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**POC-SCALE TESTING  
OF AN ADVANCED FINE COAL DEWATERING EQUIPMENT/TECHNIQUE**

**Prepared for**

**U.S. Department of Energy  
Pittsburgh Energy Technology Center  
Pittsburgh, PA 15236**

**By**

**D. Tao  
J.G. Groppo  
B.K. Parekh  
Center for Applied Energy Research  
University of Kentucky  
Lexington, KY 40511**

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## **EXECUTIVE SUMMARY**

Froth flotation technique is an effective and efficient process for recovering of ultra-fine (minus 74  $\mu\text{m}$ ) clean coal. Economical dewatering of an ultra-fine clean-coal product to a 20% level moisture will be an important step in successful implementation of the advanced cleaning processes. This project is a step in the Department of Energy's program to show that ultra-clean coal could be effectively dewatered to 20% or lower moisture using either conventional or advanced dewatering techniques.

The cost-sharing contract effort is for 48 months beginning September 30, 1994. This report discusses technical progress made during the quarter from October 1 - December 31, 1997.

### **OBJECTIVES AND SCOPE OF THE PROJECT**

The main objective of the proposed program is to evaluate a novel surface modification technique, which utilizes the synergistic effect of metal ions-surfactant combination, for dewatering of ultra-fine clean coal on a proof-of-concept scale of 1 to 2 tph. The novel surface modification technique developed at the UKCAER will be evaluated using vacuum, centrifuge, and hyperbaric filtration equipment. Dewatering tests will be conducted using the fine clean-coal froth produced by the column flotation units at the Powell Mountain Coal Company, Mayflower Preparation Plant in St. Charles, Virginia. The POC-scale studies will be conducted on two different types of clean coal, namely, high-sulfur and low-sulfur clean coal. The Mayflower Plant processes coals from five different seams, thus the dewatering studies results could be generalized for most of the bituminous coals.

## **APPROACH**

The project team consist of the University of Kentucky Center for Applied Energy Research (UKCAER), Powell Mountain Coal Company (PMCC), Andritz Ruthner Inc., and WesTech Engineering, Inc.

The UKCAER is the prime contractor of the project which has been divided into nine (9) tasks. The clean-coal froth generated by the 'Ken-Flote' columns at the PMCC Mayflower Preparation Plant will be utilized for dewatering studies using hyperbaric, centrifuge and vacuum dewatering techniques.

## **ACCOMPLISHMENTS DURING THE QUARTER**

Laboratory vacuum filter leaf tests have been conducted to study the effects of adding coarse coal particles of 10×25, 25×35, 35×50, and 50×100 mesh size fractions on the dewatering of PMCC low-sulfur clean coal slurry. A central composite experimental design was conducted for test planning. Two new moisture terms, namely, apparent moisture and modified moisture, were used to evaluate the dewatering performance. The

‘  
apparent

moisture

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was the overall moisture determined for the filter cake obtained in the experiments. The

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modified

moisture

was defined as the moisture of -100 mesh fine coal in the filter cake in presence of coarse coal particles.

Two series of designed tests were performed to examine the effects of coarse coal particles. The high, medium, and low level of each factor (the dosage of coarse coal particles) were 5%, 3%, and 1% (by weight) of solids in the coal slurry for both series of tests. Slurry was not stirred in the first series of tests and was stirred in the second series.

Results showed that stirring slurry during cake formation had very significant effects on cake moisture. Without stirring addition of coarse coal particles at dosages of 1%, 3%, or 5% produced apparent cake moisture of 31% to 33% and modified cake moisture of 33.5% to 36%, depending on the dosage of coarse coal particles. With stirring, apparent cake moisture was 23.5% to 25.5% and modified cake moisture was 24.5% to 27% with the same dosage of coarse coal particles. The statistical analysis of experimental data indicated that the coarse coal fractions that had most significant effects on cake moisture depended on which cake moisture (apparent or modified) was used for evaluation, whether slurry stirring was used and what range the dosage of coarse coal particle was in.

Laboratory ceramic disk filter leaf dewatering tests were conducted using two different types of disks, i.e., low-and high-porosity. The tests were conducted using a 30 percent solids slurry of 100x200 and minus 200 mesh coal slurries. The low porous ceramic disk filter was not very effective in capturing high amount of solids using the 100x200 mesh coal. However, the

high-porosity disk provided a filter cake with 30 percent moisture filter cake at 14.5 Kg/m<sup>2</sup> solids loading. Increasing cake drying time from 30 to 60 sec. lowered filter cake moisture to 23 percent.

Both the low- and high-porosity filters gave satisfactory results with 30 percent solids of minus 200 mesh coal. With the low porosity filter 45 sec. cake formation time and 30 sec. drying time provided filter cake with 28% moisture with 4.6 Kg/m<sup>2</sup> solids loading. With the high-porosity filter, a 32% moisture cake at a solid loading of 16.2 Kg/m<sup>2</sup> was obtained.

Further studies are in progress with ceramic filter to study effect of percent solids and various reagents addition.

## INTRODUCTION

For cleaning of coal finer than 0.5 mm (28 mesh) processes based on surface chemical technique such as froth flotation and oil agglomeration are the most effective. However, the froth flotation process, which is commercially used, produces a product containing 80% moisture. The recently developed column flotation technique, which provides higher recovery of low-ash product, also suffers from the same problem of high moisture product. Dewatering of the fine coal to a low (~20%) moisture level using conventional filtration equipment has not been possible. This project offers a novel surface-modification approach to dewater fine coal slurry to a low-moisture level using conventional and advanced dewatering equipment. The surface modification approach has provided significant reduction in filter cake moisture in laboratory studies at University of Kentucky Center for Applied Energy Research.

The aim of this program is to test the UKCAER-developed novel coal surface modification approach on a pilot scale at the rate of 1-2 tph of solids using vacuum, centrifuge, hyperbaric and ceramic disc filtration techniques. The proof-of-concept testing was performed at the Powell Mountain Coal Company Mayflower Plant located in St. Charles, Virginia using vacuum, centrifuge, hyperbaric filter. Test work using the ceramic filter is being conducted at the University of Kentucky Center for Applied Energy Research.

The project involves a teaming arrangement between the University of Kentucky for Applied Energy Research (CAER), the Powell Mountain Coal

Company (PMCC), the Andritz Ruthner Inc. (ARI), and WesTech Engineering Inc. (WEI).

## **APPROACH**

A team of scientists and engineers from the Center for Applied Energy Research (UKCAER), Powell Mountain Coal Company (PMCC), Andritz Ruthner Inc. (ARI), and WesTech Engineering Inc. (WEI) was formed to accomplish the objectives of the program. Each team member brings fine-particle dewatering knowledge and experience to the project. The UKCAER is managing the project and is conducting the major part of the study. The PMCC provided assistance and a facility for conducting the pilot scale tests. The ARI conducted laboratory dewatering tests and also pilot-scale tests using the hyperbaric pressure filtration unit at the PMCC. Figure 1 shows the project organization chart. The project schedule is shown in Figure 2.

The CAER collected clean-coal froth samples from the Mayflower plant for the laboratory studies. Samples of clean-coal slurries were also sent to ARI for studies using their laboratory scale hyperbaric unit. At both organizations, emphasis were given to identify optimum process and operating conditions using vacuum and pressure techniques to dewater the clean-coal slurry to about 20% level moisture. It was hypothesized that the proposed research can achieve low- moisture products on a pilot scale to the same extent which has already been achieved in laboratory studies.

