DYNAMIC TESTING OF GASIFIER REFRACTORY

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PRIMARY GOAL

- To devise a mechanism of refractory degradation under typical Gasifier operating conditions.

OUTLINE

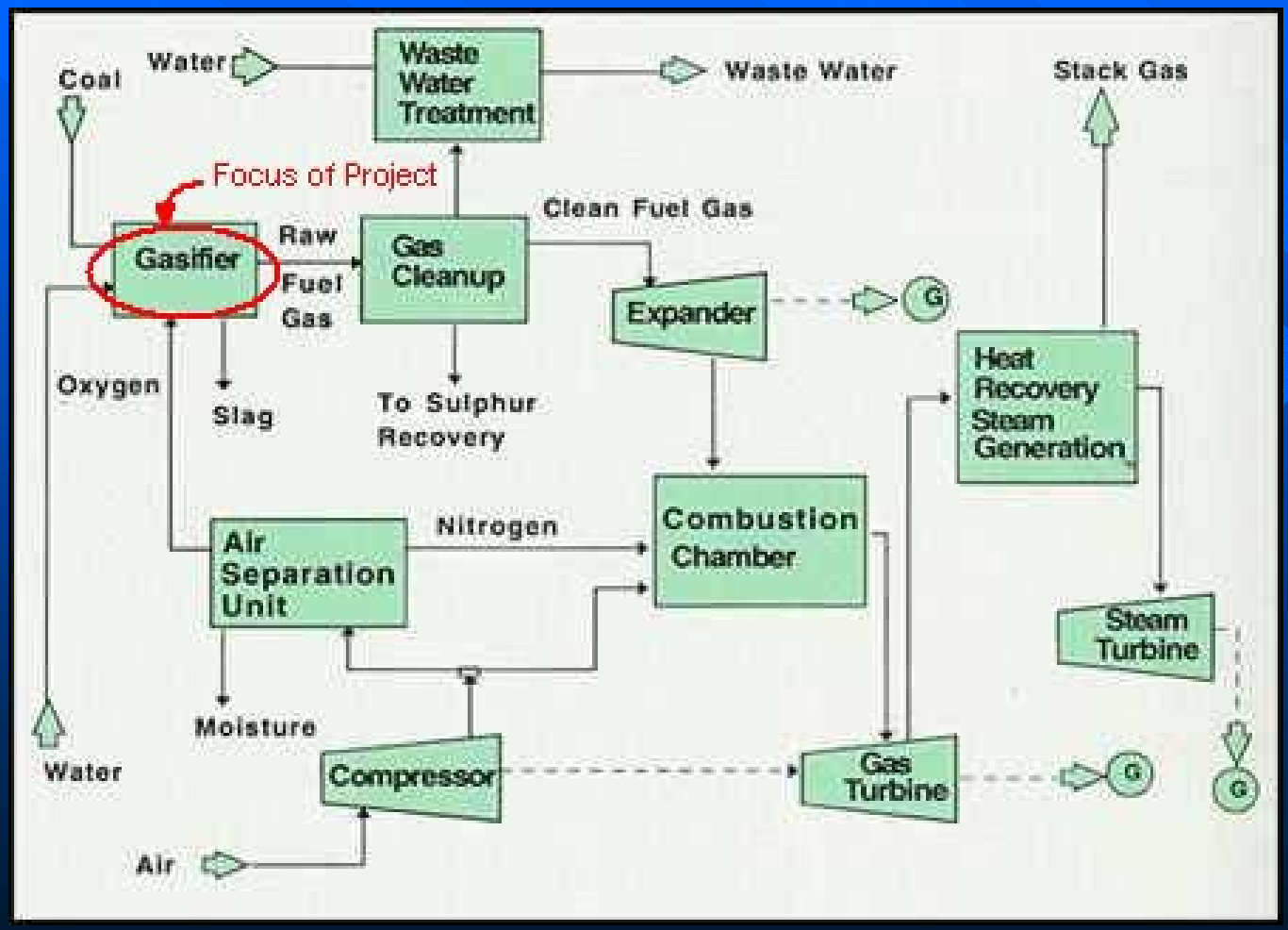
- Background
- Testing
- Equipment setup
- Constraints
- Future objectives.

