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POC-SCALE TESTING OF A DRY TRIBOELECTROSTATIC SEPARATOR FOR FINE COAL CLEANING

By

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Abstract

It is the objective of the project to further develop the triboelectrostatic separation (TES) process developed at the Federal Energy Technology Center (FETC) and to test the process at a proof-of-concept (POC) scale. This process has a distinct advantage over other coal cleaning processes in that it does not entail costly steps of dewatering. The POC-scale unit is to be developed based on i) the charging characteristics of coal and mineral matter that can be determined using the novel on-line tribocharge measuring device developed at Virginia Tech and ii) the results obtained from bench-scale TES tests conducted on three different coals.

During the past quarter, most of the personnel assigned to this project have been performing work elements associated with the engineering design (Task 3) of the TES process. This activity has been subdivided into three subtasks, i.e., Charger Tests (Subtask 3.1), Separator Tests (Subtask 3.2), and Final POC Design (Subtask 3.3). In Subtask 3.1, several different tribocharging devices have been constructed using materials of various work functions. They are currently being tested to establish the best materials to be used for designing and manufacturing the optimum tribochargers that can maximum charge differences between coal and mineral matter. In Subtask 3.2, bench-scale cleaning tests have been conducted to study the effects of the various operating and design parameters on the performance of the electrostatic separator. Two different TES units have been tested to date. One uses drum-type electrodes to separate charged particles, while the other uses plate-type electrodes for the separation. The test results showed that a major improvement in separation efficiency can be achieved by recycling the middlings back to the feed stream. It has also been established that the major source of inefficiency arises from the difficulty in separating ultrafine particles. Understanding the behavior of the ultrafine

particles and finding appropriate methods of handling them would be the key to further improving the separation efficiency of the TES process. It has been established that the optimum lies in the 62 and 350 microns when using the plate type separator. Finally, in Subtask 3.3, engineering work has been initiated in order to address issues related to the design, scale-up, construction and operation of a POC-scale TES unit.

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Executive Summary

The Federal Energy Technology Center (FETC) developed a triboelectrostatic separation (TES) process that is capable of removing mineral matter from coal without using water. A distinct advantage of this dry coal cleaning process is that it does not entail costly steps of dewatering which is a common problem associated with conventional fine-coal cleaning processes. It is the objective of this project to conduct a series of proof-of-concept (POC) scale tests at a throughput of 200-250 kg/hr and obtain scale-up information. Prior to the POC testing, bench-scale test work will be conducted with the objective of increasing the separation efficiency and throughput, for which changes in the basic designs for the charger and the separator may be necessary. The bench- and POC-scale test work will be carried out to evaluate various operating parameters and establish a reliable scale-up procedure. The scale-up data will be used to analyze the economic merits of the TES process.

Work conducted during the current reporting period pertains to:

- continued studies of the charging characteristics of coal, pyrite and other mineral matter (e.g., quartz) using the on-line charge measurement device developed at Virginia Tech;
- detailed testing of bench-scale TES units to determine the smallest particle size that can be effectively treated by the TES process, and
- construction and testing of a hybrid bench-scale TES unit which can overcome some of the shortcomings of the original entrained-flow TES separator.

In Subtask 3.1, static mixers made of copper, aluminum, and copper-nickel alloy were constructed to study the charge characteristics of samples of clean coal and quartz. The test results have been used to identify operating conditions that optimize the charge differences

between coal and mineral matter. In Subtask 3.2, separator test results obtained to date suggest separation efficiencies can be obtained with both of the drum-type and plate-type TES unit when treating coal feeds that do not contain ultrafine particles. It was also found that the performance of the plate-type unit is superior to that of the drum-type TES unit under the test conditions employed in the present work. Furthermore, a series of separator tests were conducted during the current reporting period to determine the smallest particle size that can be effectively treated by the TES process. Test results show that separator performance deteriorates when feed particle size is less than 230 mesh. In Subtask 3.3, evaluation of the POC-scale unit design has now been initiated using engineering guidelines developed in Subtask 3.1 and Subtask 3.2.

INTRODUCTION

Numerous advanced coal cleaning processes have been developed in recent years that are capable of substantially reducing both ash- and sulfur-forming minerals from coal. However, most of the processes involve fine grinding and use water as cleaning medium; therefore, the clean coal products must be dewatered before they can be transported and burned. Unfortunately, dewatering fine coal is costly, which makes it difficult to deploy advanced coal cleaning processes for commercial application.

