United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-183/184 Oct. 1981

EPA

Project Summary

Coal:dRDF Demonstration Test in an Industrial Spreader Stoker Boiler. Use of Coal:dRDF Blends in Stoker-Fired Boilers. Volumes I and II

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In one concept involving 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 report summarized here (Phase II or a two-phased program) considers a demonstration test of the co-firing of coal and a densified form of refuse-derived fuel (d-RDF) in an industrial spreader stoker boiler in Erie, Pennsylvania. In a 402-hr period, 1,702 tons of d-RDF were co-fired with coal. An additional 231 hr of coal baseline testing were completed to provide a basis of comparison for the test results. Phase I was conducted with a smaller, institutional, spreader stoker heating boiler at Hagerstown, Maryland.

The demonstration tests investigated (1) the material handling characteristics of d-RDF; (2) boiler performance, i.e., boiler efficiency, spreader limitations, steam production, combustion properties, slagging, fouling, clinkering, and corrosion; (3) environmental performance, i.e., particulate emissions (size, mass rate, and resistivity, gaseous emissions (SO_x, NO_x, Cl, F, HC), and trace metal emissions (Pb, Cr, Cd, Be, and Zn).

In general, the test demonstrated that co-firing coal and d-RDF can be performed with minimal impact on the performance of an industrial power plant. The boiler was able to deliver maximum rated steam capacity with adequate boiler response and fuel burnout at coal:d-RDF blends up to 1:4 (by volume). The slight decrease in boiler efficiency occurring during blend firing was attributed to the high moisture and hydrogen content of the d-RDF pellets. There was no significant difference in particulate emissions of either the electrostatic precipitator (ESP) inlet or outlet as a result of firing with blends. ESP collection efficiency was not effected by the blend firing. Increases in heavy metals (lead, cadmium, zinc, chromium) and chloride emissions were noted. Sulfur emissions decreased as the d-RDF substitution was increased.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research projects that are fully documented in separate reports (see Project Reports ordering information at back).

Introduction

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 generating 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. Use of RDF need not be limited to large users, however, and may in fact be more valuable to small power generating facilities. Small industrial and institutional boiler owners may find RDF an attractive and cheaper supplement 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 composed of 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. For the smaller, stoker-fed boilers, however, a densified form of RDF (i.e., d-RDF) is used.

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 co-firing 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:

"Densification of Refuse-Derived Fuels: Preparation, Properties, and Systems for Small Communities," EPA-600/2-81-188,

"Fundamental Consideration for Preparing Densified Refuse-Derived Fuels," EPA-600/2-81-180, and

"A Field Test Using Coal: d-RDF Blends in Spreader Stoker-Fired Boilers," EPA-600/2-80-095.

The results reported herein represent the second phase of a two-phase d-RDF combustion evaluation program. Phase I was conducted in an institutional spreader stoker heating boiler located in Hagerstown, Maryland (EPA Report No. 600/2-80-095). During Phase I, 285 tons of d-RDF were combusted. Phase II demonstration testing was conducted in a larger, industrial, spreader stoker boiler operated by General Electric in Erie, Pennsylvania. In a period of 402 hours, 1,702 tons of d-RDF were combusted with coal. An additional 231 hours of coal baseline testing was completed to provide a basis of comparison for the test results.

The demonstration tests were designed to investigate (1) the material handling characteristics of d-RDF after 6 months of storage in an open coal yard; (2) boiler performance, i.e., boiler efficiency, spreader limitations, steam production, combustion properties, slagging, fouling, clinkering, and corrosion; (3) environmental performance, i.e., particulate emissions (size, mass rate, and resistivity), gaseous emissions (SO_x, NO_x, Cl, F, HC), and trace metal emissions (Pb, Cr, Cd, Be, and Zn).

Previous field tests involving co-firing coal and densified refuse derived fuel (d-RDF) have typically been of short duration and were performed under less than desirable boiler operating conditions and boiler specifications. Therefore, the objective of this demonstration test was to conduct longer-term co-firing tests in a boiler representative of those used throughout industry. Sufficient testing, with the exception of long-term corrosion studies, was to be conducted to establish whether or not d-RDF (1) has any detrimental effects on the boiler system or its performance and (2) if it can be burned within existing environmental constraints.

Site Selection

After establishing the site selection criteria, a site was located. A detailed discussion of the selection criteria that were established are included in the report. The basic criteria for selecting a test and demonstration site were:

1. that the site have a spreader stoker boiler with traveling grate (front ash drop) capable of producing 75,000 to 150,000 lb/hr of steam at 500 to 1,000 psig with at least 200°F superheat,
2. that the site have multiple boilers and sufficient steam capacity to permit operating the test boiler at any desired steam load,
3. that the site have adequate fuel storage capacity, a feeding system, and other facilities readily adaptable to testing requirements, and
4. that the power plant management be sufficiently interested and cooperative to ensure successful completion of the program.

After reviewing approximately 40 candidate sites, the General Electric Power Plant in Erie, Pennsylvania, was determined to be the most suitable. This power plant has three Babcock and Wilcox* spreader stoker-fired boilers rated at 100,000, 150,000, and 175,000 lb/hr of steam with 285°F superheat at 675 psig. The 150,000-lb/hr boiler was selected for the demonstration test.

Boiler performance was evaluated to determine boiler efficiency and fireside corrosion. The flue gas was continuously monitored at the boiler outlet to provide necessary data for calculating the efficiency. The instruments on the boiler control panel were monitored to document operational characteristics of the system.

