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Project Summary

Coal/d-RDF Co-Firing Project Milwaukee County, Wisconsin

R. S. Hecklinger and F. R. Rehm

The potential for reduction in fuel cost impelled Milwaukee County to explore the possibility of supplementing coal with refuse derived fuel at the Milwaukee County Institutions' Power Plant.

A Research and Development Project was carried out to mix a densified refuse derived fuel (d-RDF) with coal at the fuel receiving point and to co-fire the mixture in a spreader-stoker fired boiler.

Two basic series of test runs were conducted. For the first series, coal was fired to establish a "base line." For the second series, a mixture of coal and d-RDF was fired.

The full report describes the equipment used to densify refuse derived fuel, procedures used to prepare and handle the coal and d-RDF mixture and test results.

The results include the effect of coal and d-RDF mixture on plant operations, boiler efficiency, stack emissions, and extraction procedure toxicity.

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).

Introduction

Milwaukee County, Wisconsin owns and operates an extensive County Institutions complex. Energy needs are served by a co-generation power plant. The power plant produces electricity, heating steam, and chilled water.

In an effort to control inflating energy costs, the County, in 1977, embarked on a program to determine the feasibility of using energy from refuse to supplant fossil fuels presently fired in the boilers at the power plant.

After exploring the viability of several alternatives, a Research and Development Project was formulated to determine the feasibility of co-firing coal and densified refuse derived fuel (d-RDF) in one of the existing spreader-stoker fired boilers.

Concurrently, the Americology Division of the American Can Company was developing and placing in operation a refuse processing and resource recovery plant in the City of Milwaukee. The Americology Plant was designed to receive and process municipal refuse from the City of Milwaukee and surrounding communities to produce fuel and recyclable materials. The refuse derived fuel (RDF) was intended for use as a supplementary fuel in a large, pulverized coal-fired utility generating station.

The full report summarizes the coal/d-RDF co-firing demonstration.

Densification

Various equipment and techniques for densifying RDF have been proposed. A modified John Deere 390 Stationary Cuber was installed in the Americology Plant. A feed chute was provided to divert a portion of fluff RDF normally produced to the cubing machine where it is densified and subsequently mixed and co-fired with lump coal at the County Institutions' power plant.

A trial program was undertaken to evaluate the suitability of the 390 Cuber for producing densified cubes. The following five parameters were examined to determine impact on cube quality and integrity:

1. RDF particle size
2. Cuber feed rate

3. Cuber die length
4. RDF moisture content
5. Use of binder material

Twenty-seven trials were run during which the above five parameters were adjusted and combined. The best results were obtained under the following condition:

1. RDF particle size at 90 percent passing a three-quarter inch screen
2. Cuber feed rate maintained at three to four tons per hour
3. Use of 13-inch straight sided dies
4. No attempt was made to add moisture in the cuber. Daily samples were taken and analyzed for moisture content
5. No use of binder material

More than 380 tons of d-RDF were produced during the trial program. Of that quantity, nearly 130 tons were shipped to the Milwaukee County Institutions' Power Plant and co-fired with coal. Production of d-RDF was terminated due to a mechanical failure of the cuber press wheel. Cuber component wear was much higher than anticipated.

The circumstances of this trial period indicate that cuber maintenance costs could exceed the value of d-RDF as a fuel. However, metallurgic changes in the press wheel and dies could reduce these costs to an acceptable level.

Feeding

Coal is normally fed through a screen into a hopper where a reciprocating feeder discharges the coal onto a moving belt. As the coal was conveyed upward to a moveable tripper and into selected coal bunkers, it readily became apparent that the tendency of the d-RDF material to "bridge" in the hopper and retract onto the reciprocating feeder made it impractical to co-feed coal and d-RDF without some means of preventing retraction of d-RDF.

A number of modifications were made to produce a more positive feed of d-RDF including adjustment of the length and rate of stroke of the pneumatic ram to provide control of the d-RDF feed rate.

