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Introduction

Large-scale hot-gas filter testing over the past 10 years has revealed numerous cases of cake buildup on filter elements that has been difficult, if not impossible, to remove. At times, the cake can blind or bridge between candle filters, leading to filter failure. Physical factors, including particle-size distribution, particle shape, the aerodynamics of deposition, and system temperature, contribute to the difficulty in removing the cake, but chemical factors such as surface composition and gas–solid reactions also play roles in helping to bond the ash to the filters or to itself. This project is designed to perform the research necessary to determine the fuel-, sorbent-, and operations-related conditions that lead to blinding or bridging of hot-gas particle filters.

Objective

The objectives of the project are threefold:

- Determine the mechanisms by which a difficult-to-clean ash is formed and how it bridges hot-gas filters
- Develop a method to determine the rate of bridging based on analyses of the feed coal and sorbent, filter properties, and system operating conditions
- Suggest and test ways to prevent filter bridging

Approach

The primary deliverable will be a graphics-driven computer model that can be used to predict problems and so develop control strategies based on data from the analyses of coal and sorbent and system conditions. The research is designed around five tasks. Task 1 is to perform detailed sampling at large-scale operating hot-gas filter test units, gather representative archived samples from completed programs, and physically and chemically characterize the samples. Task 2 involves thermochemical equilibrium modeling of appropriate test procedures along with laboratory measurement of the rates and mechanisms of tensile strength development in ash cakes. Task 3 involves dynamic bench-scale testing of the formation of ash in pressurized fluidized-bed combustors and determining the factors affecting the rates of residual cake development under both fluidized-bed combustion and gasification conditions. Task 4 involves creating a graphical interface

computer code to tie all of the knowledge together and make possible the prediction of rates of filter blinding and bridging based on coal, sorbent, filter, and system parameters. Task 5 involves reporting the results.

Project Description

The Electric Power Research Institute (EPRI) is the prime project contractor. All research is carried out by the Energy & Environmental Research Center (EERC). The EERC, through its Cooperative Agreement with the U.S. Department of Energy (DOE) Morgantown branch of the Federal Energy Technology Center (FETC), is able to approximately match funds contributed by the commercial sponsors: EPRI, Lurgi-Lentjes-Babcock (LLB), PowerGen, Schumacher America, Westinghouse, Electricité de France, the Netherlands Energy Research Foundation (ECN), ABB Carbon, and the Electric Power Development Company (EPDC).

Results

Task 1 – Field Sampling and Archive Sample Analysis. One of the objectives of this project is to determine the mechanisms by which difficult-to-clean ash is formed and the way(s) in which it blinds or bridges hot-gas filters. This task was originally designed to include extensive field work to collect, size, and quench entrained ash entering a filter vessel so that sticky and nonsticky ashes could be compared to each other and to ash bridges. However, opportunities for field sampling have not materialized during this program. Therefore, the work has shifted to analysis of archived samples of residual filter cakes, bridges, and hopper ashes. By the end of this project year, we had acquired the following: four sample sets from the Tidd pressurized fluid-bed combustor (PFBC), four archive samples from the Grimethorpe PFBC, two samples each from the Filter Development Rig (FDR) and the Gas Utilization Facility (GUF) filter from British Coal, two samples from the Buggenum Demkolec integrated gasification combined-cycle (IGCC) facility in the Netherlands as provided by ECN, two sets of entrained ash from pilot-scale filter testing in the EERC transport reactor demonstration unit (TRDU), one proprietary set from the Westinghouse filter vessel at the PyroPower circulating fluidized-bed combustor (CFBC) in Karhula, Finland, two samples from the FETC 0.3-MW_t gasification and hot-gas cleanup facility, two samples from ABB Carbon, and two additional samples from Demkolec sent by ECN. These are the last archived ash samples that will be included in the program. These samples have either been analyzed and results presented in quarterly reports or are currently being analyzed.

Tidd PFBC Samples. The results of the chemical analyses indicated that changes in ash behavior in the Tidd advanced particle filter (APF) are related to system operation, such as complete spoiling of the cyclone upstream of the APF. When the cyclone was completely spoiled during the 1995 testing, much larger ash particles entered the APF. These larger particles differed in composition from the APF ash samples collected in May and October 1994. Also, the removal of fines from the sorbent caused an increase in ash particle size entering the APF. Ash bridging was minimized, probably because smaller particles, which were removed or diluted from the APF ash, are more easily sintered together than larger particles.

