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FUNDAMENTAL MECHANISMS IN FLUE GAS CONDITIONING

QUARTERLY REPORT
January 1995 - March 1995

Prepared for

U.S. DEPARTMENT OF ENERGY
Pittsburgh Energy Technology Center
P.O. Box 10940
Pittsburgh, PA 15236

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SRI-ENV-95-293-7375-Q15

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April 11, 1995

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INTRODUCTION

This project is divided into four tasks. We developed our Management Plan in Task 1. Task 2, Evaluation of Mechanisms in FGD Sorbent and Ash Interactions, focused on characteristics of binary mixtures of these distinct powders. Task 3, Evaluation of Mechanisms in Conditioning Agents and Ash, was designed to examine effects of various conditioning agents on fine ash particles to determine mechanisms by which these agents alter physical properties of ash. We began Tasks 2 and 3 with an extensive literature search and assembly of existing theories. We completed this phase of the project with publication of two special Topical Reports. In our literature reviews reported in Topical Reports 1 and 2, we emphasized the roles adsorbed water can have in controlling bulk properties of powders. During the next phase of the project we analyzed a variety of fly ashes and fine powders in the laboratory. The experiments we performed were primarily designed to define the extent to which water affects key properties of ashes, powders, and mixtures of sorbents and ashes. We have recently completed a series of pilot-scale tests designed to determine the effects that adsorbed water has on fabric filtration and electrostatic precipitation of entrained fly ash particles in actual flue gas environments. Under Task 4 we will issue our Final Report that will summarize the results of our laboratory and pilot-scale work and will also include a model of flue gas conditioning. The project schedule has been extended until July 31, 1995 at no additional cost to DOE/PETC to allow for completion and review of the final report and the Flue Gas Conditioning Model. This extended schedule will also allow the results of the project to be presented at the Eleventh Annual Coal Preparation, Utilization, and Environmental Control Contractor's Conference to be held in Pittsburgh in July, 1995.

PROJECT ACTIVITIES DURING THE REPORTING PERIOD

In addition to a few measurements performed on Bell Ayr Powder River Basin coal ash (ID # 4118) collected during our most recent pilot-scale test, our efforts during this reporting quarter have been directed toward production of the Draft Final Report and the Flue Gas Conditioning Model. In addition to these efforts, a project review meeting was held at PETC in early February.

As we discussed in our Quarterly Report covering October through December 1994, we were not able to induce electrostatic reentrainment of the Bell Ayr Powder River Basin coal ash collected in our pilot-scale ESP. This ash did not reentrain even though a wide range of temperature and humidity conditions were generated within the ESP. To help understand this behavior, we measured the tensile strength of this ash as a function of relative humidity (RH). As with other ashes we have characterized in this way, the Bell Ayr Powder River Basin coal ash exhibited a relative minimum in tensile strength. For this ash, this minimum tensile strength exists between 22 and 50 % RH. Table 1 compares the tensile strength of this ash with measured values for the eastern bituminous low-sulfur coal ash that did reentrain during our second pilot-scale test (ID # 4058). These data are also presented in Figure 1.