REFRACTORIES

- Heat resistant materials with mechanical and chemical strength
- Combination of Silica & Alumina
- Types of refractories:
  - Preformed (Bricks, Tiles, special shapes)
  - Unformed (castables, plastics, gun mixes)
  - Special materials (ceramic fibers)

TYPICAL IGCC PROCESS

(Integrated Gasification Combined Cycle)



ROLE OF GASIFIERS

- Core equipment in power generation.
- Generates combustible gas for power generation.
- High efficiency production of electricity
  - Reduces CO_2 production
  - Minimizes generation of gaseous pollutants

OPERATING CONCERNS

- Chemically abrasive environment.
- Exposed to a combination of high temperature, pressure and corrosive fluids.
- Thermal cycling

OUR PRIMARY DEFENSE IS THE REFRACTORY LAYER

Refractory life impacts operating costs and plant availability

GASIFIER ATMOSPHERE

- High temperature
  - Chemical equilibrium favorable for ash/refractory reactions
  - Liquid slag assures rapid reaction
- Reduced form of ash components
  - More corrosive
  - Liquid at lower temperature than oxidized form
- Operating Conditions
  - Thermal cycling

FOCUS OF PROJECT

Corrosion is the degradation of material surfaces or grain boundaries of refractories. To control, we need to:

- Identify microstructure attacked
- Determine mechanism
- Estimate rates of attack

Running slag is the primary concern

ROLE OF RUNNING SLAG

- Transports corrodents to refractory surface
- Thin slag allows gases to participate in reactions
- Penetration of slag into refractory
  - Dissolution of cement below the surface
  - Crystallization resulting in expansion/bursting
- Continues to reestablish chemical driving force

TESTING METHODS

- Static Tests
  - » Cup Test
- Dynamic Tests
  - » Drip slag test
  - » Gradient slag test
  - » Rotary slag test
  - » Dip & Spin test

STATIC TESTS

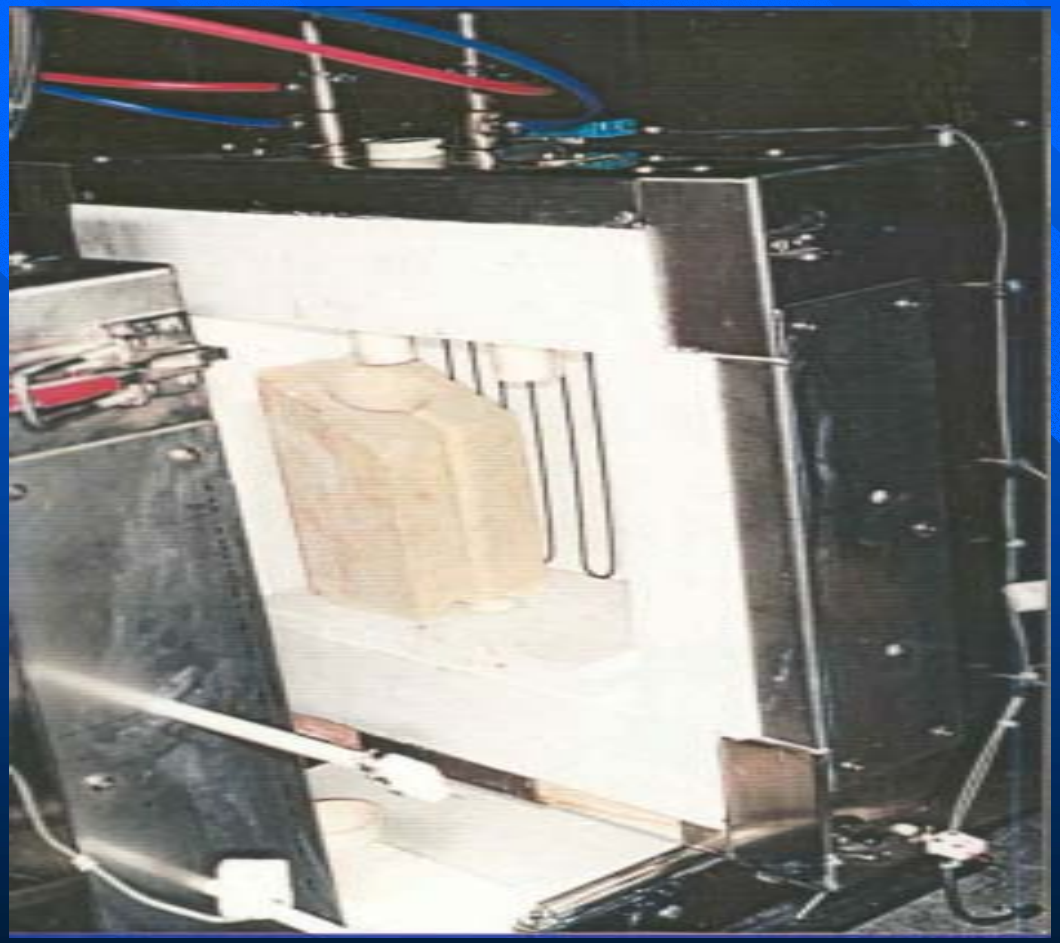
The slag is fed into the cup and kept at high temperature and allowed to penetrate. The degree of penetration is a measure of refractory efficiency.

