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The Influence of Ash Particles Interactions During Pneumatic Transport, Triboelectric Beneficiation

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ABSTRACT

Pneumatic transport, triboelectric beneficiation has been shown to effectively beneficiate combustion ashes at laboratory, demonstration and commercial scales. Relative to ash characteristics, these accomplishments are a consequence of two fundamental factors. First, the ashes consisted of liberated particulate, distinctively carbon or ash. Second, the carbon particulate was charged positively and the ash was charged negatively, the magnitude of which was between 10^{-6}-to-10^{-4} C/kg. This magnitude is expected to decrease as the extent of liberation decreases.

Is it then possible to circumvent poor charging characteristics by adding particles that enhance charging? For example, if an ash beneficiates very well in comparison to another ash, is it possible that, when they are mixed with each other, a synergistic affect on beneficiation occurs? We examine this possibility for two ashes and their mixtures. The data suggest synergistic interactions are not promoted by ash mixing. Rather, beneficiation performance for producing low LOI products from mixtures is calculable by assuming a simple mathematical addition of the performance data of each ash. Therefore, the beneficiation performance for ash mixtures can be predicted if the beneficiation performances of the components of the mixture are known.

1. INTRODUCTION

In 1999, 860 million metric ton of coal was burned and about 100 million metric ton of coal combustion product was produced at coal-fired power plants in the US[1]. Because of the need to control NO_x emissions, expanded, beneficial uses of ashes have been hampered by increases in their unburned carbon content[2]. Therefore, fly ash beneficiation has become a focus of research and development for industrial applications.

One of these, pneumatic transport, triboelectric technology, has been examined thoroughly in fundamental and engineering development work[3-10]. It relies on the charging properties of fly ash particles in which the carbon becomes positively charged and ash becomes negatively charge. This bipolar charge is a consequence of the differences in particulate surface properties and is established via particle-particle and/or particle-wall contacts[11]. By passing the bipolar charged carbon and ash mixture through an electric field, ash particles can be separated or beneficiated from carbon particles.

However, the distribution of mineral matter relative to the carbon constituents in coal, and combustor design and operation, affect the extent to which carbon and ash are segregated in distinct, separate particles. If they are mixtures of ash and carbon, the establishment of high-magnitude bipolar charge becomes ineffectual. As a consequence, beneficiation performance can decline.

To examine whether beneficiation performance can be assisted by charging agents, much in the same way fundamental experimentation has suggested for other powdered materials[12], we mixed two ashes that behaved significantly different to triboelectric beneficiation and then processed the mixtures in a laboratory-scale separator. The results of this study are presented. They have ramifications for the industrial situation where a central processing unit beneficiates ash from different sources.

2. EXPERIMENTAL

A schematic of the separation system is presented in Figure 1. From the vibratory feeder, the ashes were gas transported through an insulated and heat traced tube. At the exit of the tube, the charged particles are injected into a parallel electrode separation chamber. During the experiments, the voltage across the electrodes was regulated between 5kV and 25 kV. The unburned carbon reported to the negative electrode and ash reported to the positive electrode.

