons per hour) were expected but never realized. There is no clear explanation for this because a number of factors influence the performance and capacity of the pellet mill. These factors include: equipment configuration, die and roller condition, stability of feedrate, feedstock properties (e.g., moisture, density, and particle size) and presence of oversized textiles. The interrelation of these and other factors affected the performance of the pellet mill to produce d-RDF. Because of this, the following discussion does not treat each factor individually, but summarizes general observations about the densification process.

During early operations, there were frequent blockages and downtime. These were evenly attributed to the poor performance of feed preparation equipment and the densifier. Other factors such as operator experience also contributed to these problems. Controlling the flowrate of the feed proved to be an important factor affecting the pellet mill performance. Results indicated that an improved system would include added surge capacity to control fluctuations from the shredder and the air classifier and a system to control volumetric feedrate. The condition of dies and rollers proved to be an important factor affecting throughput. Although new dies and rollers and reconditioned dies improved pellet production, the improvement was short lived. The abrasive nature of the feedstock dulled the sharp edges after less than 45 Mg (49.6 tons), and the production capacity decreased. Feedstocks more consistant and denser than processed MSW, such as feed and wood waste, have not caused the jamming and surging problems experienced with the MSW. This indicates that process modifications to improve the homogeneity of the MSW feedstock would improve the densifier capacity.

Many equipment modifications were made to improve production. Increasing motor size of the densifier to reduce jamming is not a solution. Improvements in the feeder appeared to produce better results. Continuing equipment adjustments were necessary, especially to the roller position.

Power consumption measurements in these experiments were confused because of errors in meter connections. Subsequent investigations indicated a higher than expected power consumption, perhaps related to differences in feedstock. Production of 1-inch pellets (compared to 1/2 inch pellets) indicated that increased reliability and decreased feedstock processing requirements could be gained. Additional investigations are required.

Wear on die and roller shells appeared to be the most significant maintenance requirement. Wear appeared to be similar to other feedstocks (e.g., feed) but occurred much sooner, probably because of inorganic fines. With respect to roller wear, techniques available to reduce abrasive fines in the feedstock hold promise of extending the roll and die life significantly.

Die and roller wear significantly affected machine performance and resulted in increased blockages, decreased pellet densities, and increased maintenance requirements. Excessive wear is attributed to the ash content (inorganic fines) of the feedstock. Based upon results of this work, it is projected that a die life of 3,200 Mg (3,550 tons) cover be expected for a low ash feedstock (10 to 12 percent ash). Subsequent economic analyses are based on these estimates.

d-RDF (Pellet) Properties

In the study, some physical properties of pellets chosen for investigation were moisture content, ash, and pellet density. These properties were chosen because of their probable relationship to the use of d-RDF as a supplement to coal in stoker-fired boilers. The densification process results in a 5 percent loss of moisture in the feed, and preferred pellet moisture is in the range of 15 to 20 percent. Since the expected ash content of d-RDF is in the range of 6 to 8 percent, the ash contents in excess of 20 percent experienced in this work was caused by the inability to remove the inorganic fines. Low ash contents are desirable to reduce shredder and densifier wear and to maximize heat value. Pellet density is important to ensure proper flow through storage and feed systems. Moisture below 15 percent produced higher density pellets, whereas moisture above 30 percent results in poorly formed pellets. Die hole inlet taper appeared to be the major controller of pellet density; the more severe the taper, the more dense the pellet. Information of pellet bulk density, dimensions, integrity (ability to maintain stable dimensions) and similar materials handling characteristics are discussed in the full report.

It was necessary to store the pellets outside for close to a year until shipped for combustion tests. This afforded the opportunity to monitor the effects of long storage and handling on the d-RDF. Results of the monitoring indicated that the pelletized form of d-RDF makes it less attractive as a food source. Although a variety of crawling insects were found, they were no greater in numbers or type than those found in ordinary soil. Odors generated by the stored d-RDF were objectionable only when the covers were removed or the piles excavated. While covered, dusting from the piles posed no problem, but during handling, flakes blown from dry, broken pellets created minor offsite dusting.

At the end of the first summer, after 10 months of storage, smoldering seams of pellets with temperatures above 150°C (300°F), hot enough to ignite the plastic covers, surfaced where the pellets had been repiled. Four times such outbreaks occurred, and 500 tons of pellets were lost. Composting was believed to trigger an oxidation reaction that caused the smolderings. Recommendations based upon these and other observations were made to improve storage. These are to use a ventilated cover, control length of storage to no more than 8 weeks, and to restrict handling of the stored pellets.

Cost of Densification

Cost of densification will be the key to the success of the d-RDF concept. The study evaluated the technical and economic considerations of d-RDF for small communities, processing up to 200 Mg (222 tons) of MSW per day. Projections for the capital and operation and maintenance costs were made for several selected processes. For a system designed to produce 9 Mg (9.9 tons) of pellets per hour, a cost of $9.20 per Mg ($8.28 per ton) is projected for the capital and operating costs of the densification module. Costs of the front end system, (i.e., the refuse receiving and processing system) is not included.

Details of the analyses done to estimate the cost of the plant, front end processing, and d-RDF module are provided in the full report. The report also provides details on estimating costs of producing d-RDF and for estimating if the process is economical for small communities.

The full report was submitted in fulfillment of Grant No. 804150 by the National Center for Resource Recovery, Inc., Washington, DC, under the sponsorship of the U.S. Environmental Protection Agency.

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Carlton C. Wiles *is the EPA Project Officer (see below).*

The complete report, entitled "Densification of Refuse-Derived Fuels: Preparation, Properties and Systems for Small Communities," (Order No. PB 82-103 904; Cost: $14.00, subject to change) will be available only from:

National Technical Information Service
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