As a means of avoiding problems associated with the fine coal dewatering, the Federal Energy Technology Center (FETC) developed a dry coal cleaning process, in which mineral matter is separated from coal without using water. In this process, pulverized coal is subjected to triboelectrification before being placed in an electric field for electrostatic separation. The triboelectrification is accomplished by passing a pulverized coal through an in-line mixer which is made of copper, whose work function lies in-between those of carbonaceous material (coal) and mineral matter. Thus, coal particles impinging on the copper wall lose electrons to the metal, thereby acquiring positive charges, while mineral matter impinging on the wall gain electrons to acquire negative charges. The charged particles then pass through an electric field where they are separated according to their charges into two or more products depending on the configuration of the separator. The results obtained at FETC showed that it is capable of removing more than 90% of the pyritic sulfur and 70% of the ash-forming minerals from a number of eastern U.S. coals. However, the BTU recoveries were less than desirable.

The laboratory-scale batch TES unit used by FETC relied on adhering charged particles on parallel electrode surfaces and scraping them off. Therefore, its throughput will

be proportional to the electrode surface area. If this laboratory device is scaled-up as is, it would suffer from low throughput capacities and high maintenance requirements. In general, surface area-based separators (e.g., shaking tables, magnetic drum separator, electrodynamic separator, etc.) have lower throughput capacities than volume-based separators (e.g., flotation cell, dense-medium bath, cyclones, etc.) by an order of magnitude. Furthermore, the electrodes of the laboratory unit need to be cleaned frequently, creating a high maintenance requirement if it is scaled-up to a commercial unit. The bench-scale continuous TES unit developed at FETC, on the other hand, separates positively and negatively charged particles by splitting the gaseous stream containing these particles in an electric field by means of a flow splitter, so that the oppositely charged particles can be directed into different compartments. This device is fundamentally different from the laboratory unit in that the former is a surface area-based separator, while the latter is volume-based a separator. The bench-scale unit is referred to as an *entrained flow* separator by the in-house researchers at FETC. Thus, the entrained flow TES unit is a significant improvement over the laboratory unit with regard to throughput capacity.

In the present work, the entrained flow separator concept will be utilized for developing a proof-of concept (POC) separator that can be scaled-up to commercial size units. To accomplish this, it is necessary to develop bench-scale separator(s) that can achieve high Btu recoveries while maintaining the high degree of separation efficiencies. It is the objective of the present investigation during the past reporting period to develop efficient separator(s) by studying the mechanisms of triboelectrification and investigating better ways of separating the charged particles. An important criterion for developing efficient separators is that they can not only provide high degree of separation efficiencies

but also have high throughput capacities, which are essential ingredients for commercialization.

OBJECTIVES

It is the objective of the project to further refine the TES process developed at FETC through bench- and POC-scale test programs. The bench-scale test program is aimed at studying the charging mechanisms associated with coal and mineral matter and improving the triboelectrification process, while the POC-scale test program is aimed at obtaining scale-up information. The POC-scale tests will be conducted at a throughput of 200-250 kg/hr. It is also the objective of the project to conduct a cost analysis based on the scale-up information obtained in the present work.

Specific objectives of the work conducted during the current reporting period can be summarized as follows:

- to study the triboelectrification mechanism using static mixers and on-line tribocharge analyzer with the objective of conditions for maximizing separation efficiency (Subtask 3.1),
- to study the material work function using static mixers made of copper, aluminum, and copper-nickel alloy with the objective of identifying the ideal tribocharging materials for the TES process (Subtask 3.1),
- to determine the smallest particle size that can be effectively treated by the TES process using the plate-type TES unit with provisions to recycle the middlings stream (Subtask 3.2); and

- to study key issues related to the design, scale-up, construction and operation of a POC-scale unit (Subtask 3.3).

WORK DESCRIPTION

Task 3.1: Tribocharger Tests

The separation efficiency of a TES unit depends critically on the surface charges of the particles involved. In general, the larger the difference between the charges of the particles to be separated is, the higher the separation efficiency would become. It is, therefore, the objective of this subtask to develop a highly efficient charger that can be used for triboelectrostatic separation.

Particle Charge Measurement Using Tribochargers Made of Different Materials

During the previous reporting periods, the mechanisms of triboelectrification were studied using an *in-situ* tribocharge-measuring device. This novel device developed as part of this project was used to establish that coal particles are charged positive while mineral matter (represented by quartz) is charged negative, which provides a basis of the TES process.

During the current reporting period, there was a problem with the electrometer (Keithley Model 650) that had been used for charge measurement. Therefore, the equipment was sent to the manufacturer. Also, the computer that had been used for data acquisition was damaged. While this equipment was being repaired, new static mixers were constructed. Three different mixers were made from different materials, i.e., copper, aluminum, and copper-nickel alloy. The purpose of making different static mixers was to study the effects of changing the work functions of the materials that make-up the static

mixer charger. The results of this study will be useful for maximizing the charge differences between the materials to be separated. The entire charge measurement system has been restored in early April 1998. Results of the charge measurements conducted using the three different static mixers will be reported in the next quarterly report.