With such modifications, a coal/d-RDF mixture in which the energy from refuse approached 15 percent of the total boiler energy input was achieved. This was not as high as anticipated for the project, but it was the maximum that could be achieved without major modifications to the power plant coal feed equipment.

Although the coal and d-RDF appeared to be well mixed on the conveyer belts, there was a tendency for the two fuels to demix in a layered manner as it fell into the bunkers. This was, perhaps, due to the difference in density of the two fuels. Thus, throughout the test program substantial variations in coal to d-RDF ratios were experienced at the bunker outlets.

Combustion and Steam Generation

Fuel from the bunkers is fed through two gravimetric weigh scales to two conical chutes. Each conical chute feeds two Hoffman spreader stokers. There are four spreaders for each of three identical coal fired furnaces and boilers in the Institutions' Power Plant. Boiler #3 was selected for the coal/d-RDF cube firing test.

The generated steam is used to drive two back-pressure turbine generators, one condensing turbine generator, chiller system auxiliaries, and other plant auxiliaries. Thus, the County Institutions' Power Plant is a co-generation system producing electrical energy, high and low pressure heating steam, and chilled water.

Gas cleaning for each coal-fired boiler is accomplished by a mechanical collector followed by a three-field electrostatic precipitator. The standard for particulate emissions as established by the Wisconsin Department of Natural Resources for the Institutions' boilers is 0.15 pounds of particulate emission per million Btus of heat input.

Boiler Operation

In operation, the coal/d-RDF mixture fed reasonably well through the conical chutes and the spreader stoker feeders. On occasion, however, manual rodding was required when higher percentages of d-RDF were experienced. By the time fuel reached the boilers very little of the refuse could be characterized as "cubed." Throughout the fuel-handling system there was progressive breakdown of the densified material. Once in the furnace, the d-RDF burned well. The coal/d-RDF mixture did tend to clinker more than coal alone. This entailed constant operator attention.

Steaming ability was limited when d-RDF was fired along with coal. The plant operators had devised a system to increase the feeder stroke in order to maximize steam generation rates with poor quality fuel. Even with the maximum extended stroke, the test boiler was not able to achieve steam generation rates that had been easily attained when firing coal alone. This was due to the volumetric limitations of the spreader feeder equipment when firing the less dense coal/d-RDF mixture.

When d-RDF fuel was bunkered with coal, the refuse material could be handled without incurring housekeeping problems in the boiler plant. Some minor odor problems were reported by operating personnel.

Test Program

A comprehensive test program was developed to establish the impact of burning d-RDF on boiler performance, stack emissions, and the leachate potential of the ash residues.

The test program was accomplished in two phases. First, base-line data were established when firing coal alone. Then a mixture of coal and d-RDF was fired continuously for a period of eight days. A schematic depicting the parameters measured for coal and the coal/d-RDF mixture is shown in Figure 1.

At all times during the test program two coal fired boilers were operated continuously. Test boiler, Unit #3, was held at constant load while the second boiler, Unit #2, automatically adjusted for varying load requirements of the Institutions' co-generation system.

The performance test showed a difference in efficiency between coal runs and coal/d-RDF mixture runs of 2.0 percent, largely due to the higher moisture and hydrogen content of the refuse.

A summary of stack emissions is presented in Table 1.

The quantity of particulate entering the precipitator was somewhat less from the coal/d-RDF mixture than when coal was fired alone. This is partly due to reduced rate of steam generation during the period when the coal/d-RDF mixture was fired. In all measures, the performance met applicable emission standards.

As a whole, emission levels of various trace metals are low. There was an approximate 10-fold increase in cadmium emissions when burning a coal/d-RDF mixture. Since the average weight of d-RDF in the fuel mixture was just over 20 percent, more tests are needed at higher d-RDF fuel mixtures in order to draw any specific conclusions.