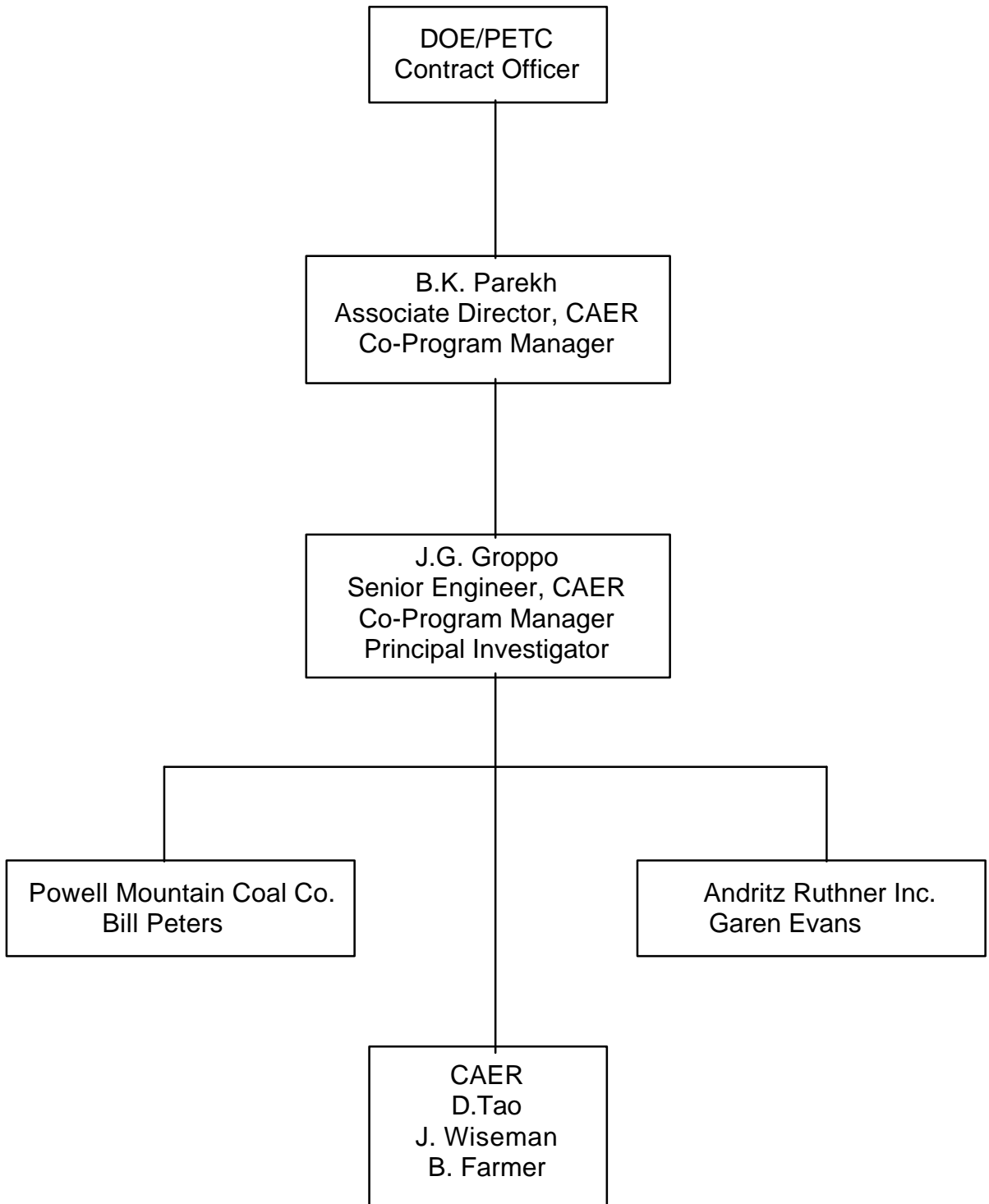


Figure 1. Project management organization chart



The basic components of the process have been tested in the laboratory. The proposed work is to evaluate all of the component steps on a consistent basis, and, to the extent possible in laboratory studies, demonstrate the feasibility of their integration. The outcome of this program will be to identify a process/technique combination which is able to achieve a 20% or lower moisture in the fine clean-coal product and to provide technical and economic evaluations of the integrated concept in sufficient detail for a coal company to decide to install the dewatering process in their plant.

## RESULTS AND DISCUSSION

The project has been divided into tasks and subtasks listed in Table I. Each task and subtask has specific objectives which can be inferred from its title. During this quarter (October to December 31, 1997) work was done on Tasks 2, 6, 7 and 8.

### **Task 2. Sample Analysis and Laboratory Testing:**

The laboratory dewatering tests were conducted using both compliance (low-sulfur) and non-compliance (high-sulfur) clean-coal slurries obtained from the Powell Mountain Coal Co. The low-sulfur and high-sulfur clean-coal froth slurry had the  $D_{50}$  (median size) of 29.5 and 37.3  $\mu\text{m}$  and solids concentration about 15 and 20%, respectively. The proximate analysis of both coals showed that PMCC low-sulfur coal contained 5.72% ash, 31.70% volatile matter, 69.78% fixed carbon and PMCC high-sulfur coal had 5.58% ash, 33.05% volatile matter, and 59.77% fixed carbon.

#### Vacuum Dewatering

In the last quarter major efforts were devoted to the investigation of the effects of the addition of coarse coal particles in 10×25, 25×35, 35×50, 50×100 mesh size fractions on

-100 mesh fine coal vacuum dewatering performance. It is believed that addition of coarse coal particles to fine coal slurry changes the morphology of the filter

cake, improves cake porosity, and therefore, may reduce cake moisture. The dewatering tests were conducted with the PMCC low-sulfur

Table I. Outline of Work Breakdown Structure

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Task 1.	Project Work Planning	
	Subtask 1.1	Project Work Plan
	Subtask 1.2	Project Work Plan Revisions
Task 2.	Samples Analysis and Laboratory Testing	
	Subtask 2.1	Acquisition and Characterization of Samples
	Subtask 2.2	Laboratory Scale Testing
	Subtask 2.3	Optimization of Parameters
	Subtask 2.4	Analysis of Data
Task 3.	Engineering Design	
	Subtask 3.1	Conceptual Design Package
	Subtask 3.2	Final Design Package
	Subtask 3.3	Construction Schedule
Task 4.	Procurement and Fabrication	
	Subtask 4.1	Bid Packages
	Subtask 4.2	Fabricate/Assemble Components
	Subtask 4.3	Deliver POC-Scale Module and Install
	Subtask 4.4	Maintenance and Operating Manual
Task 5.	Installation and Shakedown	
	Subtask 5.1	Install and Tie-in Module
	Subtask 5.2	Startup Procedures/Shakedown
	Subtask 5.3	Operators Training
Task 6.	System Operation	
	Subtask 6.1	Test Coal No. 1
	Subtask 6.2	Test Coal No. 2
Task 7.	Process Evaluation	
Task 8.	Equipment Removal	
Task 9.	Reporting	
	Subtask 9.1	Monthly Reports
	Subtask 9.2	Project Final Report

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coal slurry sample of the column flotation froth product. The coarse coal particles, obtained from the PMCC coal preparation plant, were wet-screened and air-dried prior to the use in the dewatering tests.

*Vacuum Filter Leaf Dewatering Tests with Coarse Coal Particles*

A central composite experimental design was developed to characterize effects of each coarse coal particle size fraction and its interactions on fine coal (-100 mesh) dewatering. The four size fractions--10×25, 25×35, 35×50, and 50×100 mesh--were the four factors investigated in the study and were labeled as  $w_1$ ,  $w_2$ ,  $w_3$ , and  $w_4$ , respectively. Each factor was tested at three levels--high, medium, and low which were coded as +1, 0, and -1 in the experimental design, respectively. The software *Design Expert 4.08* developed by Stat-Ease Inc., Minneapolis, Minnesota, was used to perform the design and statistical data analysis.

Table II lists the experimental conditions and cake moisture obtained in each designed test. The first three tests were baseline tests in which no coarse coal particles were added. The rest of thirty tests were from the four factor, three level central composite experimental design. In all of these tests slurry inside the vacuum filter cell was in quiescent condition during filtration. In other words, the cake slurry was not stirred. The level, i.e., dosage of each coarse coal particle size fraction, is in weight percentage relative to a constant weight of 14g of the fine coal in 100 ml slurry used for each test. The

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apparent  
moisture  
,

Table II. Experimental conditions and dewatering results

test #	w <sub>1</sub> (%) 10-25 mesh	w <sub>2</sub> (%) 25-35 mesh	w <sub>3</sub> (%) 35-50 mesh	w <sub>4</sub> (%) 50-100 mesh	m <sub>0</sub> (%)	m <sub>1</sub> (%)
1	0	0	0	0	30.41	30.41
2	0	0	0	0	31.46	31.46
3	0	0	0	0	31.03	31.03
4	3	0	3	3	32.06	33.85
5	1	5	5	1	32.96	35.43
6	5	5	1	1	31.00	33.31
7	1	5	1	5	31.86	34.25
8	1	5	1	1	32.36	33.99
9	1	1	5	5	31.52	33.81
10	3	3	3	3	32.06	34.46
11	5	1	1	5	32.04	34.47
12	3	3	3	3	32.65	35.12
13	5	5	1	5	32.67	36.01
14	3	3	0	3	31.81	33.62
15	7	3	3	3	32.96	36.33
16	3	3	3	3	31.55	33.89
17	3	3	3	0	33.43	35.35
18	3	3	3	7	31.96	35.14
19	5	5	5	5	29.17	32.59
20	0	3	3	3	32.37	34.17
21	3	3	3	3	31.71	34.06
22	1	1	1	5	32.64	34.29
23	3	7	3	3	32.29	35.53
24	5	5	5	1	32.67	35.96
25	1	5	5	5	34.32	37.84
26	5	1	5	5	31.21	34.26
27	3	3	3	3	32.59	35.05
28	1	1	5	1	32.77	34.38
29	5	1	1	1	32.13	33.77
30	3	3	3	3	32.38	34.81
31	3	3	7	3	32.89	36.17
32	5	1	5	1	33.09	35.60
33	1	1	1	1	33.13	33.97

was the overall moisture determined for the cake obtained from the experiment. Since it is known that lower moisture is always associated with coarse coal particles even if they are filtered separately rather than together with fine coal, it may be more reasonable to exclude this effect to explore the net effect of coarse coal particles on fine coal dewatering. A new term

modified  
moisture

was thus introduced to take into account this effect, defined using the following equation:

$$m_1 = [(w_1 + w_2 + w_3 + w_4 + 100)m_0 - (11.28w_1 + 11.79w_2 + 13.24w_3 + 12.05w_4)] / 100 \quad (1)$$

where  $w_1$ ,  $w_2$ ,  $w_3$ ,  $w_4$  is the dosage in Wt% for 10×25, 25×35, 35×50, and 50×100 mesh size fraction, respectively.  $m_0$  is the apparent cake moisture in Wt%. The coefficients 11.28, 11.79, 13.24, 12.05 are the cake moistures of the four coarse coal particle size fractions obtained when they were filtered separately. The modified moisture is the actual moisture of -100 mesh coal.

Figure 3 shows apparent cake moisture and modified moisture of the dewatering test results listed in Table II. As can be seen, the modified moisture (moisture of -100 mesh material) was always higher than the apparent moisture. The apparent moisture ranges from 31 to 33% while the modified moisture varies between 34 to 36%. However, neither the apparent cake moisture nor the modified moisture was lower than the baseline moisture of the first 3 tests, indicating that addition of coarse did not improve fine coal dewatering. It is

believed that coarse coal particles added to the quiescent slurry rapidly settled down to the bottom of filter cake and had no beneficial effects on the size distribution or microstructure of the rest of the cake. The fact that even the apparent cake moisture was higher than the baseline moisture may be due to greater cake thickness when coarse coal particles were added to the slurry. It has been well established in the previous tests that thicker cake gave rise to higher moisture.

