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FINAL TECHNICAL REPORT
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Project Title: **GASIFICATION COPROCESSING OF ILLINOIS BASIN COAL
AND RDF: PHASE II**

ICCI Project Number: 96-1/4.1B-1
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ABSTRACT

The project objective was to investigate the gasification potential of coprocessing refuse-derived fuel (RDF) with high-sulfur Illinois Basin coal. The project addressed two critical issues confronting the Illinois Basin: identifying methods of increasing the market share of Illinois Basin coals and finding ways to utilize municipal solid waste (MSW). MSW is a major solid waste whose disposal poses long-term problems of groundwater contamination and methane emissions. MSW is routinely processed to recover plastics, aluminum, and other metals as part of state-mandated recycling requirements. Following removal of other noncombustibles, the particle size of the remaining material, which consists primarily of paper and food products, is reduced by shredding. The resulting material, termed refuse-derived fuel (RDF) fluff, has a calorific value of ~6000 Btu/lb and is a significant and recurring energy resource. Landfill disposal has become increasingly expensive, entailing tipping fees of \$30-\$40/ton of MSW. Collection of these fees could reduce the cost of gasification feedstocks when RDF is coprocessed with Illinois Basin coals. This, in turn, is likely to provide economic incentives for using these high-sulfur coals for gasification.

The technical viability of size reduction of RDF fluff—an essential preparatory step prior to making a gasifier feed slurry—was confirmed. Initially, the maximum solids loading (coal plus RDF fluff) for a slurry with a viscosity of 1000 cP was determined at 55%. Subsequently, by using additives and optimizing the test conditions, the slurry solids loading was increased to 60%. The energy consumption involved in coal/RDF grinding was also reduced.

During Phase II, the coal/RDF grinding unit operation was scaled up from 5 lb/h to 50 lb/h, and a pilot plant comprising a continuous wet grinding rod mill system was commissioned and used to prepare 200-lb batches of coal/RDF slurry for testing in a research gasifier. Gasification testing was conducted for three slurry samples: an available coal/water test sample, an Illinois coal/water sample, and an Illinois coal/water/RDF sample. These tests were conducted using a 0.5 million Btu/h gasifier operated in an oxygen-blown mode capable of processing 30-40 lb/h feed. Following initial problems with atomization, the tests were completed successfully. A high carbon conversion was achieved with the Illinois coal slurry. Carbon conversion for the coal/RDF sample was somewhat lower, primarily due to the atomization problems experienced with the laboratory gasifier due to the small size of the lines and nozzles. Analysis of the product gas confirmed that no furans were present.

EXECUTIVE SUMMARY

The project objective was to investigate the potential for gasification coprocessing of refuse-derived fuel (RDF) with high-sulfur Illinois Basin coal. The project addressed two critical issues confronting the Illinois Basin: identifying methods of increasing the market share of Illinois Basin coals and finding a way to utilize the increasing quantities of waste generated in metropolitan areas of the coal producing region. Municipal solid waste (MSW), which consists of household, commercial, and institutional wastes, is a major solid waste whose disposal poses long-term problems of groundwater contamination and methane emissions. The total quantity of MSW generated in the United States in 1990 is estimated at 160-200 million tons, making it a significant and recurring energy resource. Landfill disposal has become increasingly expensive, entailing tipping fees of \$30-\$40/ton of MSW. Reduction of the total volume of MSW and its utilization have therefore become high-priority issues. MSW is routinely processed to recover plastics, aluminum, and other metals as part of state-mandated recycling requirements using standard off-the-shelf technology. Following removal of other noncombustibles, the particle size of the remaining materials is reduced by shredding. The resulting material is termed refuse-derived fuel (RDF) fluff, and has an as-received calorific value of 5,900-6,500 Btu/lb. For ease of handling this material is also densified by pelletization with or without binders to produce densified RDF (dRDF).

Combustion of MSW or RDF by themselves or along with coal in boilers tends to cause boiler corrosion and slagging problems, in addition to releasing emissions of mercury, hydrochloric acid gas, PCBs, PAHs, dioxins, and furans generated from the combustion of certain components in these materials in an oxidizing environment and in the presence of chlorine. In gasification technology, on the other hand, the high-temperature, high-pressure partial oxidation conditions in the gasifier are an ideal environment for conversion of nearly all carbonaceous materials and destruction of most organic species. The economic incentive for the proposed approach relies on the revenues accrued from collecting tipping fees for accepting MSW. The process can be expected to lower gasifier fuel costs, thereby lowering electricity costs. It is anticipated that coprocessing Illinois Basin coals with RDF will:

- ▶ Reduce gasification plant levelized costs by reducing net fuel costs
- ▶ Demonstrate a new application for Illinois Basin coals, thus increasing their market share
- ▶ Utilize a major recurring solid waste, thus reducing the volume of waste going to landfills, and
- ▶ Eliminate the twofold problem of SO₂ emissions resulting from combustion of high-sulfur coals and emissions of mercury, hydrochloric acid gas, PCBs, PAHs, dioxins, and furans resulting from combustion of certain components in RDF.