Opacity measured by visual observations was reported to be less than five percent in all cases. However, visual emissions from boiler Unit #3 when firing the coal/d-RDF mixture were virtually undetectable, whereas visual emission

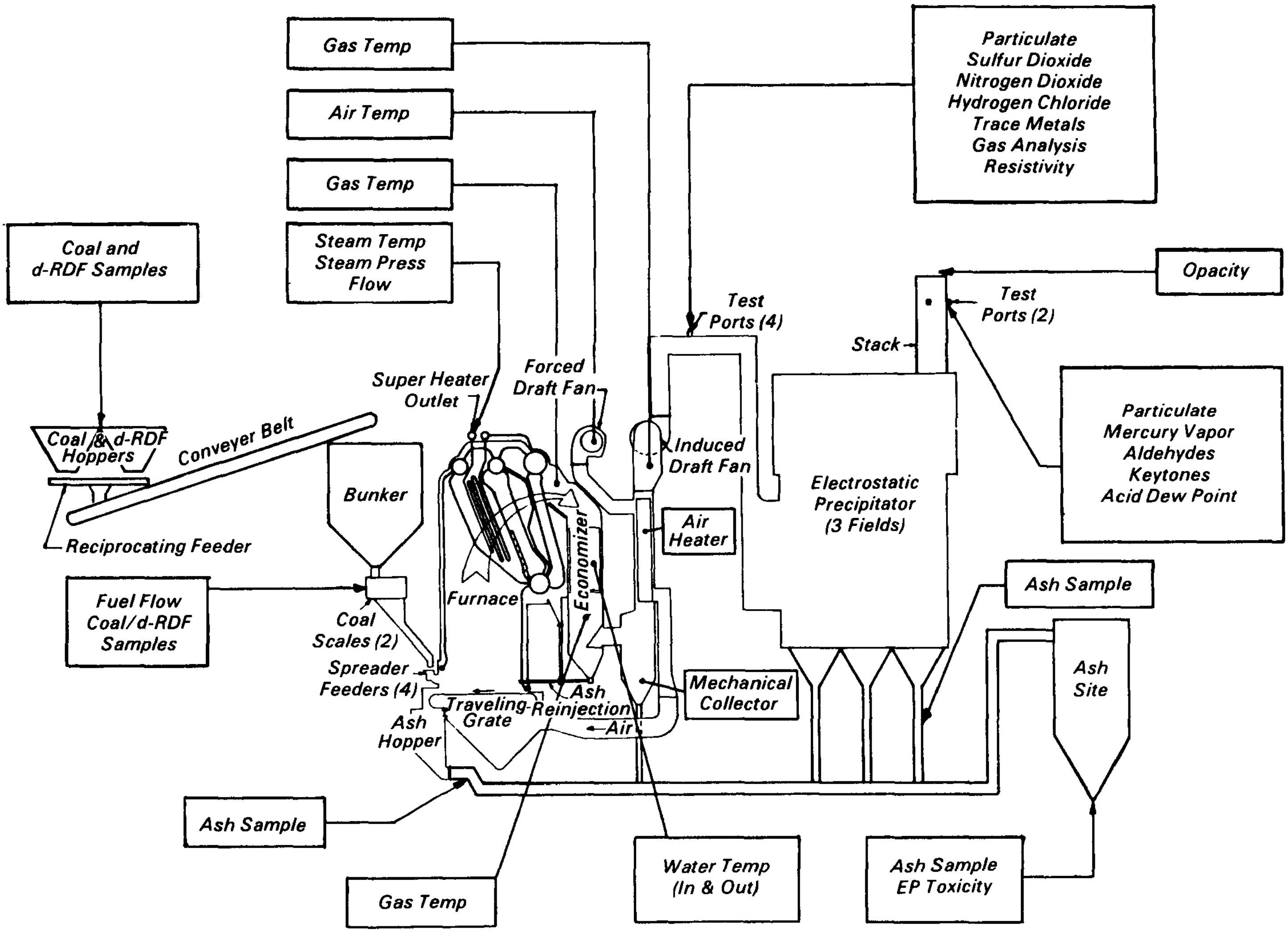

Figure 1. *Schematic of test program.*

Table 1. Stack Emissions

	Coal	*Coal/d-RDF Mixture*
*Particulate**	*0.090*	*0.063*
*Sulfur Dioxide**	*2.96*	*2.97*
*Nitrogen Dioxide**	*0.44*	*0.49*
*Hydrogen Chloride**	*0.063*	*0.206*
*Mercury Vapor**	*<0.0000001*	*0.0000005*
*Aldehydes**	*<0.001*	*0.004*
*Ketones**	*0.040*	*0.048*
Acid Dew Point, °F	*295*	*305*
Trace Metals†		
Lead	*0.0047*	*0.0077*
Cadmium	*0.0006*	*0.0058*
Zinc	*0.0286*	*0.0242*
Mercury	*0.00002*	*<0.00001*
Beryllium	*0.00004*	*0.00006*

**Measured in lbs/10[6] Btus.*
†All trace metals are measured in lbs/hr.

from boiler Unit #2, which fired coal alone, were light but nevertheless detectable.

The difference in acid dew point analysis of 295°F for coal fired runs and 300°F for the coal/d-RDF runs, is not considered significant.

Although sulfur dioxide emissions were expected to be lower when firing a mixture of coal and low sulfur d-RDF, average results from the test runs remained constant for both fuels.

The type of fuel fired appeared to have no significant impact on the level of nitrogen dioxide produced.

As expected, the level of hydrogen chloride emitted increased significantly when firing a coal/d-RDF mixture. However, the increase is greater than might have been expected if chlorine levels in the two fuels are compared.

Inlet particulate to the precipitators was analyzed for resistivity and breakdown voltage. No conclusions can be drawn from the results obtained.

Combined ash samples from the ash silo were analyzed for extraction procedure (EP) toxicity. The results suggest that concentrations of contaminants for EP toxicity characteristics, measured in mgs/l, decrease when d-RDF is fired with coal. It also appears that EP toxicity is likely to be less than EPA's maximum allowable concentrations for boilers firing a coal/d-RDF mixture.