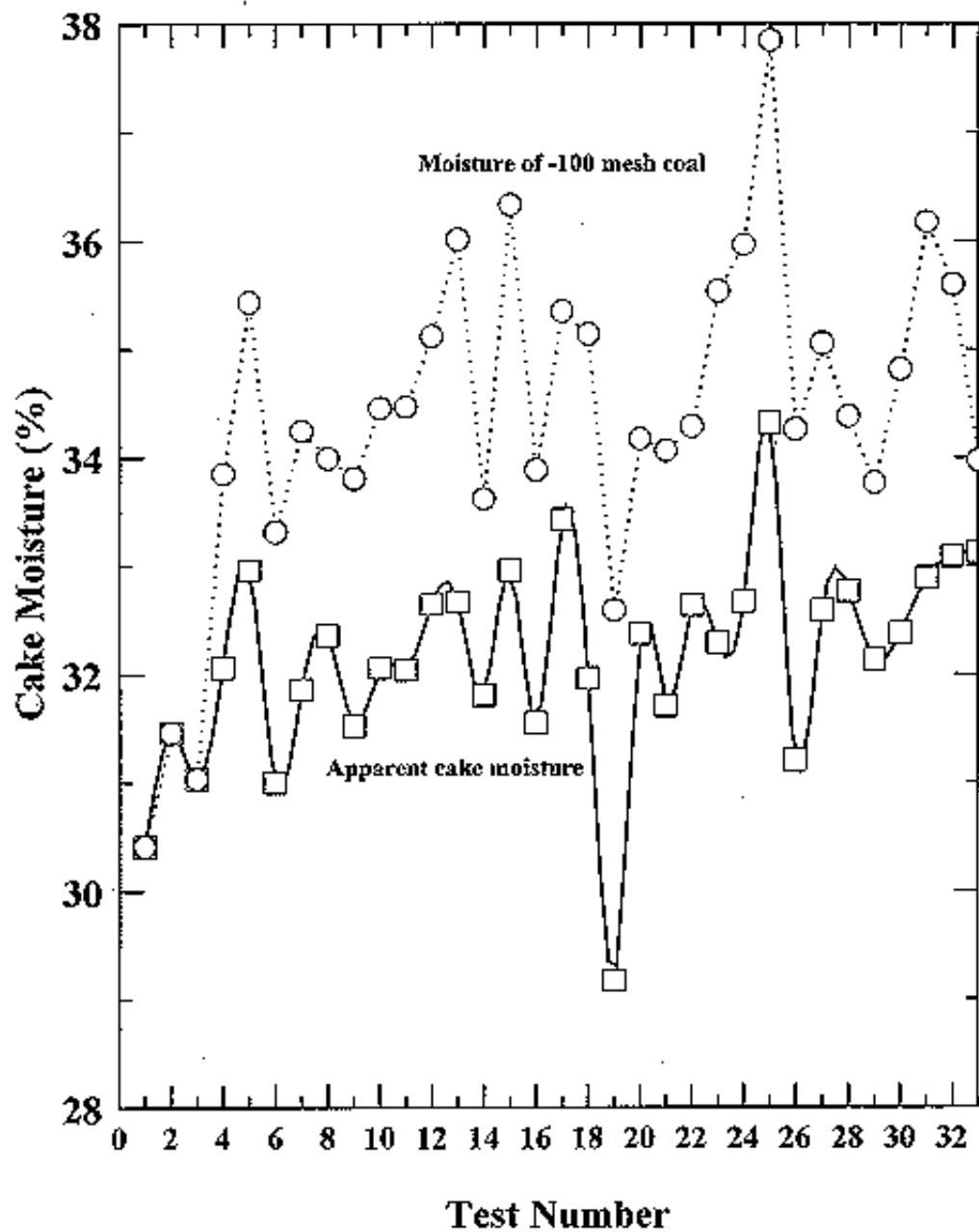


Figure 3. Cake moisture in designed experiments without slurry stirring

Statistical data analysis was conducted to examine effects of each individual coarse-coal particle size fraction and its interactions on cake

moisture. It was found that the apparent cake moisture was best fit by the quadratic model shown in Equation (2):

$$m_0 = 31.738 + 0.2354w_1 - 0.0096w_2 + 0.3400w_3 - 0.0150w_4 + 0.02142w_1^2 - 0.0093w_2^2 + 0.0017w_3^2 + 0.0232w_4^2 - 0.0689w_1w_2 - 0.0513w_1w_3 - 0.0456w_1w_4 + 0.0403w_2w_3 + 0.0428w_2w_4 - 0.0916w_3w_4 \quad (2)$$

The ANOVA (analysis of variance) results indicate that  $w_1$ ,  $w_4$ , and  $w_3w_4$  have the most significant impacts on the apparent cake moisture. Figures 4-5 show two 3D plots of the response surface of the apparent moisture as a function of the most significant factors. Both plots indicate that higher dosage of  $w_1$ ,  $w_3$ , or  $w_4$  will produce lower cake moisture, which is consistent with the Equation (2). However, the response surface is quite flat in both Figure 4 and Figure 5, indicating that  $w_1$ ,  $w_3$ , and  $w_4$  have limited effects on cake moisture.

The modified cake moisture was also analyzed statistically and the best fitting model is the quadratic model shown in Equation (3):

$$m_1 = 31.585 + 0.507w_1 + 0.209w_2 + 0.590w_3 + 0.220w_4 + 0.0262w_1^2 - 0.0088w_2^2 + 0.004w_3^2 + 0.0259w_4^2 - 0.0827w_1w_2 - 0.0642w_1w_3 - 0.0583w_1w_4 + 0.0423w_2w_3 + 0.0452w_2w_4 - 0.1073w_3w_4 \quad (3)$$

The ANOVA (analysis of variance) results show that  $w_2$ ,  $w_3$ , and  $w_2w_4$  have the most significant impacts on the modified cake moisture. Figures 6-7 show the 3D plots of the response surface of the modified moisture as a function of the most significant factors. In contrast with Figures 4-5, these two plots show

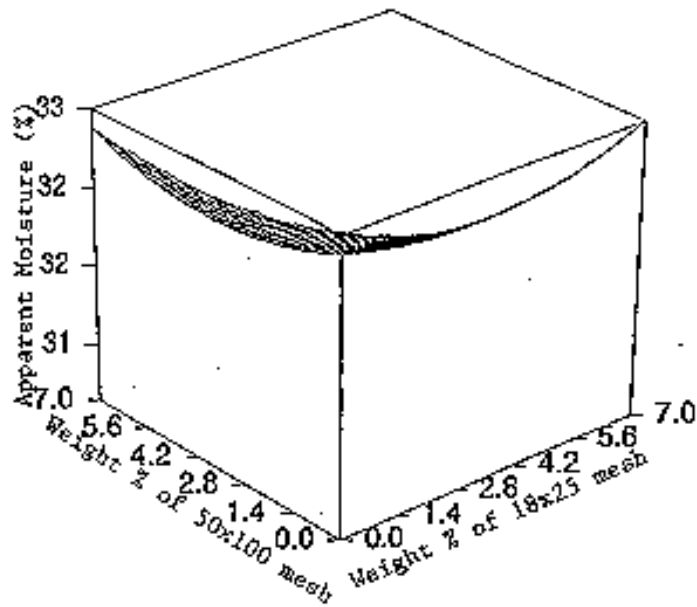


Figure 4. Apparent cake moisture as a function of dosage of 18-25 mesh and 50-100 mesh coarse coal without slurry stirring

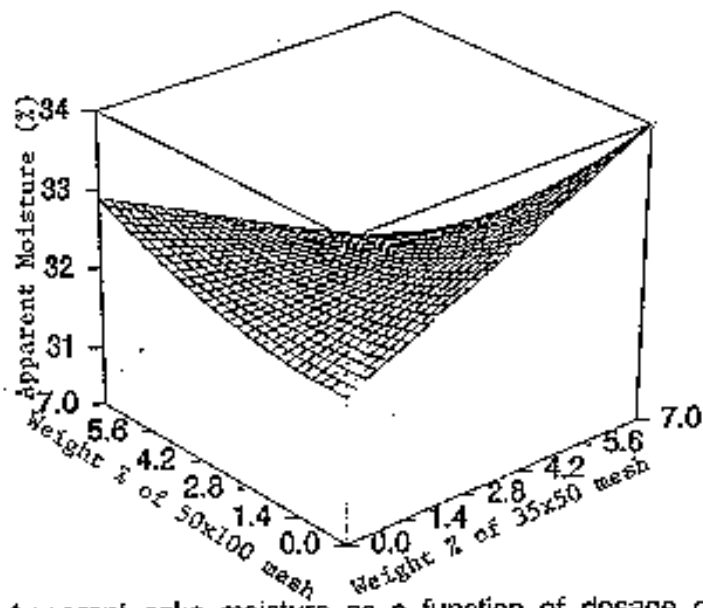


Figure 5. Apparent cake moisture as a function of dosage of 35-50 mesh and 50-100 mesh coarse coal without slurry stirring

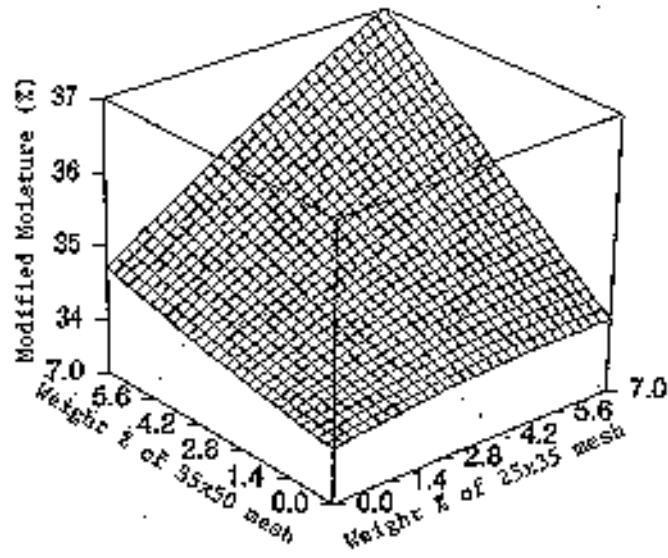


Figure 6. Modified cake moisture as a function of dosage of 25-35 mesh and 35-50 mesh coarse coal without slurry stirring

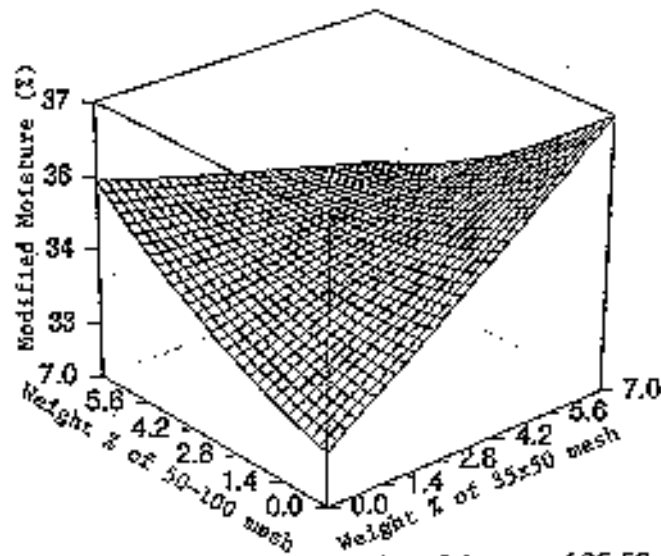


Figure 7. Modified cake moisture as a function of dosage of 35-50 mesh and 50-100 mesh coarse coal without slurry stirring

that higher dosage of  $w_1$ ,  $w_3$ , and  $w_4$  had adverse effects on the modified cake moisture. In other words, addition of coarse coal particles will increase the moisture of

-100 mesh fine coal. This conclusion is in agreement with the data shown in Figure 3.

