United States
Environmental Protection
Agency

Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

SWRP
0308

Research and Development

EPA/600/S2-85/113 Dec. 1985

EPA

Project Summary

Test Firing Refuse-Derived Fuel in an Industrial Coal-Fired Boiler

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This research program evaluated the performance of an industrial boiler when co-firing coal and refuse-derived fuel (RDF). An optimum boiler operating load and RDF feed rate were determined for the boiler tested. Boiler efficiencies and stack emissions were also studied, and the economics of preparing and utilizing RDF in the boiler were evaluated. The operational characteristics of the RDF feed system and the reliability and practicability of receiving, storing, and firing RDF are reported.

An RDF Receiving and Feed Facility was designed and constructed to feed RDF to boiler No. 5, which had been modified to fire RDF, at the Oscar Mayer and Company, Madison, Wisconsin plant. Boiler No. 5 is one of two base load coal-fired boilers used by Oscar Mayer to produce steam for electrical generation and process purposes. The co-firing tests were conducted at various boiler loads and feed rates to determine an optimum operating condition. RDF from the Madison Area Resource Recovery Center was augered onto a slider belt conveyor and transported to the boiler house, where it was mechanically split into six fuel streams and fed into the test boiler.

Twenty-one tests were run from July 1980 to May 1981. Studies included evaluation of the coal and RDF; bottom ash, economizer ash, cyclone ash, and fly ash; underfire and overfire air; boiler efficiency; and gaseous emissions including SO_2, NO, HCl, and CO. Sixty-two trace elements in the fuel and ashes were measured.

The tests demonstrated that RDF could reliably be fed into an industrial boiler at feed rates up to 48%, on a heat input basis, while maintaining a steady steam load. Particulate emissions under these test conditions were not significantly increased when firing RDF. There was no negative physical impact on the boiler.

This Project Summary was developed by EPA's Hazardous Waste Engineering 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).

Purpose and Objective

This research project was structured to:

1. Evaluate an industrial boiler's performance when cofiring coal and RDF at various boiler loads and feed rates to determine optimum operating conditions.
2. Evaluate air emissions and the performance of an existing mechanical air cleaning system when cofiring coal and RDF in an industrial boiler.
3. Analyze the economics of utilizing RDF in an industrial boiler.
4. Evaluate the operational characteristics of the RDF feed system and the reliability and practicability of receiving, storing, and firing RDF at an industrial operation.

Operation and Performance

The project was to demonstrate that RDF prepared from municipal solid waste can be effectively co-fired with coal in a retrofitted industrial spreader-stoker boiler rated at 125,000 lb steam/hr (55,555 kg/hr) equipped with a multi-cyclone particulate collector.

The best operating load, based on steam demand and boiler operation, was judged to be 90,000 lb steam/hr (40,000 kg/hr) with 33% of the steam load carried by RDF. This represents a coal feed rate of 3.5 ton/hr (3,200 kg/hr) and an RDF feed rate of 3.8 ton/hr (3,500 kg/hr).

The RDF, as produced for the test program, had an average heating value of 5,785 Btu/lb (13,455 kJ/kg) with 21% moisture and 14% ash as received. The RDF had a nominal top size of 2 inches (5 cm), 90% less than ¾ inch (1.9 cm), and mass mean size of 0.30 inches (0.76 cm).

Fuel Analysis and Emissions

Analyses of coal and RDF indicated that RDF had higher volatile matter and lower fixed carbon contents than coal. The ultimate analyses showed that RDF was lower in carbon, nitrogen, and sulfur, and higher in moisture, hydrogen, chlorine, ash, and oxygen contents than coal. Coal had about twice as high a heating value as RDF on an as-fired basis. The main reason for the difference in heating values is the higher oxygen, moisture, and ash content of RDF.

Boiler efficiency decreased 1% for each 10% of heat load replaced by RDF. This decrease in efficiency was due primarily to additional moisture in the RDF and additional moisture from combustion of hydrogen in the RDF.