From the four different sampling times, the stickier ashes tend to have a smaller particle-size distribution and also contain more sulfur, aluminum, and silicon. This may indicate that the smaller particles are derived mainly from the coal ash (aluminosilicate material), whereas the larger particles are derived mainly from the sorbent material. Scanning electron microscopy (SEM) analyses indicated that potassium was present in ash agglomerates and necks between sintered particles. Therefore, the coal rather than the sorbent is the main cause of ash stickiness. Surface analyses showed some surface enrichment of potassium in the Tidd ashes and enrichment of sulfur in necks between particles. Potassium or sulfur could condense on aluminosilicate particles in the filter vessel and flux the particles. The fluxing of the particles would form a thin liquid layer on the surface, causing the surface of the particle to become sticky. The presence of sulfur in the necks may

also have a similar influence. A small weight percentage of sulfur can be incorporated into aluminosilicates and flux the material, also causing a sticky surface, which can sinter into a hard deposit. Therefore, minimizing fine material by removal of the upstream cyclone or removal of fines from the sorbent or coal could resolve ash buildup problems. Also, careful coal selection (low-Na and K coals) could aid in solving ash-related problems in filter systems. Results from the physical testing of the Tidd ashes is given in the Task 2 section of this summary.

Grimethorpe PFBC Samples. The four samples (Runs 155, 159, 160, and 161) are filter fines from the Electric Power Research Institute filter during four runs at Grimethorpe between 1991 and 1992. Runs 155 and 159 produced difficult-to-clean ashes while firing a run-of-mine and a partly cleaned Kiveton Park coal, respectively, with Middleton limestone as the sorbent. Runs 160 and 161 produced easier-to-clean ashes while firing a partly cleaned Kiveton Park coal with Cadeby dolomite as the sorbent. The use of a cleaned coal and a dolomite sorbent helped to reduce the ash stickiness problem in the Grimethorpe filter vessel. Some of the ash stickiness may have been related to the potassium content in the ash, and the source of the potassium was probably the coal. The magnesium content in the ash may also play a role in the ash stickiness, as the runs using dolomite had less problematic ash. SEM and fine-particle technique (FPT) analyses were performed on the ashes. The FPT is a computer-controlled SEM technique developed at the EERC used to determine the sizes and compositions of individual ash particles. SEM analyses showed that the Grimethorpe ashes were agglomerated, which indicates that the FPT may be giving sizes of agglomerates rather than sizes of individual ash particles. The analysis of entrained ash collected from the gas stream entering the filter vessel would be more useful in determining the effect of particle size on ash behavior. Initial results from surface analyses show enrichment of potassium and iron on the sticky ashes.

FDR and GUF Gasifier Samples. Two filter fines samples from the FDR and two from the GUF filter were received from British Coal for inclusion under this project.

Cluster analysis was used on the data from the fine-particle analyses of size and composition distributions of these ashes to develop new chemical categories better suited to samples formed under gasification conditions. The new categories were entered into the data reduction software, which was then used to determine the distribution of chemical types in the ashes. Results for the FDR samples show a direct correlation between coal type and ash cleanability. Run conditions were similar for the two samples, although two different coals (Thoresby and Kiveton Park) were used. The greater amount of potassium-, sodium-, and chlorine-bearing aluminosilicate phases in the Thoresby FDR ash may be responsible for the stickiness of the ash. The potassium and sodium are likely to react with the aluminosilicate, thus reducing the melting point. This promotes a stickier, agglomeration-prone ash. Thermochemical models indicate that up to 15 wt% chlorine can react with aluminosilicates to reduce the melting temperature, which can cause ash to become sticky and agglomerated.

Transport Reactor Demonstration Unit Samples. The DOE Federal Energy Technology Center at Morgantown has funded the construction of the TRDU at the EERC to demonstrate acceptable performance of hot-gas filter elements in a pilot-scale system prior to long-term demonstration tests. The primary focus of the experimental effort in the 3-year project is the testing of hot-gas filter element performance (particulate collection efficiency, filter pressure differential, filter cleanability, and durability) as a function of temperature and filter face velocity during short-term operation (100–200 hr). The Hot-Gas Filter Ash Characterization project sponsors have agreed to provide some particulate sampling and analytical support for the filter test program.

Results from the most recent TRDU tests are being reported in a separate paper being given at this conference. Two tests were conducted during the weeks of March 25–31, 1996, and April 15–21, 1996.