Task 3.2 Separator Tests

The primary objectives of this subtask are i) to evaluate bench-scale TES units of different designs, and ii) to investigate the effects of various operating parameters on the performance of the TES units. The information obtained from this task will be used for obtaining engineering guidelines for the design, manufacture, operation, and optimization of the 200-250 kg/hr POC unit. The bench-scale tests have been conducted using a separator that is capable of processing 1-30 kg/hr of coal in a feed stream. The bench-scale test data will be used to develop scale-up criteria for POC unit.

Most of the bench-scale tests have been conducted using the entrained-flow (or open-gradient) TES unit equipped with two drum-type electrodes (one positive and the other negative). It was designed to provide high electric field gradients that may be conducive for separating charged particles. Initially, this unit was used in conjunction with an in-line mixer charger, as originally proposed. However, feeding coal through an in-line mixer charger created problems in plugging and inefficient particle charging. Both of these problems seriously limited the capacity and efficiency of the bench-scale TES unit. Therefore, the in-line mixer charger was replaced by a “turbocharger”, which is designed to create charges by agitating a feed coal by means of rotating blades. As described in the previous quarterly report, the use of this turbocharger drastically improved the efficiency in

charging mechanism, which helped increase the throughput capacity of the bench-scale TES unit with no significant loss in separation efficiencies.

The bench-scale tests conducted to date using the TES unit equipped with a turbocharger and two drum-type electrodes showed that its maximum throughput is approximately 30 kg/hr. This exceeds the original goal of 20 kg/hr by 50%. However, the separation efficiencies were relatively low, which necessitates multiple stages of scavenging and cleaning operations to bring the overall separation efficiencies to the level that can be acceptable to the potential users, i.e., utility companies. This is particularly the case with coal feeds containing large amounts of ultrafine particles. Preliminary scale-up calculations showed that a relatively large POC unit should be built in order to meet the targeted throughput capacity (200-250 kg/hr). It is, therefore, necessary to develop methods of improving the separation efficiency.

The bench-scale TES unit described above may have three basic problems. These include:

- i) the short retention times for the particles in the electric field,
- ii) the lack of provisions for recycling the middlings fraction, and
- iii) the large diameter drum-type electrodes, which makes the equipment bulky.

The first two factors may be responsible for the low efficiency problem. The third problem may increase the costs of equipment, particularly when multiple stages of cleaning and scavenging are employed to compensate the low efficiency problem. In an effort to overcome these problems, a new bench-scale TES has been designed and constructed as shown in [Figure 1](#). In this new design, the two drum electrodes have been replaced by two plate electrodes, which provide much longer retention times for the particles in the electric

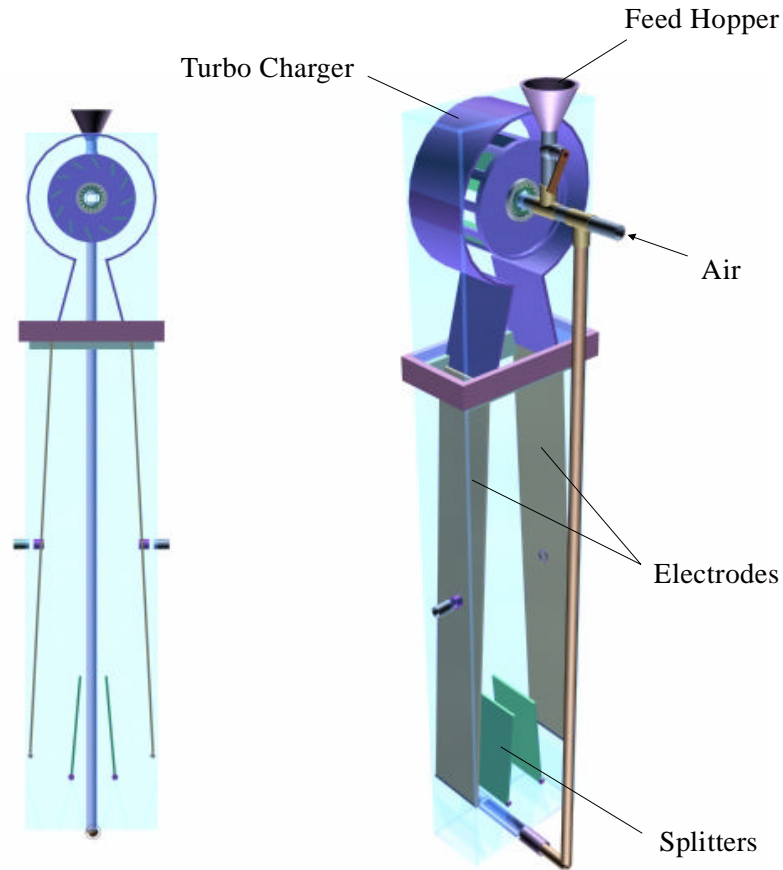


Figure 1 Schematic representation of a bench-scale TES separator incorporating the new design features.

