QUARTERLY TECHNICAL PROGRESS

REPORT 4

JULY-SEPTEMBER 1995

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

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

DOE Contract No. DE-AC22-94PC94155

November 6, 1995

LEGAL NOTICE

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

Froth flotation technique is an effective and efficient process for recovering of ultra-fine (minus 74 μm) clean coal. Economical dewatering of an ultra-fine clean coal product to a 20 percent 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 percent or lower moisture using either conventional or advanced dewatering techniques.

The cost-sharing contract effort is for 36 months beginning September 30, 1994. This report discusses technical progress made during the quarter from July 1-September 29, 1995.

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) and Andritz Ruthner 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

During this quarter, vacuum dewatering studies of the low sulfur clean coal slurry was conducted using various types of reagents. Using some of the CAER synthesized reagent, a filter cake moisture of 30 percent moisture was obtained. Addition of $FeCl_3$ did not provide lowering of moisture, however, it did provide improved filtration kinetics.

The WesTech Engineering Inc. supplied 3-ft. diameter by 2-ft. wide rotary vacuum drum unit was installed at the PMCC Mayflower preparation plant. After initial shakedown testing, baseline dewatering tests were conducted on both the high sulfur (non-compliance) and low sulfur (compliance) clean coal slurry. For both the coals, the filter cake moisture ranged from 23 percent to 32 percent depending on the operating conditions of the equipment. The solids throughput through the machine at one rpm speed of the drum was 10 lbs dry solids/sq. ft./hr. for both coals. The optimum cake thickness at one rpm drum speed was found to be about 5 mm.

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, froth flotation process, which is commercially used, produces a product containing 80 percent moisture. 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 percent) moisture level using conventional filtration equipment has not been possible. This project offers a novel surface-modification approach to modify coal surface so it could dewater 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 and hyperbaric filtration technique. This proof-of-concept testing is being performed at the Powell Mountain Coal Company Mayflower Plant located in St. Charles, Virginia.

The project involves a teaming arrangement between the University of Kentucky for Applied Energy Research (CAER), the Powell Mountain Coal Company (PMCC), and the Andritz Ruthner Inc. (ARI). The project will extend for a period of 36 months.

APPROACH

A team of scientists and engineers from the Center for Applied Energy Research, Powell Mountain Coal Company, and Andritz Ruthner Inc. has been formed to accomplish the objectives of the program. Each team member brings fine particle dewatering knowledge and experience to the project. The UKCAER, who is the prime contractor, will manage the project and will conduct the major part of the study. The PMCC will provide assistance and facility in conducting the pilot scale tests, and ARI will conduct 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 for the first two years of the program 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 will be given to identify optimum process and operating conditions using vacuum and pressure techniques to dewater the clean coal slurry to about 20 percent level moisture. It is believed that the proposed research can achieve low moisture product on a pilot scale to the same extent which has already been achieved in laboratory studies.

The basic components of the process has been tested in laboratory. The purpose of the proposed work here 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 percent or lower moisture in the fine clean coal product and to provide technical and economic evaluation of the integrated concept in sufficient detail for a coal company to decide to install the dewatering process in their plant.