During these weeks, 138.5 hours of coal feed and 107 hours of gasification were achieved, with the system gases and fly ash passing through the filter vessel during the whole test campaign. The TRDU was operated at three different average temperatures of 925 °, 900 °, and 860 °C to alleviate some deposition problems seen in the disengager. One ash bridge was observed between two adjacent candles. The bridge was very soft and fell off during the removal of the tube sheet from the filter vessel; however samples from the bridge were obtained before it fell. The bridge formed where one slightly warped candle came close to an adjacent candle.

Chemical analyses of selected samples from that test series were also completed. These analyses indicate that the standpipe material was approximately 50% coal ash, while the dipleg and filter vessel samples were approximately 75% coal ash. Sodium also seemed to be preferentially remaining in the larger particle sizes, indicating a possible interaction with the standpipe material. Most of the fine ash reaching the filter vessel was composed of coal ash, with most of any start-up bed material reaching the filter vessel remaining in a relatively large size distribution. The bridge material recovered from the hot-gas filters was similar in chemical composition to the coal ash, indicating that the finer coal ash is the material that was being reentrained onto the filter, while the larger bed material particles were not reentrained during the backpulsing sequence.

Another test series with the TRDU was completed during that quarter, for 105 hours of coal feed and 94 hours of gasification with no major system upsets. One candle failed after only 8 hours of gasification, but the gasifier was kept operating for an additional 16 hours before being shut down. After replacement of the broken candle, the test was resumed before another candle failed after an additional 68 hours of gasification and prematurely ended the scheduled 200-hour test. The average gasifier temperature was a relatively low 825 °C to alleviate the formation of sintered deposits seen in previous tests. No deposition was observed in these lower-temperature tests. The candles were backpulsed 390 times during these tests before one candle had a major failure. The baseline “cleaned” filter differential pressure increased from 30 to 60 inches of water over the course of the test. The particulate inlet loading was approximately 3500 to 4000 ppm, and the filter ash averaged 55 wt% carbon. The filter ash particle size was approximately 7 μm and was essentially representative of the coal ash from very early in the gasification test. Short backpulse intervals of approximately 10 minutes were required to keep the pressure drop down, but even then there was a rapid initial recovery of the pressure drop across the filters. The reasons for the poor permeability of the cake are still being investigated.

Task 2 – Laboratory-Scale Testing. The objective of the laboratory testing is to determine the rates and mechanisms of ash sintering and ash–filter interactions under controlled conditions. Extensive thermochemical equilibrium modeling is used to determine system, ash, and filter parameters that must be included in the experimental matrix to ensure that the experimental work reflects realistic conditions. In other activity, ash collected from the field and produced in the bench-scale work is being treated to hot-gas conditions to determine the effects of ash particle size, ash composition distribution, cake pressure drop, gas composition, temperature, and exposure time on strength development in ash cakes.

Thermochemical Equilibrium Modeling. To help in determining possible chemical reactions that may make ash sticky, as well as to help determine appropriate conditions for laboratory testing, thermochemical equilibrium modeling of ash and gas compositions is being performed with an ideal solution model called the Facility for the Analysis of Chemical Thermodynamics (FACT) code. Using the FACT code, we have estimated the quantities of alkalis in the vapor phase, ash slag, and liquid salt that may occur in ash and cause its sticking problems under combustion and gasification conditions.

The code predicts the formation of liquid phase containing K_2SO_4 , Na_2SO_4 , K_2CO_3 , and Na_2CO_3 at temperatures as low as 700 °C. Experimental verification has shown that a sulfate–carbonate blend with a

composition similar to that of the predicted liquid salt is stable for only a short time (about 10 minutes) in the presence of $\text{SO}_2\text{-CO}_2\text{-O}_2$ (5000 ppm/20 vol% balance) atmosphere at 727°C . After cooling to room temperature, the liquid crystallizes and forms intermediate phases: $\text{NaK}(\text{SO}_4)_x(\text{CO}_3)_y$ and NaKCO_3 . Over longer times, the material converts to complex sulfates, which may have somewhat higher, but still troublesome, melting points. The transition to a higher melting point may also cause the material to solidify at a constant temperature, thereby making the deposit much harder.

Thermodynamic calculations suggest that liquid salt and silicate may form immiscible phases. Under nonequilibrium conditions, we may expect some dissolution of Na^+ and K^+ ions from the salt into surface layers of silicate, generating stress. Gradients of stress can be the major driving force for mass transport, thereby promoting the segregation of sulfate from silicate glass.