This method is NOT considered reliable .

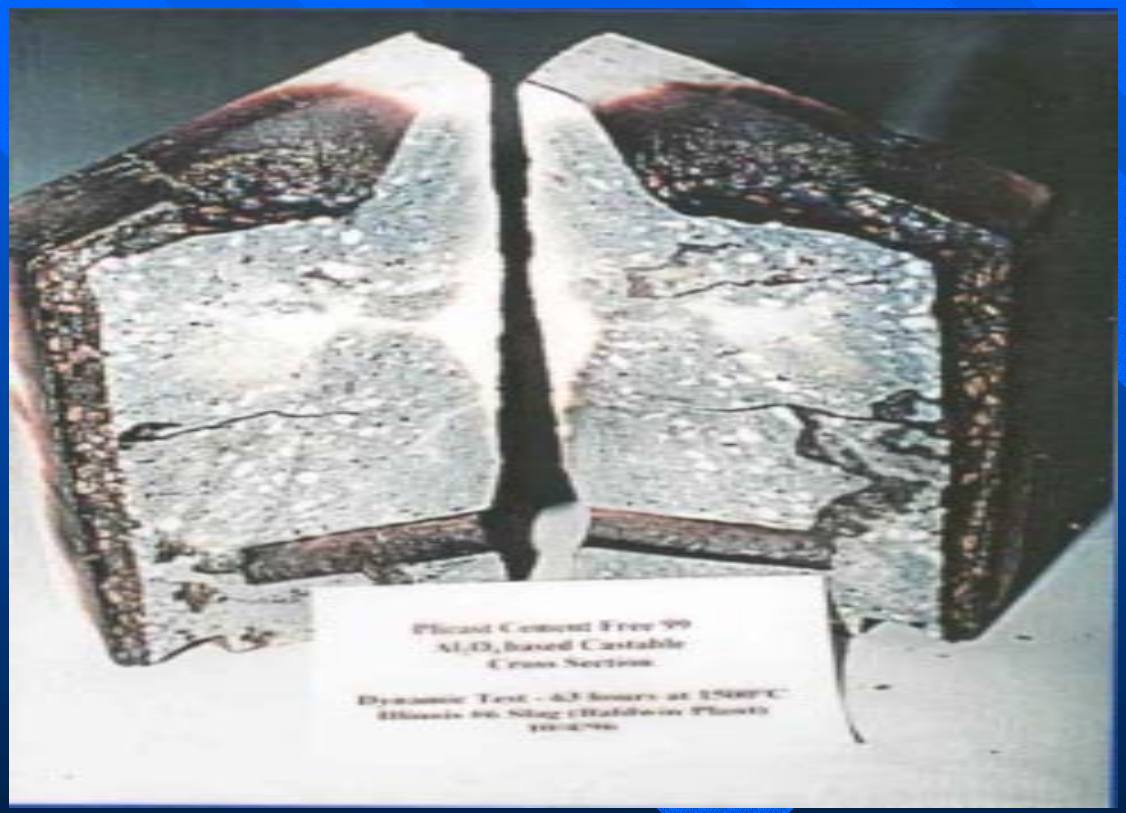
DYNAMIC TESTS

- Study the effect of flowing slag
- Simulate actual flowing conditions during the test.
- Development of Dynamic Slag Application Furnace (DSAF).
- Tested specimen undergoes combination of drip, gradient and flow test.