field. The retention time can be controlled by controlling the length of the electrodes and the velocity of the compressed air that is used to move the feed. The angle and the distance between the two plates allow control of field gradients, which may also contribute to increased separation efficiency. A key element in the design change is the provision for the recycling of the middlings stream. To do this, the bench-scale TES unit has been converted from a two-product system to a three-product system. The proportion of the middlings stream that is recycled can be controlled by controlling the flapper gates located at the bottom. An added advantage would be that the equipment can be more compact in the lateral (horizontal direction), although it may have to be taller. The compactness of the

design will allow several units to be installed in parallel to achieve high throughput per volume.

Thus, the new bench-scale TES separator consists of a turbo charger, two plate electrodes, a high-voltage power supply, and a circulation conduit for recycling middlings particles. Each plate electrode has dimensions of 4x20 inches. The distance between the two electrodes is 3 inches at the top and 5 inches at the bottom. This pie-shaped arrangement of the two plate electrodes is designed to provide a laminar flow of air current in the electric field. A potential difference of 30 kV is usually applied between the two electrodes. A feed sample is fed pneumatically to the turbocharger by means of compressed air. The discharge from the turbocharger falls into the electric field created between the two electrodes. The particles are then separated into three products, i.e., clean coal, reject, and middling streams. The middling stream is pneumatically recycled back to the feed line, so that they are recharged (while going through the turbo charger) and given a second chance to be separated (while passing through the electric field). The electrode plates can be mechanically rapped to discharge the particles that adhere to the electrodes. However, this is not necessary for bench-scale experiments, which require relatively short operation times.

As shown in the previous quarterly report, reasonable separation efficiencies can be obtained with both of the drum-type and plate-type TES unit when treating coal feeds that do not contain ultrafine particles. It was also shown also that the performance of the new separator with the plate-type electrodes was superior to those of the drum-type TES unit. Much of this improvement may be attributed to the design changes that provided significantly longer retention times and the provisions to recycle the middling stream. It

should be noted, however, that the drum-type separator was never run while recycling the middlings stream.

One important aspect of the results reported during the previous quarter (9th) was that the separation efficiency deteriorated when feed samples contained significant amounts of ultrafine particles. It was, therefore, decided to determine the lower particle size limit for the new bench-scale TES unit with plate-type electrodes, which has been main focus of the work conducted during the current reporting period.

Sample Preparation

The bench-scale TES tests were conducted using a clean coal sample from the Sewell seam provided by the A.T. Massey Coal Company. It was crushed first in a roller crusher, and then pulverized in a hammer mill to minus 270 mesh. The mill product was dry-screened to obtain eight different size fractions, namely: +45, 45x65, 65x100, 100x150, 150x200, 200x230, 230x270 and minus 270 mesh. The samples of different size fractions were kept in an oven at 112°C overnight to remove the moisture from the surface of the coal particles. The sample preparation was done one day before each test program to minimize possible surface oxidation.

Separator Test Results

A series of bench-scale tests were conducted on the Sewell Seam coal samples of different size fractions using the TES unit with the plate-type electrodes. The particles in a feed stream were charged by the turbo charger, and the charged particles were discharged into the electric field created between the plate electrodes. In all tests, the potential difference between the electrodes was set at 30 kV, and the feed rate was fixed at 12.5 kg/hr. The middlings fraction was pneumatically fed to feed stream. A given

feed coal sample was cleaned in multiple stages to establish grade vs. recovery curves. [Figure 2](#) shows the flowsheet for the multiple-stages of cleaning operations employed in the present work.

Each of the different size fractions of the coal sample used in the bench-scale test work had considerably different feed assays. The feed assays varied from 4.93 to 11.25% as shown in [Table I](#). Therefore, it was necessary to normalize the grade of each product with respect to the feed grade, so that the results obtained with various size fractions can be compared with each other. The clean coal and refuse products were not analyzed for sulfur, as they the feed coal contained very little pyritic sulfur.