A new thermochemical equilibrium code database was used in repeat calculations of possible liquid phases in both PFBC and fluidized-bed gasification systems. The new database includes the liquid silicates that contain sulfur and hydroxyl groups, phases that could not be predicted with the previous database but were observed in laboratory testing. The modeling predicts that the sulfur content in amorphous ash (slag) linearly increases with partial pressure of sulfur components in flue gas. Unfortunately, much of the thermodynamic data of interest are extrapolated to the lower temperatures of hot-gas filter systems. This seems to be a weakness of both old and new versions of the codes.

High-Temperature Tensile Strength Testing. Powder tensile testing using the high-temperature tensile tester (HTTT) was performed on a variety of ashes over the project to determine the relative magnitudes of factors affecting the stickiness of filter ashes such as humidity, particle-size distribution, and liquid content. In early testing using the Tidd ash compacted with a weight, slight sintering occurred at the higher compaction levels at 700°C , and the cake did not break uniformly. Sintering was even more pronounced at 750°C . An electron microscopic examination of the cakes revealed the ash was not uniformly compacted and that average densities were too high. The cake preparation procedure was modified and now involves a vacuum method that provides a more uniform ash cake and allows a direct comparison between a powder tensile strength and the pressure drop needed to form the ash cake.

Using the vacuum compaction procedure, much higher porosities were obtained than before. The trends show that tensile strength increases as the temperature and density increase. However, at the highest temperature (750°C), the prepared ash cake was beginning to sinter. This resulted in tensile strengths that exceeded the capacity of the HTTT, but also showed that at strengths over 3 grams per square centimeter, the cake is strong enough to support itself against gravity and so could cause significant filter bridging.

Continued high-temperature tensile testing of archived ash samples from the Tidd Station sampled in February 1995 has concentrated on the effect of water vapor on strength development. The results show that for this source of reacted ash, there was an increase in cake tensile strength with temperature, but a decrease in strength with the presence of water vapor. The effect of water vapor is contrary to what had been anticipated from field observations. One hypothesis is that the increased gas flow rate through the cake when the water is added expands the cake, which increases porosity and weakens the cake. This is not normally what would happen in a real system, so a modification of the HTTT was made to alleviate any built-up pressure that may occur in the ash cake when this test method is used. Another possibility is that monolayers of adsorbed water reduce the van der Waals attraction between the particles. The effect of water vapor on strength development was also evaluated using the long-term pellet sintering with Grimethorpe samples, with results similar to those for the HTTT.

Two samples from Escatron were obtained for testing using the HTTT. One sample has a much lower bulk density than the other. There is little difference in the total strength between the two samples. However, a more important parameter in the formation of ash bridges is the tensile strength per unit weight of cake, which is much greater for the low-density ash at comparable temperatures. In addition, the lower-density ash cakes deformed plastically before breaking. This could allow a filter deposit of this material to accumulate to much greater thicknesses than the high-density cake before it would shear off under its own weight. Finally, the tensile strength of the Escatron ash samples could be measured to much higher levels than the Tidd ashes before they separated from the HTTT.

The HTTT was used to assess the effects of various amounts of liquid on ash stickiness. The tests were done at room temperature on a PFBC ash with ethylene glycol, a low-volatility wetting liquid with approximately the same viscosity as molten alkali sulfate, at hot-gas filter temperatures. Three concentrations of liquid were identified as affecting strength development: liquid necks, a thin liquid coating surrounding individual particles, and encapsulation of two or more particles. Ash strength tests show that the addition of 1% liquid to an ash increases the force required to break the cake by up to 60%.

Long-Term Pellet Sintering. To determine the effect of particle-size distribution on sintering rate and strength, filter hopper ash from Grimethorpe Test No. 159 was separated using a five-stage cyclone. Indications are that in the case of the Grimethorpe No. 159 ash, little difference exists between size fractions and strength development at the temperatures tested. One reason may be the small differences in classified size fractions. Another may be that the smaller sticky particles have already agglomerated into larger, less sticky particles. This may be a problem with testing of all ash collected from filter hoppers, since that ash has already reacted while in the filter cake.

Two samples from the Demkolec gasifier system were provided by ECN. No ash-sticking problems were indicated, but long-term pellet sintering tests were performed to determine at what temperature ash sintering may become a problem. The ash showed no signs of sintering up to a temperature of 340°C in a CO, CO₂, and H₂ atmosphere. The next tests will be run at temperatures of 340°C and 390°C and will include H₂S in the gas environment.

