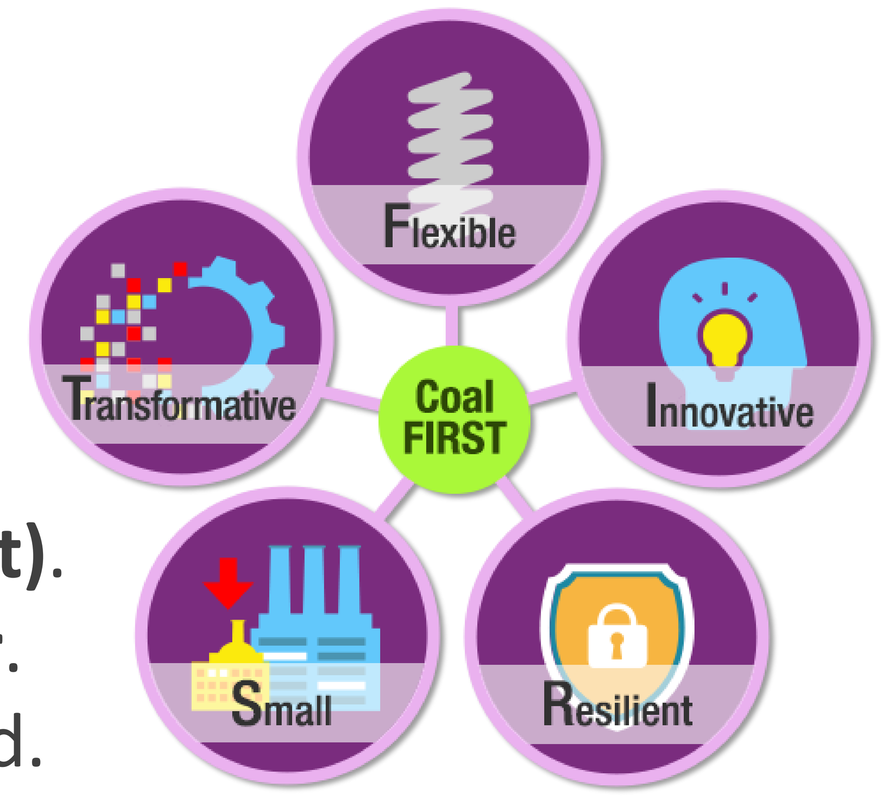
NETL GASIFICATION SYSTEMS

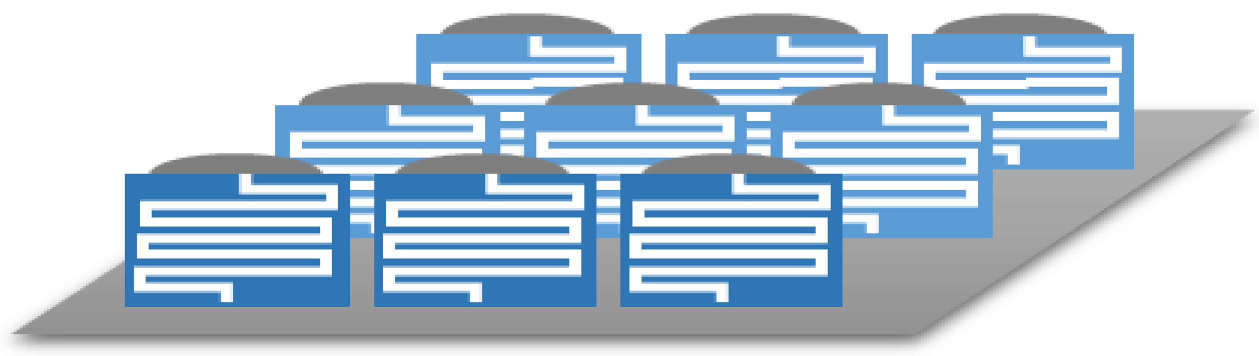
The Gasification Systems Program at NETL is focusing on high-performance, modular, small-scale gasification systems to reduce investment risk, enhance reliability, and create alternative markets for coal through a diverse and cutting-edge research portfolio.

A Modular Approach to Traditional Gasification

Thinking Beyond Economies of Scale
Small systems enable lower project risk.

Modular units allow for more **flexible** operation.
Improve efficiency through **innovation**.
Create secure, stable, and reliable power **(resilient)**.
Modular systems are **small** and can be built **faster**.
Fundamentally **transform** how plants are designed.



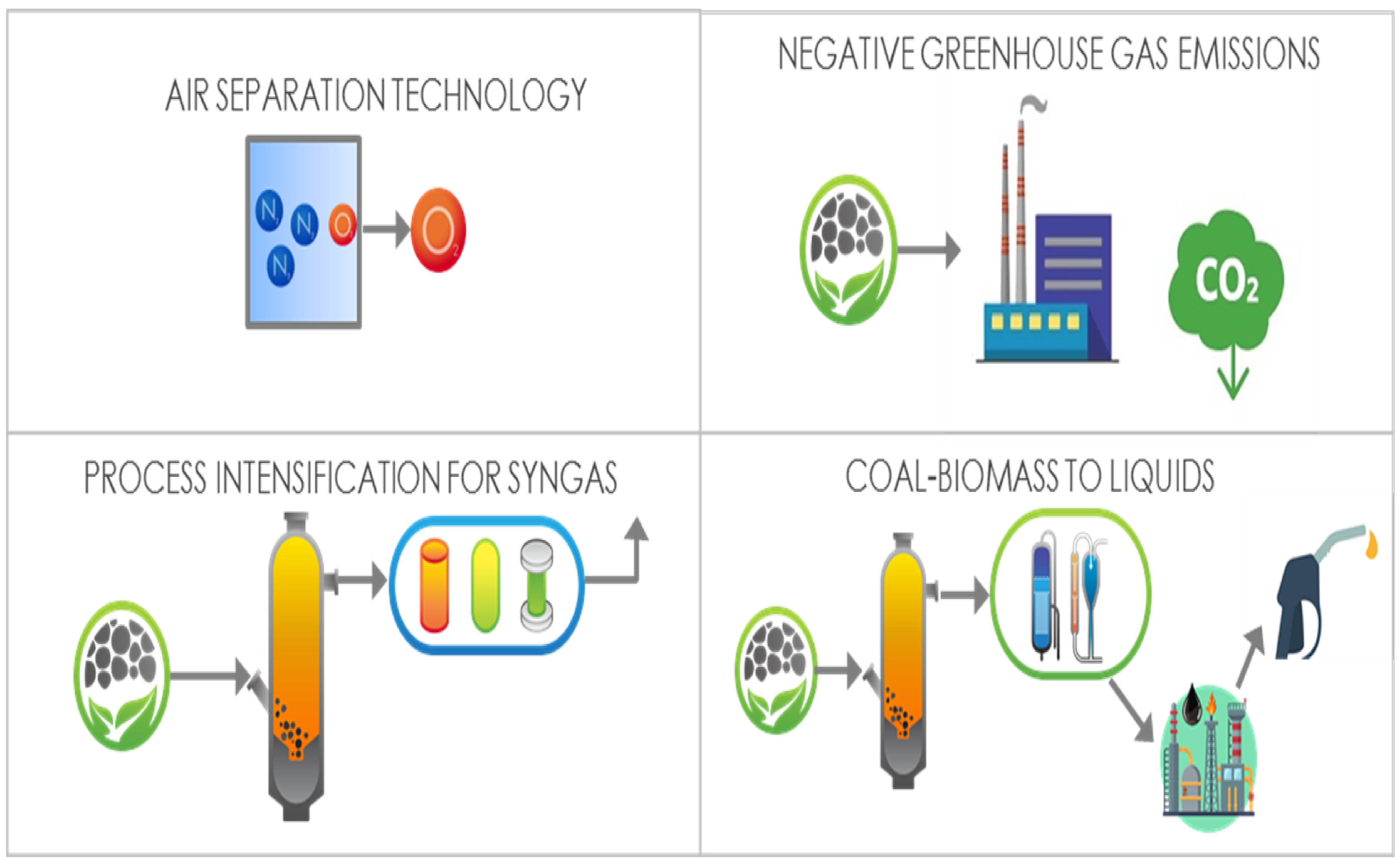


Coal FIRST Goal: Develop coal plant of the future to provide secure, stable, and reliable power.

Key Program Technology Areas

Innovative new methods for **oxygen production**, including **membranes**, **cryogenics**, and **oxygen carriers**!

Create a **CO_2-negative coal plant** using **carbon-neutral** biomass and carbon capture **(BECCS)**!



Improving gasifier designs to **increase syngas heating values**, **reduce reactor size**, and **lower oxygen demand**!

Fischer-Tropsch synthesis optimization, enabling the creation of **high-quality liquid fuels**!

Reduce Investment Risk

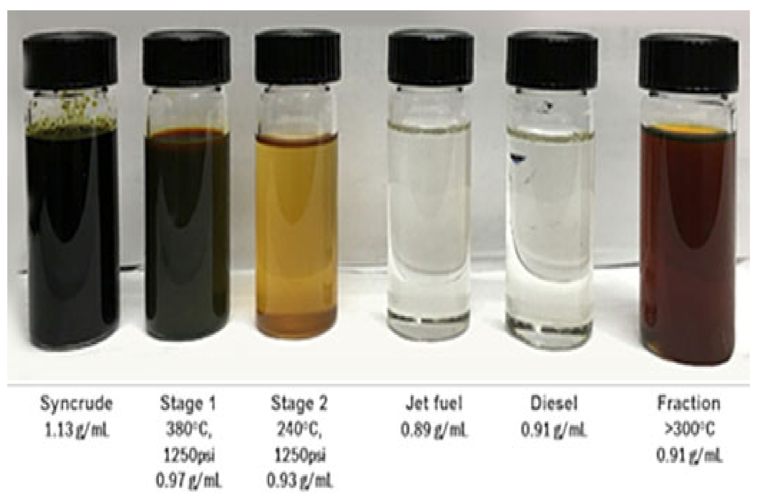
Smaller sizes means **lower initial capital investment**! **Faster** construction means **shorter payback periods**! **Lower baseline emissions** means **lower likelihood** to lose profits to regulation compliance!

Enhance Reliability

Warm-gas cleanup, **innovative refractory materials**, and **low thermal input gasification** (such as with microwaves) can **greatly reduce maintenance** and **shorten plant downtimes**, for **highly reliable** power and/or chemical production!

Create New Coal Markets

Modular system **flexibility** makes coal products **more accessible to more industries**. **Byproduct reuse** and **improved coal-to-liquids performance** reduce the costs and environmental impacts of using coal!



GASIFICATION SYSTEMS

FY 2020 BUDGET REQUEST

$10,300k

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TECHNICAL PROFOLIO LEAD:
Jonathan Lekse

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University of Kentucky
RTI International
Southern Research
NC State University
INL Idaho National Laboratory
UAF University of Alaska Fairbanks
Pacific Northwest National Laboratory
University of South Carolina
Los Alamos National Laboratory EST. 1943
Oak Ridge National Laboratory
TDA Research

U.S. DEPARTMENT OF ENERGY
NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Oxygen Production for Gasification

Development of tailored oxygen carrier materials for oxygen production for gasification reactions and other applications.