Table III. Experimental conditions and dewatering results with stirred slurry

test #	w <sub>1</sub> (%) 10-25 mesh	w <sub>2</sub> (%) 25-35 mesh	w <sub>3</sub> (%) 35-50 mesh	w <sub>4</sub> (%) 50-100 mesh	m <sub>0</sub> (%)	m <sub>1</sub> (%)
1	0	0	0	0	25.06	25.06
2	0	0	0	0	25.00	25.00
3	0	0	0	0	25.56	25.56
4	3	0	3	3	23.46	24.47
5	1	5	5	1	25.01	26.53
6	5	5	1	1	23.60	25.03
7	1	5	1	5	23.85	25.27
8	1	5	1	1	23.71	24.65
9	1	1	5	5	23.88	25.25
10	3	3	3	3	24.35	25.82
11	5	1	1	5	24.78	26.34
12	3	3	3	3	25.64	27.27
13	5	5	1	5	25.00	27.11
14	3	3	0	3	24.74	25.91
15	7	3	3	3	24.23	26.20
16	3	3	3	3	26.64	28.39
17	3	3	3	0	24.60	25.72
18	3	3	3	7	24.44	26.42
19	5	5	5	5	25.19	27.81
20	0	3	3	3	24.34	25.42
21	3	3	3	3	23.06	24.38
22	1	1	1	5	25.04	26.08
23	3	7	3	3	24.64	26.66
24	5	5	5	1	23.64	25.49
25	1	5	5	5	24.12	26.01
26	5	1	5	5	24.02	25.92
27	3	3	3	3	25.21	26.78
28	1	1	5	1	24.64	25.60
29	5	1	1	1	24.38	25.40
30	3	3	3	3	23.77	25.17
31	3	3	7	3	25.16	27.21
32	5	1	5	1	24.43	25.90
33	1	1	1	1	24.35	24.84

Table III shows the experimental condition and cake moisture for each designed test in another series of dewatering tests. In all of these tests slurry inside the vacuum filter cell was stirred using a mechanical mixer. The mixer was positioned slightly above the top of the filter cake so that it did not disturb cake formation and drying. The first three tests were baseline tests in which no

coarse coal particles were added. The remaining thirty tests were from the four factor, three level central composite experimental design.

Figure 8 shows filter cake moisture data obtained for tests listed in Table III. In comparison with the results shown in Figure 3, cake moisture shown in Figure 8 was much lower than that shown in Figure 3. Apparent cake moisture was 23.5-25.5% when slurry was stirred during filtration. This represents a cake moisture reduction of more than seven absolute percentage points. Similarly, modified cake moisture was about 25-27% with stirring, as opposed to 34-36% without stirring, which is a nine absolute percentage point difference. The results indicated that stirring of slurry during filtration had very significant effects on cake moisture. It is believed that without slurry stirring fine particles concentrated on top of filter cake due to its slower settling velocity and blocked capillary pores in the cake, increasing cake resistance. With stirring, particle size distribution will be relatively homogenous throughout the filter cake.

Results also showed that, with stirring, the addition of coarse coal particles produced apparent cake moisture that was about two absolute percentage points lower than the baseline moisture of 25% obtained without

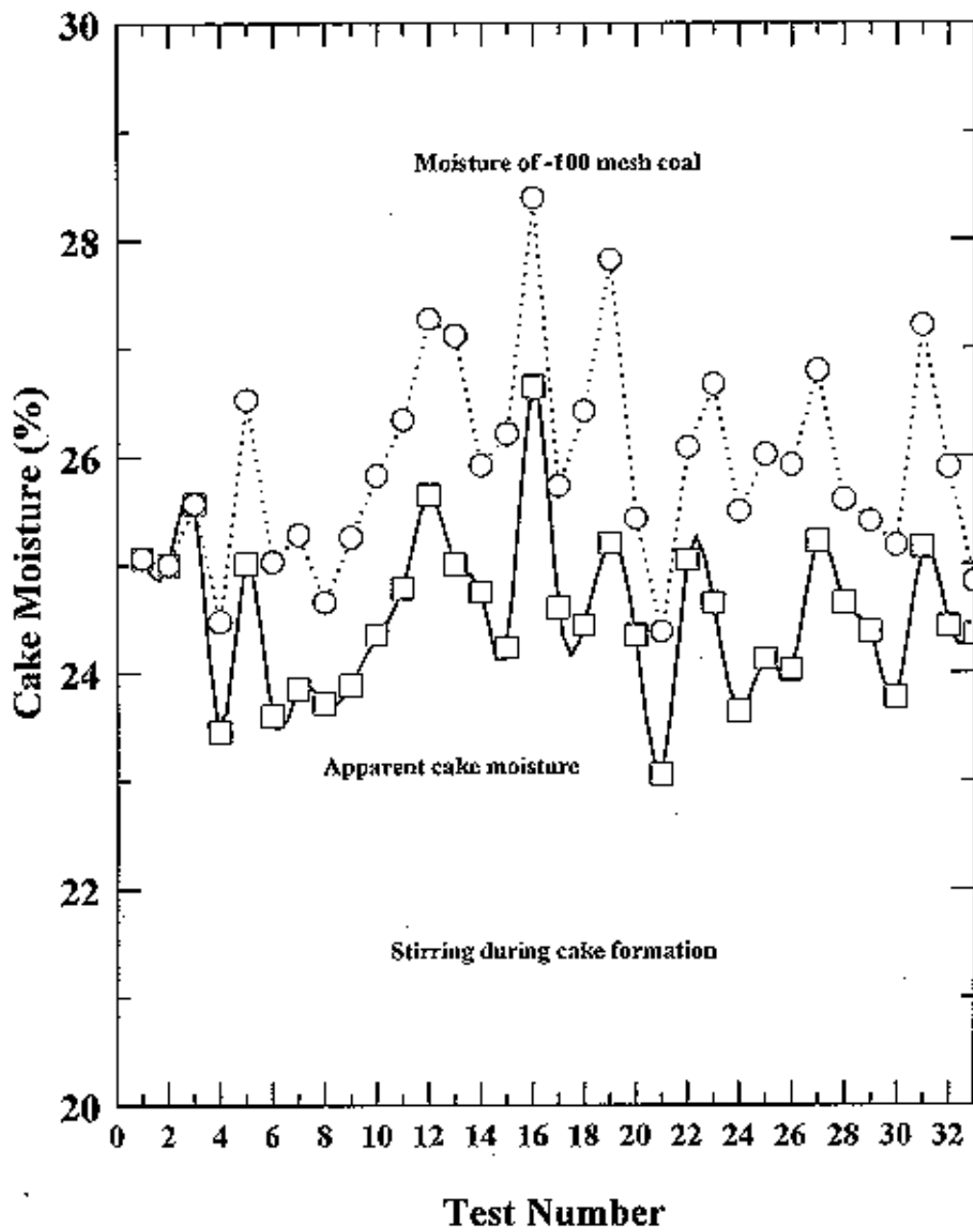


Figure 8. Cake moisture in designed experiments with slurry stirring

coarse coal particles, depending on the dosage of coarse coal size fractions. However, the modified cake moisture was significantly higher than the baseline moisture.

The statistical analysis of dewatering results showed that the apparent cake moisture can be best fit by Equation (4):

$$m_0 = 24.505 + 0.0446w_1 + 0.0038w_2 + 0.0265w_3 + 0.0231w_4 - 0.0350w_1^2 - 0.496w_2^2 + 0.0066w_3^2 - 0.0203w_4^2 + 0.0163w_1w_2 - 0.0184w_1w_3 - 0.0589w_1w_4 + 0.0528w_2w_3 + 0.0356w_2w_4 - 0.0491w_3w_4 \quad (4)$$

The ANOVA analysis indicated that  $w_2^2$ ,  $w_1w_4$ , and  $w_2w_3$  have the most significant effects on the apparent cake moisture. Figures 9-12 show the 3D plots of the response surface of the apparent cake moisture as a function of the most significant parameters. The convex shape of the response surface plots indicated that higher moisture content was obtained with addition of two or more coarse size coal fractions.