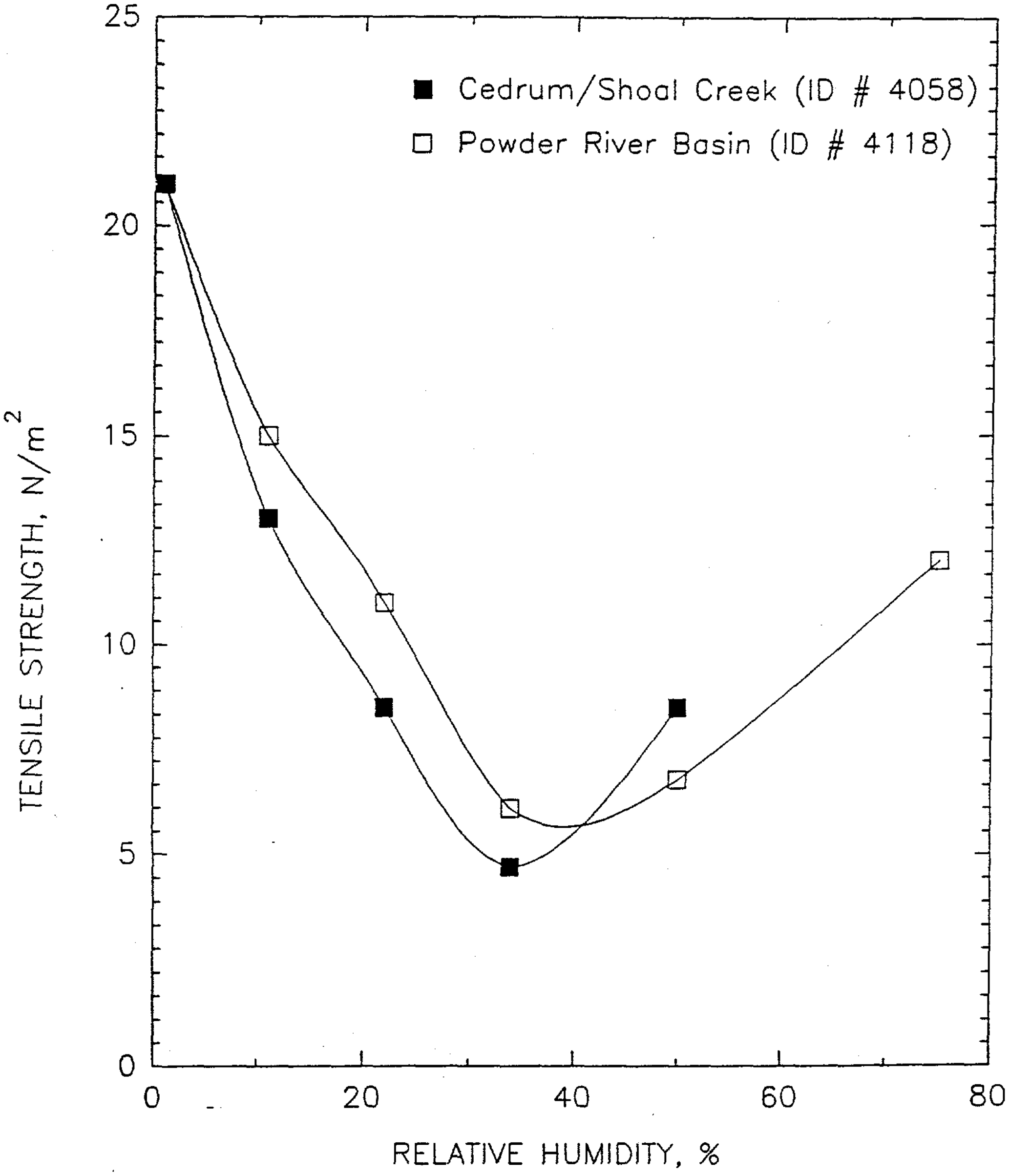

Figure 1. Tensile strength as a function of relative humidity for Bell Ayr Powder River Basin coal ash (ID # 4118) and Cedrum/Shoal Creek coal ash (ID # 4058).

Table 1
Tensile Strengths of Ashes Collected in the Pilot-Scale ESP, N/m^2

ash	RH used to Condition and Test Samples, %					
	1	11	22	34	50	75
Bell Ayr (ID # 4118)	>21	15	11	6.1	6.8	12
Cedrum/Shoal Creek (ID # 4058)	>21	13	8.5	4.7	8.5	

Two factors tend to hold previously collected ash on the ESP plate. In most cases, the electrical clamping force derived from the applied electric field across the ash layer and the resistance to current flow through the layer is sufficient to hold the collected ash on the plate. However, this clamping force will diminish and possibly even become a repelling force as the resistivity of the ash drops due to a drop in ash temperature and/or the adsorption of water onto the surfaces of the particles. The magnitude of the effects of temperature changes and adsorbed water on ash resistivity and clamping force depend on the particular characteristics of the ash and the structure of the ash layer. Figure 2 shows the dependence of resistivity on temperature for the two ashes described above. Figure 3 shows the effects that water vapor conditioning has on the laboratory-measured resistivity of the Bell Ayr Powder River Basin coal ash. (Similar behavior has been noted for the other ashes we have characterized.) Because in many of our pilot-scale trials we increased the relative humidity and lowered the ash temperature concurrently (as would occur with simple water injection), the reduction in clamping force can be linked to an increase in relative humidity.

The overall tensile strength of the ash layer provides the second factor that helps to hold the collected ash layer on the ESP plate. Although we have observed that the magnitude of this tensile strength varies as a function of the amount of water adsorbed on the surfaces of the ash particles (Figure 1), its overall contribution to holding the ash on the plate is always positive.