[Figure 3](#) shows the results obtained with the eight different size fractions. Seven of them were narrowly sized (mono-sized) samples, and one was a by-zero (270 mesh x 0) coal sample. The three intermediate size fractions (i.e., 100x150, 150x200, and 200x270 mesh) gave more or less the same combustible recovery vs. grade curve. The

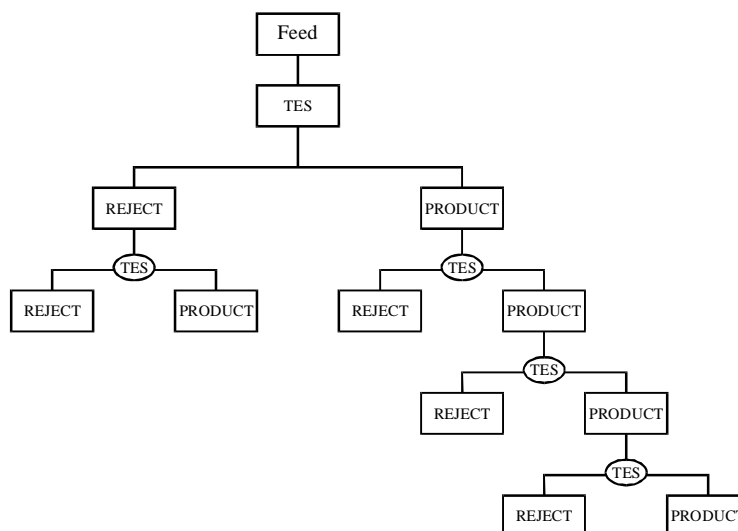


Figure 2 Flowsheet used for the multiple-stages of the bench-scale TES process employed in the present work.

Table I. Ash Contents of the Different Size Fractions of the Sewell Seam Clean Coal Sample

Particle Size (mesh)	Ash Content (%)
+45	7.20
45 x 65	4.95
65 x 100	4.93
100 x 150	5.36
150 x 200	6.43
200 x 230	8.03
230 x 270	9.67
-270 x 0	11.25

results improved as the particle size increased to 65x100 and then to 42x65 mesh. As the particle size was further increased to +42 mesh, however, the recovery dropped substantially. The recovery decreased also with decreasing particle size. The slope of the recovery vs. grade curve was rather steep at 230x270 mesh. With the 270x0 mesh coal sample, the results deteriorated further.

Based on the data shown in [Figures 3](#), a set of combustible recovery vs. ash-rejection curves have been constructed and given in [Figures 4](#). In each diagram, the diagonal line drawn between the top left-hand corner (100% combustible recovery) and the lower right-hand corner (100% rejection) represents the zero separation efficiency. The farther a recovery vs. rejection curve is from this diagonal line, the higher the separation efficiency is. As shown, the results obtained with the five intermediate size fractions (i.e., 200x230, 150x200, 100x150, 65x100, and 45x65 mesh) fall on a single recovery vs. rejection curve, which represents the best results. As the particle size moves up or down from these optimum size range, i.e., 230 to 45 mesh, the separation efficiencies deteriorated significantly.

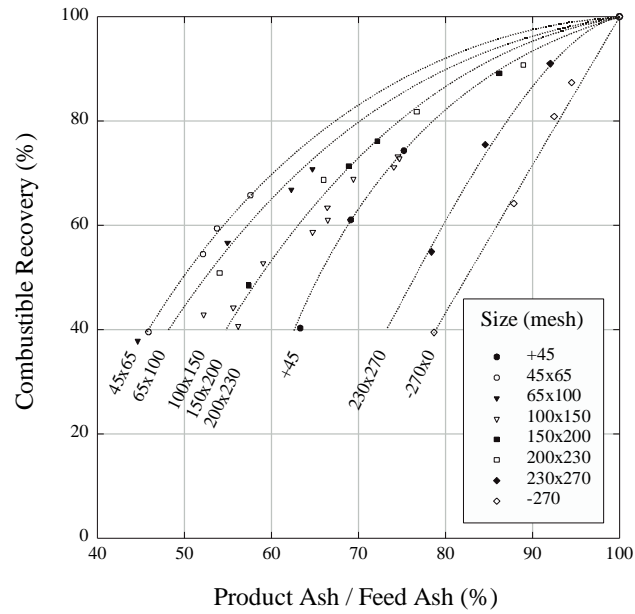


Figure 3 Combustible recovery as a function of normalized product ash content. The test results were obtained on the plate-type bench scale TES unit with different size fractions of the Sewell Seam clean coal sample.