The modified cake moisture was also analyzed statistically and the best fitting model is the linear equation shown in Equation (5):

$$m_1 = 24.255 + 0.132w_1 + 0.145w_2 + 0.133w_3 + 0.161w_4 \quad (5)$$

Figures 13-18 show the 3D plots of the response surface of the modified moisture as a function of any combination of two factors out of the four. All these plots indicated that addition of coarse coal particles into fine coal slurry increased cake moisture of

-100 mesh fine coal although it decreased moisture content of the overall filter cake. The increase in cake moisture was in part

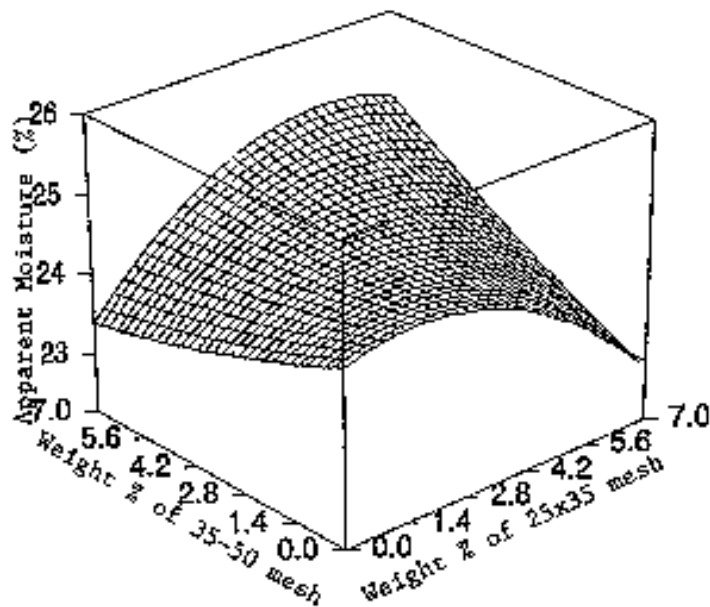


Figure 9. Apparent cake moisture as a function of dosage of 25-35 mesh and 35-50 mesh coarse coal with slurry stirring

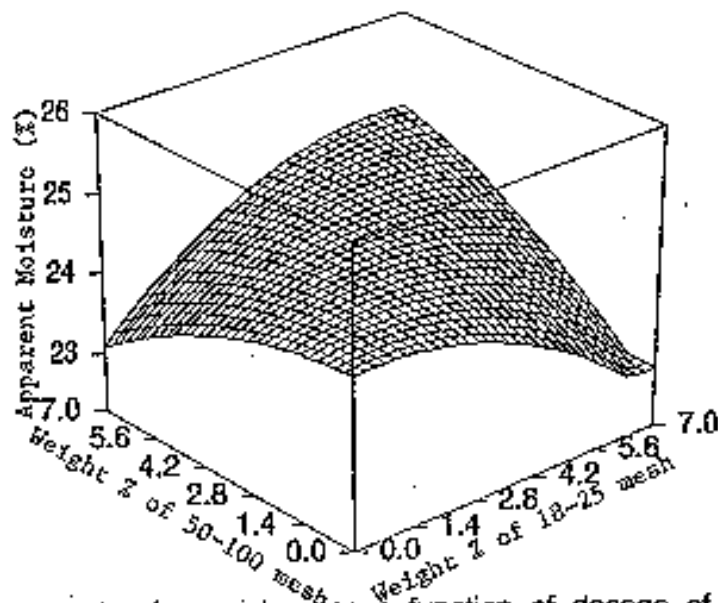


Figure 10. Apparent cake moisture as a function of dosage of 18-25 mesh and 50-100 mesh coarse coal with slurry stirring

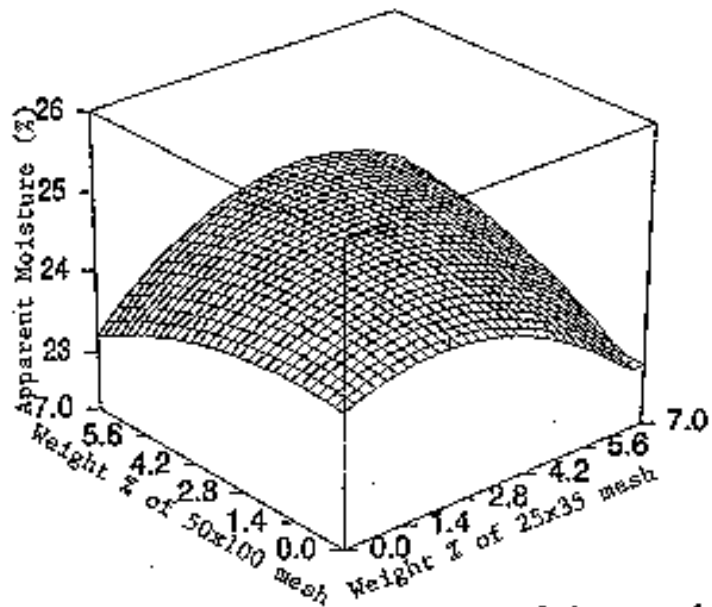


Figure 11. Apparent cake moisture as a function of dosage of 25-35 mesh and 50-100 mesh coarse coal with slurry stirring

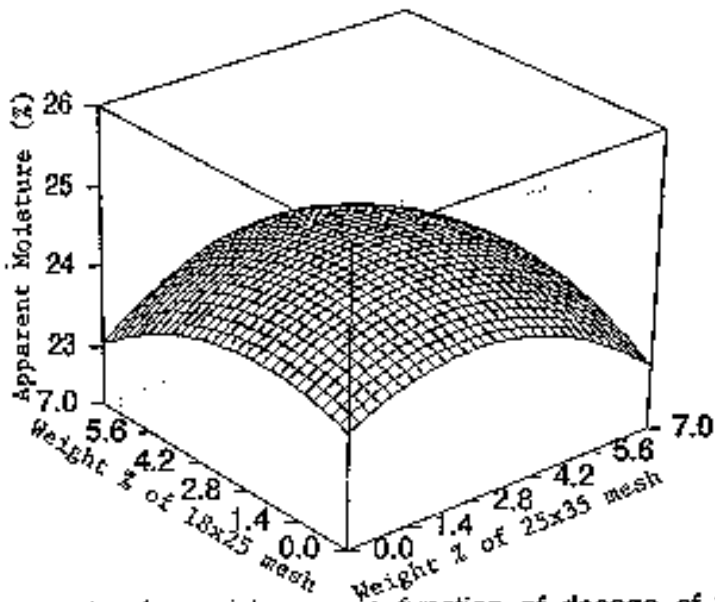


Figure 12. Apparent cake moisture as a function of dosage of 25-35 mesh and 18-25 mesh coarse coal with slurry stirring

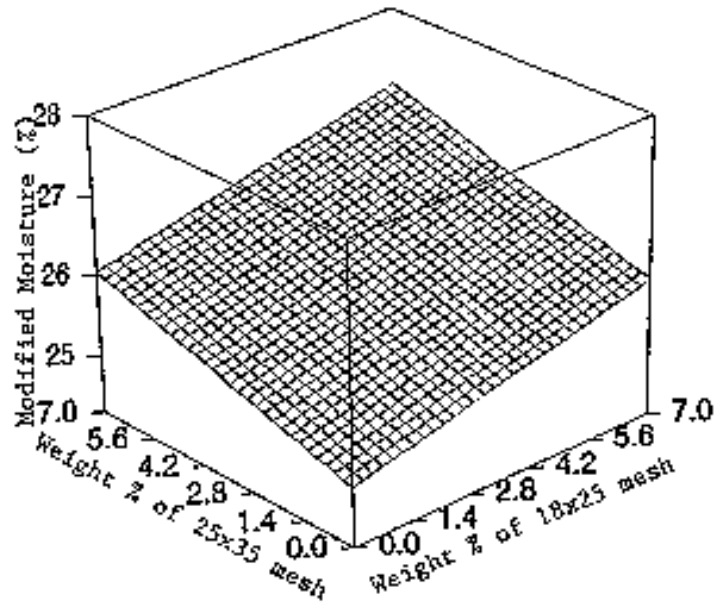


Figure 13. Modified cake moisture as a function of dosage of 18-25 mesh and 25-35 mesh coarse coal with slurry stirring

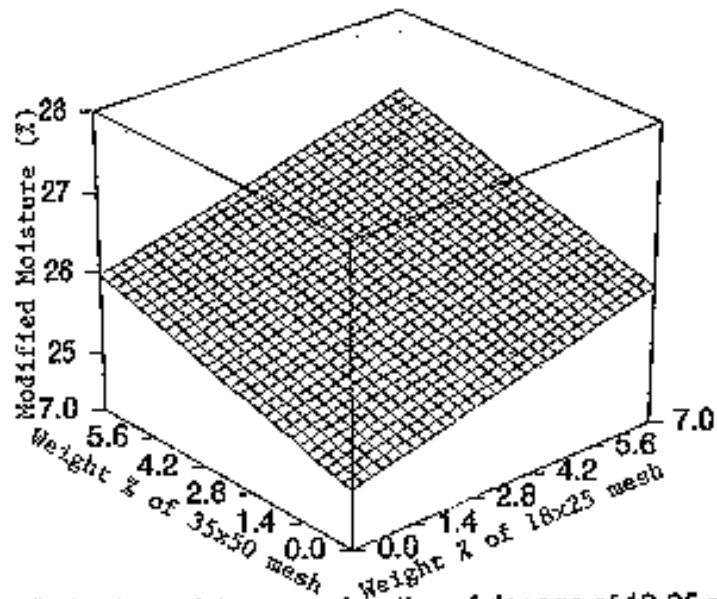


Figure 14. Modified cake moisture as a function of dosage of 18-25 mesh and 35-50 mesh coarse coal with slurry stirring