DYNAMIC SLAG APPLICATION FURNACE



DSAF SPECIMEN



STATIC vs. DYNAMIC TEST

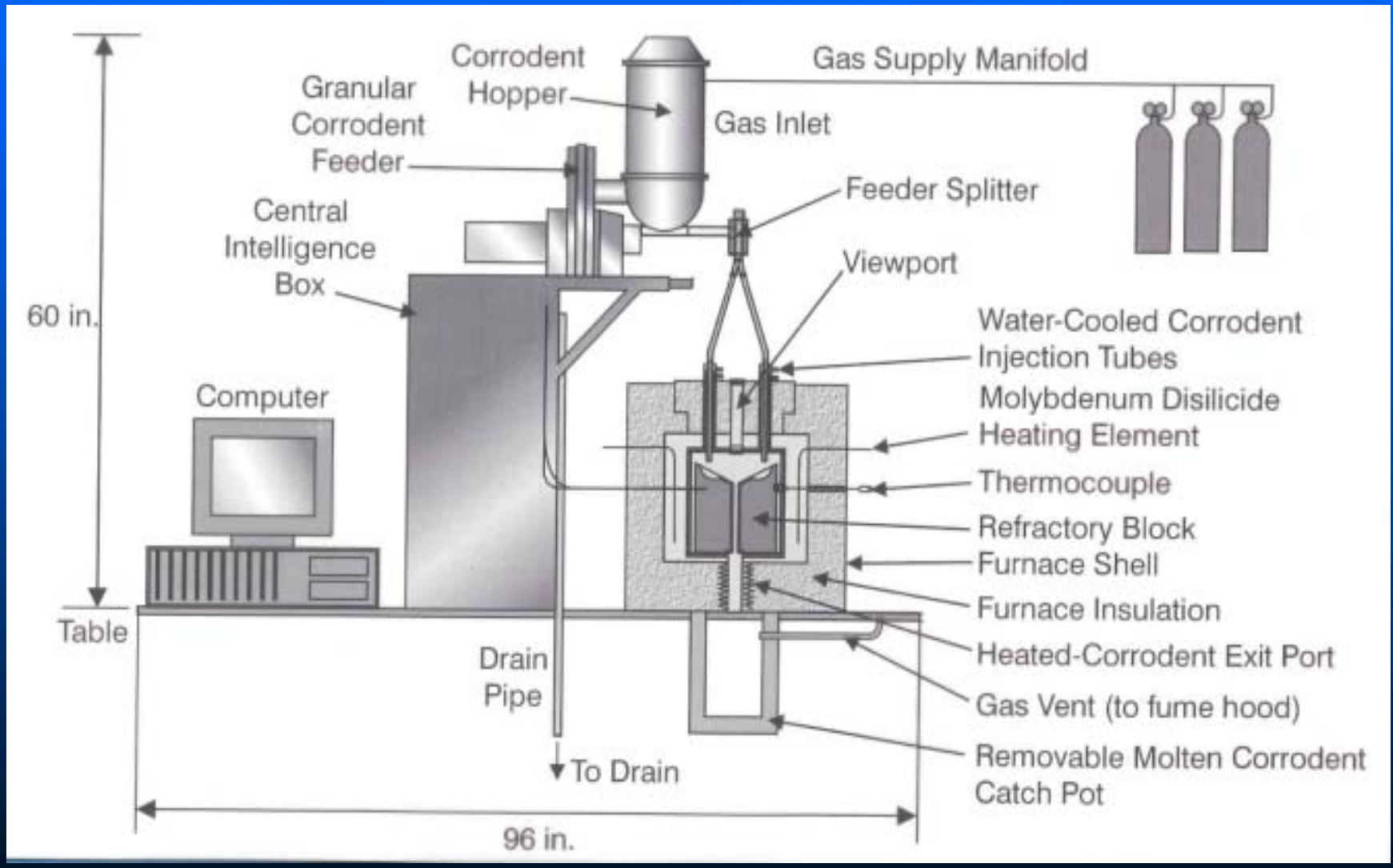
RESULTS FROM DSAF

- Coal slags were tested with various refractory compositions
- Static tests were misleading indicators of performance.
- Samples that failed the static tests performed better in the DSAF tests.

CADCAF

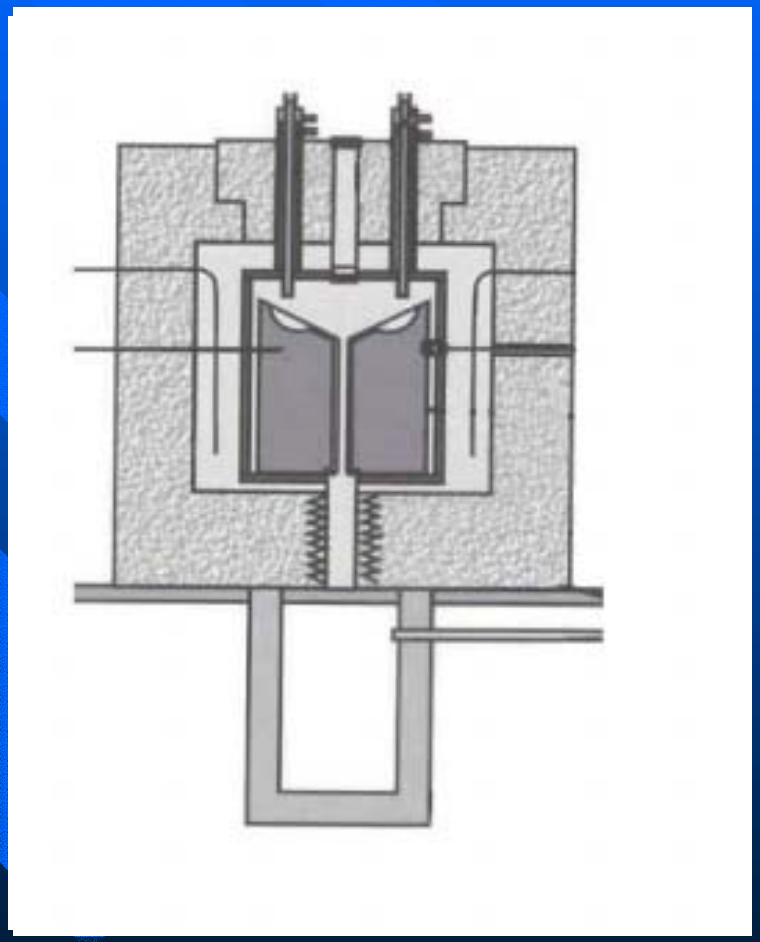
- Controlled Atmospheric Dynamic Corrodent Application Furnace (CADCAF)
- Simulates the chemical environment in the Gasifier.
- Major constituents are N_2, and H_2 (gas makeup limited for safety purposes)
- Atmosphere reducing with respect to iron

CADCAF


Corrodent Hopper
Gas Supply Manifold
Granular Corrodent Feeder
Gas Inlet
Feeder Splitter
Central Intelligence Box
Viewport
60 in.
Water-Cooled Corrodent Injection Tubes
Computer
Molybdenum Disilicide Heating Element
Thermocouple
Refractory Block
Furnace Shell
Furnace Insulation
Table
Heated-Corrodent Exit Port
Drain Pipe
Gas Vent (to fume hood)
To Drain
Removable Molten Corrodent Catch Pot
96 in.