Conclusions

1. The modified John Deere 390 Stationary Cuber was not able to make cubes of refuse derived fuel of sufficient density and durability to remain intact during transportation and handling.
2. The Cuber experienced a wear rate and deterioration of parts that rendered it unsuitable for extended use to produce d-RDF. Improved metallurgy is needed to reduce wear rates to an acceptable level.
3. The d-RDF/coal mixture presented difficult handling and mixing problems with the existing power plant equipment and resulted in a non-uniform mixture reaching the stoker. This caused erratic feeding of the refuse mixture with adverse impact on the boiler steaming rate. An improved design is needed to achieve and maintain a uniform coal/d-RDF mixture.
4. The low density d-RDF, when mixed with coal at 20 to 25 percent d-RDF by weight, increased the specific volume of fuel to the point that the feeders on the test boiler had difficulty maintaining 70 percent of rated boiler load.
5. The coal/d-RDF mixture developed clinkers on the stoker grate more readily than coal.
6. At the firing rate tested (20 to 25 percent d-RDF by weight), the d-RDF produced no adverse effect on stack emissions or EP toxicity when compared to coal alone.
7. Additional developmental work is required to reduce the high cost of d-RDF cube production to a level competitive with the cost of coal.
8. Additional developmental work is necessary to improve d-RDF density for enhanced handling and firing of a coal/d-RDF mixture in conventional coal-handling and firing equipment.

R. S. Hecklinger is with Charles R. Velzy Associates, Inc., Armonk, NY 10504; and F. R. Rehm is with County of Milwaukee, Milwaukee, WI 53233.
***Michael I. Black** is the EPA Project Officer (see below).*
The complete report, entitled "Coal/d-RDF Co-Firing Project, Milwaukee County, Wisconsin," (Order No. PB 86-135 381/AS; Cost: $11.95, 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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