Particulate emissions ranged from 0.60 to 1.28 lb/million Btu (0.26 to 0.55 kg/million kJ). Co-firing tests in the Fall of 1980 produced excessive particulate emissions; but those conducted in the Spring of 1981 showed no significant increase in particulate emissions as compared to the coal-only tests. It is believed that operating experience and lower RDF ash content contributed to the improvement in the later tests.

When RDF and Illinois coal were co-fired at 90,000 lb steam/hr (40,000 kg/hr) with 33% of the heat load carried by the RDF, the sulfur dioxide emissions were reduced by half to 2.8 lb/million Btu (1.2 kg/million kJ), the hydrogen chloride emissions were increased 50% to 0.33 lb/million Btu (0.14 kg/million kJ), the carbon monoxide emissions were insignificant, and the nitric oxide emissions remained about the same at 0.4 lb/million Btu (0.17 kg/million kJ).

The trace element analyses of the fuels indicated that RDF was higher than coal in 36 out of 63 elements analyzed. Elements that were higher in concentration in RDF than in coal showed a general increase in all ashes with an increasing input of RDF. When RDF was burned, trace metals were measured in the fly ash. Lead and zinc were each 2% of the total particulate emissions. The other trace metals were each one to three orders of magnitude lower.

The RDF receiving and feed system operated dependably, providing a clean and constant flow of RDF to the boiler. The combination feeders distributed the RDF evenly throughout the boiler, maintaining a constant steam load.

Economic Analysis

The RDF storage and feed system at the Oscar Mayer and Company Plant in Madison, WI could be expanded to burn 12,500 to 15,000 tons per year of RDF while operating at 5 tons/hr, 10 to 12 hrs. per day, 5 days per week. The fuel replacement rate would be approximately 40%. The projected operating costs to receive and burn 12,500 and/or 15,000 tons of RDF annually in the system described is $90,000 or $7.20 and $6.00 per ton respectively. The total September 1981 capital cost to install a permanent system as described would be $700,000. The cost to expand the test facility to a permanent installation is estimated to be about $400,000. The economic analysis for this project indicates that the conditions to develop a market appear favorable.

Recommendations

The cofiring of RDF and coal in a retrofitted industrial spreader-stoker boiler should be further examined. It is recommended that additional cofiring of coal and RDF examine boiler performance while firing RDF in the size range of 1 inch to 4 inches. RDF in this size range can be recovered from the residue stream at Madison's Energy Recovery Plant, further reducing the quantity of waste being landfilled.

Proper air distribution in a boiler retrofitted to cofire coal and RDF is essential. Further testing is needed to optimize air distribution in a boiler which is cofiring coal and RDF in order to minimize excess air and reduce particulate emissions. Tests should include varying the ratio of underfire air to overfire air, and the location, angle, and penetration of the overfire air jet stream.

The short-term cofiring of coal and RDF was successfully accomplished in a retrofitted industrial spreader-stoker boiler. No significant problems related to boiler operation or performance were evident during this test program. To further substantiate these preliminary findings, a long-term coal and RDF cofired test program at optimum boiler load and RDF feed rates should be conducted to:

1. Ensure boiler operator proficiency.
2. Establish a broad basis for evaluating emissions.
3. Investigate boiler fouling, corrosion, slagging, superheater degradation, and additional maintenance problems.

The composition and characteristics of particulate from a coal and RDF cofired boiler varies from that of a straight coal-fired unit; therefore, the performance of various types of particulate control equipment need to be studied under the cofired condition.

Finally, the cofiring of coal and RDF in an industrial spreader-stoker boiler should be encouraged, both as a method of energy recovery and as a means of reducing landfill space requirements.

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***Michael Black** is the EPA Project Officer (see below).*
The complete report, entitled "Test Firing Refuse-Derived Fuel in an Industrial Coal-Fired Boiler," (Order No. PB 86-115 094/AS; Cost: $16.95, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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