Because of the dependence of the electrical clamping force and the tensile strength on ash temperature and adsorbed water, the overall force adhering the ash to the plate can change significantly as temperature and humidity change. Figure 4 demonstrates how relative humidity affects the way these two factors combine with the characteristics of the collected ash to either hold the ash on the plate or cause electrostatic reentrainment. Figure 4(a) shows for two ashes how the electrical clamping force becomes negative after enough water is adsorbed on the surfaces of the ash particles. (As mentioned above, this increase in adsorbed water is usually accompanied by ~~drops~~ decreases in ash temperature and subsequent reductions in the resistivity of dry ash.) Figure 4(b) presents a generalized relationship between tensile strength and relative humidity for these same two hypothetical ashes. In Figure 4(c), the electrical clamping force has been added to the adhering force due to the tensile strengths of the ashes to demonstrate that for an ash with the proper characteristics, electrostatic reentrainment can occur over a finite range of conditions.

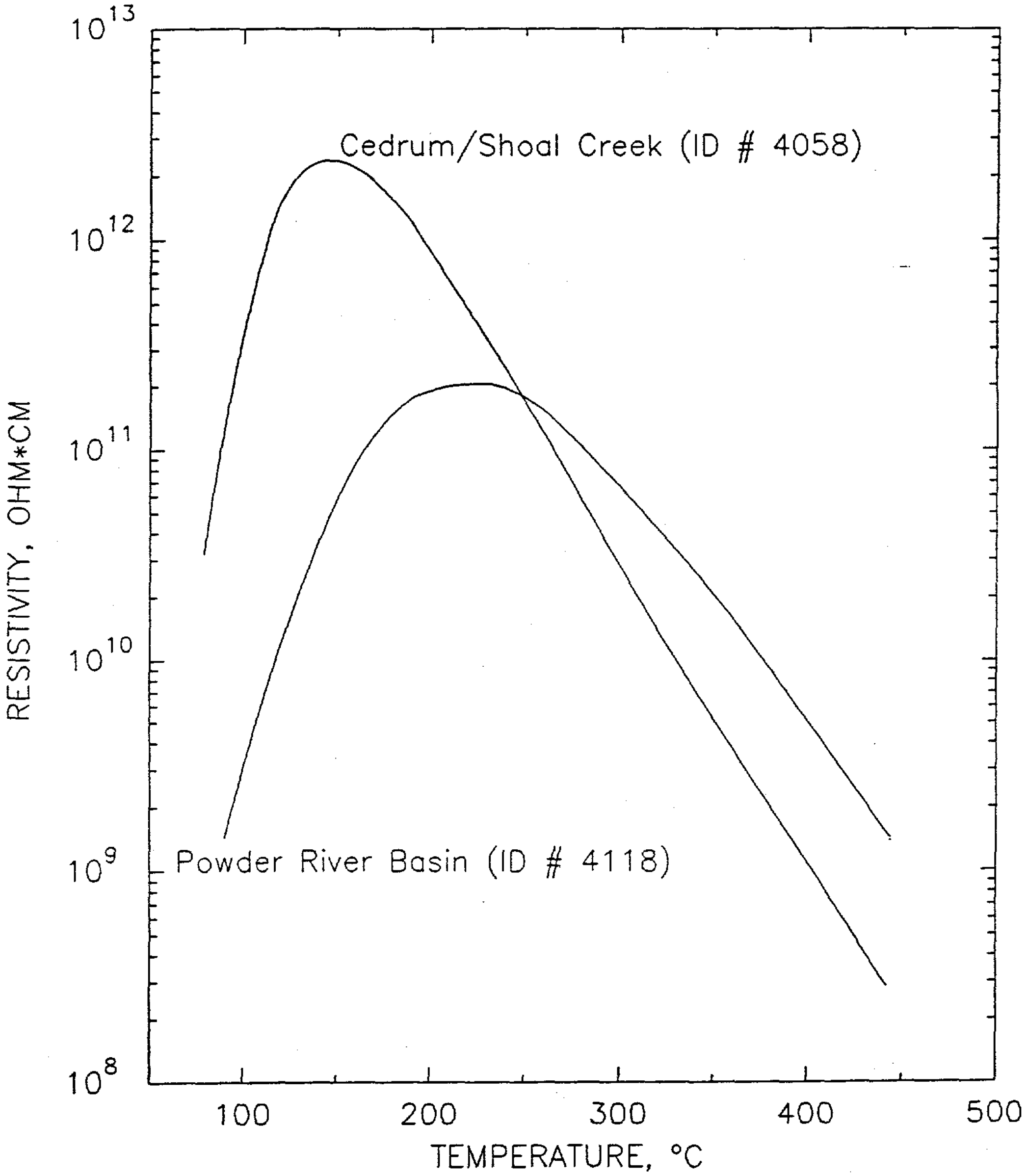

Figure 2. Resistivity as a function of temperature for Bell Ayr Powder River Basin coal ash (ID # 4118) and Cedrum/Shoal Creek coal ash (ID # 4058). These data were measured for ash samples conditioned at about 9 % water by volume.

