DOE/PC/92550--T1

EVALUATION OF HYPERBARIC FILTRATION

FOR FINE COAL DEWATERING

DOE Grant No. DE-FG22-92PC~~92520~~ 92550

Twelfth Quarterly Technical Progress Report
(July 1, 1995 - September 30, 1995)

by

B.K. Parekh (PI)
University of Kentucky

R. Hogg (Co-PI)
The Pennsylvania State University

A. Fonseca (Co-PI)
Consol Inc.

OBJECTIVES AND SCOPE OF WORK

The main objectives of the project are to investigate the fundamental aspects of particle-liquid interaction in fine coal dewatering, to conduct laboratory and pilot plant studies on the applicability of hyperbaric filter systems and to develop process conditions for dewatering of fine clean coal to less than 20 percent moisture.

The program consist of three phases, namely

Phase I	-	Model Development
Phase II	-	Laboratory Studies
Phase III	-	Field Testing

The Pennsylvania State University is leading efforts in Phase I, the University of Kentucky in Phase II, and Consol Inc. in Phase III of the program. All three organizations are involved in all the three phases of the program. The Pennsylvania State University is developing a theoretical model for hyperbaric filtration systems, whereas the University of Kentucky is conducting experimental studies to investigate fundamental aspects of particle-liquid interaction and application of high pressure filter in fine coal dewatering. The optimum filtration conditions identified in Phase I and II will be tested in a Consol Inc. coal preparation plant using an Andritz Ruthner portable hyperbaric filtration unit.

INTRODUCTION

Most of the coal presently used by the utility industry is cleaned at preparation plants employing wet processes. Water, while being the mainstay of coal washing, is also one of the least desirable components in the final product. Coarse coal (+3/4 inch) is easily dewatered to a 3-4 percent moisture level using conventional vibrating screens and centrifuges. However, the main problem of excess product moisture occurs in fine (minus 28 mesh) coal and refuse. Even though fines may constitute only about 20 percent of a contemporary cleaning plant feed, they account for two-thirds of the product surface moisture. This high surface moisture offsets many of the benefits of coal cleaning, and can easily undercut the ongoing programs on recovery of fine clean from refuse as well as producing an ultra-fine super clean coal fuel.

Currently, most of the coal preparation plants utilize vacuum disk or drum filter technology for dewatering of the fine coal, providing dewatered product containing about 25 percent moisture. The coal industry would prefer to have a product moisture in the range of 10 to 15 percent. Although the desired product quality can be obtained using thermal dryer, there are problems associated with this technology such as high capital costs and a source of air pollution.

In the present research project, an alternative to thermal drying, hyperbaric filtration which has shown potential in lowering moisture content in fine coal to less than 20 percent level, is being investigated in detail. The project will develop fundamental information on particle-liquid interaction during hyperbaric filtration and apply the knowledge in developing optimum conditions for the pilot plant testing of the hyperbaric filter system.

Phase I - Model Development:

Mathematical relationships describing the various stages in the hyperbaric filtration cycle have been described in previous reports and shown to be generally consistent with the results of laboratory and pilot-scale studies. The various model elements include structure-related parameters such as the pore size distribution in the cake and specific cake resistance. The development of an overall, predictive model for the process requires the establishment of specific relationships between these parameters and readily measurable quantities such as the composition and particle size consist of the filter feed. Existing, approximate relationships have been found to be inadequate to explain experimental results. For example, estimates of specific cake resistance for different applied pressures suggest some degree of compressibility of the cake. Yet the cake density appears to be essentially independent of pressure. In addition, we have shown that the approximate relationships, while reasonable for uniform particles, are mathematically inconsistent for cakes containing a broad range of particle sizes.

In order to accommodate the inconsistencies noted above, we have formulated a simplified binary packing model. The basis for the model is that the cake consist of two layers: a uniform bed comprised of the coarser particles of an inner layer, adjacent to the filter medium, which consists of the finer fraction, occupying the voids in the coarse-particle bed. Particles in the coarse layer exhibit relatively close packing and the layer is incompressible. Packing in the inner layer, on the other hand, is strongly influenced by inter-particle forces and aggregation (flocculation). As a result, the inner layer can exhibit significant compressibility yet maintaining constant density for the overall, composite cake.