In contrast to the lack of bridging in the filter system, there have been instances at the Demkolec plant of large volumes of ash sticking in dump trucks hauling the ash for disposal purposes. Therefore, small amounts of ash were blended with tap water to see if a chemical hydration reaction (cementation) would occur. Neither of the ash samples appeared to react in a cementitious hydration manner.

Cake-Sintering Tests. Very long-duration tests are also being performed with ash cakes on filters to determine the mechanisms by which the residual cakes stick to the filters. Previous laboratory methods of producing ash cakes on filters using archived samples seldom produced ash cakes that would stick to the filter after testing in a simulated reactor furnace. For this reason, in order to more realistically evaluate ash–filter interactions, filters from the bench units with ash cakes already formed were used for testing in this task. Ash cake–filter interaction experiments have been performed on filters obtained from the pressurized fluidized bed reactor (PFBR) after burning a Belle Ayr subbituminous coal. The filters used were from Industrial Filter & Pump (IF&P), Schumacher, and 3M Company. The reactor furnace operated for 450 hours.

Task 3 – Bench-Scale Testing. The objective of Task 3 is to perform dynamic bench-scale tests on ash formation and long-term ash cake formation in PFBC systems and cake formation in fluidized-bed and fluid-bed gasification systems to help develop methods to predict possible filter bridging and blinding conditions and suggest possible strategies for mitigating these problems.

Four ash formation tests using a washed Pittsburgh No. 8 bituminous coal from the Consol Enlow Fork mine were completed under combustion conditions with the bench-scale PFBR. They consisted of tests with two size distributions of Plum Run dolomite sorbent at two different temperatures. In addition, the same test matrix was completed using Belle Ayr Powder River Basin subbituminous coal and Plum Run dolomite. The Belle Ayr coal was also tested at two temperatures using no sorbent to investigate the sulfur capture effects of the high level of calcium present in the coal ash. No cyclone-spoiling options were run in these ash formation tests because of the relatively large particle-size distribution of the filter vessel fly ash. Results from multicyclone particulate sampling indicate that high operating temperature and the fine dolomite gave a somewhat finer ash size distribution leaving the reactor when the washed Enlow Fork coal is fired. However, for the Belle Ayr subbituminous coal, operating temperature and dolomite size or the presence of dolomite at all appeared to have no significant effect on the ash particle-size distribution. The Belle Ayr coal gave a finer particle-size distribution than the washed Enlow Fork coal because of the presence of more organically associated cations in the Belle Ayr coal.

The chemical composition of the multicyclone particulate samples shows that most of the dolomite is removed in the coarsest size range of the multicyclone train. A large part of the aluminosilicate minerals in the Enlow Fork combustion tests was removed in the smaller size fractions (Cyclones 3 and 5), while the finest size fraction (final filter) was determined to be a sulfur-rich aluminosilicate with small amounts of potassium or magnesium sulfate present. This composition suggests the presence of a sodalite- or nosean-type compound, which has a lower melting temperature. Calcium in the Belle Ayr ash was enriched in the smaller size fractions (Cyclones 3 and 5), while the smallest size fraction (final filter) was mainly sodium sulfate, known to have melting temperatures in the range at which these filters are operating.

Analytical characterization of the remaining PFBR samples, including FPT analysis on the smallest-size-fraction material from the Enlow Fork (Pittsburgh No. 8) samples, was completed. For the larger samples (Cyclone 5), both the calcium and potassium aluminosilicate categories are more prevalent at 1650 °F than at 1500 °F, indicating more interaction between calcium and potassium with the aluminosilicates at a higher temperature. In the final filter samples (the smallest particle sizes), the largest difference in the samples is in the increase in the weight percent of the sulfur-rich category at the higher temperature, indicating more sulfation. The FPT results show particles with larger diameters than normal captured in the smallest multicyclone. This implies that these samples are either highly agglomerated, with this agglomeration presumably taking place after the fly ash has been removed from the sample stream, or that the particles are very porous.

In addition to the ash formation tests, limited analytical support was provided to other bench-scale work funded under a separate DOE program, which focused on the utilization of in-bed alkali getters. Initial tests showed that high sodium levels in the coal could result in severe filter blinding. However, in-bed alkali getters effectively reduced the vapor-phase alkali concentrations. This reduction is of a magnitude great enough to control ash deposition, bed agglomeration, and filter blinding, but not to a level low enough to meet current turbine manufacturer recommendations for vapor-phase alkali. Bauxite was the best getter tested. Kaolinite was less effective because of its tendency to form sintered deposits from its fine fraction. Other aluminosilicates were tested for their ability to capture sodium, as well as chlorine and sulfur, by forming sodalite and nosean. Although some capture of sulfur and chlorine was noted, it was not at a rate high enough to make them effective getters under PFBC conditions. The effectiveness of in-bed alkali getters could be improved by pelletizing the material prior to feeding it into the PFBC. Recycle of the fly ash back to the combustor should also improve the overall effectiveness of the getters for capturing alkalis and, if coupled with pelletization, should decrease bridging problems associated with the fine ash.