Overview

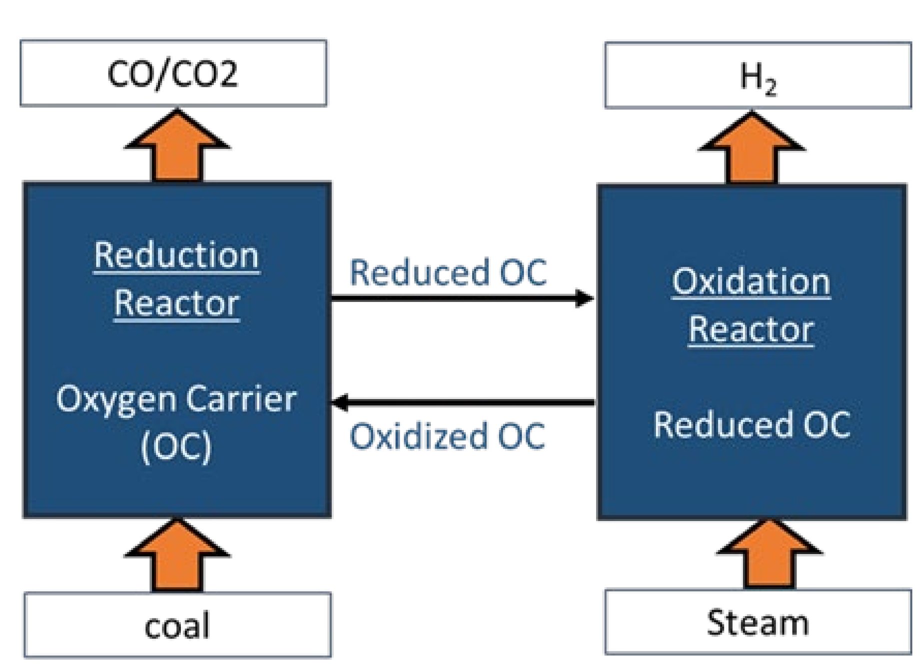
This task is developing tailored oxygen carrier materials for uses in an oxygen production module that can be added to a gasification system as an in situ source of oxygen for gasification reactions. These carrier materials will have tunable oxygen delivery properties to respond to a variety of opportunities and fuels. Aside from innovative carrier materials, designs for an oxygen production module and an optimized process to produce syngas using a combination of coal and oxygen carriers are under development.

Benefits

The modular systems that are currently being studied could benefit from the use of an oxygen carrier material if that carrier can be made competitive with a scaled-down cryogenic process in terms of cost and efficiency. Perovskite materials under development as carriers are favorable as a type of stable material that can rapidly and reversibly store and release large quantities of oxygen due to their nonstoichiometric nature. Ferrite materials under development have been shown to have thermodynamics that favor the partial oxidation of coal to carbon monoxide (CO) instead of the complete oxidation to carbon dioxide (CO_2), which makes them ideal for gasification reactions.

Recent Results

- High conversion of H_2 (~80%) was achieved during steam oxidation at 800°C.
- 25-cycle test with oxygen carrier reduction with coal and oxidation with steam showed very stable performance.
- A computational fluid dynamics (CFD)/Multiphase Flow with Interphase eXchanges (MFiX) module is currently in development. Experimental/CFD results will be used to expand current MFiX model to a full pressure-swing adsorption (PSA) simulation.



QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 5.1

PROJECT BUDGET

DOE Share:
$3,419k

Total Award Value:
$3,419k

CONTACTS

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PERFORMER

AIR SEPARATION TECHNOLOGY

U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Radically Engineered Modular Air Separation System Using Tailored Oxygen Sorbents

Design and demonstrate a modular air separation unit small-scale gasification.

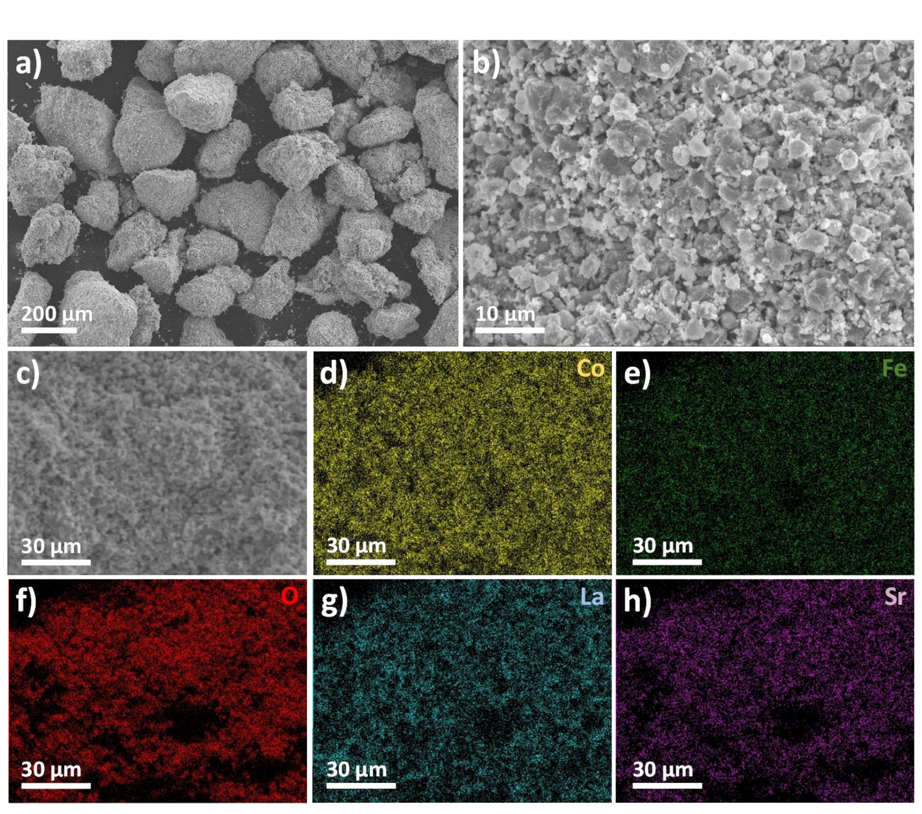
Overview

North Carolina State University will develop and demonstrate a radically engineered modular air separation unit (REM-ASU) for small-scale coal gasifiers. Compared to state-of-the-art separation technologies, the REM-ASU will have reduced capital costs and energy consumption. The REM-ASU technology will be demonstrated at pilot scale, generating commercial implementation data. Three approaches will be used: (1) oxygen sorbent (OS) synthesis, characterization, and screening; (2) pilot-scale OS production and pilot REM-ASU unit design, construction, and operation; and (3) process and techno-economic modeling.

Benefits

A successful project may result in advanced oxygen sorbents with greater than 2 weight percent oxygen capacity and high activity; robust, steam-resistant oxygen sorbents with high-equilibrium oxygen partial pressure to allow effective oxygen generation without a vacuum desorption step; a tailored oxygen sorbent and modular ASU that can readily integrate with a 1- to 5-MW modular coal gasification system that reduces energy consumption by more than 30% compared to state-of-the-art ASUs; and demonstration of the sorbent and REM-ASU system to validate its robustness and performance.

Recent Results



- Developed $(La_xSr_{1-x})Co_yFe_{1-y}O_3$ – CoFe (LSCF-CF) composites with 2.2 to 4.2% O_2 capacity.
- LSCF-CF OS high activity demonstrated.
- Designed low temperature $SrFeO_3$-based OS for chemical looping air separation.
- Demonstrated steam resistant $SrFeO_3$-based OS for 1,000 cycles with minimal degradation.

QUICK FACTS

AWARD NUMBER:
DE-FE0031521

PROJECT BUDGET

DOE Share:
$2,044k

Performer Share:
$520k

Total Award Value:
$2,564k

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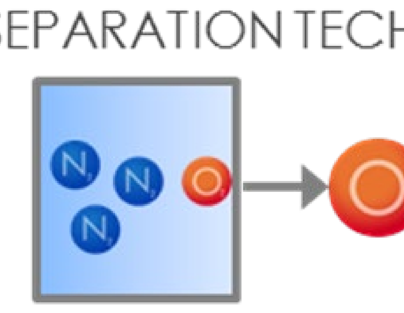
PARTNERS

NC STATE UNIVERSITY

AIR SEPARATION TECHNOLOGY



Pilot Testing of a Modular Oxygen Production System Using Oxygen Binding Adsorbents

Design, fabrication, and testing of a 10- to 20-kg/day modular O_2 production system.

Overview

Research Triangle Institute (RTI) will design, fabricate, and test a 10- to 20-kg/day modular O_2 production system. The effort will include optimization and scale-up of the oxygen binding adsorbent; process studies to form the adsorbent material into structured beds for rapid pressure-swing adsorption (PSA) cycles with low pressure drop, fast mass transfer, and low attrition; cycle development studies to optimize the PSA process; and development of simulation tools for rapid cycle modeling and numerical evaluation/optimization. In addition, the unit will undergo parametric and long-term testing for at least 1,000 hours.

Benefits

If proven successful, the technology could reduce the cost of air separation and, therefore, the cost of products from all oxygen-intensive industries. Producing O_2 using the proposed binding materials should cost (depending on the O_2 capacity) 30 to 40% less than cryogenic distillation.

Recent Results

- Structured sorbent module development.
- Begun initial design of pilot O_2 production system.
- Techno-economic analysis performed.

QUICK FACTS

AWARD NUMBER:
DE-FE0031527

PROJECT BUDGET

DOE Share:
$3,000k

Performer Share:
$799k

Total Award Value:
$3,799k

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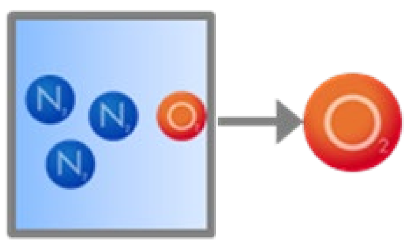
RTI INTERNATIONAL

AIR SEPARATION TECHNOLOGY



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Modularization of Ceramic Hollow Fiber Membrane Technology for Air Separation

Develop a membrane stack and module for air separation and oxygen production using an intermediate-temperature ceramic hollow fiber membrane.

Overview

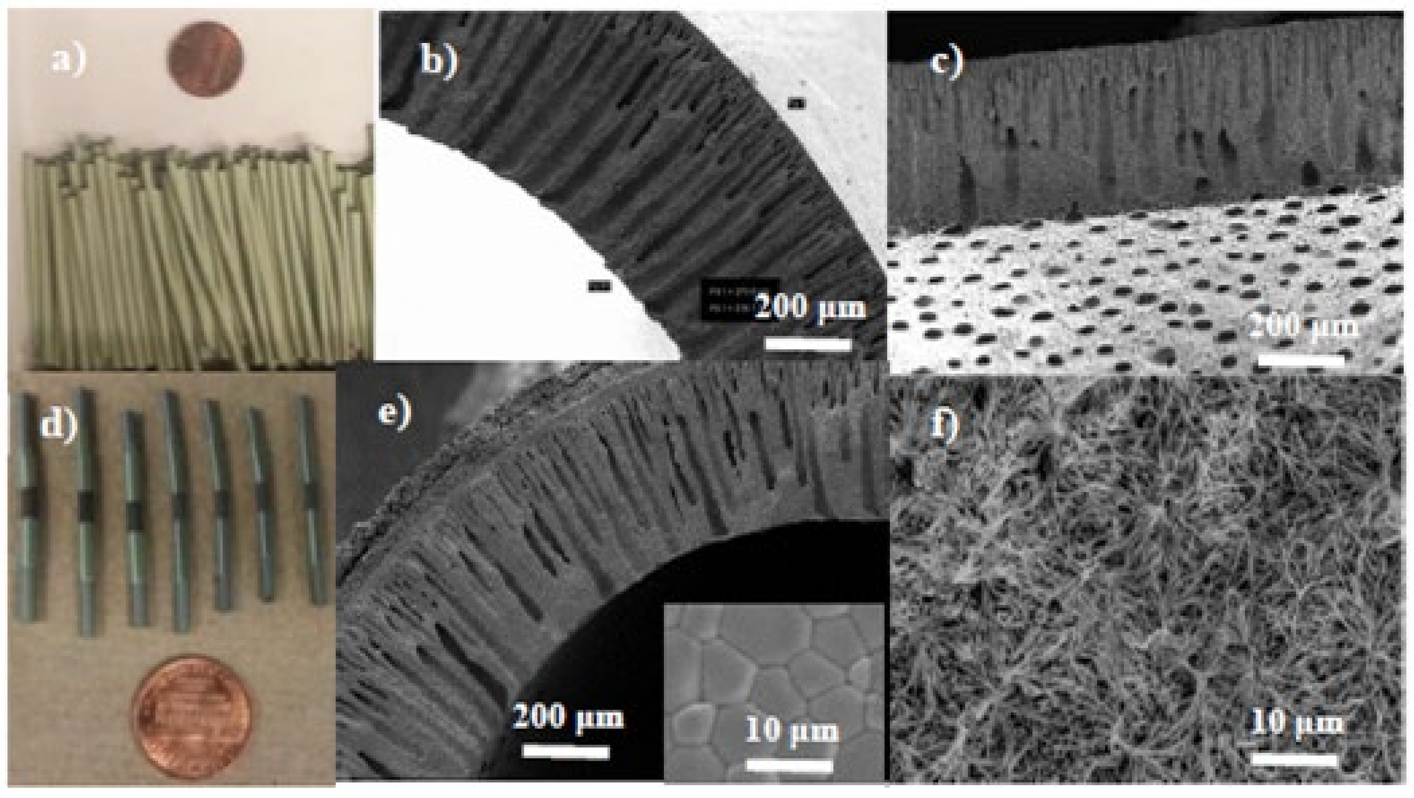
The University of South Carolina has been developing a membrane stack and module for air separation and oxygen production by scaling up an innovative technology involving an intermediate-temperature ceramic hollow fiber membrane. The technology is then incorporated into a Radically Engineered Modular Systems (REMS) gasification skid and supports the oxidant feed of an oxygen-blown REMS gasifier scaled to various ranges.

