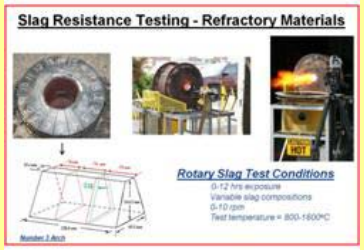
NETL-RUA
Regional University Alliance

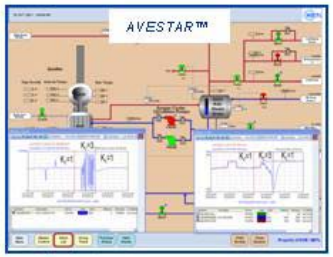
Morgantown, WVA
March 5, 2013

U.S. DEPARTMENT OF ENERGY

Materials



Simulations



Modeling

CSC Fouling

Refractory/TC Wear

RSC Fouling

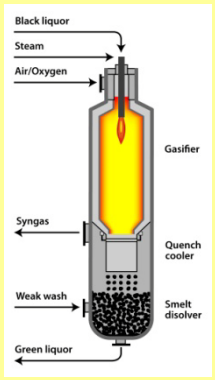
Advanced Gasification Technology

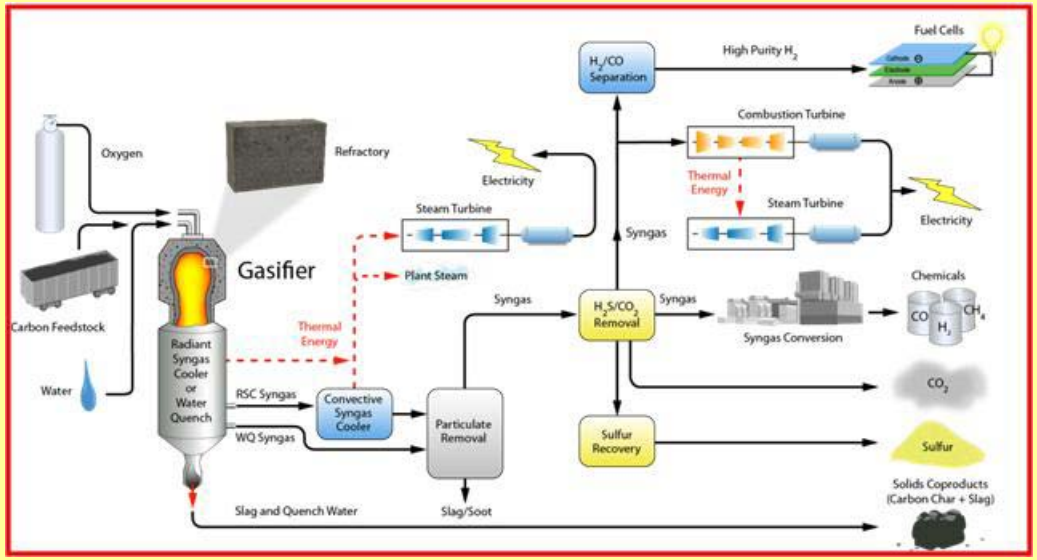
James P. Bennett - Technical Coordinator

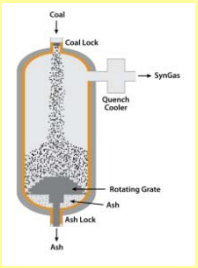
Chris Guenther - Division Director

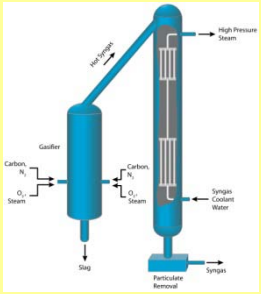
NETL Carnegie Mellon PENNSTATE University of Pittsburgh VirginiaTech WestVirginiaUniversity URS

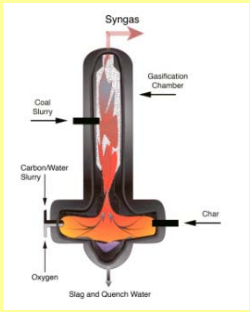
Industry Challenges

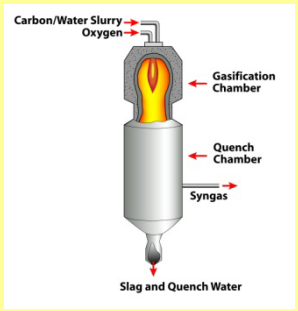


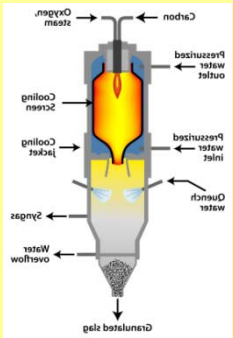












- ***Carbon feedstock flexibility (coal, low rank coal, petcoke, biomass)***
- ***Low cost of electricity (cost competitive with existing power generating systems)***
- ***Meet or exceed current or future EPA emission requirements***
- ***Increase gasifier reliability, availability, maintainability (85-90 pct power, 95 pct chemical)***
- ***Syngas output flexibility***
- ***Educated, trained workforce***
- ***Predictive models of gasification process***

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FY 2013 Research Program Makeup

Gasification Team
James Bennett
(Team Tech. Coord.)