LEAKAGE TESTING

- Refractories formed are porous.
- No commercially available sealants for high temperature.
- The glue should be strong enough to hold pressure, but must be removable.
- Lots of trial & error methods for sealing the crucible.



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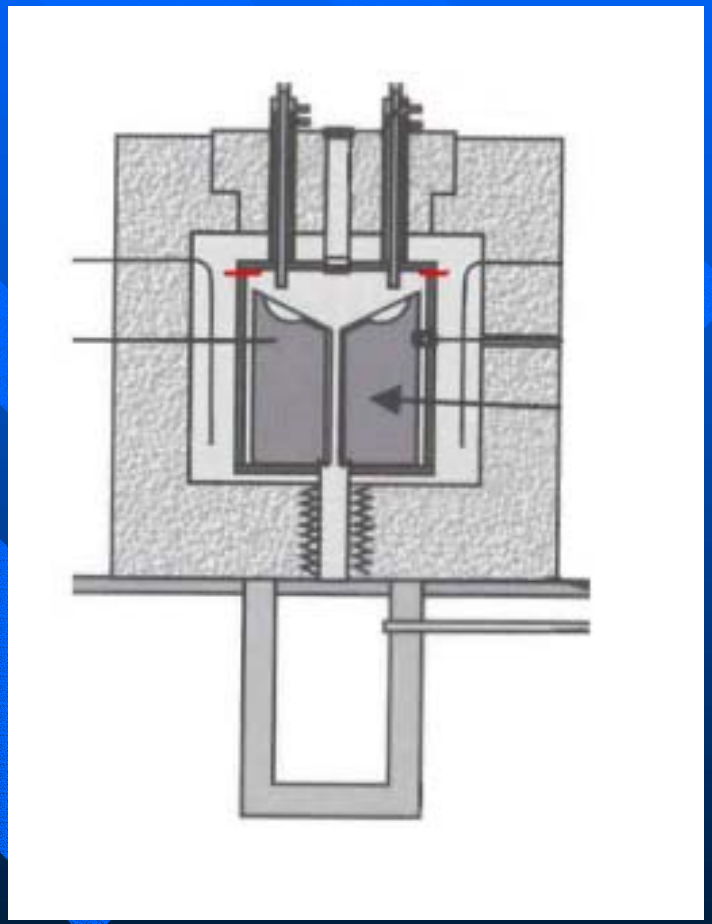

FUTURE OBJECTIVES

- Currently , the CADCAF is in its final shakedown stage. (Leakage testing)
- Preliminary tests to verify previous findings under new conditions.
- Study the effect of thermal shock.
- Identify a mechanism for slag/refractory interaction and refractory loss under slagging gasification conditions.

DIVISION OF TASKS

- TASK 1:
  - Selection of materials for initial screening
    - » One acidic and one basic slag
      - Slag obtained from Tampa Electric Polk Power Station
    - » 5 commercial refractories.
      - Refractory brick currently in use at the Polk Station
      - Salazar and Sons
      - Albany Research Center

DIVISION OF TASKS

- TASK 2:
  - Broad brush screening of 2 ashes with 5 refractories.
  - Analysis of specimens using SEM &XRD
- TASK 3:
  - **Directed CADCAF testing**
    - » Based on 2nd stage results, repeat the tests to get more information on previous findings.

DIVISION OF TASKS

- TASK 4:
  - Thermal Shock tests.
    - » Study the effect of slag phase change and thermal shock.
- TASK 5:
  - Identification of Mechanism
    - » Assumptions will be verified.
    - » Final model that describes the behavior will be proposed.

SUMMARY

- Developing methods to test refractory degradation under simulated Gasifier conditions.
- Reducing atmosphere and flowing slag are important considerations.
- Resolving equipment sealing issues.
- Future work will focus on testing and model development.

THANK YOU