Cost savings through close-coupled gasification and combustion of biomass

Robert E. Austin, III*
*Duke Engineering & Services, P.O. Box 1004, Charlotte, North Carolina, USA 28201-1004
Fax: (704) 382-2778; reaustin@dukeengineering.com

Introduction

The cost of everything always seems to be rising. In particular, landfill costs and energy costs. Yet many of the things thrown away have valuable stored energy that can be used to offset the burning of fossil fuels for energy. Gasifying and then combusting the waste converts the waste to a hot gas stream, whose heat can then be used for process heating, steam generation, etc.

Landfill costs are rising in this country. Costs above $30 a ton are not uncommon. Energy costs are likewise rising: natural gas prices have more than doubled in the past year. Some customers are paying over $5.00 per million British Thermal Units (MMBTU) for natural gas where they were paying less than $2.50 per MMBTU a short time ago. Other fuel prices have likewise risen. Regulators typically discourage the combustion of less expensive fuels than natural gas, such as coal and residual fuel oil, because of environmental concerns. However, the convergence of high waste disposal costs and high energy costs makes turning the waste into energy very economical…

For example, suppose a facility produces 5,000 tons per year of pallets that have to be disposed of. Landfill disposal at $30 per ton would cost $150,000 per year. However, these pallets contain approximately 60,000 MMBTU of energy. To produce this much heat energy firing natural gas would cost at least $240,000 per year (at only $4.00 per MMBTU). By using the pallets for their heat value, an annual cost savings of $390,000 in avoided landfill and energy costs can be realized. This savings does not count savings from not having to haul the pallets off, which could be another $33,000 or more.

Technology & Applications

A traditional wood-fired grate boiler may not be the best solution for burning waste due to environmental restrictions, however. Gasifier technology offers the opportunity to combust the waste efficiently while maintaining low emissions. One possible technology solution is a lineal hearth gasifier close coupled to a cycloburner combustor unit that can burn the waste much more efficiently than traditional combustion technologies. Other gasifier technologies include vertical fixed and fluid bed gasifiers.

By burning the waste in an oxygen-starved atmosphere in the gasification side of the unit, the volatile chemicals are converted to carbon monoxide (CO) and hydrogen gas (H_2). Most of the ash stays in the gasifier section and is drawn off by an ash augur.

In a close-coupled gasifier, the gaseous products, called syngas, are injected into a cyclone burner. In the cyclone burner, combustion air is injected to allow full combustion and the gas is burned. The cyclone burner swirls the gas in two vortices, which spins fly ash out and allows for a long residence time to allow complete combustion. The result is high combustion efficiencies with a high temperature (up to 2,600?F) and low particulate outlet gas stream. By immediately combusting the syngas after gasification, high system thermal efficiency is achieved.

An important point is that a unit of this type does not require co-firing (the simultaneous combustion of another fuel such as natural gas with the waste). The only fossil fuel required on the unit is to start the process initially. Once started, the unit runs entirely on the waste fuel fed to it without any supplemental firing of fossil fuel.

This unit can take the place of a fossil fuel fired burner in any system. In some systems, the only change necessary is to tie the hot gas outlet into the process requiring the heat. For example, a municipality has successfully disposed of both wastewater treatment sludge and wood waste from its landfill using a system incorporating one of these units. Wood waste that was previously filling up the landfill is ground in a tub grinder and fired in the gasifier / combustor. The hot process gas is used directly to dry wastewater treatment plant sludge in a rotary dryer. The final dried sludge product is marketed as fertilizer.

Another use for the unit is the direct generation of steam for an industrial process. The process heat from the gasifier / combustor takes the place of a solid fuel burner in a traditional simple Rankine steam cycle. This facility might be appropriate for a large waste stream for cogeneration of heat and electricity. For example, a 70,000 ton per year waste stream (at an average 4,500 BTU per pound) would produce about 2 MW of electricity and an average of 50,000 lb/hr of steam for process use (assuming 8,000 hours per year of operation). For a smaller facility, or a user with high fuel rates but not high electricity rates (fairly typical in the Southeastern U.S.), the turbine-generator set might not be needed.

Emissions typically are low, but the exact nature depends on the chemical content of the waste stream. Typical emissions from the combustion of most materials are relatively low in particulate and carbon monoxide: the particulate is spun out in the cyclone burner and gasifier units are *designed* to burn the carbon monoxide. Nitrous oxide is normally lower than other combustion techniques due to the staged nature of the combustion process. Tests with fuels with sulfur have shown a tendency for the sulfur to remain in the ash rather than be present in the flue gas as sulfur oxides. Of course, with the cost savings from avoiding landfills and fossil fuel purchase, emissions treatment equipment, if necessary at all, can usually be economically justified.

In order to determine if a facility is a candidate for this technology, the first step is to quantify the waste stream. The amount of waste produced on a per annum basis and a waste fuel analysis is required to judge the preliminary economics. Waste fuel analysis at a minimum should include testing for heating value, moisture and ash content. Traditionally, the technology has been used to burn biosolids, but certain waste chemicals streams might also be gasified and combusted. It is also necessary to know how much heat or electricity could be economically used at or near the site, and see how well this heat demand matches with the waste production. If there is a large wastewater sludge stream, then drying the sludge by firing the waste for heat might make economic sense. Every facility is unique. Even if a close coupled gasifier / combustor does not make economic sense, there are other gasification technologies available that might function.