Development of the model leads to a description of cake structure in terms of two parameters: a limiting particle size which distinguishes between the "coarse" and "fine" fractions, and a pressure-dependent, fine-fraction porosity. Evaluation of these parameters by analysis of test data is in progress. Extension of the model to allow prediction of limiting moisture content, and its application to the simulation of process alternatives such as split-feed dewatering are also being investigated.

Phase II - Laboratory Studies:

During this quarter, most of the efforts were directed toward writing the final report on the project. One paper was presented on the topic at the 19th International Mineral Processing Congress, San Francisco, California. A part of the paper published is given below.

EXPERIMENTAL

Froth flotation slurry from two different preparation plants processing Pittsburgh No. 8 and Pocahontas No. 3 coal were used for the study. Particle size distribution was determined using the Cirus Granulometer, which utilizes laser beam scattering principle. Representative samples of slurry were obtained from a 5-gallon bucket which was continuously stirred. Dewatering studies were conducted using 70 mm diam. by 2 in. (5 cm) high, pressure vessel. The filtration cell was modified to provide continuous stirring of slurry during the filtration cycle (Figure 1). Details of the filtration procedure is given elsewhere (Sung et al., 1994).

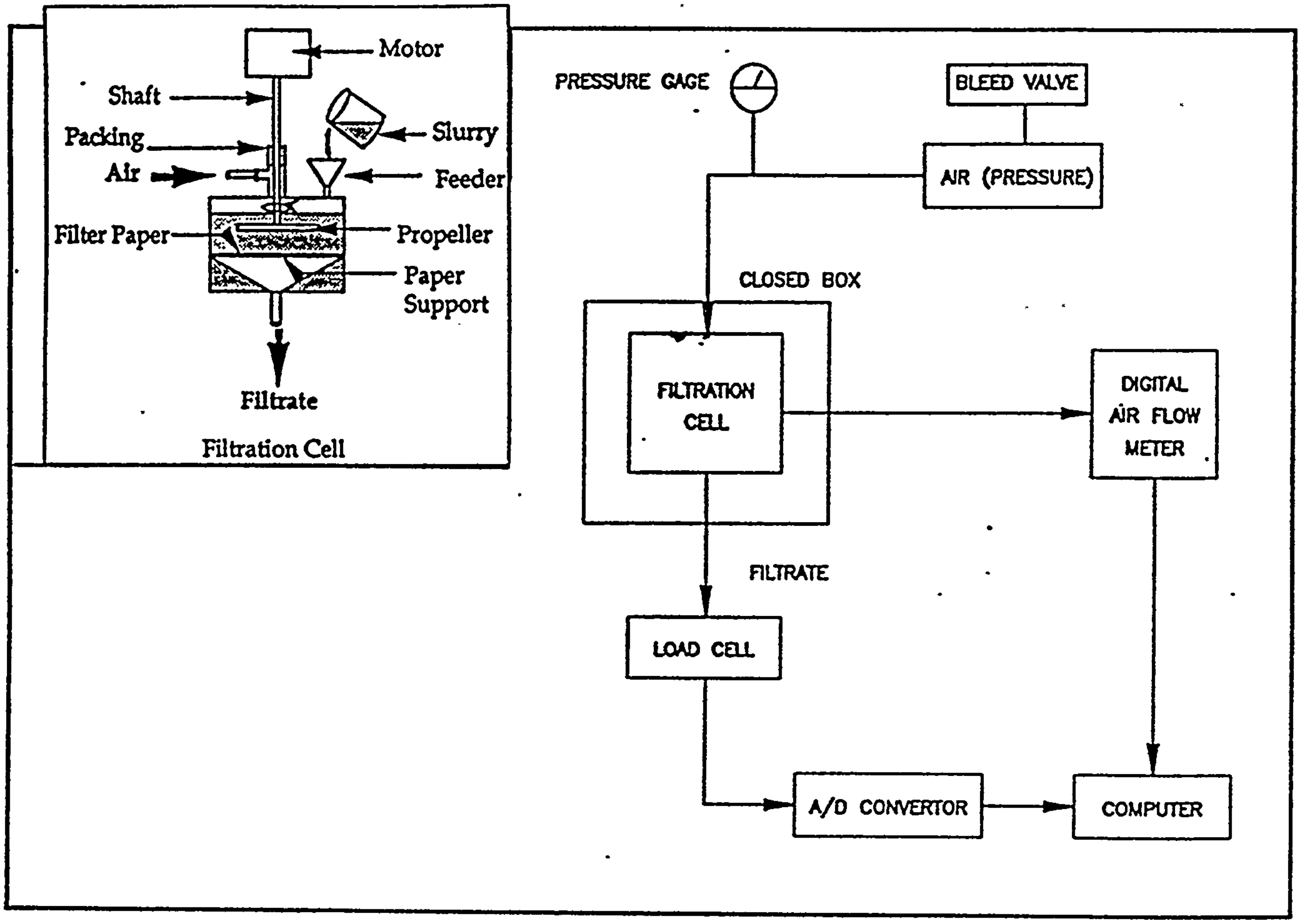