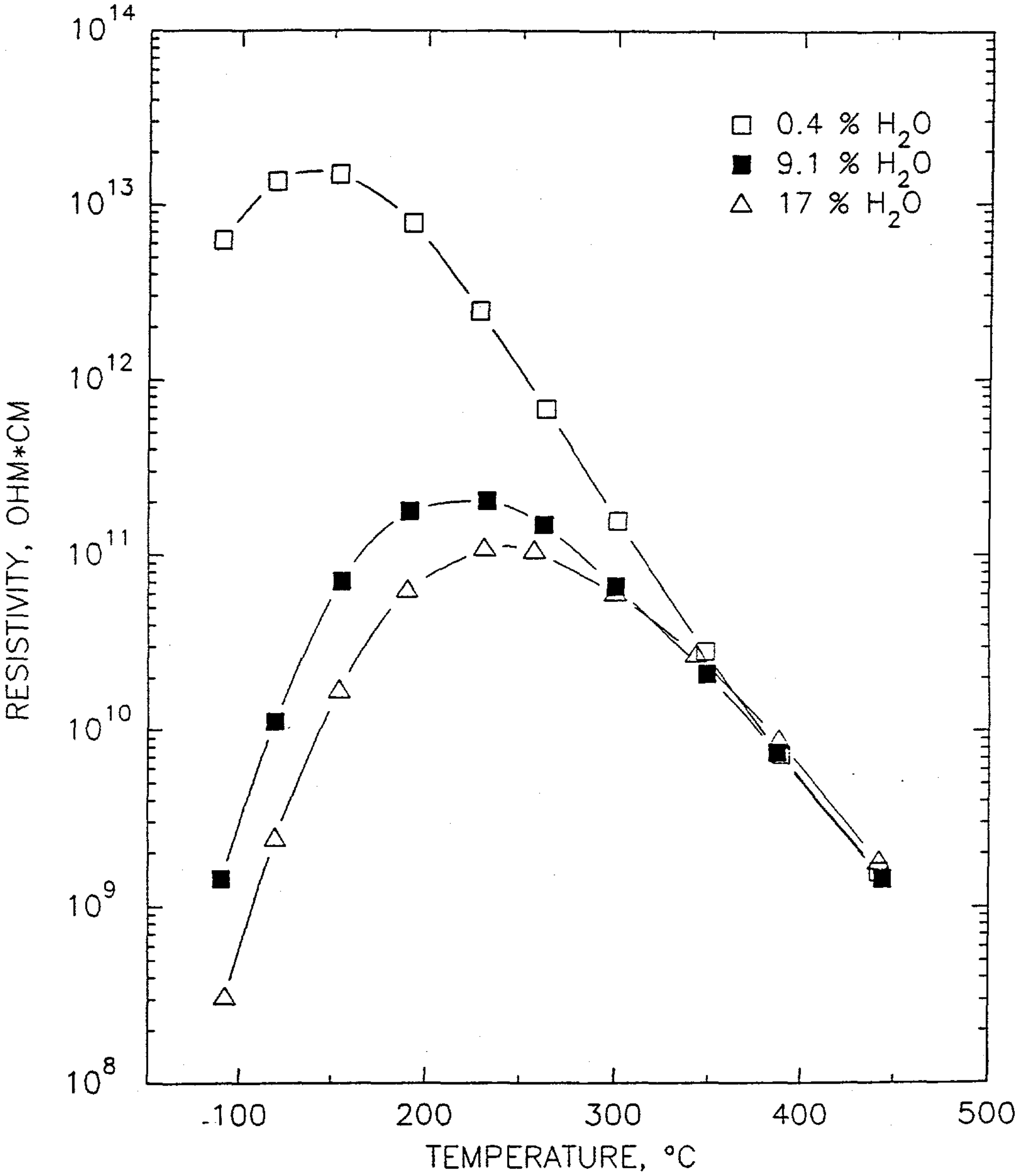

Figure 3. Resistivity as a function of temperature for Bell Ayr Powder River Basin coal ash (ID # 4118). These data were measured for ash samples conditioned at three different moisture contents.