Benefits

Successful development of this technology may improve performance, reliability, and scale-up flexibility, as well as reduce capital and operating costs. These improvements could have broader impacts on the development of high-performance and durable air-separation technologies for oxygen intensive industries.

Recent Results

- New membrane design with novel architecture, material system, and microstructure.
- Showing reduced capital cost of membrane cell and lower operating cost.



QUICK FACTS

AWARD NUMBER:
DE-FE0031473

PROJECT BUDGET

DOE Share:
$1,539k

Performer Share:
$393k

Total Award Value:
$1,932k

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UNIVERSITY OF SOUTH CAROLINA

AIR SEPARATION TECHNOLOGY

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Pressure-Driven Oxygen Separation

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions.

Overview

Pacific Northwest National Laboratory (PNNL) is developing air separation technology based on mixed ion-conducting membranes in planar architecture and stacks, employing doped CeO_2 as the ion conductor and $LaMnO_3$ as the electronic conductor supported on low-cost porous substrate of MgO-Al_2O_3 composites. This technology utilizes the difference in oxygen partial pressures across the membrane in an air separation unit to drive the separation of oxygen.

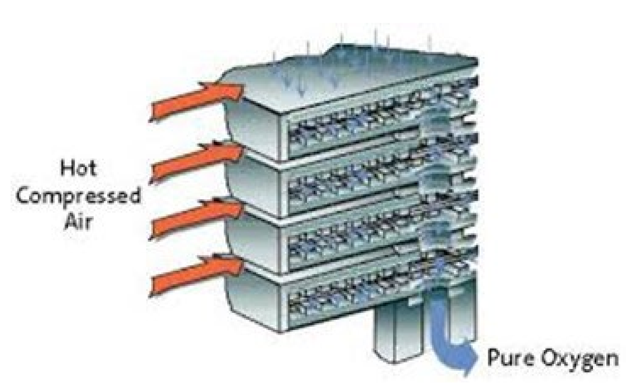
PNNL is focusing on multiple technological aspects for increasing performance efficiency and reducing costs of this technology, including best use of low-cost materials, planar stack architecture design allowing reliable and low-cost fabrication/processing and stack/seal performance, minimizing interactions between ionic and electronic conducting phases during sintering to maximize oxygen permeability in the composite membranes, and controlling sintering so as to minimize warping and cracking of the planar composite membranes.

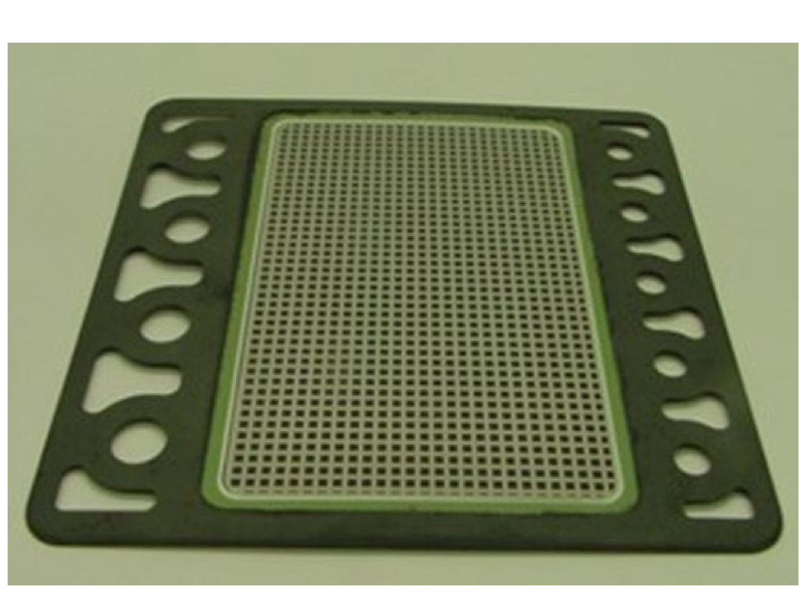
Benefits

This membrane-based oxygen separation approach is intended to enable small-scale, modular air separation units providing 10 to 40 tons of high-purity oxygen to 1- to 5-MWe gasifiers at low cost and high energy efficiency.

Because the air separation membrane is of the ion transport type, it provides extremely high oxygen selectivity. But unlike conventional ion transport membranes that require operating temperatures of 1,450 to 1,650°F, PNNL's membrane is targeted for operation at 1,100 to 1,300°F. At these milder conditions, energy demand for heating input gases is lower, and equipment durability should be improved.

Recent Results





- Material properties and interactions of the membrane and support structure characterized.
- Fabricated composite structures by tape casting with controlled microstructures.
- Alternative methods to co-sinter large area parts with minimal interactions at the membrane/support structure.
- Low-cost manufacturing and materials and achievable oxygen flux are showing good techno-economic potential.

QUICK FACTS

AWARD NUMBER:
FWP-73130

PROJECT BUDGET

National Laboratory Share:
$1,000k

Total Award Value:
$1,000k

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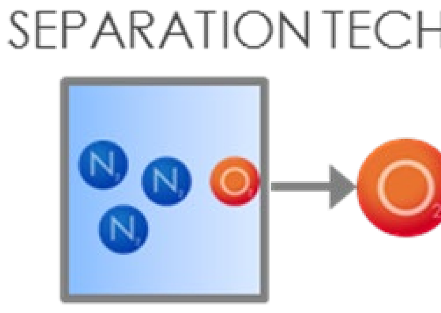
David Reed

PERFORMER

Pacific Northwest
NATIONAL LABORATORY

AIR SEPARATION TECHNOLOGY



High Selectivity and High Throughput Carbon Molecular Sieve Hollow Fiber Membrane-Based Modular Air Separation Unit for Producing High-Purity O_2

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions.

Overview

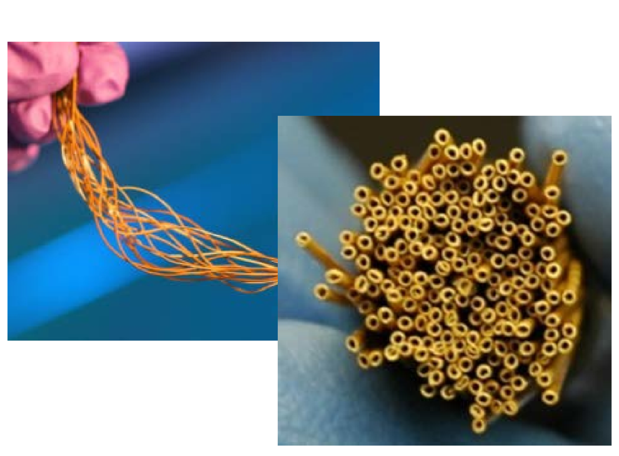
Los Alamos National Laboratory (LANL) is developing carbon molecular sieve (CMS) hollow fiber membranes for use in a modular air separation unit (ASU) for high-purity O_2 production. A two-stage membrane process is envisioned and will be optimized to achieve O_2 purity of up to 95% while minimizing process energy consumption. Core to the proposed work is development of polybenzimidazole (PBI)-derived CMS hollow fiber membranes having exceptional O_2/N_2 selectivity and high O_2 permeance. The PBI-CMS hollow fiber membranes will be obtained via controlled pyrolysis of PBI hollow fibers having microstructures tailored for gas separations (PBI hollow fiber manufacturing methods recently discovered/patented by the LANL team).

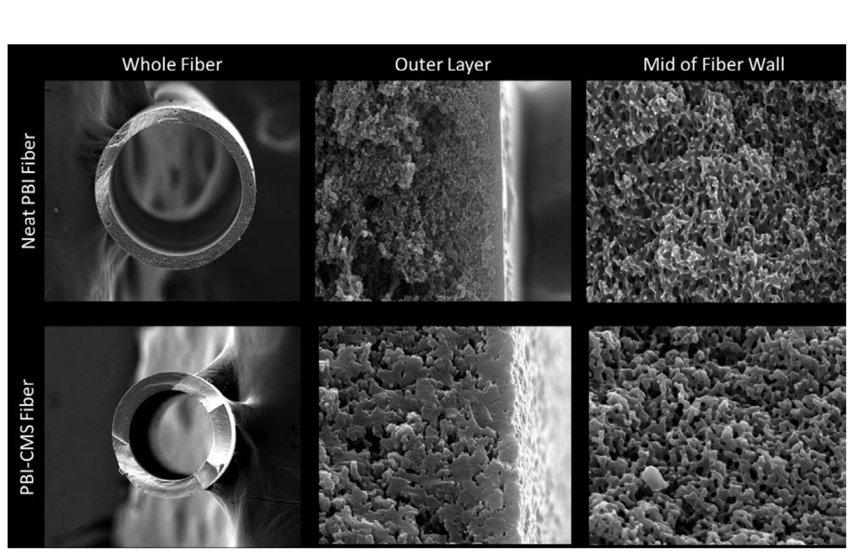
Current work is focusing on optimizing the PBI-CMS hollow fiber membrane fabrication protocols, pyrolysis, and process design of the membrane system in context to energy plants and systems.

Benefits

Membrane-based ASUs have better energy efficiency than industry-standard cryogenic methods, provided materials having high O_2/N_2 selectivity and high productivity membrane systems based on these materials are developed. PBI-CMS membranes have exceptional separation performance potential, and when deployed in high packing-density and low-cost hollow fiber membrane modules familiar in industrial application, should enable energy-efficient high-purity O_2 production at modular scales.

Recent Results





- Achieved O_2/N_2 selectivity of 15 in the PBI-CMS hollow fiber membranes (permitting achievement of the target for O_2 purity assuming a two-stage membrane process).
- Significant improvement in the O_2 permeance of the PBI-CMS hollow fiber membranes from 0.05 to 1.8 GPU.
- Promising initial results obtained towards achieving asymmetric morphologies in hollow fiber fabrication (necessary for industry deployment).

QUICK FACTS

AWARD NUMBER:

FWP-FE-1049-18-FY19

PROJECT BUDGET

National Laboratory Share:

$1,000k

Total Award Value:

$1,000k

CONTACTS

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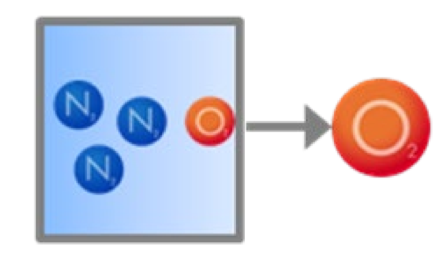
PERFORMER

Los Alamos NATIONAL LABORATORY EST. 1943

AIR SEPARATION TECHNOLOGY



U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Oxygen Separation from Air Using a Novel Mixed Matrix Membrane

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions.

