Advanced Gasification R&D

With more than 15 years of experience, RTI has an established track record in advanced gasification research. RTI has carried out various pilot-scale demonstrations of novel, sorbent-based syngas desulfurization technologies, as well as multi-contaminant control processes. RTI is also developing membrane materials/processes and catalytic processes for the conversion of coal to substitute natural gas, hydrogen, chemicals/fuels, and electricity. Our experience in coal gasification is also being leveraged into research programs devoted to biomass conversion and biofuels production.

RTI Demonstrates High-Temperature Syngas Desulfurization Technology

The most mature advanced gasification technologies in the RTI portfolio are a high-temperature desulfurization system (HTDP) and the direct sulfur recovery process (DSRP). RTI's HTDP uses a regenerable sorbent to capture the hydrogen sulfide (H_2S) and carbonyl sulfide present in the syngas generated during coal gasification. Process development for this technology is at an advanced stage, with RTI and Eastman Chemical completing a pilot-scale demonstration of the process at Eastman's Kingsport, Tennessee, gasification plant.

RTI's HTDP is based on a transport reactor design that allows for high-throughput processing of syngas and continuous high-temperature, high-pressure operation. RTI has also developed novel sorbent materials with high reactivity, attrition resistance, and long-term stability over many regeneration cycles—properties that fully support transport reactor operation.

The RTI syngas desulfurization sorbent's combination of physical and chemical properties and sorbent performance earned RTI a prestigious *R&D 100* award for the development of this sorbent.

RTI's novel sorbent captures H_2S and COS at high temperatures (i.e., 300–700 °C), maintaining a higher thermal efficiency than conventional desulfurization options. With the assistance of a commercial catalyst manufacturer, RTI has produced over 10,000 pounds of this desulfurization sorbent and can offer this material as a commercial product.

A pilot-scale demonstration of RTI's HTDP, which treated actual syngas from Eastman's gasification plant for over 3,000 hours, achieved greater than 99% sulfur removal, producing a product syngas with below 10 ppm of sulfur. The demonstration also provided an abundance of operational data, which RTI will use for scaling up to a demonstration plant—to process roughly a 50MW equivalent slipstream of syngas from a commercial gasifier.

Complementing RTI's high-temperature desulfurization technology is the direct sulfur recovery process (DSRP). During regeneration of RTI's sorbent in the HTDP, the sulfur on the sorbent is converted to sulfur dioxide (SO_2). The DSRP uses a small slipstream of syngas to catalytically reduce this SO_2 to elemental sulfur according to the following reaction:

$$SO_2 + 2H_2 \text{ (or } 2\,CO) \rightarrow 2H_2O \text{ (or } 2CO_2) + S$$

The main advantage of the DSRP is that its high-temperature, high-pressure operating conditions allow direct thermal and process integration with HTDP. The DSRP also works well with low-gas mixtures containing low concentrations of SO_2 that cannot be processed by other technologies. The catalyst used in the DSRP is commercially available. RTI has demonstrated integrated operation of a HTDP and DSRP pilot plant at Eastman Chemical. During 110+ hours of integrated operation, the DSRP system achieved 90–98% removal of the inlet sulfur. The DSRP catalyst proved to be very robust, demonstrating consistent reaction rates in multiple experiments over a 3-year period.

In several independent economic studies of RTI's HTDP compared with conventional gas cleanup technologies such as Selexol and Rectisol, RTI's technology had a net 2–3 percentage-point increase in the overall integrated gasification combined cycle (IGCC) thermal efficiency and a significant reduction in capital cost.

RTI Offers a Suite of Technologies for Multi-Contaminant Removal from Syngas

To complement RTI's high-temperature desulfurization technologies, RTI has assembled specialized fixed-bed testing systems to evaluate catalysts and sorbents for the removal of other contaminants typically found in coal gasification syngas at high temperature. RTI is focused on contaminants such as mercury, ammonia, chlorine, arsenic, cadmium, selenium, and carbon dioxide (CO_2). Some of these sorbents demonstrated contaminant removal from a slipstream of real coal-derived syngas. RTI is currently engaged in laboratory-scale demonstration of pre-combustion CO_2 capture technology. This CO_2 separation technology is based on regenerable mixed oxide sorbents and shows excellent CO_2 removal rates from syngas at high temperatures. For more information related to this CO_2 capture technology, please refer to the RTI brochure, "Carbon Capture Technologies."

Co-Production Processes Offer Flexibility to Produce SNG, Hydrogen, and Electricity

IGCC provides the flexibility to co-produce substitute natural gas (SNG); hydrogen; premium hydrocarbon liquids, including transportation fuels; and electric power in desired combinations from coal and other carbonaceous feedstock in an environmentally friendly manner. Rising costs and a limited supply of crude oil and natural gas provide a strong incentive for the development of coal gasification-based, co-production processes.

RTI is developing a novel, catalytically assisted gasification process to convert low-rank coals into SNG; electricity; and high-pressure, "sequestration-ready" CO_2. This process is composed of two steps. In the first step, a transport reactor is used to instantaneously heat coal particles, resulting in near-complete volatilization and shattering. In step two, the gaseous product from the transport reactor is fed into a fluidized-bed reactor containing a supported catalyst that converts the gaseous products into a methane-enriched syngas. This raw SNG product is conditioned by removal of the CO_2, desulfurization, filtration to remove char, and methanation to adjust the SNG composition required to meet natural gas pipeline specifications. Any char generated during the gasification process is combusted using oxygen at high pressure, with CO_2 as a diluent to generate steam and electricity.

Leveraging the flexibility of IGCC processes, RTI is also developing a highly efficient "steam-iron" process technology for the co-production of electricity and hydrogen. The process consists of reduction of a novel iron-based catalyst using coal-derived syngas followed by its oxidation with steam to produce pure hydrogen. To overcome problems that have plagued past development efforts with steam-iron processes, RTI is using the latest advances in catalysis to improve catalyst reactivity, chemical stability, and mechanical strength.

Reverse-Selective Membrane Technology Shows Promise for Syngas Cleaning

RTI is pursuing membrane-based separation technology as an alternative approach for removing acid gases from syngas. RTI has developed a syngas cleaning technology based on reverse-selective membranes that, unlike typical commercial membranes, separate materials based on their chemical properties rather than size. This allows impurities (e.g., CO_2, H_2S) to be removed at low pressures while maintaining the useful hydrogen-rich process gas at high pressure. A number of membrane materials possessing both high CO_2 and H_2S permeabilities and high selectivities for CO_2 and H_2S over H_2 have been identified, and process modeling shows significant cost incentives over conventional amine systems. RTI has completed a demonstration with a pilot-scale prototype membrane system at Eastman Chemical's gasification plant in Kingsport, Tennessee.

RTI Pursues Breakthroughs in Biomass Gasification

RTI is conducting research in the cleanup of syngas produced through biomass gasification. For more information refer to the RTI brochure "Biomass Conversion and Biofuel Technologies."

More Information

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