Fuel

The d-RDF for the demonstration was produced at two pilot-scale plants. Commercial sources were not available. Even with d-RDF supplying less than half the fuel demand of this industrial boiler, more than 6 month's production was needed to accumulate enough d-RDF for a 400-hr test.

Both d-RDF's were formed as 1/2-inch-diameter cylindrical pellets. One pellet type, produced by the National Center for Resource Recovery (NCRR) contained approximately 30 percent ash and had a heating value of 6,755 Btu/lb on a dry weight basis. The other pellet type, produced by Teledyne National, contained 14 percent ash and had a dry weight heating value of 8,123 Btu/lb.

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

Moisture contents of the d-RDF ranged from 14 to 34 percent, and bulk densities ranged between 30 and 35 lb/ft^3. The ash content of the d-RDF produced by NCRR was later reduced significantly by modifications to the process. The d-RDF was shipped to Erie, Pennsylvania, via truck from production sites in Washington, D.C., and Baltimore, Maryland. Some of the NCRR production had been stored in the open several months before shipment.

At Erie, the d-RDF was stored up to 6 months in an open coal yard through winter and spring weather. The piles of d-RDF formed a protective crust 6 to 8 inches thick. While in storage, the pellets increased in moisture and fines content. Also, the aged pellets expanded and formed serrated edges that subsequently created some handling problems.

Five different coals were used during the blend firing and coal baseline tests. These coals had sulfur contents ranging from 1.7 to 6.8 percent and ash contents ranging from 9.5 to 18.2 percent on a dry weight basis.

Results

While being conveyed to the bunker, the d-RDF blended thoroughly with the coal. The low bulk density, high elasticity, and fibrous shape of the deteriorating pellets following the 6-month storage, required rodding, however, for them to flow out of the feed hopper. In the bunker, the coal: d-RDF blend would "rat hole" and demonstrate angles of repose in excess of 90°. Bunker vibrators and air blasters did not eliminate the need to manually rod the fuel blend into the nonsegregating distribution chutes feeding out of the bunker. Very little modification of the existing fuel-handling system was required—only a crusher bypass plate and a backstop at a conveyor transfer were installed. Otherwise the fuel handling system was used as it existed.

When compared with coal, the d-RDF blends required more frequent ash removal because of the increased ash content and decreased heating value of the fuel. Except for the manual removal of the infrequent clinkers, no ash handling problems were noted with the pneumatic ash handling system.

At a 1:2 (coal:d-RDF) volumetric blend ratio, a 2 to 3 percent reduction in boiler efficiency was experienced because of the increased flue gas moisture formed in d-RDF combustion. When firing at full load with coal:d-RDF blends, the combustion flame was observed to require considerably more combustion volume. Puffs of flame were observed in the screen tube section. This increased flame activity is directly associated with the higher volatile content of d-RDF as compared with that of coal. No significant increases in hydrocarbons or carbon monoxide were detected in the flue gas, however.

The combustion of d-RDF blends exhibited the same range of particulate emission rates as coal only. Mass rate of particulate emissions was measured for every test at the electrostatic precipitator inlet. This location was selected because the particulate characteristics of any uncontrolled boiler would probably be similar to those measured at this location in the system. To measure precipitator efficiency during periods when the boiler was operated at capacity, simultaneous measurements of particulate concentrations were made both upstream and downstream of the electrostatic precipitator. The electrostatic precipitator performance was unchanged by the substitution of d-RDF for coal.

Lead emissions increased by a factor of six. Cadmium, zinc, and chromium emissions increased 50 to 100 percent when firing d-RDF. The substitution of d-RDF for coal had no significant effect on NO_x, CO, or hydrocarbon emissions. But, as expected, d-RDF caused a 30 to 50 percent decrease in SO_x emissions.

Discussion

The principal objective of the effort described herein was a *demonstration* test. Thus, all testing was performed under typical power plant operating conditions. The realities of plant operation meant that control of the test conditions (i.e., of the predictive or "independent" variables of the experiment) was not as tight as could be expected in a laboratory situation. This gives rise to much apparent scatter in the data with concommitant uncertainty in the results. Such lack of tight control is not unexpected, and in fact, is representative of everyday power plant operation.

In general, this test clearly demonstrated that co-firing coal and d-RDF can be performed with minimal impact on the operational performance of an industrial power plant. The boiler performed well, demonstrating an ability to deliver maximum rated steam capacity with adequate boiler response and fuel burnout at coal:d-RDF blends up to 1:4 (by volume). A slight decrease in boiler efficiency (2.5 percent drop) occurred during blend firing. This drop was attributed to the high moisture and hydrogen content of the RDF pellets. There was no significant difference in particulate emissions at either the electrostatic precipitator (ESP) inlet or outlet as a result of firing with blends. ESP collection efficiency was not affected by the blend firing. Increases in heavy metals (i.e., lead, cadmium, zinc, chromium) and chloride emissions were noted. Sulfur emissions decreased as the d-RDF substitution was increased.

The full report was submitted in fulfillment of Contract No. 68-03-2426 by the Systems Technology Corporation, Xenia, OH 45385, under the sponsorship of the U.S. Environmental Protection Agency.

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The complete reports were authored by N. J. Kleinhenz of Systems Technology Corporation, 245 North Valley Road, Xenia, OH 45385, and are entitled, "Coal:dRDF Demonstration Test in an Industrial Spreader Stoker Boiler. Use of Coal:dRDF Blends in Stoker-Fired Boilers":
Volume I. (Order No. PB 82-100 868; Cost: $12.50, subject to change)
Volume II. Appendices A, B, C, and D (Order No. PB 82-100 876; Cost: $18.50, subject to change)
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