A 100-hr cake formation test was performed on the PFBR using washed Pittsburgh No. 8 coal and Plum Run dolomite. Results of particulate sampling at the filter vessel inlet and outlet indicate a candle filter collection

efficiency of 99.4%. Analysis of the ash passing through the filters shows that it may be in a vapor phase in the vessel. Chemical analysis of the sized entrained ash samples shows that the sorbent maintains a relatively large size distribution, while the coal ash is found in the smaller size fractions. The residual filter cake is most similar in chemical composition to the smallest size fraction of the coal ash, except the residual cake is significantly more sulfated. SEM analyses were completed on the ash-filter interface for the Schumacher, 3M, and IF&P filters tested during the EERC's 100-hour run of the PFBR in fall 1996. Ash samples from the same run were also analyzed separately using SEM and surface analysis. Results show relatively little interaction between the ash and filter material in the exposed filters. Particle agglomeration is visible in high-magnification views of the ash samples. Ash surfaces are enriched in sulfur, phosphorus, and chlorine in the largest particles, suggesting that the presence of these elements may promote agglomeration.

Pressurized thermogravimetric analyses (PTGA) were performed on quenched entrained ash collected during the 100-hour PFBR test. The PTGA analyses were performed in simulated PFB flue gas to determine the kinetics of the sulfation reactions. However, very little weight was gained by the quenched ash, and there was a weight loss below 700°C. One possible explanation for the weight loss may be the decomposition of nonstable phases such as residual carbonates and/or sulfates (such as iron sulfate) in the fine particles. At higher temperatures, much less weight gain occurred than was expected through the sulfation of the calcium. It may be that the reaction rims of calcium sulfate which formed on the ash particles were much less permeable than those formed on calcined limestone run as a check standard. Also, competing decomposition reactions such as calcination of residual limestone may have occurred at the same time in the entrained ash as the calcium sulfation, thus reducing the total weight gain. The reacted PTGA ash will be analyzed by SEM to determine whether there was a net gain in sulfur of the reacted ash. Further PTGA tests will be performed with ash lying on a substrate of filter material. In addition, size effects will be tested by running PTGA tests on the size distribution of ash that forms the residual cake, not on the bulk ash size distribution.

Task 4 – Model and Database Development. The goal of Task 4 is to create a user-friendly computer code that calculates an index number indicating the relative effects of fuel, bed material, filter type, and operating conditions on the formation of ash bridges and to create a user-friendly database for use as a research and reference tool. The potential uses for the computer code include coal selection, bed material selection, optimization of operating conditions, and design of the filter system.

The predictive computer model consists of four computational modules: ash formation, ash partitioning, physical and chemical characteristics, and cleanability. The ash formation module is based on ATRAN (Ash Transformation), an EERC program that has been initiated as part of a separate project. ATRAN predicts the size and composition distribution of the ash formed in various coal conversion systems. Using the existing ATRAN code as a building block, the ability to predict ash formation from pressurized fluidized-bed systems will be added. This adaptation is presently being verified through comparison and "tuning" with data from Tidd ash samples.

Programming of the fine-particle mechanism has been initiated. This module contains a numerical integration of interparticle forces over a size distribution range of 1 to 100 µm. The total cohesive force of the cake will be calculated to be a function of the particle-size distribution, as well as cake porosity, cake thickness, and pressure drop.

Future Activities

Future plans include conducting a 50-hour gasification tests on the CFBR/BHGFV (bench-scale hot-gas filter vessel) to develop residual cakes that have been through as many backpulsing sequences as possible. In this test, ash from the Demkolec gasifier, along with an additive, will be fed into the system. Temperature will be

varied to determine its effect on filter blinding under these reducing conditions. Bridging will not be investigated under these conditions, as the tests necessary to develop relevant data would take too long.

Future plans for the hot-gas filter testing in the TRDU include two more 200-hour tests. Toward the end of the tests, the filter bypass piping will be utilized to investigate the effects of off-line cleaning to reduce filter ash reentrainment. Other tests will look at filter aid additives, along with the effects of changing coal types.