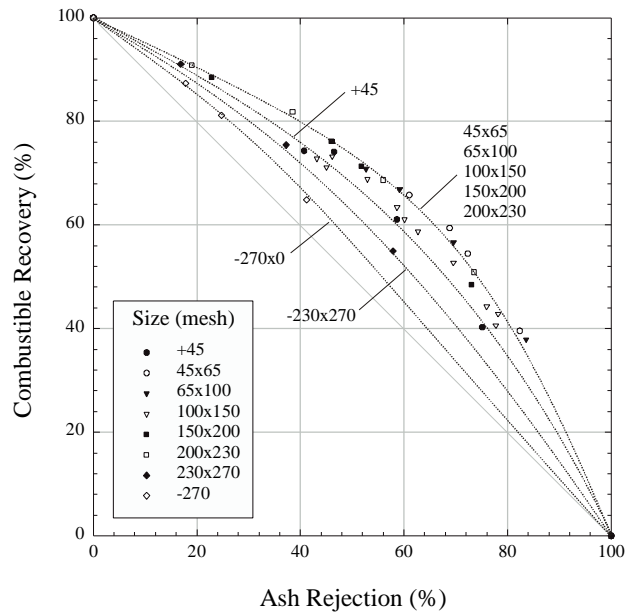


Figure 4 Combustible recovery as a function of ash rejection. The test results were obtained on the plate-type bench scale TES unit with different size fractions of the Sewell Seam clean coal sample.

In Figure 5, the separation efficiencies of all of the test results given in Figures 3 and 4 are plotted versus particle sizes. The separation efficiencies vary relatively little within the optimum size range. The smallest particle size that can be effectively treated by the new TES separator with plate-type electrodes is 230 mesh (62 μm), while the largest particle size that can be treated is 45 mesh (350 μm). The 270 mesh x 0 coal gave the worst results, possibly due to the large proportion of ultrafine (<10 μm) particles present in the sample.

The difficulty in separating has been given an explanation in the last quarterly report, which may be summarized as follows. As shown in several of the previous quarterly reports, the finer particles show higher surface charge densities, given in units of

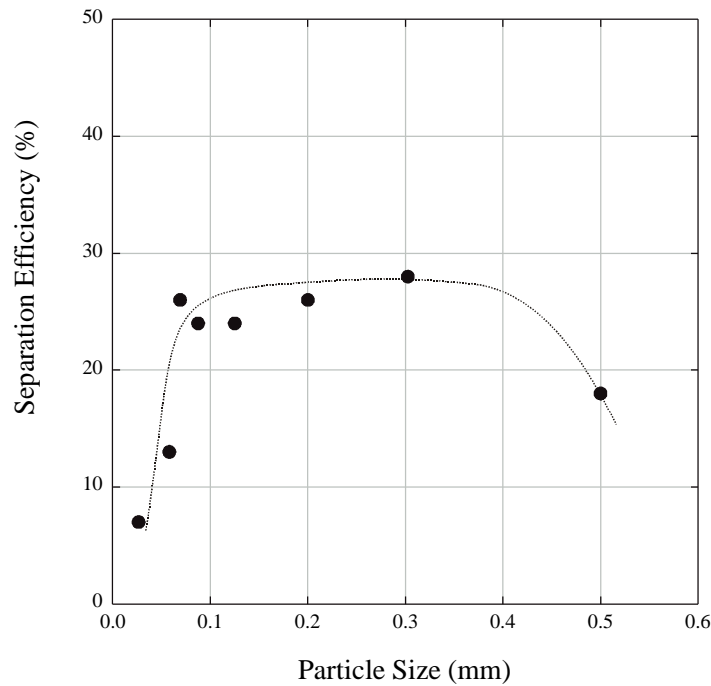


Figure 5 Separation efficiency as a function of feed particle size. The test results were obtained on the plate-type bench scale TES unit with different size fractions of the Sewell Seam clean coal sample.

$\mu\text{Coulombs}$ per gram of sample. Also, the difference in charge densities of coal and mineral matter increases with decreasing particle size. According to these results, the separation efficiency of the TES process should increase with decreasing particle size. However, the results obtained with the ultrafine coals show the contrary. The reason may be that the ultrafine particles of coal and minerals are attracted to each other, due to the large differences in surface charge relative to the mass (or inertia) of particles. This phenomenon may be referred to as heterocoagulation. It would be difficult to separate the particles from each other once the particles are heterocoagulated. If this explanation holds true of what actually happens, the problem could be solved by three possible ways. First, the heterocoagulation phenomenon should be prevented by applying some form of mechanical forces, e.g., ultrasonic vibration. Second, the ultrafine fraction may be treated separately, as has been done with the monosized samples. Finally, the ultrafines fraction may be subjected to a less vigorous charging mechanism, so that the coal and mineral particles are not attracted to each other.

Other possible reasons for the difficulties in separating the coals containing ultrafine particles may include i) entrainment, and ii) inductive charging mechanisms. These mechanisms have been discussed in previous quarterly reports.

