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Gas Cleaning:

An Integral Step in Biomass Gasification

Advanced, integrated systems meet the challenges of commercial-scale operation.

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Technological frontiers in the alternative energy industry continue to widen in countries around the globe. As such, the exploitation of biomass as a source of energy has become the fastest-growing sector among a growing roster of energy solutions. Today, more energy is produced from various forms of biomass than from all wind, solar and geothermal applications combined. Much of the excitement has centered on the quest for biomass-based transportation fuels, primarily ethanol as an additive to ordinary gasoline. However, after a resounding entrance into full commercialization spurred by the support of governments and large traditional energy corporations, the still dominant corn-derived ethanol is slowly being abandoned in favor of non-food biomass sources. It is an effort to avoid the economic dislocations brought about by the corn-ethanol boom.

New biomass conversion technologies, such as bioengineering, biochemical fermentation and advanced catalytic enzymes, have only begun to supplant such first-generation biofuels. But, one of the more promising of these remains the often-overlooked suite of technologies associated with biomass gasification. While the basic underlying science behind gasification has been firmly established for decades, recent innovations in engineering, materials and designs assure its continued viability as a reliable, sustainable and efficient source of clean, renewable energy as well as biofuels and other chemicals.

There are several strong advantages offered by this technique, but two of them stand out in dramatic contrast:

1. Gasification systems can be configured to accept five tons per hour, or more, of a wide range of non-food organic waste feedstocks, each expressing varying characteristics and reactions. They can also be adapted to a similarly wide range of operating conditions, locations and scale of facilities compared to many single-source applications. Feedstocks can include almost any carbonaceous material, such as industrial, agricultural or forestry wastes, animal residues, and municipal solid waste.
2. The thermochemical conversion of biomass by gasification can yield far more than liquid transportation fuels. Versatile gasification systems can be engineered in several innovative ways to generate highly efficient electric and thermal energy, often in combination, and to produce a broad range of valuable industrial

chemicals and other by-products – all while minimizing pollutant loads on the environment.

One new waste-to-energy system combines legacy thermochemical engineering technologies with the latest advances in electronic controls. It is configured into a three-stage process that uses gasification to convert latent hydrocarbons in waste materials into versatile, clean-burning synthesis gas (syngas). The system is configured into three main components:

- A gasification reactor which produces high-quality syngas from biomass and other carbon-based materials.
- A wet electrostatic precipitator (WESP) to clean and condition the syngas – a critical prerequisite for downstream uses.
- An internal combustion piston engine/generator and heat recovery unit for producing combined heat and power (CHP).

In essence, gasification is simply the thermochemical recombination of existing carbon, hydrogen and oxygen atoms under elevated heat and pressure and restricted oxygen. Biomass feedstocks are introduced into one of the various reactor vessel designs, often a fixed-bed, downdraft system. The fuel descends through sequential reaction zones, from drying to pyrolysis/carbonization to partial oxidation at 2,200°F or higher. Hydrocarbon bonds are cracked, and in the reactor throat a syngas is formed, most tars are oxidized, and a residual char is formed, often accompanied by in an inert, vitreous slag.

The resulting syngas is a versatile, energy-rich fuel that can cleanly be combusted to generate CHP, or chemically transformed into an array of valuable industrial chemicals, liquid biofuels, hydrogen gas for fuel cells or petroleum refining, or other valuable co-products. Before cleaning, syngas typically contains highly combustible carbon monoxide (20 percent) and hydrogen (15 percent), plus ash and recoverable CO_2, nitrogen, acid gases, methane, ammonia, etc., depending on the feedstock.

The system uses a WESP, which cleans syngas to submicron particulate levels (PM0.25), normally required by engine/generators, gas turbines and other downstream equipment. A typical advanced WESP is designed around multistage ionizing rods with star-shaped discharge points in a square or hexagonal configuration. This unique geometry generates a corona field four to five times greater than other wet or dry ESPs. The corona induces a negative charge in submicron-size gas-stream particulates, propelling them toward grounded collection plates, where they adhere as cleaned gas is passed through. The plates are cleansed with recirculating water sprays, and particulate residues are extracted for further uses.

