CRADA facts

DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY

FILTRATION
PROJECT

MEASUREMENTS OF FILTER-CAKE PROPERTIES

Capabilities

The Pressurized Fluidized-Bed Combustion (PFBC) and Integrated Gasification Combined Cycle (IGCC) programs of the U.S. Department of Energy require filtration, at temperatures from about 600 to 900 °C, of fine particles of coal ash, char, or spent and unreacted sorbent from hot-gas streams. Achieving acceptable filter lifetimes requires solutions to, or avoidance of, such problems as incomplete filter cleaning, re-entrainment (i.e., re-filtration) of particles from filter cleaning, and bridging of filter cake between adjacent filters. These and other potential problems may arise from the materials properties of filter cakes, from the filter-bank design, and from the mechanisms of filter cleaning. Avoiding re-entrainment requires that some bonding and agglomeration of particles occur in the cakes (so that the agglomerates from filter cleaning are too large to be re-entrained), but excessive agglomeration can produce poor cleaning or bridging.

For both PFBC and IGCC applications, we can form filter cakes at process temperatures, gas compositions, and gas flow rates, and measure the gas-phase permeabilities, porosities, tensile strengths, and deformation coefficients of these filter cakes to determine their dependencies on temperature, reaction time, gas composition, particle compositions, and particle size distributions. Filter-cake shear strengths and flow factors can be measured for powders "as received," for filter cakes that we have heated to process temperatures, or for powders heated in reactive gases to simulate gas-solid reactions in process filter cakes.

In PFBC systems, the degree of agglomeration in filter cakes strongly depends on ionic diffusion, chemical reactions, and formation of necks between adjacent particles, which in turn depend on the operating temperature, gas composition, particle size distribution, and frequency of filter-cleaning. When a dolomitic sorbent is used, $CaSO_4$ and MgO are elutriated from the combustor. With a filter-vessel temperature of ~ 700 °C, capture of SO_2 by sulfation of MgO occurs in the filter cakes. Agglomeration between adjacent particles of $MgSO_4$ or of $CaSO_4$ occurs by "sintering" (ionic self-diffusion and neck formation). However, the end-product produced by sulfation in the filter cakes of the Tidd PFBC demonstration plant was not $MgSO_4$, but $Mg_2Ca(SO_4)_3$ [incorrectly identified in the literature as $Mg_3Ca(SO_4)_4$]. Necks of $Mg_2Ca(SO_4)_3$ form by chemical diffusion between adjacent particles of $MgSO_4$ and $CaSO_4$. The amounts of $Mg_2Ca(SO_4)_3$ and the rate at which it was produced also have been determined for the Tidd filter unit.

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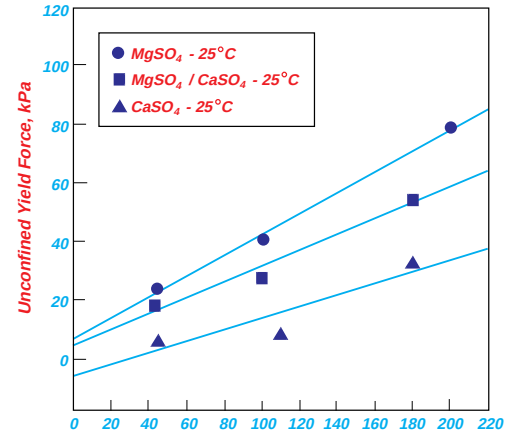
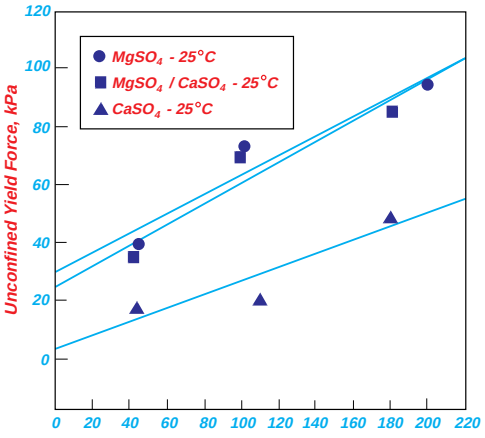
Measurements of Filter-Cake Properties

Opportunities

- Perform advanced modeling of particle deposition patterns and filter-cleaning backpulses
- Measure porosities (as function of face velocity) for more kinds of filter cakes
- Incorporate time dependence of cake permeability
- Develop and utilize filter-cake models for re-entrainment fractions
- Diagnose performances of more filter vessels, especially Particle Control Devices at the Wilsonville PSDF

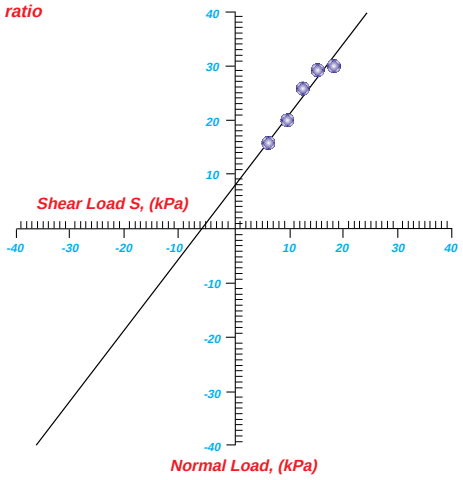


In unheated samples strength depends on $MgSO_4/CaSO_4$ ratio

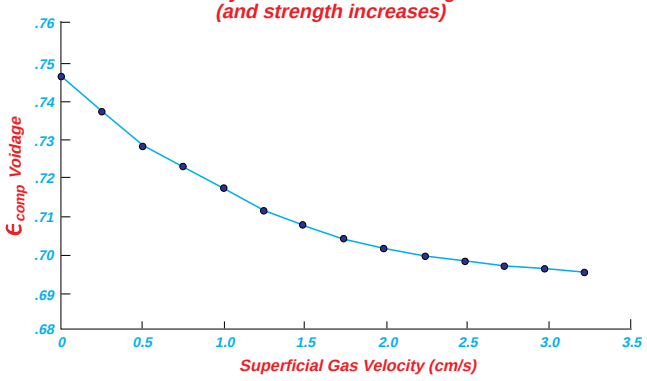


Sintering led to increased filter cake strength

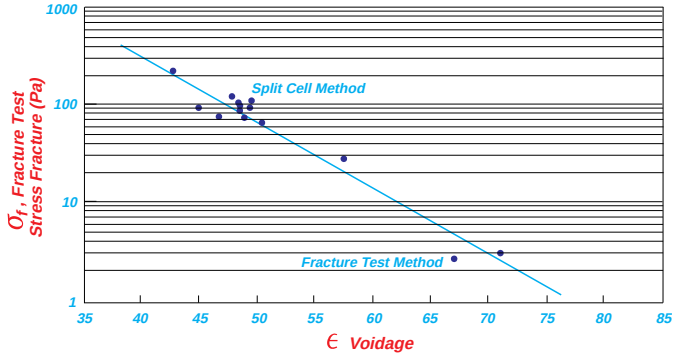
$CaSO_4$ - 23kPa/750°C



As face velocity increases cake voidage decreases (and strength increases)



Stress Fracture vs. Voidage for Calcium Carbonate (Non hygroscopic "Model Powder")



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