Overview

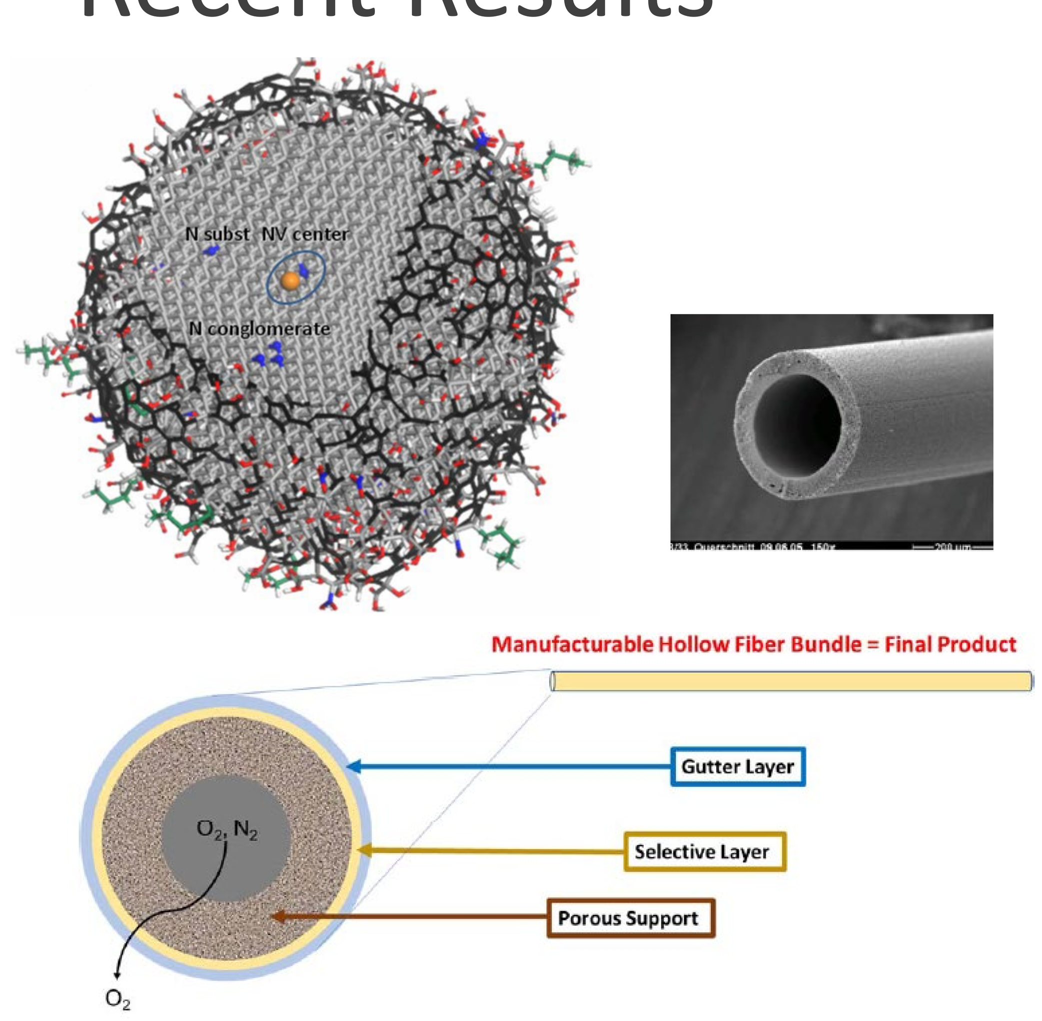
Idaho National Laboratory (INL) and Argonne National Laboratory are developing a novel type of mixed matrix membrane to be deployed in hollow fiber configuration for modular oxygen production for coal-based energy systems. Conventional membrane-based gas separation technology faces the general problems of low gas permeability, poor species selectivity, and poor durability of the membranes in operating environments. However, the team has found that a mixed matrix membrane consisting of a base polymer support layer of polysulfone, which incorporates functionalized nanodiamonds (ND) in a composite matrix, both greatly increases the material's O_2 permeability and increases the material's durability by reducing plasticization and aging.

Multiple points of technological advancement are underway, such as optimizing surface functionalization of NDs, dispersion of NDs in the matrix, selective and gutter layer fabrication, and membrane systems process design using this novel type of membrane for oxygen production.

Benefits

Membrane-based gas separation processes have advantages in that they can be readily scaled (including to the modular size ranges for energy systems of interest), reach operating conditions quickly, and respond well to either surges or slack demand. The INL team is working to make significant improvements to hollow fiber membranes for these processes, but without losing the features that make these materials readily and reliably manufacturable. In this way, mature processes for hollow fiber membrane manufacture will not be compromised, thereby de-risking the commercial deployment of this technology.

Recent Results



- NDs have been shown to improve oxygen membrane permeability by a factor of 150 and to improve membrane durability.
- Improvements have been made in membrane selective and gutter layers.
- Demonstration of phase inversion of polysulfone-ND composites ensuring that hollow fiber formation can be accomplished with desirable induced morphologies.

QUICK FACTS

AWARD NUMBER:
FWP-B000-18-061

PROJECT BUDGET

National Laboratory Share:
$1,000k

Total Award Value:
$1,000k

CONTACTS

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INL Idaho National Laboratory

PARTNER

Argonne NATIONAL LABORATORY

AIR SEPARATION TECHNOLOGY

Magnetocaloric Cryogenic System for High-Efficiency Air Separations

Development of air separation technology to be utilized in advanced coal-based modular energy systems, making substantial progress toward enabling cost-competitive, coal-based power generation with near-zero emissions.

Overview

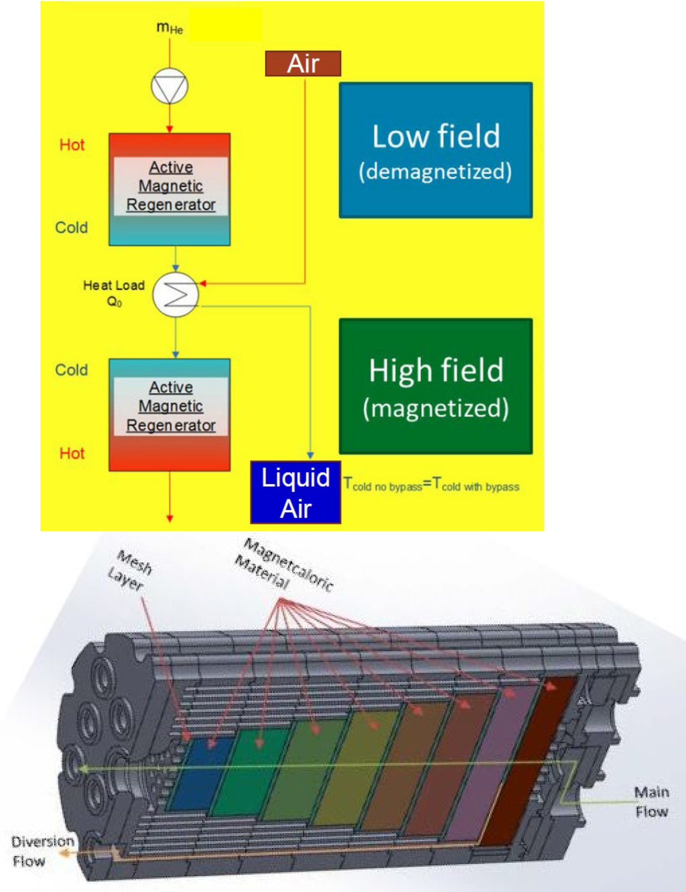
Pacific Northwest National Laboratory (PNNL) is developing the Magnetocaloric Oxygen Liquefier System (MOLS) technology in this project. MOLS uses magnetization and demagnetization of solids for refrigeration instead of conventional gas compression and expansion. The principle exploited is that highly reversible, adiabatic heating or cooling occurs in ferromagnetic materials near their Curie temperatures when they are subjected to large (approximately 6 to 7 Tesla) magnetic field changes. MOLS cycles these materials in and out of high magnetic fields, causing them to behave as solid-state refrigerants in a magnetic regenerative liquefaction cycle that minimizes the use of mechanical gas compression. MOLS results in liquefied air, which can then be subjected to conventional cryogenic distillation.

Technology development focuses on attaining the temperature reduction over the required range (to a liquid air temperature of 100K) through identification and combination of multiple layers of refrigerant materials in suitable regenerator configurations and advancing superconducting magnet design and integration with the regenerator.

Benefits

Gas compressors and expanders in cryogenic air separation units (ASUs) are the major cost drivers of conventional air separation. MOLS almost entirely eliminate the need for conventional gas compression in cryogenic-based air separation. Preliminary cost analysis indicates that MOLS will be no more or even less expensive than the conventional liquefaction technologies used in cryogenic ASUs. Moreover, MOLS is highly modular, providing good cost performance for smaller amounts of oxygen production at which conventional cryogenic ASUs would have poor cost performance.

Recent Results



- Established design basis for MOLS active magnetic regenerative liquefier.
- Designed multi-layer magnetic regenerator.
- Modeled design of new 6.5 Tesla superconducting magnet.
- Achieved cooling to 135K using multi-layer regenerators.
- Demonstrated liquefaction of methane using MOLS.

QUICK FACTS

AWARD NUMBER:
FWP-73143

PROJECT BUDGET

National Laboratory Share:
$1,000k

Total Award Value:
$1,000k

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Pacific Northwest National Laboratory

AIR SEPARATION TECHNOLOGY

Experimental Validation of Coal Gasification with Neutron Imaging

In the area of research for control of chemical reactions in increasingly modular and intrinsically efficient reactors, allowing for smaller reactors and streamlined process systems for gasification of coal into syngas, syngas cleanup, and syngas conversion.

Overview

Oak Ridge National Laboratory (ORNL) is tackling the challenge of obtaining non-intrusive measurements of coal gasification and pyrolysis reactions occurring inside high-temperature and high-pressure reactor vessels. Accurate in situ measurements are key pieces of crucial data needed by multiphase flow simulation/models (e.g., Multiphase Flow with Interphase eXchanges [MFiX]) for tuning and validation. In turn, these simulations are critical to designing the next-generation reactors needed for advanced new energy systems.

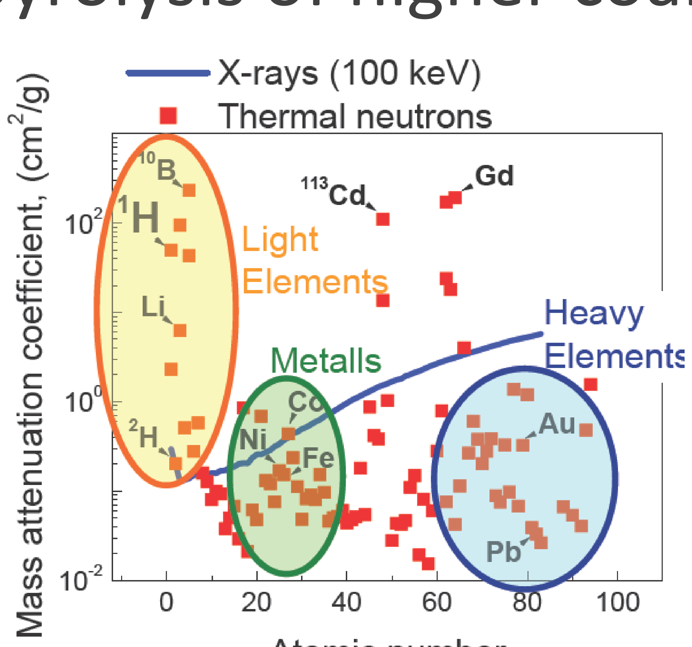
ORNL's innovative measurement approach involves neutron imaging. This leverages the properties of neutrons, which interact strongly with hydrogen but weakly with metals, giving the ability to view coal pyrolysis and gasification in situ (i.e., right through the walls of reactor vessels). ORNL is applying unique science capabilities in this work: neutron imaging at the High-Flux Isotope Reactor (HFIR), and Spallation Neutron Source (SNS) facilities are using SpaciMS (a technique developed by ORNL for capillary-based measurement of reactants and products in process conditions).

