MICROGASIFICATION TECHNOLOGY

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ABSTRACT

The Energy & Environmental Research Center (EERC) and commercial partners are providing distributed energy production from biomass through a commercial gasification technology. A project is under way in Grand Forks, North Dakota, to demonstrate power production from wood waste produced by a building products manufacturer. This paper describes the project, the economics, and the robustness of the technology. Microgasification is a technology that can be applied more economically than steam-based biomass combustion and offers the advantages of automation and low capital requirements. Microgasification includes a piston engine generator set driven by low-Btu gas produced from gasification of wood. The technology includes fuel preparation, a downdraft gasifier, gas cleaning, automated ash removal, and stoichiometric engine control. Proprietary developments have enabled the commercialization of the technology into a package that meets the demands of clients located in North America, where environmental permitting requirements can be strict and low maintenance is desired. The EERC has developed the microgasification product and is working in partnership to demonstrate the technology.

KEYWORDS: Biomass, Gasification, Small Power Systems

INTRODUCTION

The system is a downdraft biomass gasification technology employing venturi scrubbing and filtering of the gas for use in a piston engine or microturbine. Downdraft gasification was chosen for its ability to reduce the tar content of the product gas. The expected total gas contaminant concentration is 1000 ppm vs. the 100,000 ppm seen in updraft and fluid-bed gasification (1). A 100-kW prototype power system is shown in Figures 1 and 2. The process flow is as follows. Fuel is automatically conveyed to the top of the reactor and metered using a robust agricultural platform feeder. The material is gasified in the reactor and cleaned with a venturi scrubber, which is well known for its capacity to remove particulate in the submicron range (1). The gas is then passed through a series of filters. The first is a coarse filter to coalesce residual water, oil, and heavy tar.

EERC DS22722.CDR

Figure 1. Portable gasification system in operation at the EERC.

EERC DS28440.CDR

Figure 2. Portable gasification system and fuel.

The second is a rejuvenating active sawdust filter, the third a similar passive filter, and the last a fabric filter. The Energy & Environmental Research Center (EERC) has measured gas quality upstream of the last filter at <250ppm tar and <50 ppm particulate (2). The gas, normally 130 Btu/scf, is then fed to the prime mover. Systems operating spark ignition engines have been documented in the literature (3, 4). What remains unknown is the long-term performance of the engines firing low-Btu gas.

PROCESS PERFORMANCE

A conservative example of the mass and energy balance is provided in Figure 3. The overall electrical production efficiency is 12%, assuming some of the syngas is utilized for purposes other than electrical power production. Although the efficiency is only ½ that of a large power plant, the economics are well justified. The expected availability is 85%, which can produce 372,300 kWh per year. The power will be sold at $0.04/kWh or $14,892 per year. Wood waste from the building materials operation is a liability; however, a zero value is applied. The capital cost to install the system is $75,000, providing a simple payback of 5 years, excluding operation costs. Operation costs are expected to be less than $5000 per year, as the system will be automated and average approximately 15 minutes of maintenance per 8-hour shift.

The key benefits for implementation of a biomass gasification power generator are as follows:

- Completely automated to minimize operational costs
- Utilizes on-site, low-value by-products and wastes to produce value-added products
- Distributed generation of electricity
- Small footprint enables use in portable applications
- Potential chemical or liquid fuels production
- Packaged to meet the strictest environmental requirements and permitting
- Inherently safe design, low pressure, meets OSHA and NEC standards, computer-monitored, and logic-based feedback interface
- Simplified maintenance and recycled process consumables

Expected emissions are shown in Table 1 and are based on values completed from a feasibility study conducted by the EERC for permitting in nonattainment areas (5), which represents the strictest federal requirements for air pollutants. The 50-kW plant in Grand Forks, North Dakota, is federally exempt, as emissions are well below 10 tons/yr.

PROJECT STATUS

As of January 2007, the EERC is in the procurement and construction phase for the 50-kW gasification system. Figure 4 provides an example layout of the process, and Figure 5 depicts the project site and feedstock. The project is fully funded and will be operated to collect performance