Task 2—Refractory Improvement — James Bennett (NETL)
- **2.1 Refractory Development —** James Bennett (NETL)
- **2.2 Ash Management –** James Bennett (NETL)

Task 3—Conversion+Fouling — James Bennett (NETL) + Mike Bergen (URS)
- **3.1 Model Development—John** Kuhlman (WVU, NETL-RUA)
- **3.2 Devolatilization and Char Gasification —** Sarma Pisupati (Penn State, NETL-RUA)
- **3.3 Slag Viscosity and Unburnt Carbon —** TBD
- **3.4 Particle Deposition —** Nate Weiland, (WVU, NETL-RUA)

Task 4—Low Rank Coal Optimization — James Bennett/ Chris Guenther (NETL)
- **4.1 Uncertainty Quantification in Gasifier Simulations** — Mehrdad Shahnam (NETL)
- **4.2 Dev. Hierarchy of High Fidelity CFD Models for Co-fed TRIG —** Mehrdad Shahnan (NETL)
- **4.4 Model Validation in Support of TRIG Dev —** Larry Shadle (NETL)
- **4.5 Cohesive Power Model Development —** Sofiane Benyahia (NETL)
- **4.7 Fundamental Gasification Code Development —** Dirk Van Essendelft, (NETL)

Task 5—Warm Gas Cleanup — Evan Granite (NETL)
- **5.1 Warm Gas Cleanup —** Evan Granite (NETL)

Task 6—AVESTAR — Steve Zitney (NETL)
- **6.1 AVESTAR Center –** Steve Zitney (NETL)

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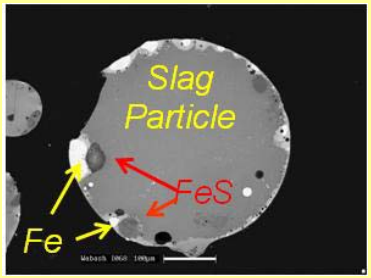
Gasifier Challenges

Material Issues



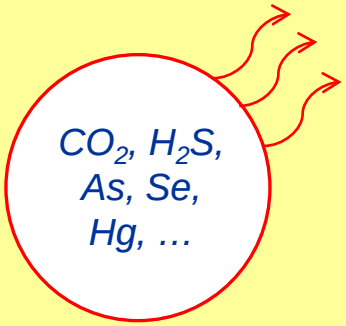
Carbon Feedstock Impurities

Slag Management

CO_2, EPA Regulated Emissions

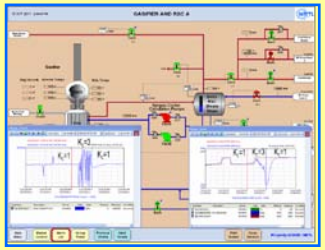
Syngas Cooler Fouling

Containment Material Wear and Corrosion



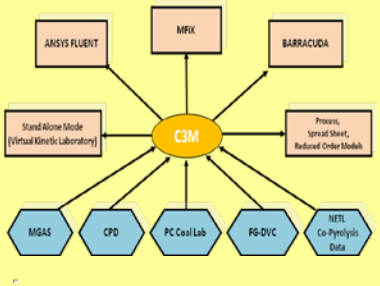
Operation, Predictive Behavior, System Design and Modeling

Carbon Feedstock Partitioning and Combustion Study and Modeling



Chemical Kinetic Management Software

Modeling Molten Slag



Operator Training

Gasification System Simulation

Physics Based Science Models to Conduct Science Based Applied Research

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Refractory Materials Used in Gasification

PROBLEM

- Refractory materials do not meet service life requirements:
  - gasifier liners
  - sensors
- Impurities in carbon feedstock melt to form corrosive liquids that lead to refractory material failure.
- Gasifier operators need materials with:
  - longer service life
  - increased reliability
  - carbon feedstock flexible
  - predictable performance
  - low cost, rapid repair

APPROACH

An RUA team is working with gasifier operators to:

- characterize current failure mechanisms
- develop improved materials.

