8310 S. Valley Hwy Suite 285
Centennial, CO 80112
Phone: (303) 867-4247 · Fax: (844) 270-1821
www.TCGenergy.com

TCG Global Gasification System

Overview

TCG Global LLC (TCG) designs, builds, sells, owns, and operates gasification plants capable of converting any carbon-containing feedstock such as biomass, coal, petroleum coke, or municipal solid waste into synthesis gas (Syngas), consisting primarily of hydrogen (H) and carbon monoxide (CO). The Syngas produced by this gasification process is a clean, dry, flexible fuel which can be (1) burned to create heat and electricity, (2) passed through any of several different catalysts to produce fluids such as alcohols and transportation fuels, including clean burning diesel, or (3) used to supply pure hydrogen gas for multiple applications.

TCG is led by Mr. Marcus Wiley, a registered professional engineer with over 40 years of experience in mine engineering and management. He is also the co-owner of multiple bore-hole mining and gasification process patents, including all patent-protected technology utilized by TCG. Mr. Wiley is a PhD candidate at Colorado School of Mines in the field of clean coal technology.

A short video introduction to TCG technology can be found at: www.TCGenergy.com

TCG Gasification Process

Gasification is accomplished with heat, pressure, and the injection of ionized water. The basic chemical reaction used in gasification is $C + H_2O = CO + H_2$. This process begins in a heated, oxygen-starved environment (known as the pyrolysis chamber), which drives off moisture and volatile gases contained in the feedstock. Pyrolysis produces carbon char and ash that moves into a separate, externally heated gasification reactor, which converts the solid carbon molecule into a gaseous state. Next, the injection of ionized water in a process known as steam reformation creates a water shift reaction to produce Syngas. The hot Syngas is water quenched and cleansed of its impurities in a proprietary, ionized water treatment system, thus delivering a clean, dry Syngas with no liquid discharge from the plant operation.

It is important to note that the TCG process is not a typical gasification process, which requires the injection of oxygen for the reaction: $2C + O_2 + H_2O = CO + H_2 + CO_2$, nor is it heated by internal feedstock combustion which is represented by $C + O_2 = CO_2$. Conventional gasification plants produce high amounts of carbon dioxide in their internal combustion processes. The externally heated TCG process actually reduces CO_2 through the following reaction: $CO_2 + C = 2CO$ and does not produce harmful combustion by-products.

Very Low Emissions Footprint

The TCG Global technology focuses on the prevention of harmful pollution from carbon utilization, rather than removing pollution resulting from conventional combustion. Since the feedstock is heated externally, no feedstock combustion by-products are released into the

atmosphere, nor are they present in the Syngas produced. All feedstock is processed in an enclosed and sealed reactor allowing contaminants to be efficiently captured and disposed of in ash collectors or through water scrubbing processes. Pollutants such as sulfur and SO_x, arsenic, and mercury typically present in many feedstocks are not released into the atmosphere in this process design, as they would be in a combustion-centric process.

TCG gasification features a unique, low emissions footprint:

- Syngas is clean and cool as it exits the gasification process.
- The gasifier fully utilizes or recycles the process water such that the facility has zero liquid discharge.
- When the gasifier utilizes its own Syngas output to fire the burner, the resulting emissions are lower than when burning natural gas.
- The gasifier can capture and recycle flue gas, including carbon dioxide (CO_2), from the external burners, allowing for zero air emission capability.
- Due to its externally heated design, the gasifier could be optionally heated using electricity, and this configuration would also produce zero emissions.
- Ash recovered from the system can be further processed to recover elements contained in the ash, and/or the ash can be used in production of cement or used as a fertilizer. A portion of the ash can be recovered as a bio-char and used as a soil amendment, which provides for carbon capture and sequestration in addition to improved crop performance.

Unique Design

The TCG gasifier design is unique in many respects:

- Flexible feedstock. Feedstock with high or low moisture content can be utilized. Virtually any type of coal can be utilized, including low rank coals, coal high in moisture and other impurities, or a blended fuel including other organics along with coal. Biomass, municipal solid waste, and tire-derived fuel can also be used for waste-to-energy projects.
- No pulverization or slurry injection is necessary.
- If make-up water is required (used to derive oxygen and hydrogen for the plant), it can contain impurities e.g. discharge water from other manufacturing facilities or water from any municipal or well source.
- Separation and injection of oxygen is not required.
- Utilizes an injection of ionized or singlet oxygen molecules (O) to enhance the chemical reaction.
- Capability to recycle un-reacted carbon particles back into the reactor chambers.
- Flexible production of various mixes of gases. Demonstrated delivery of a higher hydrogen ratio than other commercial gasifiers, with Syngas levels up to 86% hydrogen. It's also capable of varying the production of hydrogen depending upon the desired hydrogen to carbon monoxide ratio.
- Modular design, shop fabricated. Able to be constructed offsite, disassembled, and delivered via over-the-road trucks to any remote location.
- No ceramic refractory brick is required, thus reducing cost, maintenance requirements, and downtime.

