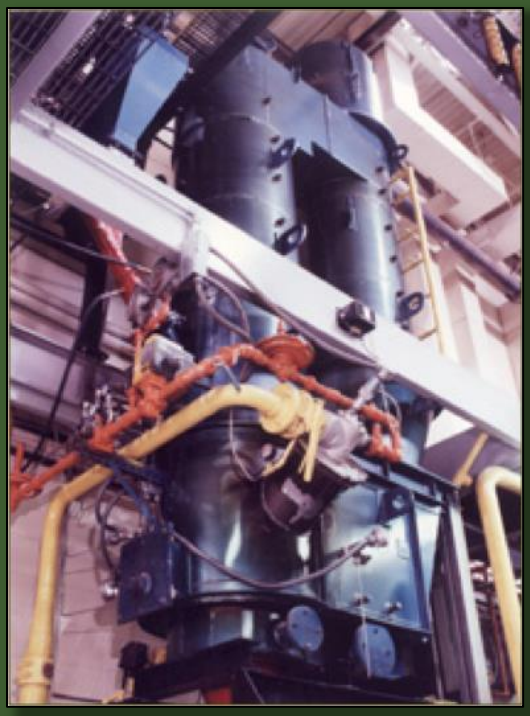
PennState College of Earth and Mineral Sciences

Earth and Mineral Sciences Energy Institute

Pilot- & Laboratory-Scale Stationary Combustion Facilities



www.energy.psu.edu

Key Contacts
Bruce G. Miller • bgm3@psu.edu
Sarma Pisupati • sxp17@psu.edu

Overview

The EMS Energy Institute, a leader in stationary combustion research since 1949, has facilities for fundamental and applied research on the nature of fossil fuels and biomass and the impact of their utilization on the environment. The pilot-scale facilities create industrially relevant flame and temperature conditions and yet have the advantage of producing samples under controlled conditions to assist in understanding the processes at a fundamental level. The facilities are typically used for:

- Conducting research to understand the fundamentals of energy conversion processes
- Conducting applied research and providing solutions to industrial problems
- Providing specialized test services such as proof-of-concepts, performance evaluations, demonstrations of new burner designs, and emissions characterization and remediation
- Promoting transfer of technology to industrial groups

Key Equipment

2 Million Btu/h Research Boiler

The multifuel capable package boiler is of A-Frame watertube construction and was designed and built by Cleaver Brooks. The boiler is equipped with ports for gaseous and particulate sampling in the radiative and convective sections of the boiler.

Examples of activities performed using the research boiler:

- Evaluating the combustion performance and determining emissions from a range of fuels including coals, synfuels, fuel oils, orimulsions, and liquid and solid biomass
- Evaluating the effect of operating parameters and hardware components on combustion and boiler performance
- Providing research support and operator training
- Characterizing emissions such as NO_x, SO_2, and inorganic and organic hazardous air pollutants
- Developing emissions factors and stack testing methodologies

1 Million Btu/h Fluidized Bed Combustor (FBC)/ 2 Million Btu/h Circulating Fluidized Bed Gasifier

The fluidized bed combustion/gasification system can be operated as a circulating or bubbling FBC or circulating fluidized bed gasifier. Fuel and limestone are fed into the combustor using screw feeders or pumps, depending on the fuel type. Numerous ports are provided in the main bed and freeboard for the measurement of pressures and temperatures and for particulate or gas sampling. The unit also has overfire air capabilities.

The fluidized bed system is routinely used to:

- Evaluate fuels such as coals, coal-water slurry fuel, coal cleaning refuse, biomass materials, and refuse-derived fuels
- Evaluate sorbents for SO_2 removal
- Perform fundamental studies on sorbent sulfation, bed agglomeration and combustion modeling, emissions formation, and particle attrition

Gasification Reactor

The gasification reactor is a laboratory-scale, fluidized-bed reaction system capable of gasifying a variety of traditional fossil fuels as well as biomass materials.

The gasification reactor is used to:

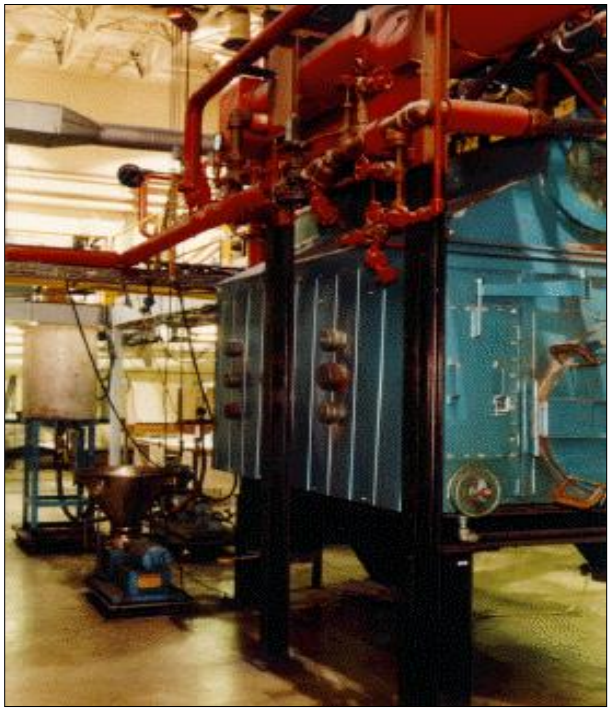
- Assess changes in operating parameters on gas production and composition
- Determine the effect of fuel type on gasification performance
- Perform co-gasification (coal and biomass) studies

Drop-Tube Reactor (DTR)

The DTR is a vertically fed, electrically heated apparatus that can simulate fuel heating rates, temperature profiles, and particle residence time of a utility boiler. The DTR system consists of four main components: a fuel feeder, a preheater, a furnace, and a sample collection probe.

The DTR is used to perform fundamental studies to:

- Determine pyrolysis and overall kinetic parameters of coals, coal blends, biomass, and petroleum coke
- Compare emissions and combustion performance of fuels
- Generate char/fly ash samples for study
- Measure relative ash deposition characteristics of fuels



Research Boiler

High Pressure, High Temperature Flow Reactor

The high-temperature, high-pressure entrained flow reactor is used to study pyrolysis and gasification kinetics, mineral matter transformations, and interactions of coal and biomass ash with refractory materials. The reactor consists of six units: the feeding unit, the gas preheating unit, the control unit, cooling unit, the analysis unit and the reaction unit.

High Pressure Fluidized Bed Reactor

The fluidized bed reactor was designed to test limestone samples for sulfur capture for power plant scrubber applications. Mixtures of SO_2 (up to 10%) and a balance of CO_2 are used to fluidize a gram-sized sample of pulverized limestone. The gas leaving the fluidized limestone is then sent to a continuous gas monitoring system for analysis of O_2, CO, CO_2, and SO_2. This system can be used to screen limestone samples for sulfur capture, as well as quantify the amount of sulfur that can be captured. This system is capable of testing samples at temperatures up to 900°C and 150psig with 4 L/min of gas flow.

High Pressure Fluidized Bed Reactor

High Pressure, High Temperature Flow Reactor