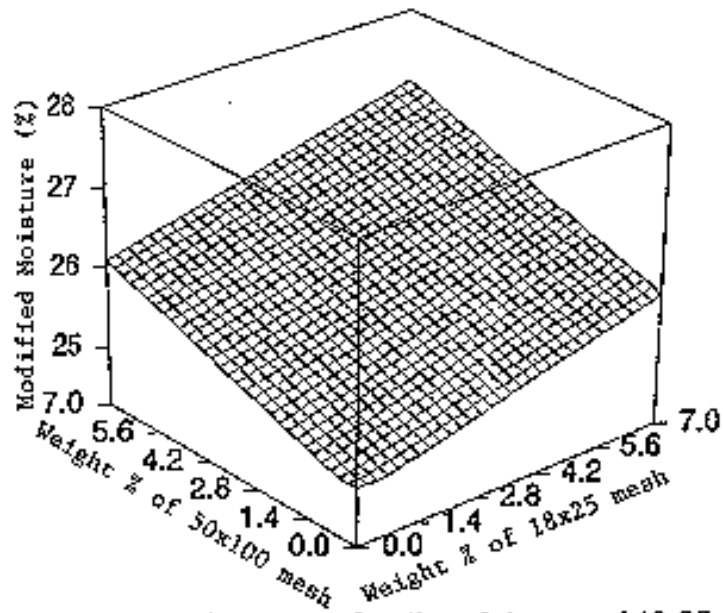


Figure 15. Modified cake moisture as a function of dosage of 18-25 mesh and 50-100 mesh coarse coal with slurry stirring

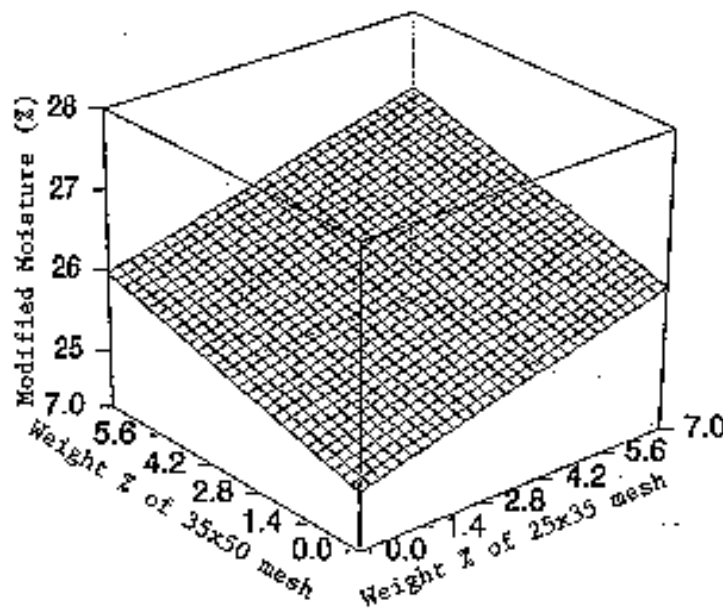


Figure 16. Modified cake moisture as a function of dosage of 25-35 mesh and 35-50 mesh coarse coal with slurry stirring

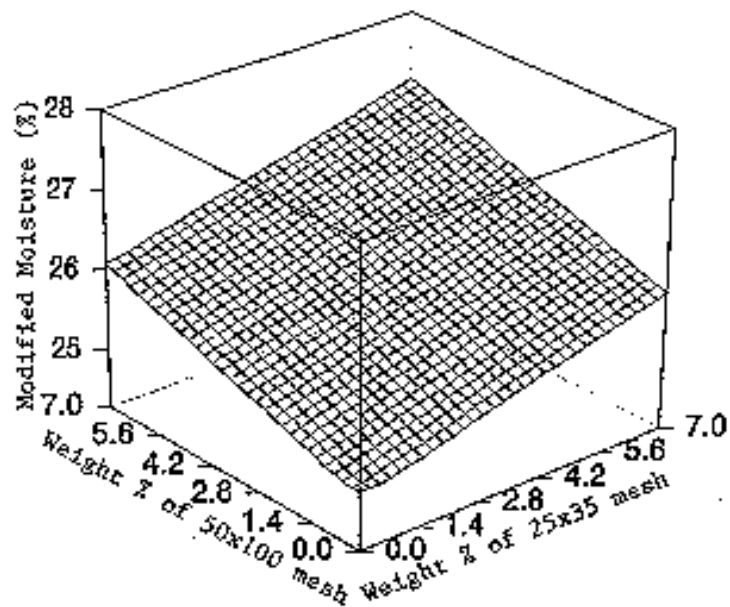


Figure 17. Modified cake moisture as a function of dosage of 25-35 mesh and 50-100 mesh coarse coal with slurry stirring

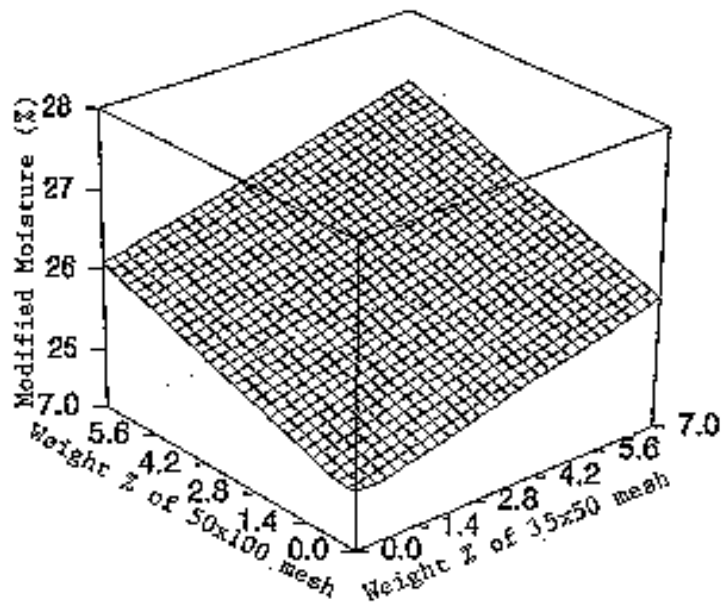


Figure 18. Modified cake moisture as a function of dosage of 35-50 mesh and 50-100 mesh coarse coal with slurry stirring

caused by increased cake thickness when coarse coal particles were added to the fine coal slurry.

#### **Task 6. System Operation:**

The Outokumpu Company provided CAER with two different types of ceramic disk filter leaves for testing. One of the disks has low-porosity and the other has high porosity. Using 1 bar water pressure, the low-porosity disk allows 600 cc/min and the high-porosity allows 3000 cc/min of water to flow through it. As there are no fine coal dewatering data available on the ceramic disk filter, it was decided to conduct systematic dewatering studies to understand effect of different variables, such as particle size, percent solids, etc.

Figures 19 and 20 show the effect the cake formation time on filter cake moisture and solids loading for 100x200 mesh size fraction coal for the low-and high-porosity filter leaves, respectively, using a 30 percent solids slurry. Note, that as expected with increasing cake formation time both filter cake moisture and solids loading increases. However, the filter cake moisture and solids loading are much less with the low-porosity disk compared to high-porosity disk. With the low-porosity disk using 45 sec. cake formation time, a 15 percent filter cake moisture is obtained at a solids loading of less than 1 Kg/m<sup>2</sup>, whereas with the high-porosity disk using 30 sec. cake formation time, a 32 percent moisture filter cake with solids loading of 14.5 Kg/m<sup>2</sup> is obtained.

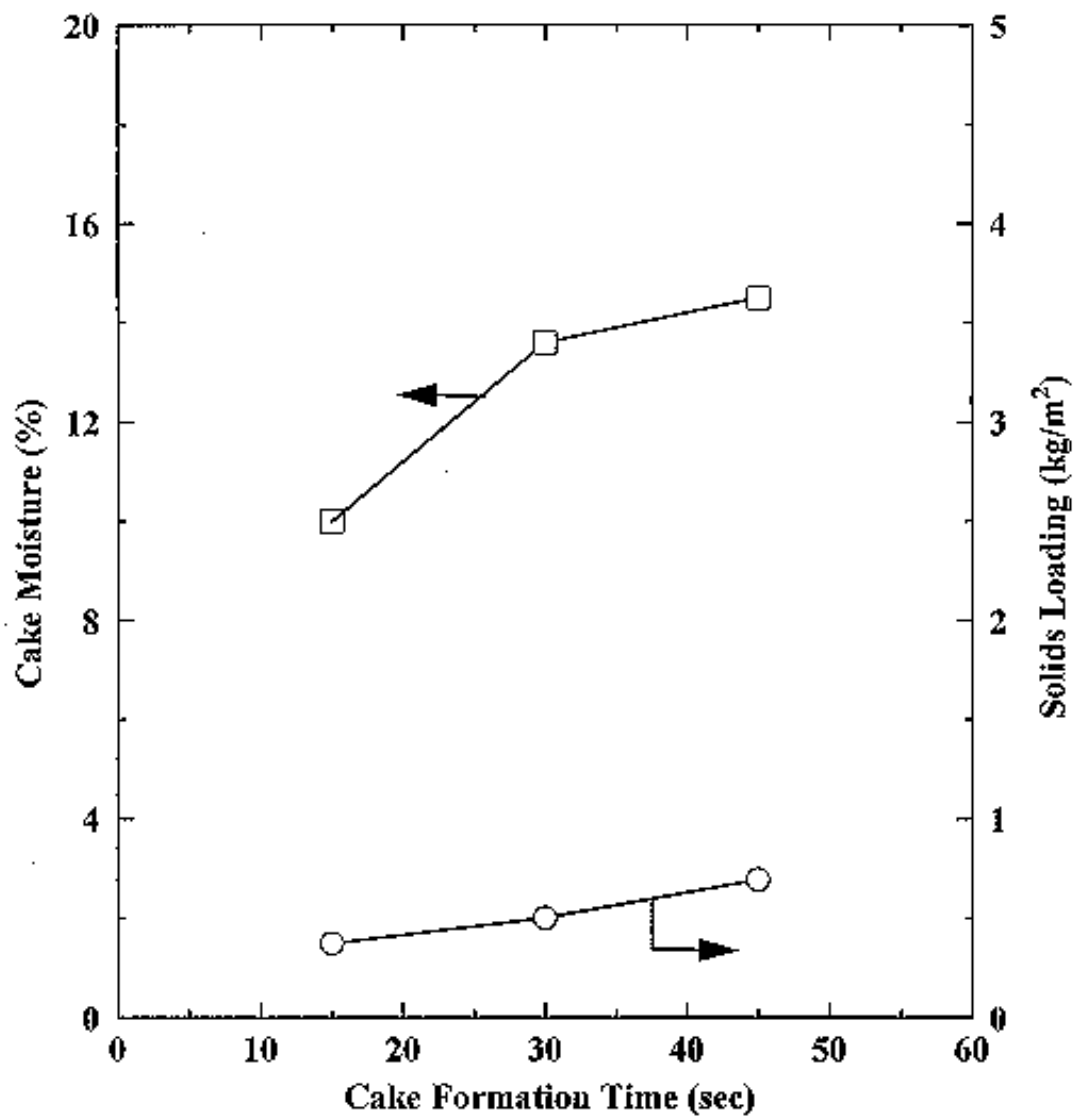


Figure 19. Effect of cake formation time on filter cake moisture and solids loading for the low porosity ceramic filter (particle size: 100x200 mesh, cake drying time: 30 sec.).