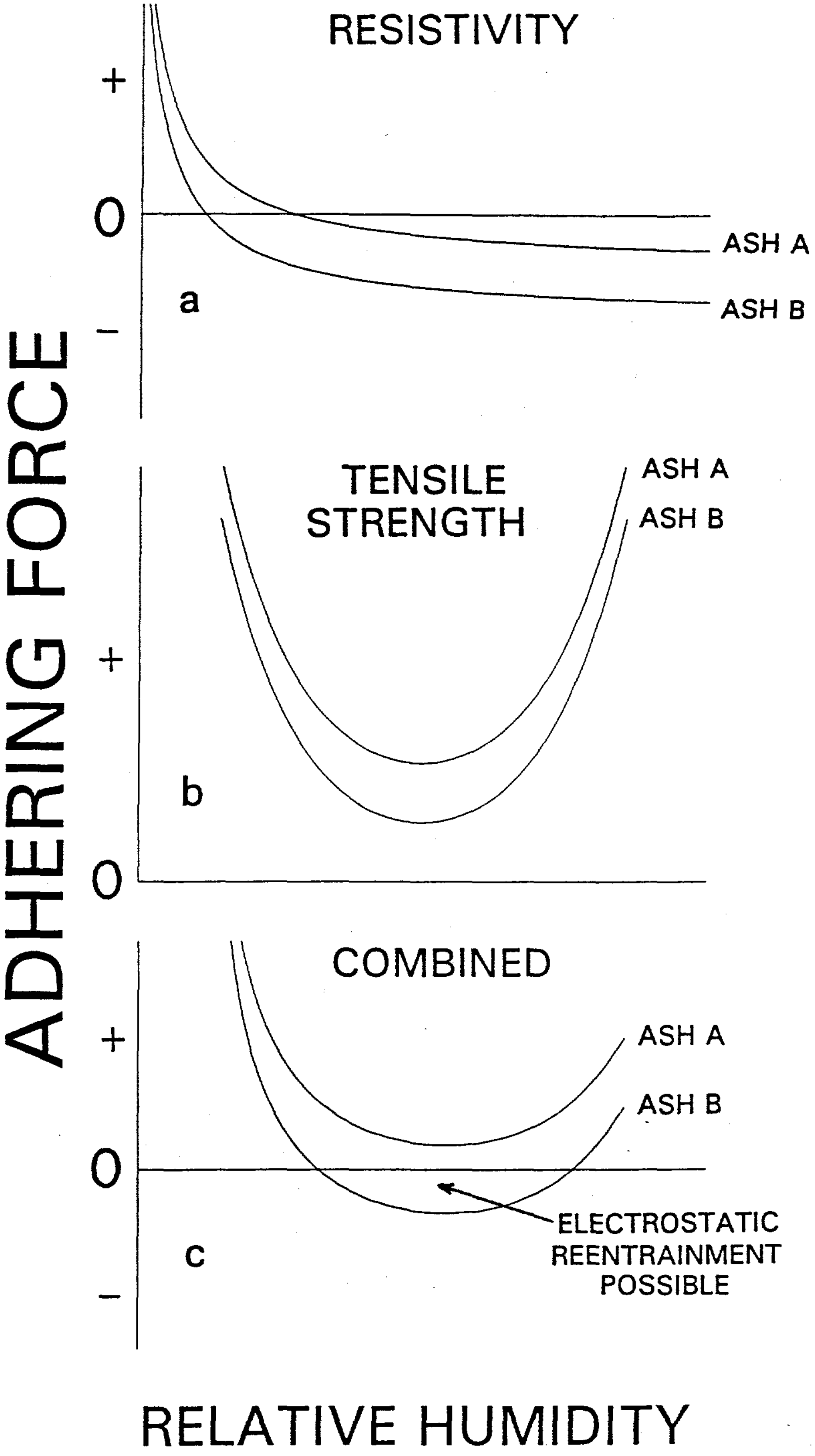

Figure 4. This figure demonstrates how relative humidity affects the way the electrical clamping force and tensile strength combine to yield conditions that can be conducive to electrostatic reentrainment.

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