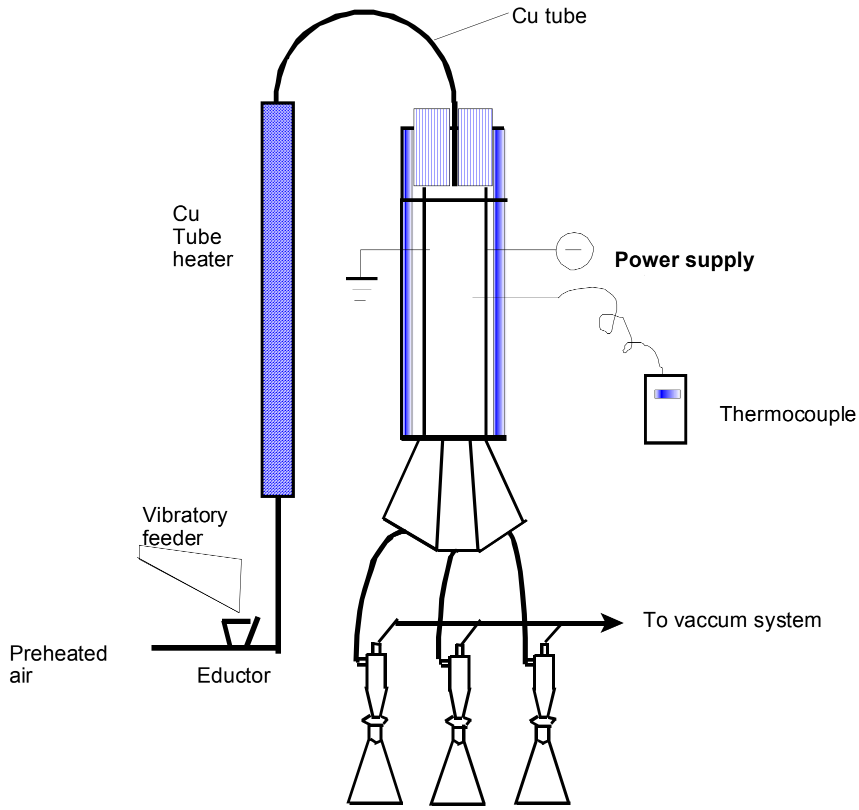

Figure 1. Schematic representation of triboelectrostatic separation system

All tests were performed using identical experimental conditions. A 250 gram sample was gas transported to the separator at a feed rate of approximately 4 kg/hr. Each of the three products generated were then reprocessed to enable the generation of recovery curves. The mass of these products was then measured, and each of them was subjected to LOI analyses.

3. RESULTS AND DISCUSSIONS

For the purpose of comparisons, all feed ash LOI's were normalized to 100%. This normalization produces the recovery curves, presented in Figure 2, for Ash 1 and Ash 2. The beneficiation performance of Ash1 was better than Ash 2. For example, at a product LOI that was 30% of the parent LOI, 74% of Ash 1 was recovered; at the same relative product LOI, only 44% of Ash 2 was recovered. At a product LOI that was 50% of the parent LOI, 83% of Ash 1 was recovered; at the same relative product LOI, 72% of Ash 2 was recovered. These data show significant differences in beneficiation for the two ashes, the magnitude of which tends to increase as the relative LOI decreases.

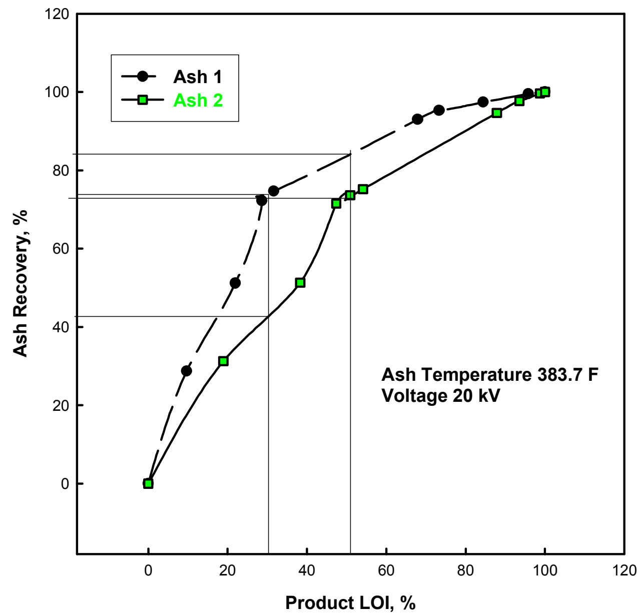

Figure 2. Recovery curves of two individual ashes

When Ash 1 was mixed with Ash 2, at a 25%-to-75% mass ratio, and the recovery data compared to a mathematical calculation based on the difference in performance for the two parent ashes, the results displayed in Figure 3 were obtained. The agreement between the experimental and calculated recovery curves was excellent. Similarly, the agreement between experimental and calculated recovery curves for the other mixtures, including 50%-50% and 75%-25%, was excellent.