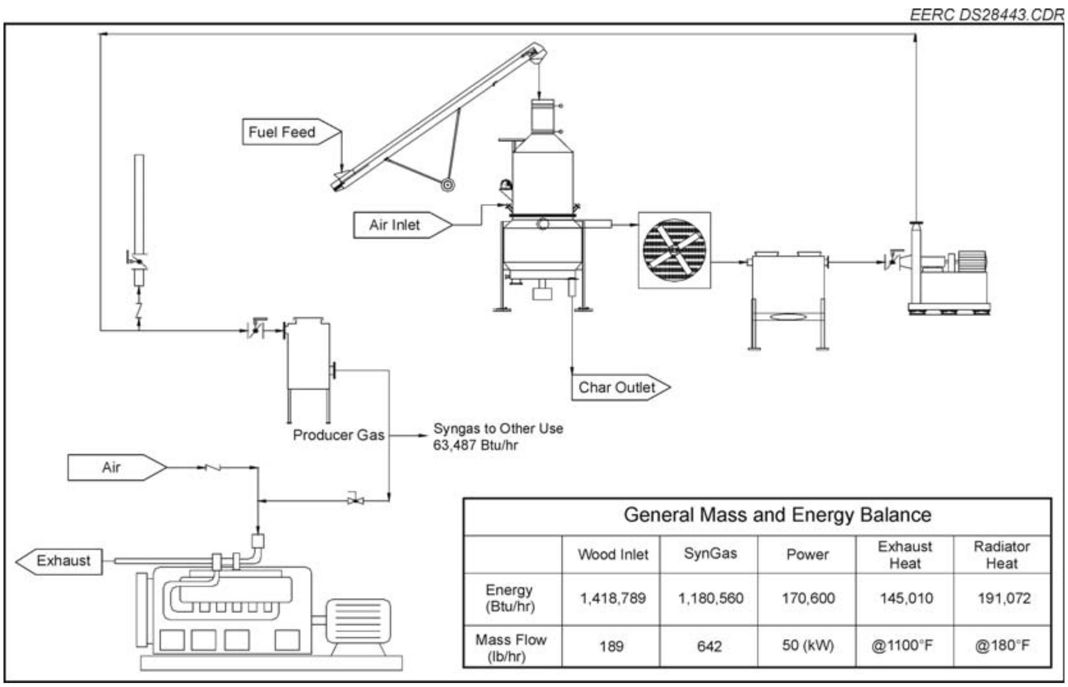

Figure 3. Mass and energy balance.

Table 1. Process Emissions

Pollutant, tons/yr	Engine	Charcoal Burner	Flare	Total Process
Particulate	0.12	0.35	0.098	0.568
Sulfur Dioxide	1.1	0.027	trace	1.127
Nitrogen Oxide	0.48	0.23	0.0001	0.710
Carbon Monoxide	0.29	0.64	0.029	0.959

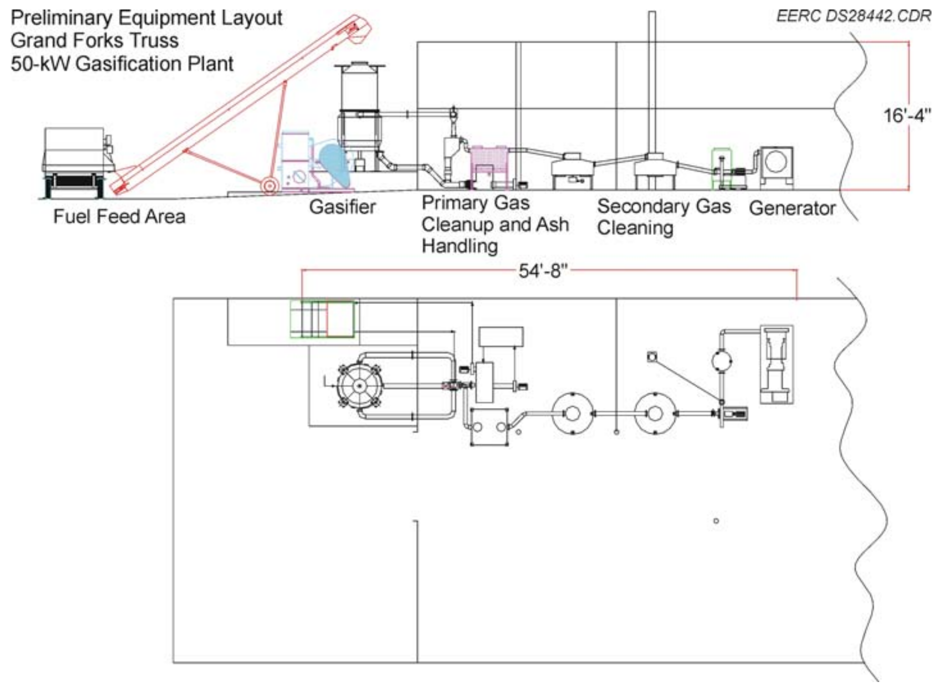

Figure 4. Plant layout.

Figure 5. Project site.

data through the last quarter of 2007. The Grand Forks Truss Company, the building products manufacturer providing the wood waste for this project, will continue commercial operation of the process in the future.

RESULTS

The EERC has processed various fuels in the portable gasifier and generated process data to support expected performance. The data include continuous operation recording maintenance, temperatures, pressures, flow rates, gas composition, and gas contamination. Test runs were completed firing 1–2 in. wood chips of both hardwood and softwood (6). The wood chips provided for robust operation over a 100-hour period. Gas quality was 100–130 Btu/scf, and contaminants of tar and particulate averaged less than 200 ppm and 50 ppm respectively. Testing was also completed for a coarse pellet wood in the form of 1-in. wood cubes (7). The wood cubes provided an extremely consistent product gas and temperature profile. Gas quality was similar to that of the wood chips, and contaminants were lower. Testing was conducted firing grass seed residue (8), which comprises the screenings from grass seed processing. Gas quality over 130 Btu/scf was obtained; however, contaminant levels were higher. The fuel consisted of very small particles, which tended to sift through the gasifier grate. Modifications would be required to handle fuels with particle sizes smaller than wood chips and sawdust. The most recent testing (9) was conducted on dry distillers grains (DDG), a residue produced from ethanol processing. The performance was similar to that of previous tests; however, modifications were completed to improve the gasifier grate and prevent sifting of the fine material. The grate modifications proved successful, and gasification performance met specifications by providing 130 Btu/scf gas. This testing has provided a significant level of experience for system operation and has led to the development of proprietary methods for charcoal removal, control of liquids, coupling to engine generators, and process control.

CONCLUSION

The development of biomass gasification energy systems is significant for the utilization of residual fuels. The production of electricity is a near-term viability with positive economics. Capital costs can be expected in the \$1000/kW to \$3000/kW range depending on the scale, and application of the technology is most feasible below 1MWe. The commercial development of power plants will have a significant impact on distributed generation and will eventually lead to applications in gas-to-liquids technology. The project implementation in Grand Forks will provide a first commercial experience and become the basis for future projects.

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