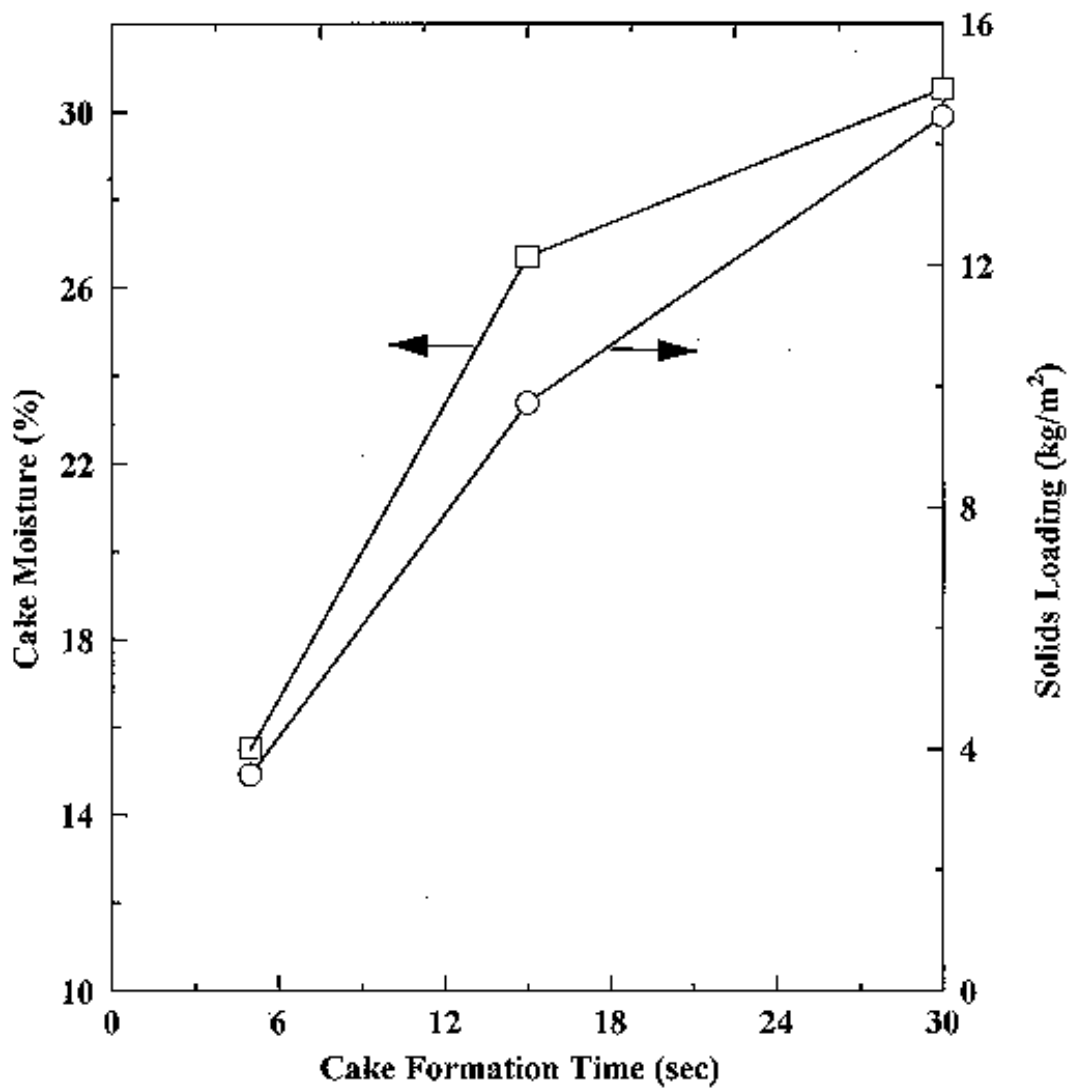


Figure 20. Effect of cake formation time on filter cake moisture and solids loading for the high porosity ceramic filter (particle size: 100x200 mesh, cake drying time: 30 sec.).

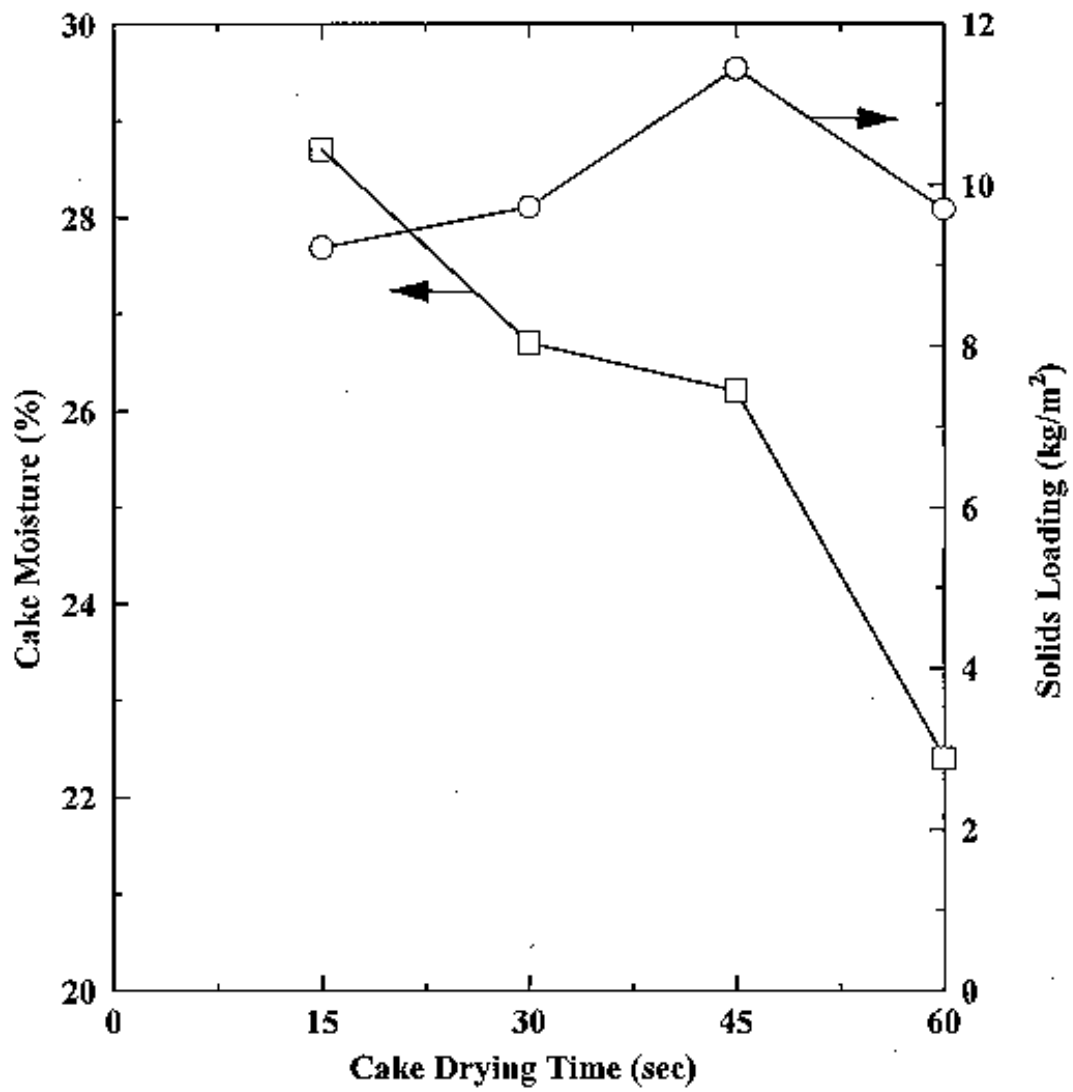


Figure 21. Effect of cake drying time on filter cake moisture and solids loading using the high porosity ceramic filter (particle size: 100x200 mesh, cake formation time: 15 sec.).

Figure 21 shows effect of cake drying time on filter cake moisture using the high-porosity filter and a 15 sec. cake formation time. It shows that using 60 sec. drying time, a filter cake with about 23 percent moisture at a solids loading about 10 Kg/m<sup>2</sup> is obtained.

Figures 22 and 23 shows dewatering data of 30% solids slurry of minus 200 mesh coal using the low-and high-porosity filters, respectively. For both filters, the filter cake moisture and solids loading increases with increasing cake formation time. For the low-porosity filter a 45 sec. cake formation time and 30 sec. cake drying time provided a filter cake with 28 percent moisture with 4.6 Kg/m<sup>2</sup> solids loading. Under the similar test conditions, the high porosity filter with 30 sec. cake formation time provided a 32 percent moisture filter cake at a solids loading of 16.2 Kg/m<sup>2</sup>.

With the low-porosity filter, increasing cake drying time to 60 sec. and with 30 sec. cake formation time a filter cake with 19 percent moisture with solids loading of 3.2 Kg/m<sup>2</sup> was obtained. For the high-porosity filter, a 60 sec. drying time provided a filter cake with 23% moisture with solids loading of 9 Kg/m<sup>2</sup>.