During the current reporting period, a theoretical model has been developed and used to simulate the separator tests conducted using the bench-scale TES unit with drum-type electrodes. The model allows calculation of the particle trajectory in a non-uniform electric field created between two drum-type electrodes. The model predicts the trajectories as functions of particle size, particle charge density (in $\mu\text{C/kg}$), feed velocity, feed point, etc. [Figure 6](#) shows the results obtained with different sizes of coal at a

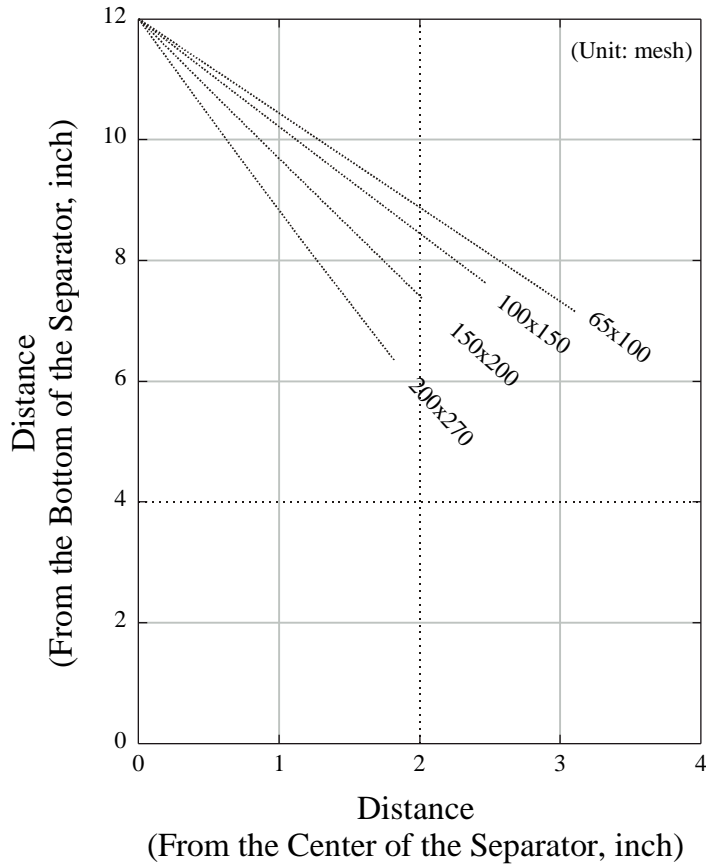


Figure 6 Simulation results obtained using a theoretical model developed in the present work to predict particle trajectory in a electric field.

particle charge density of 300 $\mu\text{C/kg}$. As shown, the smaller particles deflected less toward the electrode due to the smaller Coulomb force. This finding might be considered to provide an explanation for the difficulty in separating fine particles. However, the simulations were done under the assumption that the particles of different sizes have the same charge density, which is not realistic. As shown in previous reports, the charge density increases with decreasing particle size. Therefore, more realistic simulations will be run during the next reporting period. A detailed description of the model will be presented in the next technical quarterly report.

Construction of a Hybrid Bench-Scale TES Unit

To date, two different types of bench-scale TES units have been tested. One is equipped with drum-type electrodes without provisions for middlings recycle, and the other one is equipped with plate-type electrodes with the recycling provisions. In general, the latter produced better results than the former. It is not certain, however, whether the improvement is due to the recycling provisions, or due to the longer retention times of the particles in the electric field. Furthermore, the plate-type electrodes still have problems with the fine particles. Therefore, a new hybrid separator has been designed and constructed on bench-scale, as shown in [Figure 7](#). It consists of two grill-type electrodes, a high-voltage power supply, and a circulation conduit for recycling middlings particles. Each grill-type electrode consists of twelve 3/8" diameter cylindrical stainless steel rods separated from each other by 1 inch. The distance between the two grill-type electrodes, which are aligned parallel with each other, is 4 inches. The electrodes are connected to a high-voltage power supply capable of creating a potential difference of 30 kV between the two electrodes.

A coal sample is fed continuously to the hopper at the bottom, which collects the middling particles. The mixture of the feed and the middlings are drawn into the recycle pipe by means of compressed air. The recycle pipe is made of either copper or PVC tubing, which is used as a charging device. The charged particles are discharged from the top of the separator, and fall into the electric field created between the two grill-type electrodes. The particles are then separated into three product streams, i.e., clean coal, reject, and middling streams. The clean coal and refuse products are collected outside electrodes, while the middlings are collected in between the electrodes and recycled as has already been described.