Economic Advantages

A TCG gasification plant can provide an attractive risk-adjusted return on investment due to its superiority of design:

- Designed for a 70%-74% Btu conversion efficiency from feedstock to Syngas, but in commercial-scale, real-world testing, ***efficiencies exceeding 89%*** have been documented by Department of Energy funded research. Additionally, TCG's design has a 16%-20% production advantage when producing liquid fuels, as compared to other internally-fired gasifiers.
- A large air separation unit (ASU) for oxygen is not required.
- Minimal requirements for crushing or drying of the feedstock.
- Additional water pre-treatment requirement is not required, since water treatment and recycling is an integral part of the process itself.
- Additional Syngas cleanup equipment is not required since gas cleanup is an integral part of the process.
- Built-in redundancy of equipment allows for greater operational availability and for partial operation during maintenance.
- All system components are designed for over-the-road and standard shipping container legal load shipments. Off-site construction and re-assembly on-site ensures that site-driven labor availability will not impede rapid implementation.
- No single component requires more than 8 hours of downtime for replacement - exclusive of cool down or start up time.
- Relatively small footprint of less than 100' x 100', which also provides for a lower installation cost and a simpler permitting process.
- Design simplicity results in construction costs that are significantly lower than other gasification technologies – typically half the cost of competing solutions.
- TCG plants can be put into operation on a compressed schedule and can be operational in 12 - 24 months – typically half the time required by competing solutions.

Implementation Options

The TCG gasification process can use virtually any carbon-based material such as coal, crop and forest waste (biomass), other waste products such as petroleum coke from refineries, old tires (TDF), or municipal solid waste (MSW) as a feedstock. The design capacity for one TCG installed plant utilizes 500 tons per day of dry feedstock; plants using high moisture content feedstocks, such as biomass, have a higher design capacity. Depending on the moisture content of the feedstock, additional water may be added to provide the source of oxygen and hydrogen needed for the reaction.

With high quality coal as the feedstock, one 500 ton-per-day plant has the following range of output capabilities:

1. Generate up to 60 megawatts of electricity or
2. Produce up to 25,000 gallons of diesel daily or
3. Produce up to 100,000 gallons of mixed alcohols daily or
4. Deliver 30 million standard cubic feet of hydrogen or
5. Supply a combination of electricity and fuel products depending on the customer's needs.

Multiple TCG plants can be combined for a higher capacity at a fraction of the cost and construction lead time of a single, large conventional gasification plant.

Demonstrated Technology

A reference plant based on TCG technology was manufactured to handle in excess of 175 tons per day of coal or petroleum coke and was put into commercial operation in 2007 in Denver. The plant was purchased and moved to The University of Toledo, proving the portability features of the plant, which was dismantled, shipped, and placed back into operation in less than 90 days.

Patent Protection

The TCG gasification process integrates several individual technologies to convert carbon-containing feedstock to Syngas. The patents and pending patents underlying the gasification technology are owned by Thermo Technologies, LLC and licensed to Thermo Conversions, LLC, with which TCG Global has an agreement to develop, own, and operate gasification plants. TCG's technology relies on seven individual U.S. patents totaling over 800 claims, and it is also protected by South Africa and Mexico patents covering the identical technologies and set of claims.

Gasification is not new…

Gasification of coal was used in England and in the United States to produce "town gas" to light the city streets over a hundred years ago. The German war effort was fueled by coal gasification during World War II. Currently over 40% of South African motor fuel is derived from coal gasification, as well as 100% of their aviation fuel. Major suppliers of gasification technology include Sasol Lurgi, GE, Conoco-Phillips, and Shell with dozens of large, expensive plants operating worldwide. In the U.S. a large gasification plant is producing synthetic natural gas in North Dakota, and two integrated combined cycle (IGCC) demonstration plants are generating electricity - one in Florida and the other in Indiana. Eastman Chemical's coal gasification plant located in Tennessee once produced all Kodak film for the photography industry. It has operated successfully for over 25 years and continues to produce methanol, plastics, and other products for the chemical industry.

…but TCG Gasification is Revolutionary

TCG technology provides many advantages over competing gasification systems:

1. **High efficiency** – 89% demonstrated Btu conversion ratios.
2. **Low emissions footprint** – zero liquid discharge and zero air emissions capability.
3. **Flexible feedstock** – any carbon-containing material from biomass to coal to MSW.
4. **Flexible output** – electricity, drop-in transportation fuels, alcohols, and/or hydrogen.
5. **Low cost construction** – typically half the cost of competing solutions.
6. **Rapid deployment** – 12 to 24 months, typically half the time of competing solutions.
7. **Small footprint** – deployable to remote sites, can fit within many established plant sites.
8. **Low operating costs** – high availability rates, low cost parts and maintenance.

TCG GLOBAL

Contact TCG Global for further information on implementing gasification technology in your clean energy project.

Links and References:

[1] Additional information on Wiley Consulting, LLC can be found on our website: www.wileyconsulting.net.
[2] Additional information on gasification: www.gasification.org
[3] Additional information on bio char: http://www.biochar-international.org/biochar
[4] Coal Without Carbon report (page 26): http://www.catf.us/publications/reports/Coal_Without_Carbon.pdf