The above-cited data indicates that both ceramic filters works effectively with fine size coal.

#### Task 7. Evaluation

Flowsheet and material balances are being prepared for processing 25 TPH of clean coal using all the four (high pressure, vacuum, centrifuge and ceramic) dewatering techniques investigated in this program.

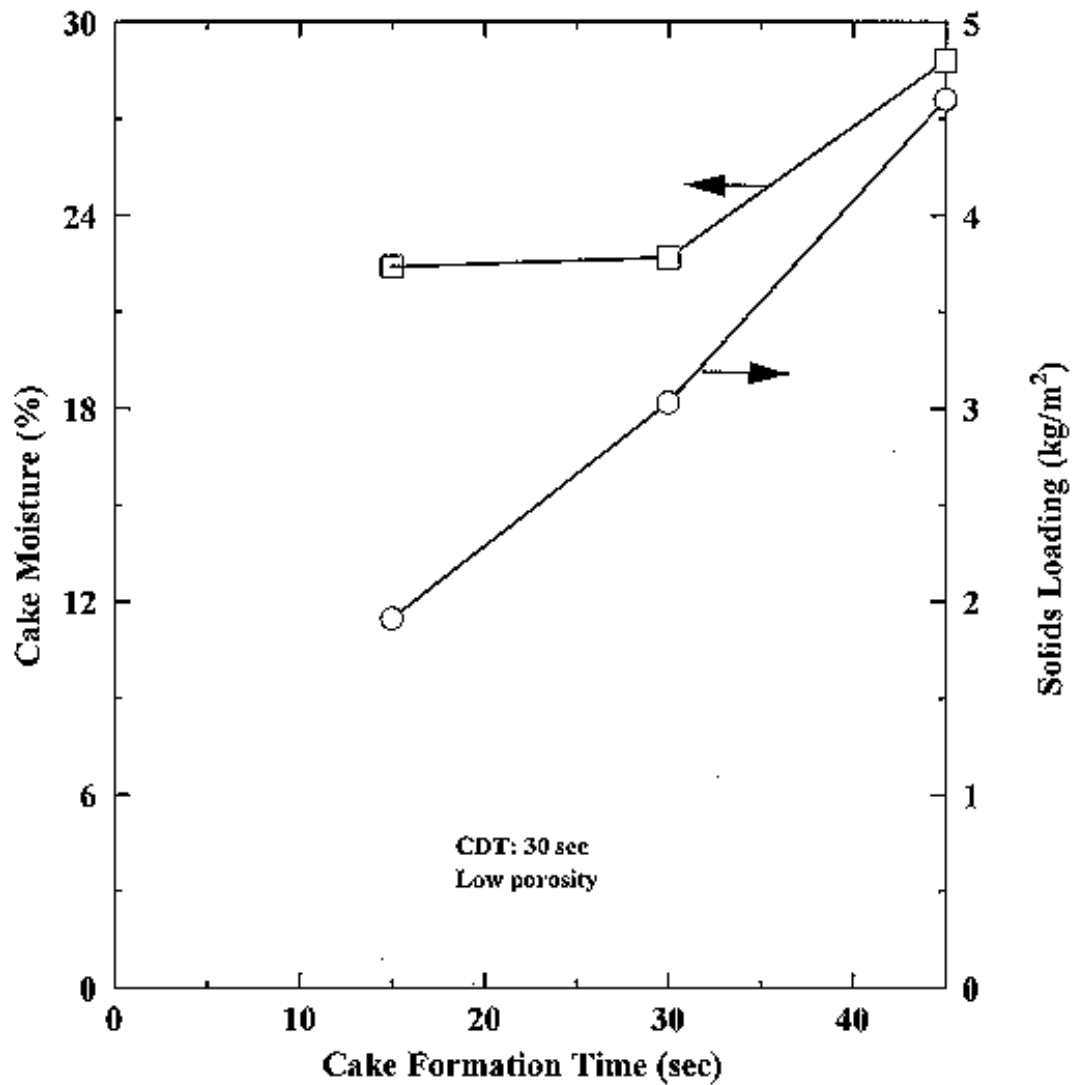


Figure 22. Effect of cake formation time on dewatering of minus 200 mesh coal slurry using the low porosity ceramic filter (cake drying time: 30 sec.).

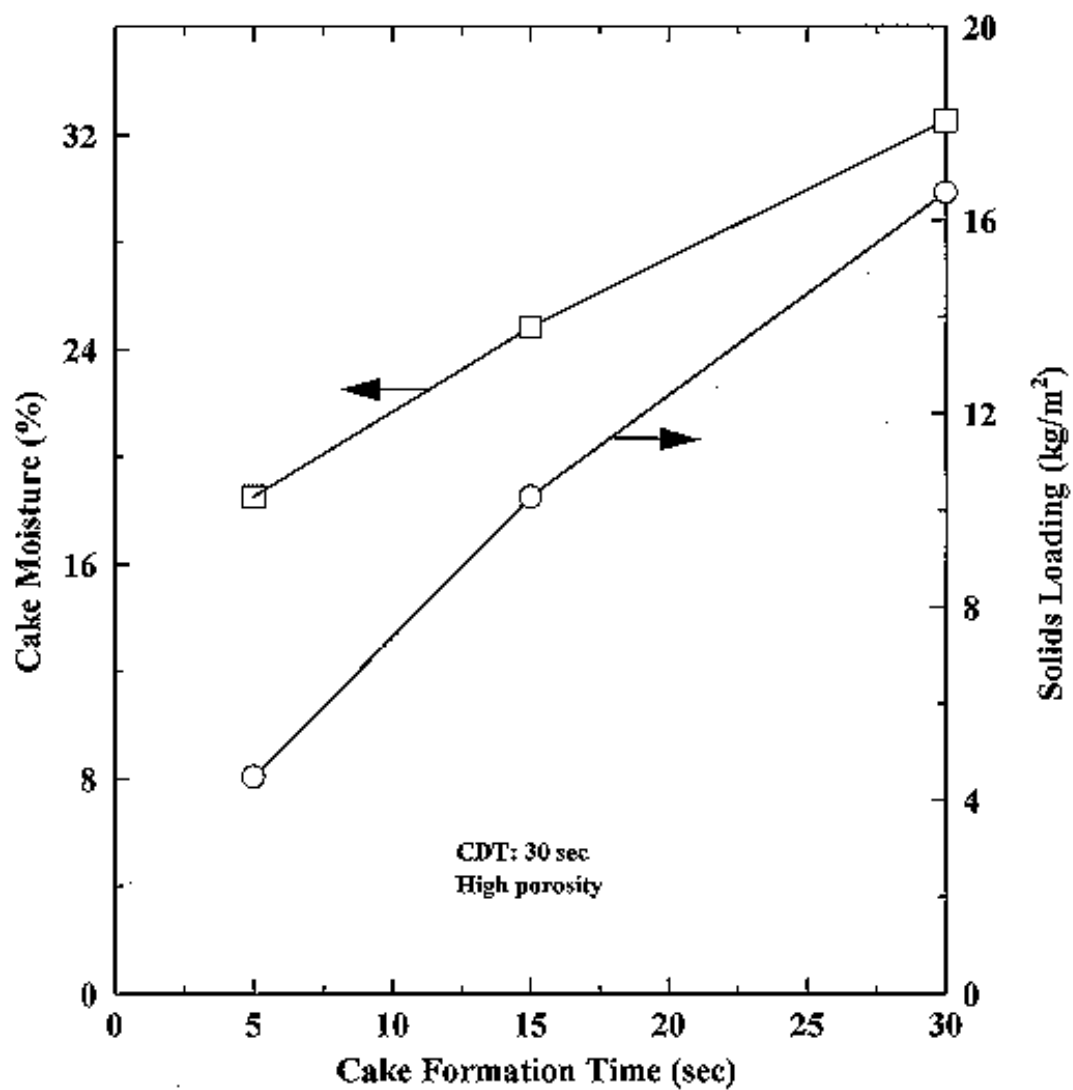


Figure 23. Effect of cake formation time on dewatering of minus 200 mesh coal slurry using high porosity ceramic filter (cake drying time: 30 sec.).

## **Task 8. Equipment Removal**

Most of the equipment and other accessories have been removed from the Mayflower preparation plant. The test site has been restored to its original shape.

### **CONCLUSIONS**

Based on the vacuum filtration results shown above, the following conclusions are made:

- Slurry stirring during cake formation had very significant effects on cake moisture. Without slurry stirring apparent cake moisture and modified cake moisture were about 32% and 35%, respectively. With slurry stirring they were about 24.5% and 26%, respectively.
- When coarse coal particles (10×25, 25×35, 35×50, and 50×100 mesh) were added to the unstirred slurry, apparent and modified filter cake moisture was about 1.5 and 4 absolute percentage points higher than the baseline moisture of 31%, respectively.
- When coarse coal particles were added to the stirred slurry, apparent cake moisture was about 1 absolute percentage point lower than the 25% baseline moisture. The modified cake moisture was, however, up to 3 absolute percentage points higher than the baseline data, depending on the dosage of each coarse size fraction.
- With the 30 percent solids slurry of 100×200 mesh coal, the low-porosity ceramic filter was not effective in capturing high percent of solids during

filtration. A high-porosity ceramic filter provided a filter cake with 32 percent moisture at 14.5 Kg/m<sup>2</sup> solids loading.

- For the minus 200 mesh coal slurry the low-porosity filter provided 28 percent moisture filter cake at 4.6 Kg/m<sup>2</sup> solids loading, whereas the high-porosity filter provided filter cake with 32 percent moisture at 16.2 Kg/m<sup>2</sup> solids loading.

### **ACTIVITIES FOR NEXT QUARTER**

More laboratory vacuum dewatering tests will be conducted in the next quarter. The efforts will be focused on studies of organic chemicals that can displace coal surface moisture and can also be readily recycled. An innovative approach to fine coal dewatering based on surfactant - polymer interaction will also be investigated.