Figure 1. Laboratory dewatering equipment set-up

RESULTS AND DISCUSSIONS

The particle size distribution and ash analyses of the Pittsburgh No. 8 and Pocahontas No. 3 coal slurries are listed in Table 1. Note, that the amount of minus 325 mesh (45 micron) material in the Pittsburgh and Pocahontas seams are 65 and 26 weight percent, respectively, which shows that Pittsburgh seam slurry consist of significantly high amounts of fines.

Table 1. Characterization data for Pittsburgh No. 8 and Pocahontas No. 3 Coal slurries.

Pittsburgh No. 8

Size (Mesh)	Weight Percent	Ash Percent	Percent Ash Distribution
+100	2.77	2.43	0.8
100x200	19.14	2.52	5.6
200x325	13.59	3.34	5.2
325x500	22.23	3.98	10.2
-500	42.27	15.92	78.2
Feed (Calc)	100.00	8.60	100.0
(Actual)		8.78	

Pocahontas No. 3

Size (Mesh)	Weight Percent	Ash Percent	Percent Ash Distribution
+28	4.5	3.02	2.4
28x48	24.8	3.61	16.1
48x100	20.5	4.20	15.5
100x200	17.3	4.44	13.8
200x325	6.9	3.95	4.9
-325	26.0	10.00	47.3
Feed (Calc.)	100.0	5.53	
(Actual)		5.55	

The effect of applied pressure on filter cake moisture with respect to cake thickness for the Pittsburgh and the Pocahontas slurries is shown in Figure 2. For the Pittsburgh coal, 70 psi pressure using 1.5 cm cake thickness appears to be optimum providing a filter cake containing 24.87 percent moisture. For the Pocahontas coal, 80 psi pressure using 1.5 cm cake thickness appears optimum providing a filter cake with 11 percent moisture. Higher cake thickness significantly increases filter cake moisture.