Because undesirable chemicals are more economically captured from smaller gas volumes before ultimate downstream combustion (and volumetric expansion), biomass gasification and cogeneration systems produce significantly less pollution than direct combustion techniques, yielding major savings in emission control costs.

Two key factors drive the successful commercialization of such systems. One is the implementation of advanced electronic controls that precisely regulate such process factors as temperature, turbulence, duration, corona, etc. This is especially critical when handling large volumes of heterogeneous municipal wastes, whose chemical composition can vary in real-time.

The second crucial factor is cleaning the syngas after it emerges from the gasifier. An effective, appropriate gas cleaning apparatus, WESP or otherwise, is a critical stage for the system – especially given the strict gas cleaning/conditioning requirements of the more advanced downstream processes, such as gas to liquid ethanol production.

Only by emphasizing and advancing the technology behind the gas-cleaning phase can biomass gasification engineers achieve broader commercial-scale implementation and gain wider acceptance in the alternative energy industry, along with the biochemical (microbial) and direct combustion processes now in vogue.

Gasification stands out as superior in many ways to the direct combustion of biomass that has become a commonly accepted interpretation of the term. A prime example is the contained burning of chipped or pelletized woody biomass to provide thermal energy and steam-generated electricity. A similar example is the mass-burn incineration of municipal solid waste for electric generation. While gasification converts up to 85 percent of fuel-borne carbon into clean-burning, energy-rich syngas, simple combustion facilities, even those using combined systems, lose much of that energy in flue gases and lost heat. Direct combustion of raw biomass emits greater volumes of pollutants and CO_2, while the gas produced by gasification is purged of pollutants and impurities before combustion – and at lower, more concentrated volumes and temperatures.

Gasification produces more concentrated kilowatts of energy per ton of fuel, with less pollution, virtual carbon neutrality, and lower total cost than many conventional or alternative processes. Further, in contrast to solar or wind energy platforms, biomass energy is a continuously available energy resource. Its reliability has been proven over years of continuous operation in facilities around the world. And because a typical gasification process is thermally self-sustaining once ignited, many gasification plants are able to continue functioning even during power outages, providing electricity to the grid when conventional power plants have gone down.

The economic viability of gasification is further enhanced by the decentralized nature of most waste-to-energy systems. Because the biomass-to-energy concept utilizes simpler, smaller-scale equipment and technologies, it is ideally suited to localized, "community energy" installations, located in proximity to both suppliers and users, thus reducing the economic and environmental costs of fuel transportation,

The system shown here features a fixed bed gasification vessel with drying, pyrolysis and gasification stages followed by a WESP to clean and condition the syngas, and an engine/generator producing CHP.

energy transmission and waste disposal.

With unique economic and environmental advantages, biomass gasification is certain to be a core technology for providing cost-effective solutions for an energy-hungry world that is facing several global-scale challenges:

- The relentless demand for new energy, fuels and chemical supplies by both rapidly developing and advanced societies.
- The complex logistics and rising costs of managing industrial, agricultural, forest, and municipal wastes, including toxic substances and environmentally damaging runoffs.
- The quest for sustainable energy, reduced CO_2 emissions, and independence from costly, unpredictable and ultimately unsustainable imported fossil fuels.
- Compliance with increasingly stringent pollution control mandates imposed by governments at every level.

Gasification can simply mean a simpler, easier, cheaper and cleaner way to turn a severe liability (unmanageable waste) into a bountiful asset (clean, sustainable energy, fuels and raw materials). Once the bridge to syngas is crossed, scientists and engineers are free to explore a virtually limitless range of secondary and tertiary reactions and processes. Some are firmly established, some newly emerging and others yet to be discovered.

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