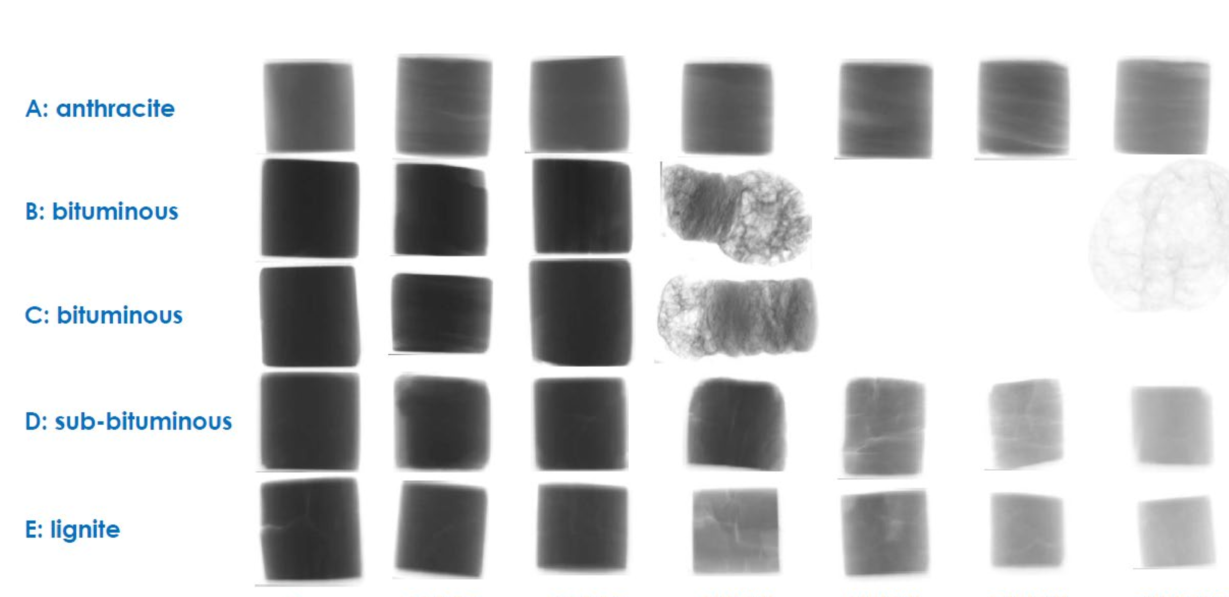
Benefits

This work is resulting in new scientific methods for neutron-based characterization of coal gasification. This will enable robust, experimentally validated models and designs for modular coal gasifiers. There is also the benefit of strong collaboration between ORNL and the National Energy Technology Laboratory (NETL) in these research areas.

Recent Results

- Neutron experiments for pre-pyrolysis of multiple coal ranks and dynamic in situ pyrolysis of poplar and lignite accomplished successfully.
- Groundwork established to continue to imaging of dynamic in situ pyrolysis of higher coal ranks and dynamic in situ gasification.





QUICK FACTS

AWARD NUMBER:

FWP-FEAB325

PROJECT BUDGET

National Laboratory Share:

$2,228k

Total Award Value:

$2,228k

CONTACTS

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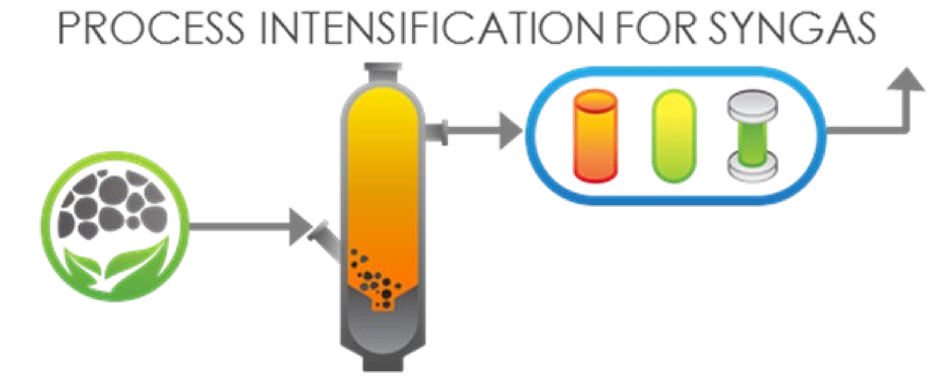
PRINCIPAL INVESTIGATOR:
James E. Parks II

PERFORMER

Oak Ridge National Laboratory

PROCESS INTENSIFICATION FOR SYNGAS



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Gasifier Design

Leveraging NETL's multiphase computational modeling expertise in reactor design problems, and utilizing MFiX and other key software tools.

Overview

This work emphasizes the application of the National Energy Technology Laboratory's (NETL) multiphase computational fluid dynamics (CFD) software (Multiphase Flow with Interphase eXchanges [MFiX]) and NETL's Optimization Toolset and other key software tools to support development of modular gasification technology. These advanced software tools and the Office of Fossil Energy (FE)/NETL's supercomputing facilities will be used to investigate different reactor configurations to determine optimal modular gasifier designs. Advanced gasification reactors will allow precise manipulation of different feedstock and bed material particles and the reactant and product gases in fluidized bed gasification reactors of interest to the program.

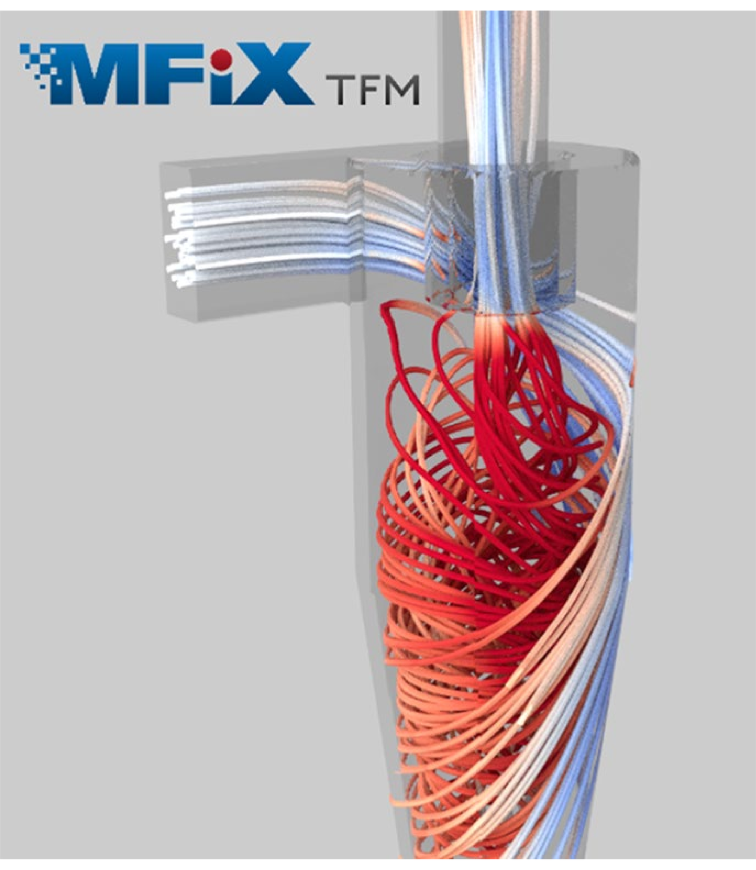
Computational modeling tools are also to be used to design, analyze, and optimize key components of modular gasifier systems, including oxygen separation and product gas cleanup systems.

Benefits

Through this research and development (R&D), NETL is providing an advanced capability to use performance predictions from multiphase flow CFD simulation to optimize reactor performance. In contrast to proprietary commercial CFD software, the MFiX suite and associated toolsets are open-source codes freely available to stakeholders, including industry and universities. This enables deployment of the tools on a wide range of problems and widespread collaboration in the user community. Feedback from the user base helps focus troubleshooting and further code development efforts.

Recent Results

- Simulations of moving bed gasifier at the Sotacarbo test facility for Alaskan Usibelli coal, validating proposed chemical kinetic mechanism and reaction rate parameters.
- Capabilities of Optimization Toolset demonstrated by CFD simulations of a fluidized bed gasifier, identifying optimum operating conditions yielding syngas product ratio of 2:1 H_2 to CO.



QUICK FACTS

AWARD NUMBER:

NETL FWP 1022405, Task 3

PROJECT BUDGET

DOE Share:
$5,461k

Total Award Value:
$5,461k

CONTACTS

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TECHNOLOGY MANAGER:
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FEDERAL PROJECT MANAGER:
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PRINCIPAL INVESTIGATOR:
William Rogers

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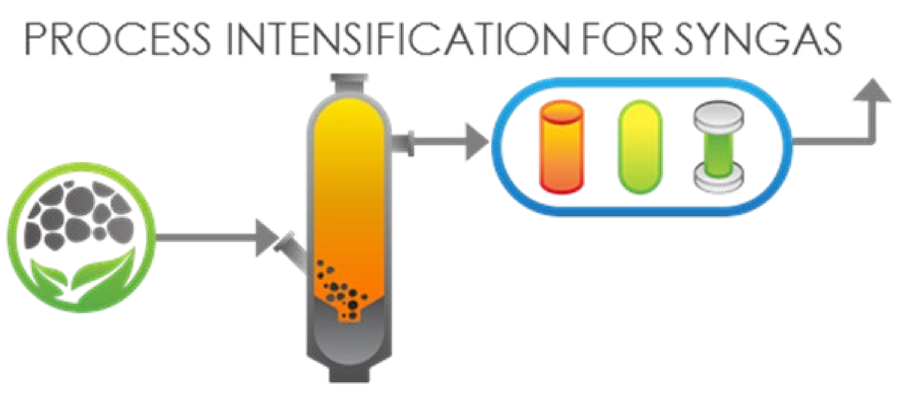

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Making Coal Relevant for Small-Scale Applications: Modular Gasification for Syngas/Engine CHP Applications in Challenging Environments

Modular gasification producing syngas to fuel reciprocating engines in combined heat and power application.

Overview

The University of Alaska Fairbanks will provide detailed engineering, design, and analysis to produce a front-end engineering and design (FEED) study for a modular design of an air-blown fixed-bed gasifier with gas cleanup to power an existing diesel engine generator. The FEED study will include technologies for lowering sulfur oxide (SO_X) and nitrogen oxide (NO_X) emissions to allow for operating the diesel engine on syngas. A model of the generating and transmission system at Golden Valley Electric Association will be created to evaluate the potential impact that a syngas/engine generation plant will have on the local electrical grid.

Benefits

This effort supports the design, construction, and operation of large test facilities for transformational coal technologies aimed at enabling step-change improvements in coal-powered system performance, efficiency, and cost of electricity. Pilots supported by the U.S. Department of Energy (DOE) will be used to assess the scalability and commercial potential of transformational coal technologies, helping mitigate risk and aiding in commercial adoption.

Recent Results

- Development of FEED study for a modular air-blown gasifier design is underway.