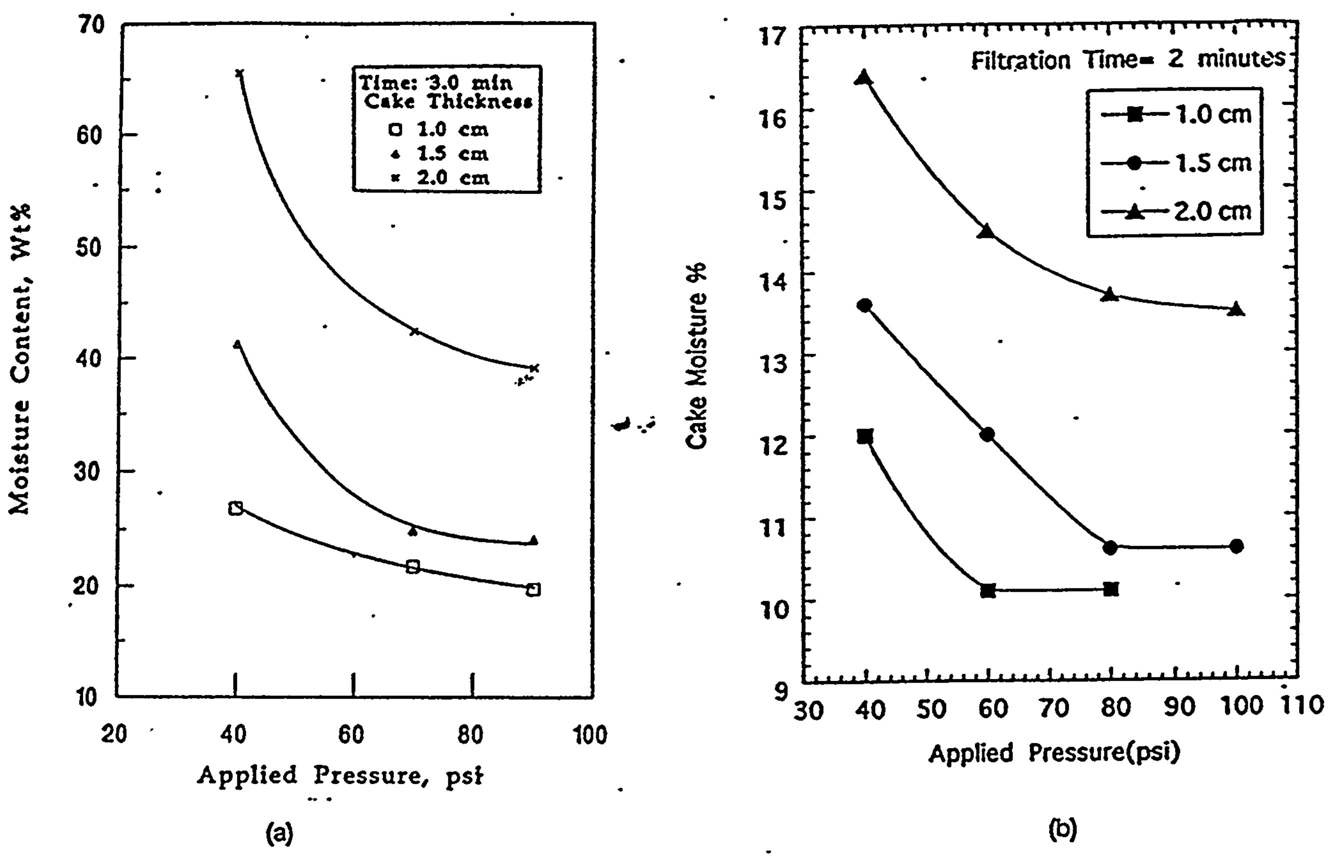

Fig. 2. Determination of optimum process condition for applied pressure. (a) Pittsburgh No. 8 coal; (b) Pocahontas No. 3

Addition of flocculant and/or surfactant lowers filter cake moisture of the Pittsburgh slurry to 16.5 percent and the Pocahontas slurry to 9.5 percent (Sung et al., 1994). In the innovative approaches described below, improved dewatering results were obtained for both slurries without addition of any chemical.

Split Stream Dewatering:

The split stream dewatering refers to classifying the clean coal slurry at a given particle size and dewatering the two-sized fractions separately and then combining them. Tables 2 and 3 list the split stream dewatering data for the Pittsburgh and the Pocahontas slurries, respectively. Split dewatering studies were conducted using both the conventional filtration set-up, i.e., keeping filter paper directly over the support plate, and the modified filtration set-up which involved inserting a 30 mesh opening screen below the filter paper and separating it from the supporting metal plate with metal springs, as shown in Figure 2. Table 2 shows that for the Pittsburgh slurry, split stream dewatering at 200, 400, and 500 mesh, provided 20.38, 16.93, and 15.88 percent moisture, respectively, using the conventional filtration set-up. These numbers translate into absolute moisture reduction improvement from 4.99 to 8.99 percent over the baseline moisture data of 24.87 percent. Using the modified filtration set-up, the feed sample was dewatered to 21.54 percent moisture, a 3.3 percent improvement in moisture reduction. Split stream dewatering at 200, 400 and 500 mesh provided a dewatered product containing 18.07, 12.90, and 12.62 percent moisture filter cake which were much lower than that obtained with conventional filtration set-up.

Table 2. Split stream dewatering data for the Pittsburgh No. 8 coal slurry using the conventional and the modified filtration support.

			Conventional Support		Modified Support	
Cut-Point (mesh)	Size Fraction (mesh)	% WT	Filter Cake Moisture (Weight %)	Improvement in Moisture Reduction	Filter Cake Moisture (Weight %)	Improvement in Moisture Reduction
200	+200	21.8	4.2		1.3	
	-200	78.2	24.91		22.75	
	Composite	100	20.38	4.49	18.07	6.8*
400	+400	46.6	6.7		1.6	
	-400	53.4	25.87		22.82	
	Composite	100	16.93	7.94	12.90	11.97*
500	+500	57.7	7.3		2.6	
	-500	42.3	27.93		26.3	
	Composite	100	15.88	8.99	12.62	12.25*
	Feed	100	24.87		21.54	3.33*

*Based on 24.87 percent filter cake moisture obtained with conventional filtration set-up.