RESULTS

- An improved performance refractory liner material has been developed, licensed, and is being produced commercially.
- Two patent applications have been filed for improved performance refractory materials.

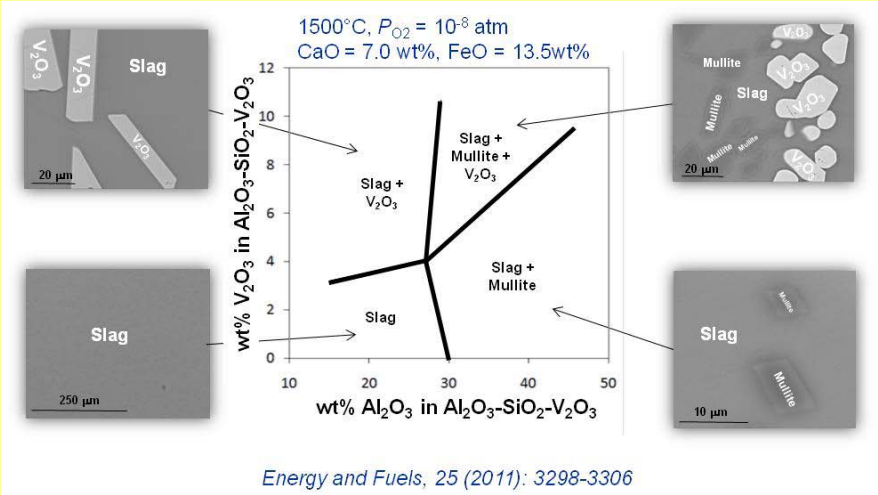
Phase Equilibrium Study of Synthetic Coal/Petcoke Slag Mixtures

PROBLEM

- Primary carbon feedstock materials are coal and petcoke.
- Impurities in feedstock melt to form corrosive slag with:
  - unknown flow characteristics,
  - impact syngas cooler fouling,
  - corrode/erode refractory liners
- Need exists to predict slag behavior during gasification.
- Thermodynamic data on vanadium oxide in petcoke slag does not exist for gasification environments.

APPROACH

A mixed team as part of the RUA alliance is working to supply thermodynamic information and phase equilibrium data on vanadium oxide.



Energy and Fuels, 25 (2011): 3298-3306

RESULTS

- Phase studies completed on coal/petcoke mixtures up to 8 wt pct vanadium oxide.
- Research recognized by ACerS for phase equilibrium award in 2012.
- Expanded work up to 20 wt pct underway.

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Carnegie Mellon NETL West Virginia University URS

Warm Gas Cleanup

PROBLEM

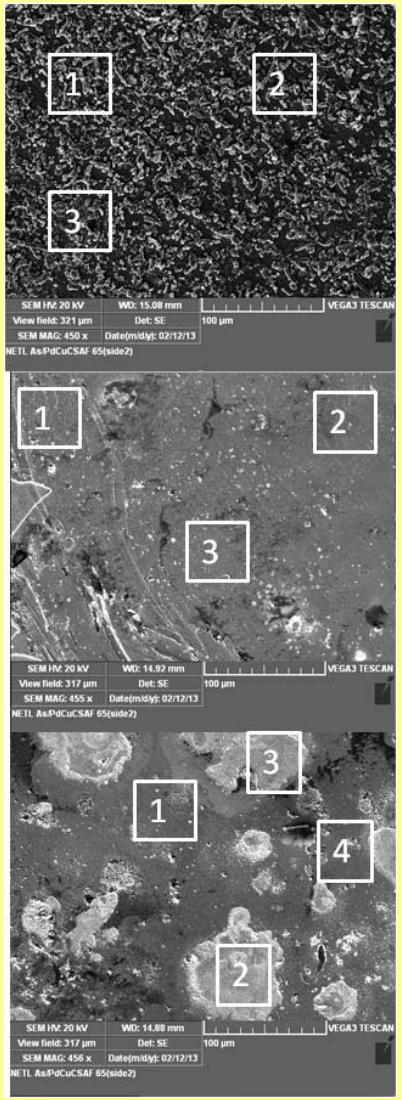
- Synthesis gas requires cleaning before use.
- Gaseous impurities include CO_2, H_2S, As, Se, and Hg.
- EPA regulations on Hg emissions require low levels in syngas.
- Removal of trace impurities difficult and expensive.
- Low cost, predictable, and long life materials or processes are needed.

APPROACH

An RUA team is working with industry to develop reusable, long life materials for use in capturing syngas impurities in a cost effective process.

