United States
Environmental Protection
Agency

Research and Development

Air and Energy Engineering
Research Laboratory
Research Triangle Park, NC 27711

EPA/600/SR-93/170 December 1993

EPA

Project Summary

Biomass Gasification Pilot Plant Study

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A gasification pilot program carried out at General Electric's (GE's) Research and Development Center, using two biomass feedstocks: bagasse pellets and wood chips. The object of the testing was to determine the properties of biomass product gas and its suitability as a fuel for gas-turbine-based power generation cycles. The feedstocks were gasified at a feed rate of about 1 ton/hr*, using GE's pressurized, fixed-bed gasifier and a single stage of cyclone particulate removal, operating at 538°C. The biomass product gas was analyzed for chemical composition, particulate loading, fuel-bound nitrogen (FBN) levels, and sulfur and alkali metal content.

Both feedstocks gasified easily. The composition and heating value of the biomass product gas were compatible with gas turbine combustion requirements. However, the particulate removal performance of the pilot facility single-stage cyclone did not meet turbine specifications. In addition, alkali metal compounds in the particulate matter (at 538°C) carried over from the gasifier exceeded turbine limits. Improved particulate removal technology, designed specifically for biomass feedstock characteristics, could meet turbine requirements for both particulate and alkali loading. FBN compounds were also measured since they can be converted to nitrogen oxides (NO_x) during combustion in a gas turbine. Since this conversion is highly dependent on gas turbine combustor design, no firm conclusions regarding NO_x production can be reached without actual combustion testing.

This Project Summary was developed by the U.S. EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, 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

The gasification performance of two biomass feedstocks—wood chips and bagasse—was evaluated in the pilot Integrated Gasification Combined Cycle (IGCC) facility located at GE's Research and Development Center in Schenectady, NY. The overall objective of this program was to evaluate biomass as a feedstock for a biomass gasification/gas turbine system, which is a potentially cost-effective and highly efficient approach for using forest and agricultural wastes for power generation. Specific objectives were to measure gas composition and to determine whether the product gas would meet gas turbine requirements.

The pilot IGCC facility consists of a pressurized, fixed-bed gasifier with a nominal operating pressure of 20 atm and a hot gas cleanup system, consisting of a high-temperature cyclone, a solid-sorbent desulfurization system, and a polishing cyclone. The gasifier has a nominal capacity for coal gasification of 1 ton/hr. Since desulfurization is not an issue for

*Readers more familiar with metric units may use the following factors to convert to that system: 1 ton = 907 kg, and 1 atm = 98 kPa.

the biomass feedstocks evaluated, only the gasifier and high-temperature cyclone were used. The product gas was flared.

Because the pilot gasifier and its associated fuel feeding system were designed for operation on coal, the issue of feeding of biomass, with its lower density and different flow properties, was addressed before gasification testing. Bagasse, which was supplied as small cylindrical pellets, was found to feed easily with some modifications to the fuel feeding equipment. However, it was necessary to evaluate several wood chip samples before one was found that could be fed at the required feed rate.

A total of 42.5 tons of bagasse was gasified during a 32-hr test, and 83.8 tons of wood chips were gasified in an 81-hr test. These quantities of fuel represented the total fuel available to the program. Wood chips were provided by the Vermont Department of Public Service. The bagasse pellets were obtained from the Winrock International Institute for Agricultural Development.

Both biomass fuels gasified readily. Their reactivity was higher than that for coal. Gasification capacities of both fuels were limited by feed rate or system capacity, and not by gasification kinetics. Product gas compositions for both biomass feedstocks indicated that they would have combustion characteristics compatible with gas turbine combustor requirements. However, particulate removal performance of the single cyclone was inadequate to meet fuel contaminant specifications. In particular, alkali metals, which are present in the fine particulate material carried over from the gasifier and which cause hot corrosion on gas turbine hot gas path components, were present at levels well in excess of turbine specification limits. The low density of particulates and their poor flow properties, which made removal from the cyclone difficult, caused the cyclone to perform poorly. This result was not unexpected since the cyclone had been designed for removing contaminants from coal gas. In order to achieve contaminant levels consistent with gas turbine requirements, it will be necessary to improve particulate removal. This improvement is well within the state-of-the-art of particulate cleanup technology.

A second class of contaminant measured was fuel-bound nitrogen (FBN) compounds. Typical of these are ammonia, cyanides, and nitrogen-containing organic compounds. A large fraction of FBN will be converted to nitrogen oxides (NO_x) during combustion in conventional gas turbine combustors. Thus, when stringent NO_x emissions requirements (< 10 ppm) are in effect, it may be necessary to consider alternative approaches to reducing the level of this pollutant. One potential approach is to utilize advanced combustion techniques such as "rich-quench-lean" to reduce the conversion of FBN. This technology is still in an early stage of development and will require significant effort to bring it to a suitable stage of commercial readiness. A second approach is to cool the fuel gas and "scrub" the gas with water to remove the FBN compounds. This approach lowers the overall plant efficiency, reduces the heating value of the fuel, and creates an environmental disposal problem associated with the disposal of the "scrub" water. Other approaches include the use of commercially available selective catalytic reduction (SCR) technology to reduce the NO_x level in the exhaust gas. Note that FBN production is a strong function of both the feedstock and gasifier, with higher temperature gasifiers such as fluidized and entrained gasifiers producing less FBN than fixed-bed gasifiers. A system tradeoff study would help determine the best system level approach to NO_x reduction by identifying the capital equipment cost differences and the associated plant efficiency impact on the overall system design.

The tests at the GE-CRD pilot plant have demonstrated the successful gasification of biomass and the general suitability of biomass fuel gas for use in a gas turbine. Areas of possible future development include improved particulate removal, improved low NO_x combustion, and pre- and post-gas cleanup.

These accomplishments represent a key step in the overall development of a Biomass-IGCC power generation system.

☆U.S. GOVERNMENT PRINTING OFFICE: 1994 - 550-067/80140

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The complete report, entitled "Biomass Gasification Pilot Plant Study," (Order No. PB94-114766/AS; Cost: $27.00; subject to change) will be available only from:
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