QUICK FACTS

AWARD NUMBER:
DE-FE0031601

PROJECT BUDGET

DOE Share:
$1,163k

Performer Share:
$291k

Total Award Value:
$1,454k

CONTACTS

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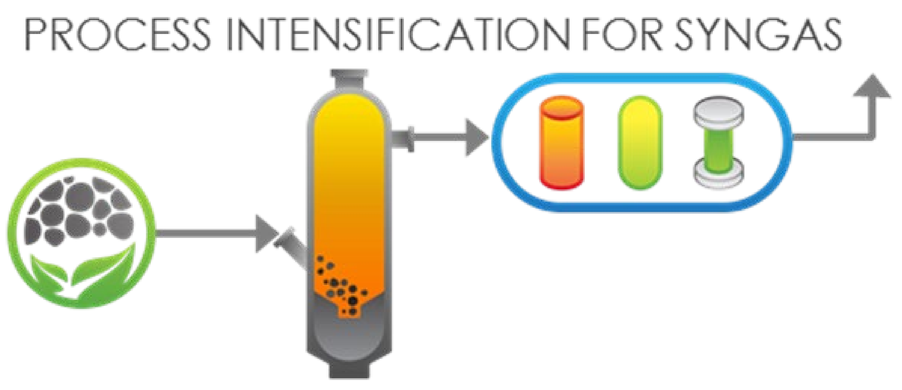
PRINCIPAL INVESTIGATOR:
Brent Sheets

PARTNERS

UAF University of Alaska Fairbanks



Advanced Manufacturing Technologies and Materials for Gasification

Identify construction materials and manufacturing technologies to build small-scale computer-modeled ARS gasification modules.

Overview

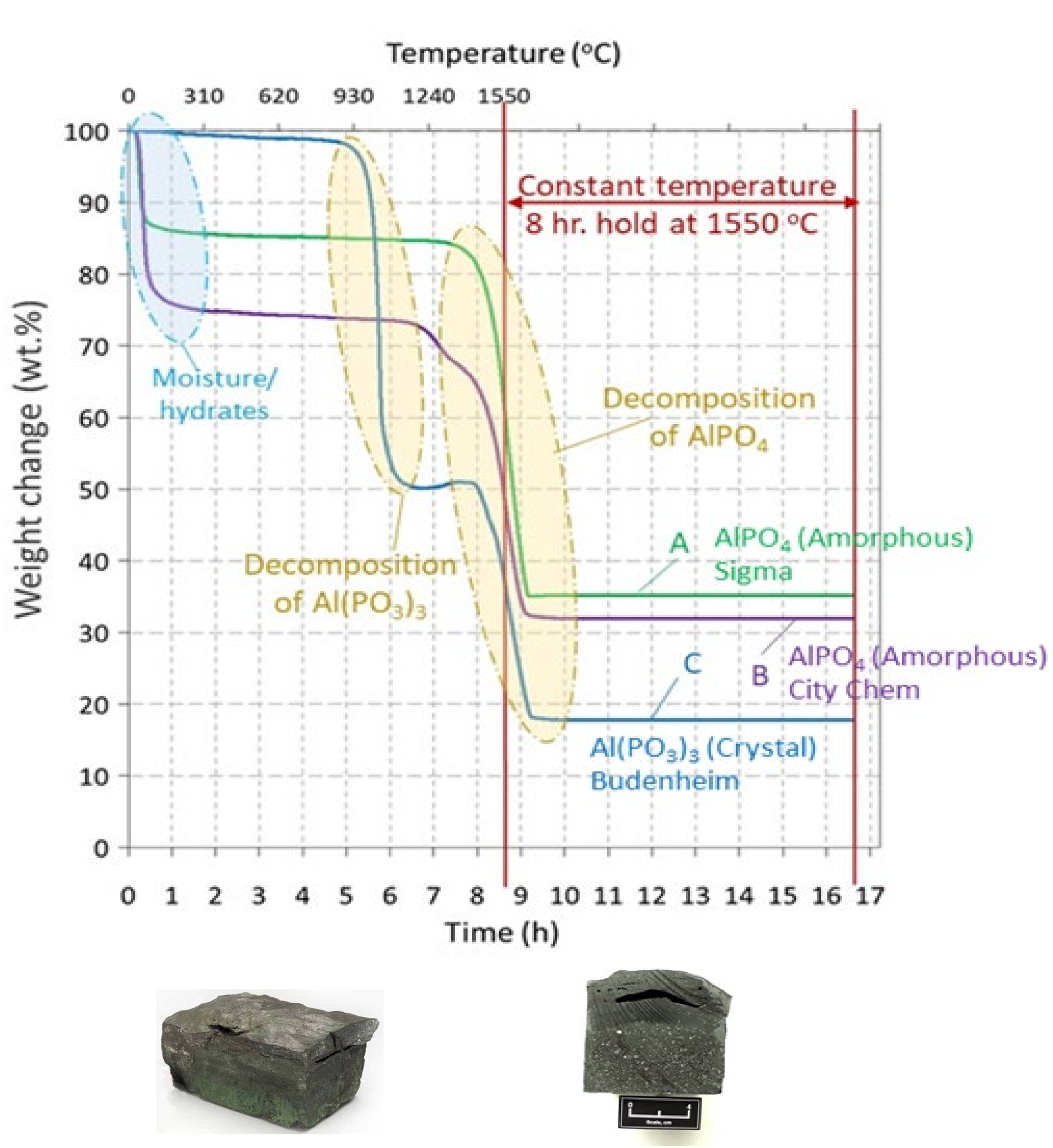
The objective of this effort is to identify materials of construction and manufacturing technologies to build small-scale computer-modeled gasification modules that will meet system performance requirement in laboratory studies (temperatures up to 1,200°C, coal as the primary carbon feedstock, an initial targeted material throughput of one ton/hour, and an initial service life of 500 hours). Samples of both reaction chamber and carbon feedstock materials, and the reaction system products/byproducts, will be evaluated to validate and modify computer models that are being leveraged to aid in synergistic research and development (R&D) across tasks.

Benefits

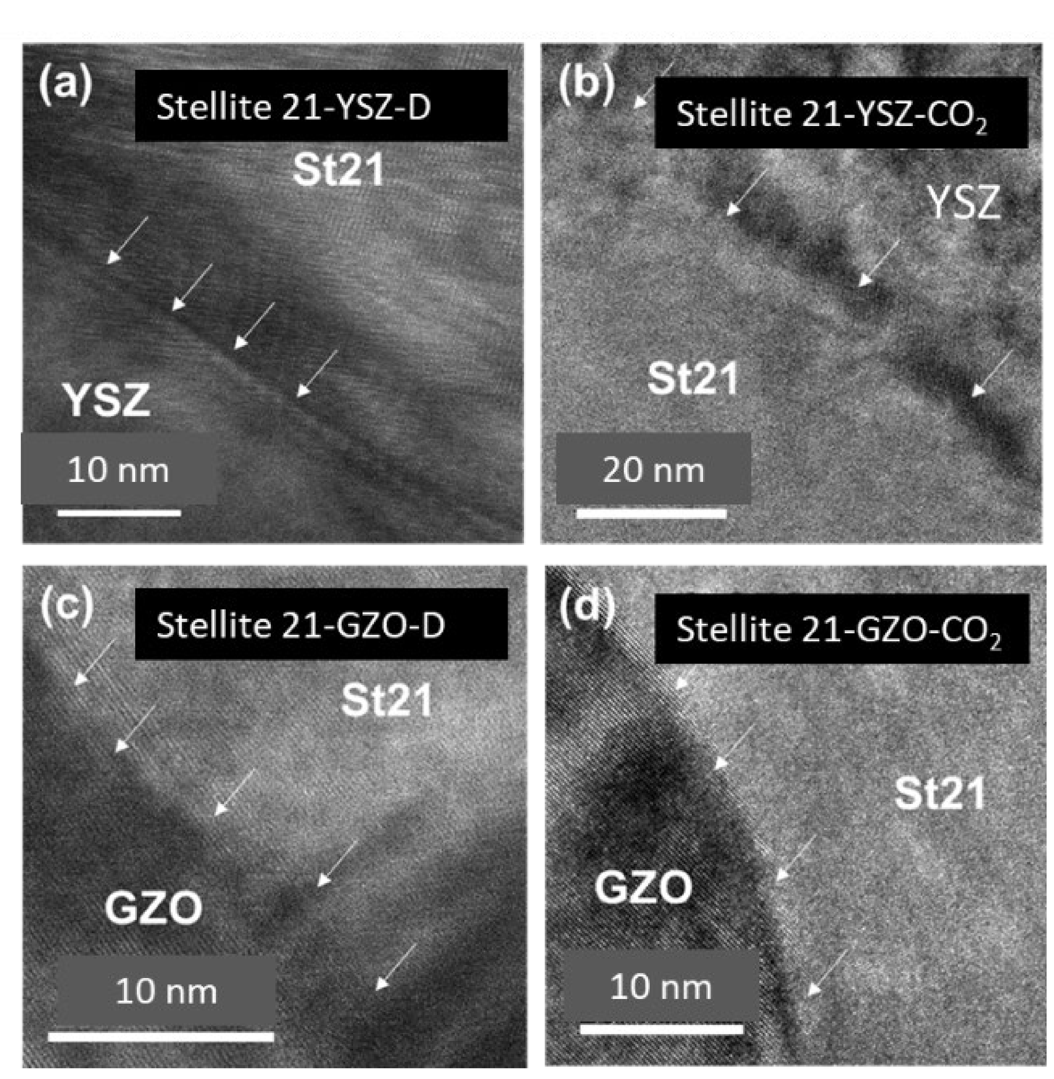
Advances in technology will allow construction of gasification systems using effective combinations of metals (to confine the process and support the reaction chamber structure) and refractory ceramics (to withstand and confine the harsh high-temperature reaction chamber environment against wear and corrosion). This will help enable systems with low costs of construction, predictable system performance and service life, and that will operate efficiently and cost-effectively.

Recent Results

Impact of raw material selection.



Particle coherency in functionally graded layers.



QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 4

PROJECT BUDGET

DOE Share:
$1,375k

Total Award Value:
$1,375k

CONTACTS

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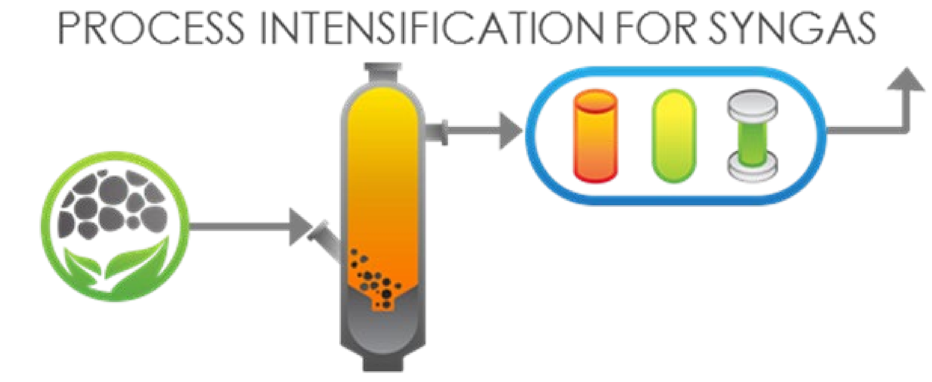
PROCESS INTENSIFICATION FOR SYNGAS



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Small-Scaled Engineered High Flexibility Gasifier

Development of a novel, 1- to 5-MW modular gasifier.

Overview

The purpose of this project is to develop a novel, cost-effective, radically engineered modular gasifier. This gasifier would have applications to 1- to 5-MW energy-conversion systems, such as combined heat and power (CHP). The pressurized oxygen-blown gasifier will use a simple, small-scale modular design and produce negligible amounts of tar. The gasifier will also be highly flexible to optimize fuel throughput and thermal efficiency, manipulate coal conversion, and produce syngas of a desired composition.

Benefits

Potential reduction of the cost of coal conversion via an optimized, factory-built modular system to allow scale-up via modular expansion and deployment at remote sites.

Recent Results

- Modeling efforts and flexible input capability for oxygen and steam have confirmed the ability to manipulate temperature distribution within gasifier.
- Gasifier design and construction underway.