RESULTS

- One patent granted for a precious metal to remove impurities.
- Technology being evaluated in field trials at a gasifier site.



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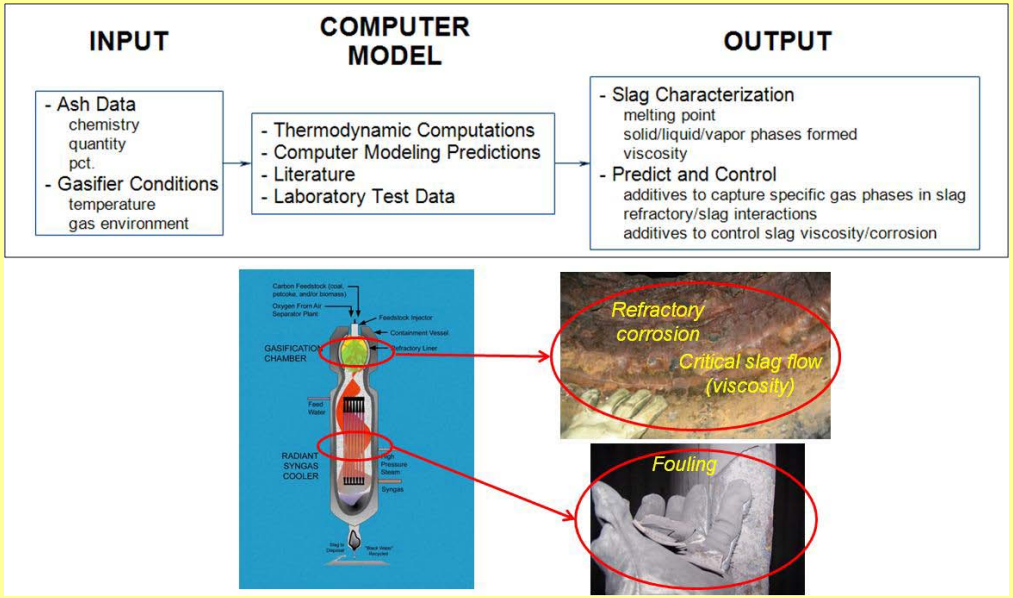
Slag Management in Gasification

PROBLEM

- Carbon feedstock has mineral or organic impurities that melt, coalesce, or remain airborne.
- Flowing slag attacks the refractory liner by corrosion, erosion, or spalling; causing material failure - downtime for repair or relining.
- Airborne slag particulates contribute to syngas cooler fouling, blocking syngas pathways - causing premature shutdown for cleaning.
- Viscosity of the slag must be maintained at specific levels so it flows, not so high that it causes accelerated material failure..

APPROACH

An RUA team is developing slag models to use in predicting their physical properties and to determine appropriate slag additives if necessary.



RESULTS

- First generation models developed
- Models under evaluation at a gasifier site.

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Conversion and Fouling

PROBLEM

- Carbon feedstock used in gasification can be ground to different particle size distributions. Sizing impacts conversion into syngas.
- The particle size distribution have different minerals and mineral quantities.
- The mineral type, quantity, size, and how they are entrapped in the carbon particles determine where they go during gasification and what they impact (refractory, syngas coolers, etc).
- Minerals can become:
  - slag flowing down gasifier sidewalls
  - entrapped in syngas coolers
  - remain airborne

Convective syngas cooler fouling source – Global Energy, Inc

APPROACH

An RUA team is evaluating different particle sizes of coal to determine gasification efficiency, mineral behavior in the different fractions, and developing models to predict system impact/behavior.

RESULTS

- A gasification system has been built.
- First generation models have been developed.

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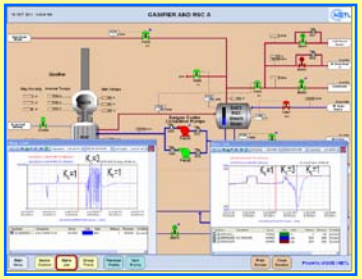
Training and Simulation - AVESTAR

PROBLEM

- Gasification processes need trained operators for plant operation.
- Training system needed for engineering education.
- Dynamic simulations of plant operations changes needed to evaluate/predict consequences of system changes before they are made.



APPROACH

- Develop a dynamic simulation-based training/research center for gasification systems
- Operate and promote the training center.
- Interface with academia for training students.

RESULTS

- 3D virtual IGCC system developed as training center (AVESTAR).
- Potential users being familiarized with system.
- Use by academia started, negotiations with industry underway.
- Evaluation of dynamic simulation capabilities underway.