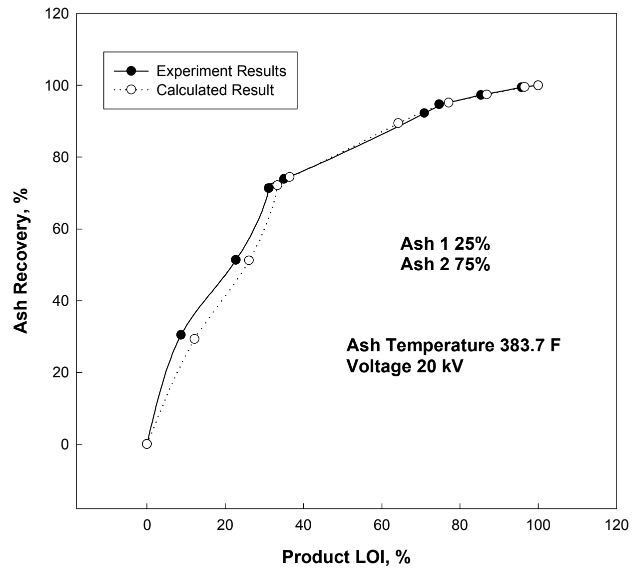

Figure 3. Comparison between experimental results and calculated results

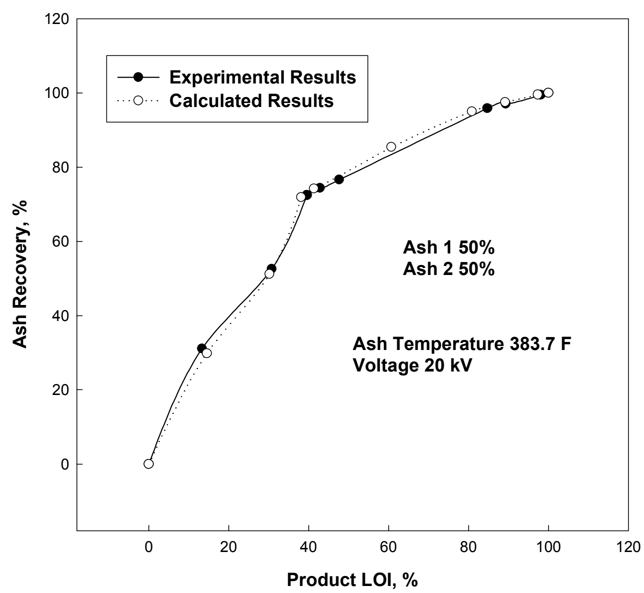

Figure 4. Comparison between experimental results and calculated results

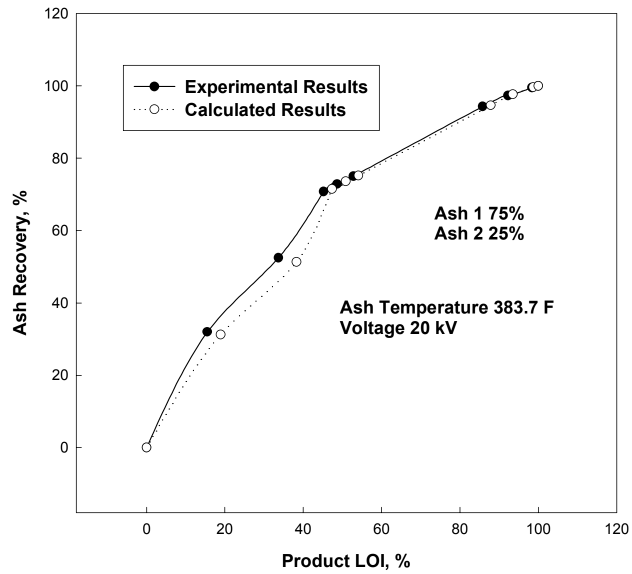

Figure 5. Comparison between experimental results and calculated results

These data show that the recovery of low LOI products during the triboelectric beneficiation of a mixture of ashes can be calculated on the basis of the recovery curves for the parent ashes. This conclusion suggests the absence of any synergistic effect between the particles of the two ashes during gas transport to the separation chamber. If synergism had occurred, it was expected that the mixing of Ash 1 with Ash 2 would either incrementally increase of decrease beneficiation performance beyond that calculated mathematically. Hence, in our case, ash particles did not act as charge transfer agents, probably because differences in beneficiation performance for the two ashes was a consequence of differences in the extent to which carbon and ash were liberated. Nevertheless, the data point to important processing information because the beneficiation performance of gas transport, triboelectric technology for ash mixtures can be predicted if the performance for each ash in the mixture is known.

4. CONCLUSIONS

The conclusions reached during this investigation were:

1. Synergistic interactions between particles of different ashes are not manifested if the liberation of carbon and ash restrains beneficiation performance.
2. If separation efficiency for each ash is known, the overall beneficiation performance of mixed ashes can be predicted mathematically.

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