QUICK FACTS

AWARD NUMBER:
DE-FE0031531

PROJECT BUDGET

DOE Share:
$1,700k

Performer Share:
$425k

Total Award Value:
$2,125k

CONTACTS

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SR SOUTHERN RESEARCH

REACTION ENGINEERING INTERNATIONAL

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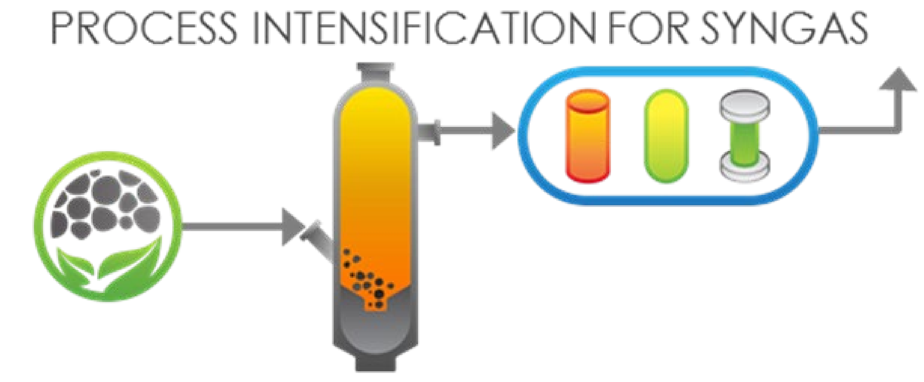
PROCESS INTENSIFICATION FOR SYNGAS



U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

Conversion of Coal Wastes and Municipal Solids Mixtures by Pyrolysis Torrefaction and Entrained Flow Gasification

In the area of research for control of chemical reactions in increasingly modular and intrinsically efficient reactors, allowing for smaller reactors and streamlined process systems for gasification of coal into syngas, syngas cleanup, and syngas conversion.

Overview

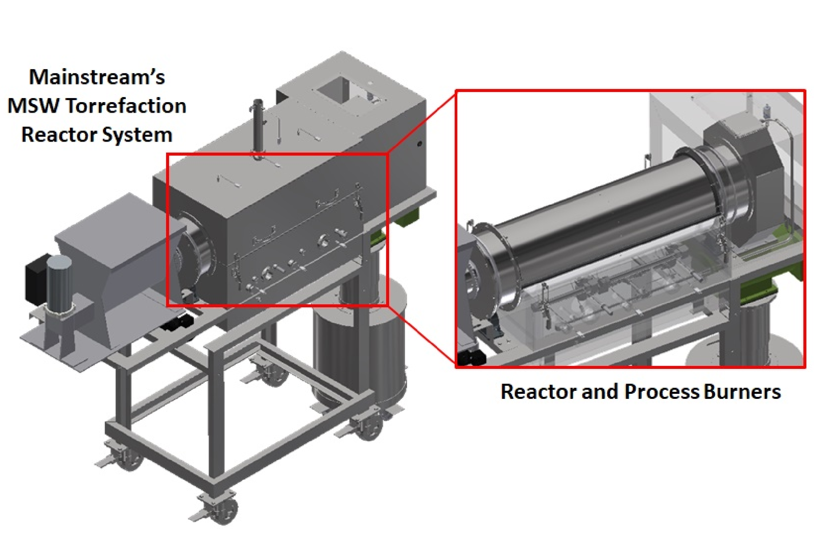
The philosophy driving Mainstream Engineering Corporation's project is that utilization of coal wastes, biomass, and municipal solid waste (MSW) as mixed feedstock in modular gasification would advantageously reduce problematic waste streams while providing a route to liquid and gaseous fuel products with low pollutant emissions. Entrained flow gasification (EFG) is a favorable choice for high-quality syngas for the synthesis of fuels. However, these gasifiers face the problem of effectively feeding large biomass and waste particles. A solution to the feeding problems is to use a low-temperature pyrolysis reactor for torrefaction of biomass mixtures, creating a feedstock similar to coal and capable of being ground down, mixed with the coal feed, and fed into the gasifier.

Current project scope involves gasification testing of torrefied MSW and waste coal in a pilot-scale EFG, enabling characterization of preparation, feeding, and slagging behavior. Also, continuous torrefaction reactor technology is to be developed.

Benefits

- Provides a way to utilize waste coal plus other opportunity fuels, eliminating waste streams while yielding valuable energy products with minimized pollutant emissions.
- Helps enable modular gasification technology suitable for strategic deployment in coal preparation locations, military installations, etc.
- Advancing towards coal waste plus MSW processing for power plants, enabling reduction in capital, operating, and maintenance costs for co-firing biomass and mixed waste with coal.

Recent Results



- Sourced representative MSW from predominate waste coal regions in United States.
- Torrefied MSW at optimal conditions with pilot-scale torrefier.
- Pilot-scale EFG testing at Energy and Environment Research Center (EERC) with torrefied MSW and waste coal (ongoing).
- Demonstrated proper slagging of MSW and waste coal.
- Completed preliminary design of continuous bench-scale torrefaction reactor.

QUICK FACTS

AWARD NUMBER:
SC0018580

PROJECT BUDGET

DOE Share:
$1,150k

Performer Share:
N/A

Total Award Value:
$1,150k

CONTACTS

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Nicholas Schwartz

PERFORMER

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COAL-BIOMASS TO LIQUIDS

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Microwave Reactions for Gasification

Develop microwave technology for coal gasification by measuring the impact of different variables for microwave conditions on conversion and product yields for coal gasification.

Overview

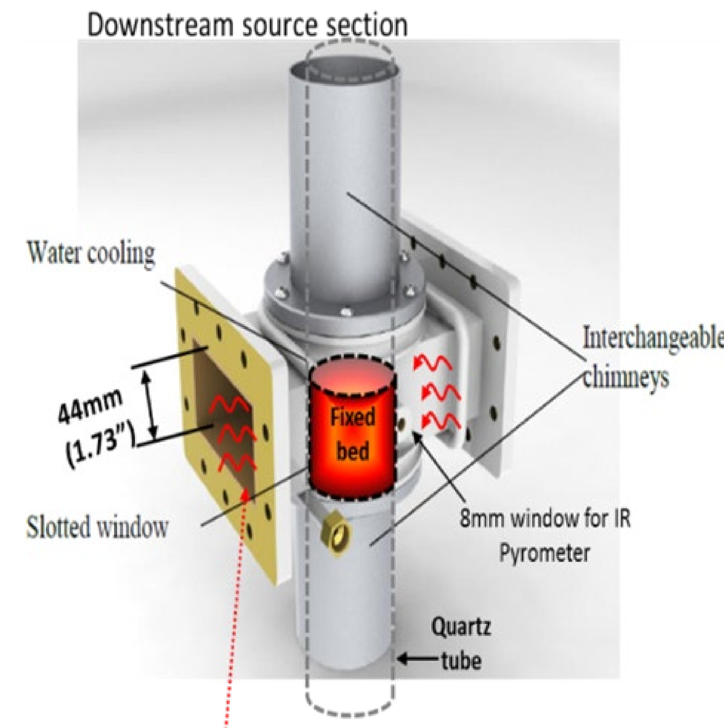
The National Energy Technology Laboratory (NETL) is focused on a microwave-based concept for coal gasification to syngas, which could result in the co-production of energy and value-added chemicals at relatively low temperatures. The underlying objective of using a microwave-enhanced process is twofold. First, the use of microwaves provides selective heating of the targeted sites of a material, thereby enhancing the activity without increasing the temperature of the surrounding bulk gas, inert catalyst support, and reactor system components. Therefore, any reaction can be initiated at the active sites or "hot spots" while the bulk temperature might be significantly lower, enhancing the selectivity limited by thermodynamics. Second, the microwaves play the role of a promoter. The energy delivered by a microwave field is not sufficient to break or form chemical bonds. However, the microwave field can induce the polarization of reacting molecules and/or catalyst surface site resulting in a weakened bond that can be more easily broken.

Benefits

Chemical conversion can be enhanced by applying radio frequency/microwave fields and/or plasmas to the catalytic reaction zone. The high-frequency microwave fields can selectively stimulate active metal sites on catalysts through dielectric and magnetic interactions without increasing the bulk gas temperature and solid medium. These conditions can result in product yields that are significantly higher than predicted by thermodynamics, which can provide savings in both energy and feed costs.

Recent Results

- Completed proof-of-concept experiments for conversion of residual carbon in ash from thermal gasifier.
- Developed high-temperature testing cell for dielectric characterization of samples under different gas and operating conditions.
- Design, construction, and operation of new Variable Frequency Microwave Reactor (B14 – Reaction Analysis and Chemical Transformation [ReACT] Lab).



QUICK FACTS

AWARD NUMBER:
NETL FWP 1022405, Task 6

PROJECT BUDGET

DOE Share:
$2,356k

Total Award Value:
$2,356k

CONTACTS

HQ PROGRAM MANAGER:
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PRINCIPAL INVESTIGATOR:
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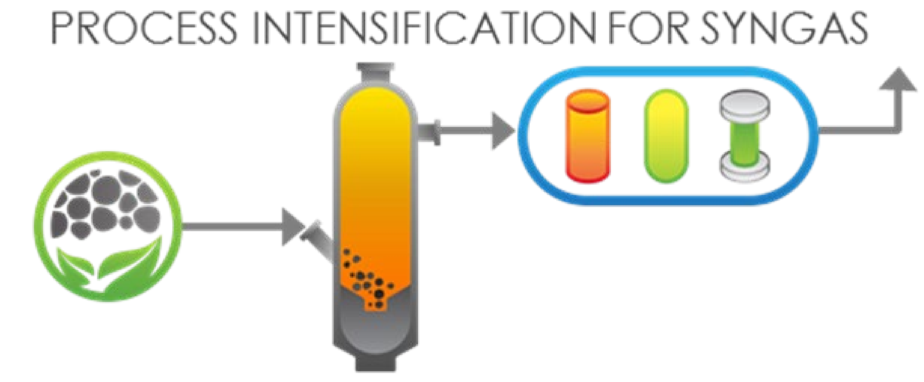
PERFORMER

NETL

PROCESS INTENSIFICATION FOR SYNGAS



U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Syngas Cleanup for Radically Engineered Modular Systems (REMS)

Develop modular designs for the cleanup of warm syngas by addressing key knowledge gaps.

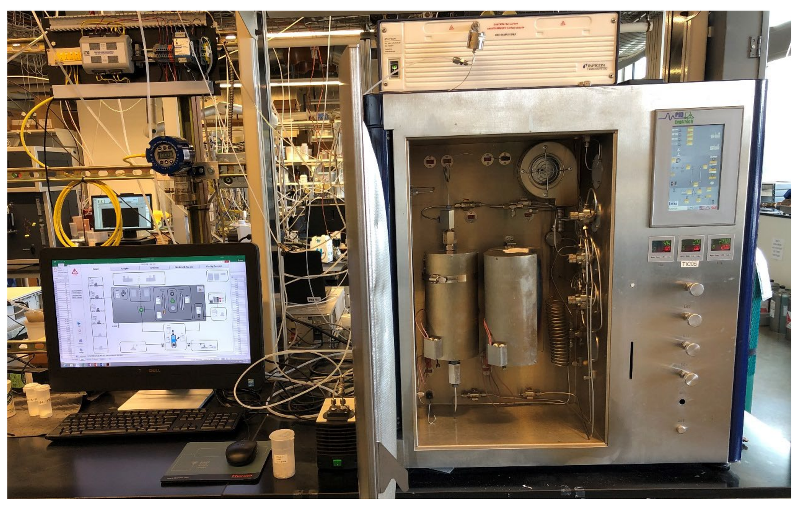
Overview

Research Triangle Institute (RTI) is developing modular designs for the cleanup of warm syngas with reduced costs, emissions, and improved thermal efficiency, enabling 1- to 5-MW Radically Engineered Modular Systems (REMS)-based plants to be cost-competitive with large, state-of-the-art commercial plants using abundant domestic coal reserves.