The specific issues addressed in our study relating to the preparation and characteristics of the coal/RDF gasifier feed slurry were its: (i) rheology, (ii) energy content, (iii) C/H/O ratio, (iv) gasification characteristics, and (v) impact of the tipping fee on energy costs. However, following initial problems with size reduction, it was concluded that grinding the RDF both in its as-produced form (RDF fluff) and after briquetting (densified RDF or dRDF) under high attrition conditions was the most suitable method of size reduction. This was established through exploratory bench-scale tests using various dry and wet grinding techniques. It was established that the particle size of the RDF needs to be reduced from nominal 1" x 1" strips to minus 20 mesh prior to wet grinding of coal and slurry preparation.

Two coal/RDF mixtures with viscosity levels at <1000 cP were determined to be pumpable. The specifications of these slurries were as follows:

- ▶ Coal/RDF/water at 50/5/45 or 55% total solids containing 9.1% RDF
- ▶ Coal/RDF/water at 55/5/40 or 60% total solids containing 8.3% RDF.

The viscosity of the 55% solids slurry was measured at 578 cP and that of the 60% solids slurry fluctuated between 825-1486 cP. On the one hand, efforts to achieve a higher RDF content in the slurry and improved slurry characteristics tend to increase the costs of slurry preparation; on the other, increasing the RDF content reduces overall slurry costs due to the tipping fees involved. After deliberation, a coal/RDF/water slurry in the proportions 50/5/40, i.e., containing 8.33% RDF as part of the total solids on a dry basis was selected for further economic analysis. At a calorific value of 7318 Btu/lb, this slurry is comparable with a typical 65% solids Illinois coal slurry containing 8,190 Btu/lb.

Confirmatory tests indicated that a slurry pH of 8-9 and 2-3 minutes of high-shear conditioning help lower viscosity. The required additive dosage is 10 lb/ton of dry solids to achieve a slurry viscosity of ~1000 cP for a 60% solids slurry. Following slurry optimization, two large batches of slurry were prepared, one containing no RDF (control sample) and the other containing the maximum sustainable level of RDF (8.33% of the total solids) which maintained viscosity below 1000 cP. The costs of slurry preparation were estimated and used to evaluate the respective impacts of (i) tipping fees, (ii) the RDF content in the slurry, and (iii) the slurry energy content on the economics of gasification coprocessing of Illinois Basin coal with RDF. In addition, the impact of the RDF component on the resulting gasifier slag was investigated with respect to its utilization potential.

The economic impact of using RDF was studied for a 233-MW IGCC plant that accepts and processes 400 tons/day of MSW from local communities to produce 200 tons/day of RDF. It is assumed that the gasifier receives a tipping fee of \$35/ton of MSW. Recyclables such as aluminum, glass, plastics, and metals are sold for an estimated \$17,640/day. The coal feed (as a 65% solids slurry) is assumed at 1,000 tons/day per 100 MW of output. Coal is delivered at the site for \$30/ton. Also, a 3% penalty on energy is applied for using slurries with a higher water or lower energy content. Based on these assumptions, it was estimated that use of a coal/RDF slurry feed would reduce costs by \$1.98 million annually.

Gasification testing was initiated using a slurry sample available at the test laboratory. Initial problems experienced with the atomizer and with on-line analysis were rectified. Testing with the Illinois coal water slurry was then conducted satisfactorily. Subsequently, a coal/RDF slurry containing 8.33% RDF on a dry basis (coal/RDF/water ratio of 55/5/40) was fired. Atomization of this slurry was not successful, so modifications were made in the pump and the pump line feeding the gasifier. However, because the clogging persisted, the slurry percent solids was gradually reduced from 60% to 51% but without success. A burner design allowing atomization with oxygen was then tested which worked satisfactorily. The gasification testing was then completed and the data analyzed.

The gas analysis components of interest are maximum levels of H₂ and CO and minimum levels of CO₂. Analysis of the tests with the Illinois coal/water slurry indicated 28.6% H₂, 33.7% CO, and 37.4% CO₂. This compares well with the results for the coal/RDF slurry which were 24.1% H₂, 21.6% CO, and 52.6% CO₂. Carbon conversion for the Illinois coal/water slurry was 79.8% and for the coal/RDF slurry it was 76.7%. The lower rate of carbon conversion and the resulting reduced emission of CO are both due to relatively poor atomization of the coal/RDF slurry, which requires further optimization.

Gas samples were analyzed for furans and dioxins. The results confirm that these materials were not found in any of the slurry samples tested.

The remainder of this report contains proprietary information and is not available for distribution except to the sponsor(s) of this project.