Table 3. Split stream dewatering data for the Pocahontas No. 3 coal slurry.

			Conventional Support		Modified Support	
Cut-Point (mesh)	Size Fraction (mesh)	% WT	Filter Cake Moisture (Weight %)	Improvement in Moisture Reduction	Filter Cake Moisture (Weight %)	Improvement in Moisture Reduction
100	+100	49.8	2.5		1.01	
	-100	40.2	15.42		14.00	
	Subtotal	100	7.44	3.56	6.13	4.87*
200	+200	67.1	3.3		1.4	
	-200	32.9	16.47		15.63	
	Subtotal	100	7.63	3.37	6.08	4.92*
400	+400	78	7.2		1.2	
	-400	22	19.7		17.8	
	Subtotal	100	9.94	1.06	4.85	6.15*
0	Composite		11.0		9.7	1.3*

*Based on 11 percent filter cake moisture obtained with the conventional filtration set-up.

Similarly, for the Pocahontas coal slurry (Table 3), the conventional set-up lowest moisture of 7.44 percent was obtained by conducting dewatering at 100 mesh split streams. With the modified filtration support, the feed was dewatered to 9.7 percent moisture compared to 11 percent obtained with the conventional set-up. Note, that splitting the slurry at 100, 200 and 400 mesh provided filter cake containing 6.13, 6.08, and 4.85 percent moisture, respectively. These numbers translate into absolute moisture reduction of 4.87, 4.92 and 6.15 percent over the baseline data of 11 percent moisture.

Paper Pulp Addition:

A few preliminary dewatering tests were conducted by addition of paper pulp to the Pittsburgh slurry. The lowest cake moisture of 16.95 percent was achieved using 12.5 Kg/t of paper. Moisture in the filter cake increases with increase in addition of paper pulp. This represents a 30 percent improvement in moisture reduction over that obtained without addition of paper pulp.

CONCLUSIONS

Pressure filtration is an effective technique for dewatering of fine coal. Addition of flocculant and/or surfactant lowers the moisture in the filter cake, however, it increases the cost of filter operation. A couple of novel approaches described in this paper can be summarized as follows:

- An effective and efficient dewatering of fine coal could be achieved using the split stream dewatering technique. For example, for the Pittsburgh No. 8 coal slurry classifying at 400 mesh, split stream dewatering using the modified filter set-up provide 12.9 percent moisture filter cake compared to 24.87 percent obtained without split stream dewatering. For the Pocahontas coal, 400 mesh split stream dewatering provided a 4.85 percent moisture filter cake compared to 11 percent moisture obtained for baseline data.

- Addition of paper pulp (12.5 Kg/t) to the Pittsburgh coal slurry provided a 16.95 percent moisture cake which is 30 percent moisture reduction improvement over the baseline data.

Phase III - Pilot Scale Testing

The results of the pilot scale testing using the Andritz Hyperbaric Filter Unit are summarized below:

Pilot scale testing of the Andritz hyperbaric filter of the Pittsburgh No. 8 flotation product (minus 100 mesh) provided a 23 percent moisture in the filter cake using about 3 bar (44 psi) pressure. Air consumption for this condition was about 160 scfm/tph and solids throughput was about 110 lb/hr-ft^2. Addition of flocculant increase moisture content of filter cake, however, addition of a cationic surfactant (100 g/t) lowered filter cake moisture from 22.8 percent to 21.4 percent using 3.5 bar (51 psi) pressure.

For the Pocahontas No. 3 froth product which was 28x0 mesh size, a 15 percent moisture product could be obtained using about 2 bar (30 psi) pressure. Under these conditions, the air consumption was 50 scfm/tph and solids throughput was about 100 lb/hr-ft^2. Addition of flocculant did not lower the filter cake moisture, however, addition of cationic surfactant (380 g/t) lowered filter cake moisture from 13 percent to 12.4 percent.

FUTURE PLANS

Prepare the final report.