Benefits

If proven successful, RTI's designs for modular warm syngas cleanup will provide a pathway to reduce the cost and increase the efficiency of producing syngas from coal or mixtures of coal. Additional benefits include increased plant availability, reduced capital costs and cost of energy production, reduced development time and cost, reduced greenhouse gas emissions, and leveraging technical breakthroughs with commercial technologies.

Recent Results



- Completed testing of low-sulfur syngas with excellent sorbent performance.
- Completed acquiring hydrodynamic data for the sorbent at key regions within the fluid-bed reactor system using the existing cold-flow unit.
- Received pilot-scale wet cake from supplier for testing.

QUICK FACTS

AWARD NUMBER:

DE-FE0031522

PROJECT BUDGET

DOE Share:

$1,599k

Performer Share:

$400k

Total Award Value:

$1,999k

CONTACTS

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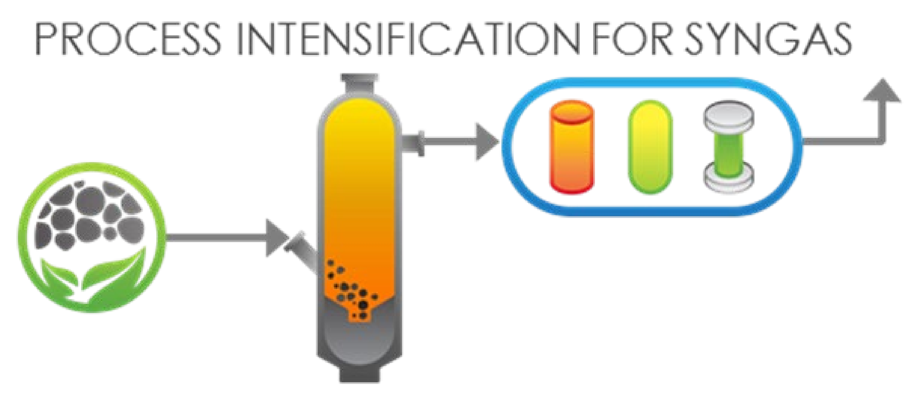
Dr. Atish Kataria

PARTNERS

RTI INTERNATIONAL



U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

Staged Opposed Multi-Burner (OMB) for Modular Gasifier/Burner

Testing of a staged OMB for use in modular applications.

Overview

The University of Kentucky Research Foundation will test a staged opposed multi-burner (OMB) gasifier for a scaled-down version of a commercial gasification technology that utilizes coal slurry as a feed for high-temperature gasification. This project has the potential for small-scale modularization with standardized burners.

Benefits

Potential enhancement of a viable technology that may (1) better realize the full potential of abundant fossil energy resources, such as coal, in an environmentally sound and secure manner; (2) achieve modularized gasification in lieu of commercial experience at low risk; and (3) satisfy the interests of end users at low cost.

Recent Results

- OMB testing at multiple conditions undertaken.
- Burner testing underway.
- Fuel flexibility testing ongoing.

QUICK FACTS

AWARD NUMBER:
DE-FE0031506

PROJECT BUDGET

DOE Share:
$1,612k

Performer Share:
$404k

Total Award Value:
$2,016k

CONTACTS

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UK CENTER FOR APPLIED ENERGY RESEARCH

PROCESS INTENSIFICATION FOR SYNGAS

Integrated Water-Gas Shift (WGS)/Pre-Combustion Carbon Capture Process

Develop an integrated WGS pre-combustion CO_2 capture technology to eliminate CO_2 emissions from integrated gasification combined cycle (IGCC) power plants and coal-to-liquid plants.

Overview

The project team will design a gasification reactor using computational fluid dynamics (CFD) and kinetic modeling to achieve optimum carbon dioxide (CO_2) removal and hydrogen recovery. TDA will perform system design and sorbent production, working in conjunction with GTI in the design and fabrication of a slipstream test unit. University of California-Irvine and Indigo Power Systems will conduct the process modeling and design, and will carryout the system and economic analyses. Praxair will support the field tests at the Praxair Facility in Tonawanda, New York.

Benefits

Develop new CO_2 capture technology for use in integrated gasification combined cycle (IGCC) and coal-to-liquid (CTL) plants that run on a wide range of coals (bituminous to low-rank) and petcoke. The integrated water-gas shift (WGS) pre-combustion CO_2 control system achieves high CO_2 capacity and removal efficiency (>90%) at temperatures well above syngas dew point for all commercial gasifiers. High-temperature CO_2 removal capability eliminates the need to condense the steam in the gas and maximizes the mass flow through the gas turbine, thereby increasing the efficiency of the power cycle. This technology will provide U.S. developers with an effective carbon capture system that is much more efficient than conventional low-temperature scrubbers.

Recent Results

- Completed production of the sorbent needed for field testing.
- Completed evaluation of the single reactor and new injector.
- Continued modifications to existing fixed-bed test rig for life-cycle testing.

QUICK FACTS

AWARD NUMBER:
DE-FE0023684

PROJECT BUDGET

DOE Share:
$4,507k

Performer Share:
$1,126k

Total Award Value:
$5,633k

CONTACTS

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Gokhan Alptekin

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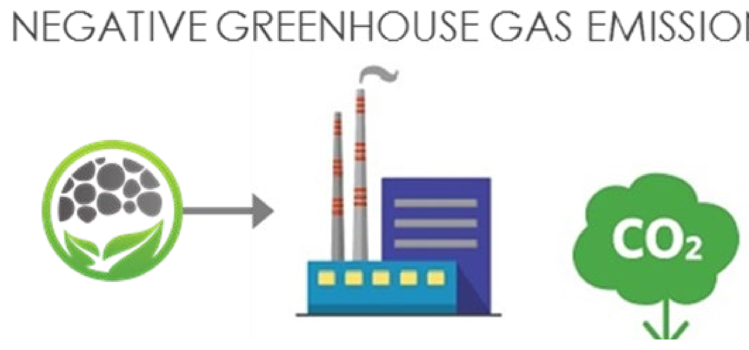
TDA Research
gti
University of California Irvine
Praxair
Indigo Power FZC — Innovative Solutions for the Power Industry

NEGATIVE GREENHOUSE GAS EMISSIONS



Warm-Gas Multi-Contaminant Removal System

In the area of research for control of chemical reactions in increasingly modular and intrinsically efficient reactors, allowing for smaller reactors and streamlined process systems for gasification of coal into syngas, syngas cleanup, and syngas conversion.

Overview

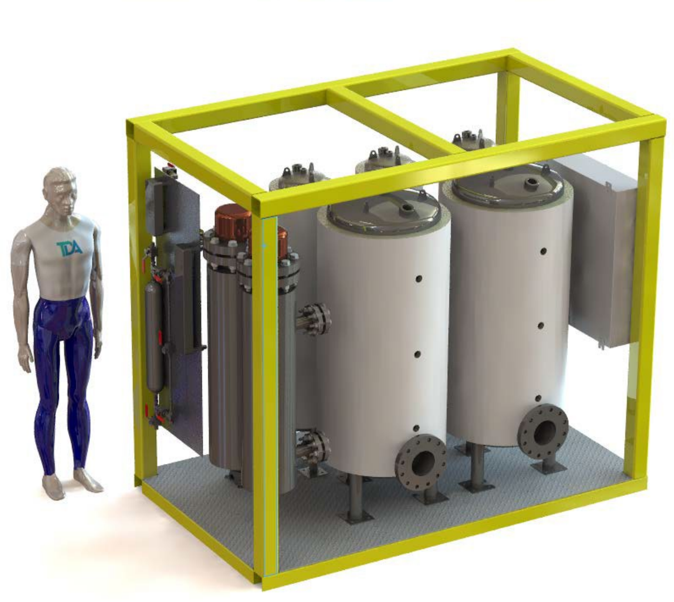
Coal-derived syngas normally contains sulfur contaminants, mainly in the form of hydrogen sulfide, which are conventionally removed prior to downstream usage of the syngas. However, conventional cleanup processes for acid gas removal may not capture certain trace contaminants, the removal of which may be demanded by more stringent regulations or by requirements of certain downstream processes. TDA Research, Inc. is developing a low-cost, high-capacity sorbent that can remove ammonia (NH_3), hydrogen cyanide (HCN), and trace metal contaminants (such as mercury [Hg], arsenic, and selenium) from coal- and coal/biomass-derived syngas in a single process step. Work is establishing operating parameters in multiple-cycle experiments and testing sorbent durability/lifetime.

Benefits

Unlike commercially available gas clean-up technologies, the TDA multi-contaminant control system operates above the dew point of the syngas (500°F). With this technology, the syngas would not have to be cooled in order to remove the contaminants, thus improving the thermal efficiency of the process.

Overall, this technology will benefit production of high-hydrogen, low-methane, ultraclean syngas, which can be versatilely used for power production with carbon dioxide (CO_2) capture, fuels or chemicals production, and polygeneration applications.

Recent Results



- Slipstream testing demonstrating continuous removal of NH_3 and Hg using coal derived syngas at the National Carbon Capture Center (NCCC).
- Techno-economic analysis estimate for cost of removing NH_3, Hg, arsine (AsH_3), and HCN contaminants is ~$3.7 MM per year ($10.1 MM with annualized capital cost) for a design basis 550-MW integrated gasification combined cycle (IGCC) plant.

QUICK FACTS

AWARD NUMBER:
SC0008243

PROJECT BUDGET

DOE Share:
$2,150k

Performer Share:
N/A

Total Award Value:
$2,150k

CONTACTS

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PERFORMER

TDA RESEARCH

NEGATIVE GREENHOUSE GAS EMISSIONS

Poison Resistant Water-Gas Shift Catalysts for Biomass and Coal Gasification

In the area of research for control of chemical reactions in increasingly modular and intrinsically efficient reactors, allowing for smaller reactors and streamlined process systems for gasification of coal into syngas, syngas cleanup, and syngas conversion.

Overview

TDA Research, Inc. is developing sour-shift catalysts to enable higher carbon monoxide (CO) water-gas shift (WGS) conversions than possible with currently available commercial catalysts. The new catalysts are being developed to operate with reasonably fast kinetics at lower temperatures where the WGS equilibrium is more favorable. The catalysts are also being developed to be resistant specifically to poisons found in biomass/coal-derived syngas.

As improved promoted Co-Mo/Al_2O_3-type sour WGS catalysts are formulated and prepared, their performance is being assessed in testing campaigns. Exactly how poisons affect the new WGS catalysts when present in syngas derived from coal/biomass combinations is an important testing focus. TDA is having larger-scale testing performed at the Energy and Environmental Research Center (EERC) in North Dakota, where EERC's pressurized fluidized bed gasifier is used to generate syngas for testing of the TDA sour WGS catalysts in shift reactors (9 liter volume).

Benefits

Extensive reserves of cheap coal in the United States, combined with substantial amounts of agricultural residues, provide the opportunity for combined coal/biomass gasification. Gasification enables syngas production; syngas can be shifted and converted to liquid transportation fuels via Fischer-Tropsch synthesis or other processes, while hydrogen can be recovered for synthesis of other value-added chemicals and products. Using the TDA innovative WGS catalysts would enable cheaper syngas production from coal/biomass blends; carbon footprint is lowered with biomass in the mix, and with capture, negative greenhouse gas emissions are possible.

Recent Results

- Second catalyst testing campaign run (high-T shift reactor online 323 hours, low-T shift reactor online 284 hours); coal-derived syngas used for part of campaign.
- Air-cooled heat exchanger between shift reactors found to enable better low-T shift reactor temperature control.
- Shift reactors operated at targeted temperatures (first stage 600°F, second 446°F).
- Surface area and elemental analyses of used catalyst performed to assess catalyst durability.

QUICK FACTS

AWARD NUMBER:
SC0004378

PROJECT BUDGET

DOE Share:
$2,058k

Performer Share:
N/A

Total Award Value:
$2,058k

CONTACTS

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PERFORMER/PARTNER

TDA RESEARCH

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