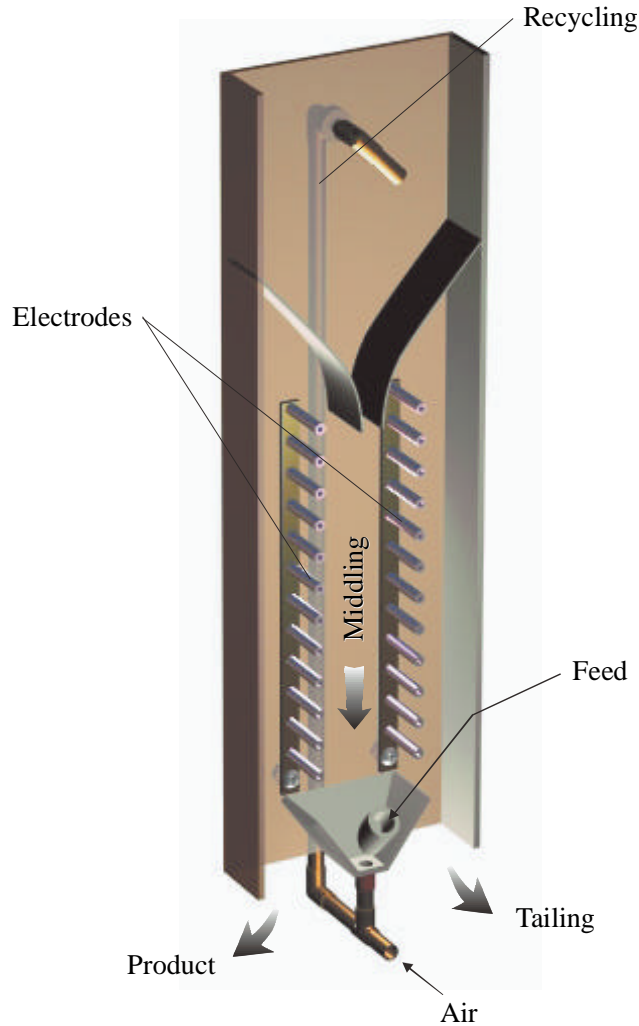


Figure 7 Schematic representation of a hybrid bench scale TES unit employed in the present work.

The new hybrid separator is designed to combine the advantages of the drum-type and the plate-type separators. The advantage of using the drum-type electrodes is that the non-uniform electric field created between the electrodes may be useful for separating finer particles. The series of small diameter (3/8-inch) electrodes should provide multiples of non-uniform electric fields. The new electrode system are also designed to provide a long retention times, which may be useful for separating finer particles. An important aspect of the new electrode design is that the particles deflected in the electric field exit the field as

soon as possible, which will prevent the probability for some of particles being recharged at one electrode and jump toward the other electrode. This phenomenon was recognized in a high-speed photographic studies conducted at FETC. In addition, the individual electrodes can be rotated to remove the particles collecting on the electrode surface.

The preliminary results obtained using the bench-scale hybrid unit showed promising results. This unit will be tested on the pulverizer reject stream during the next reporting period.

Task 3.3: Final POC Design

A preliminary evaluation of the POC-scale unit design has now begun using the engineering guidelines developed in Subtask 3.1 and Subtask 3.2. Several discussions have taken place between CCMP and CarpcO in order to address key issues related to the design, scale-up, and construction of the POC-scale test unit. A meeting was held on March 12, 1998, to discuss the issues concerning Task 3.3. The specific issues addressed in the meeting included i) the final POC design, ii) commercialization potential, and iii) the concerns regarding to the project schedule. Separate report will be submitted to DOE concerning the March 12 meeting.

SUMMARY AND CONCLUSION

The work performed during the current reporting period was concerned primarily with Task 3 (Engineering Design). In Subtask 3.1 (Tribocharger Testing), several different chargers were constructed using materials of different work functions. This task is designed to establish the materials that can be used for constructing the most ideal chargers. Unfortunately, there was a delay in collecting data due to the electronic problems

associated with the charge measuring system. The problems have been corrected, and the data collection has begun recently.

In Subtask 3.2 (Separator Testing), two different bench-scale separators have been tested on a low-sulfur Swell seam coal. These include a drum-type separator equipped with a turbocharger, and a plate-type separator with a turbocharger. The latter was tested with a middlings recycle system, while the former was tested without the recycling. Both separators produced reasonable separation efficiencies, but the plate-type separator produced better results with coarse particles, possibly because of the longer particle retention times and the provisions for middlings recycle. Despite the improvement achieved with the plate-type separator, there are difficulties in separating ultrafine particles. The tests work conducted with a series of mono-sized particles showed that the plate-type separator is effective in separating particles in the range of 230 to 45 mesh. The particles outside this optimum range are more difficult to separate. Therefore, a hybrid separator has been designed and constructed on bench-scale. This unit takes advantage of the merits of the drum- and plate-type separators. The preliminary test results showed promising results.

Finally, in Subtask 3.3 (Final POC Design), preliminary evaluations have been initiated in order to resolve key issues related to the design, scale-up and construction of the POC-scale unit.