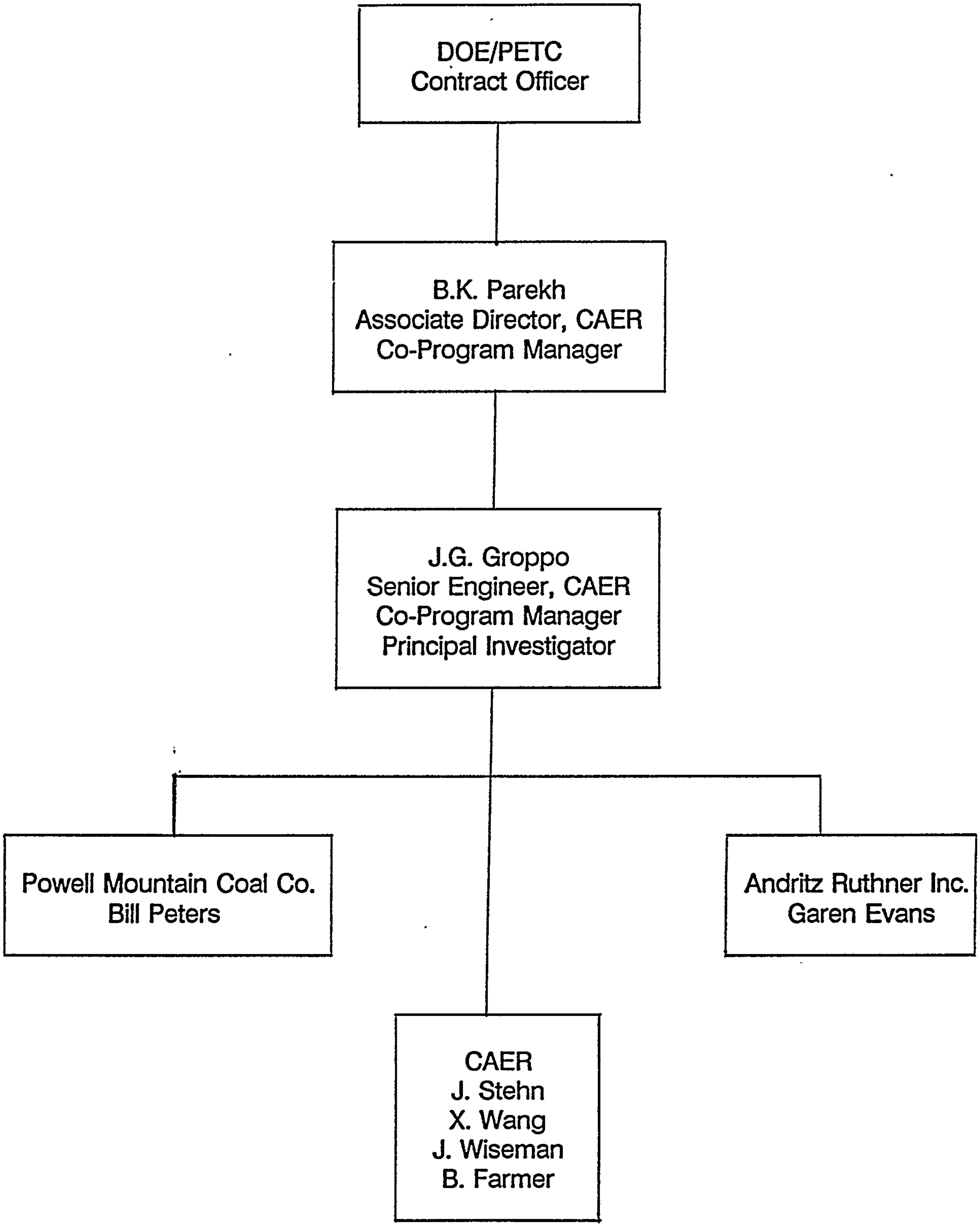


Figure 1. Project management organization chart

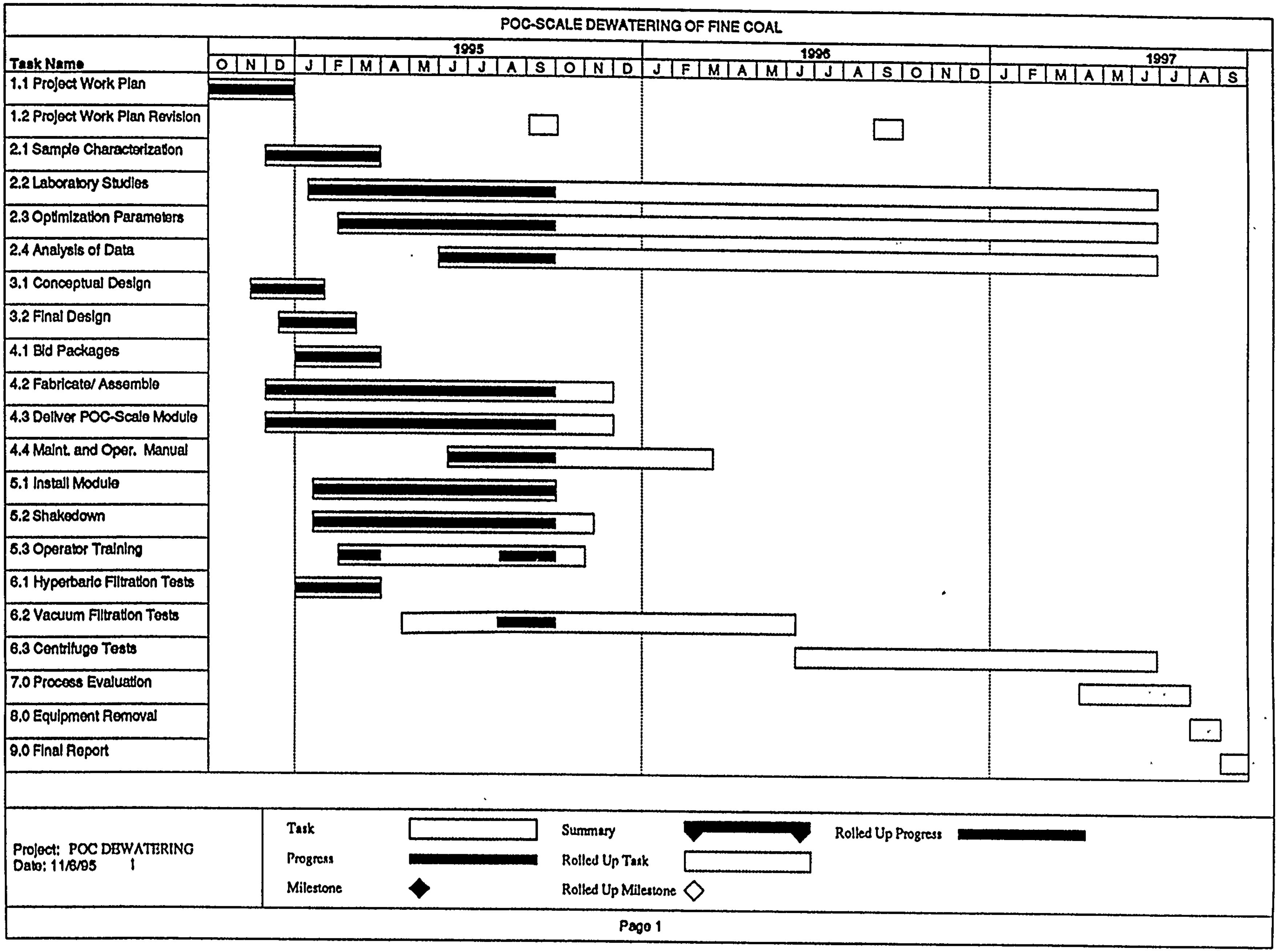


Figure 2. Up-to-date project schedule

ACCOMPLISHMENTS DURING THE QUARTER

The project has been divided into tasks and subtasks as listed in Table 1. Each task and subtask has specific objective which can be inferred from its title. During this quarter (July 1 to September 29, 1995) work was done on Tasks 2, 4, 5 and 6.

Task 2. Sample Analysis and Laboratory Testing:

Samples of the low- and high-sulfur clean coal froth slurry were collected from the columns operating at the Powell Mountain Coal Company. Figures 3 and 4 show the particle size distribution of the high sulfur and low sulfur clean coal slurries. Note, that D_{50} of high sulfur and low sulfur clean coal slurries is 25 μm and 32 μm, respectively.

Effect of Addition of Reagents:

The effect of addition of a new synthesized reagent XW-2 on the dewatering of low sulfur (compliance) coal is shown in Figure 5. Note, that with 225 g/t of the reagent provided 35 percent moisture within 40 sec. filtration time compared to 40 percent filter cake moisture obtained without addition of reagent at 80 sec. filtration time. Figure 6 shows the filtration kinetics of the low sulfur clean coal slurry as a function of the flocculant dosage. As expected, the filtration kinetics of the slurry increases significantly with the addition of flocculant.

Effect of ferric chloride dosage on dewatering characteristics of the low sulfur coal is shown in Figure 7. Note, that addition of $FeCl_3$ did not lower the filter cake

Table 1. Outline of Work Breakdown Structure

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

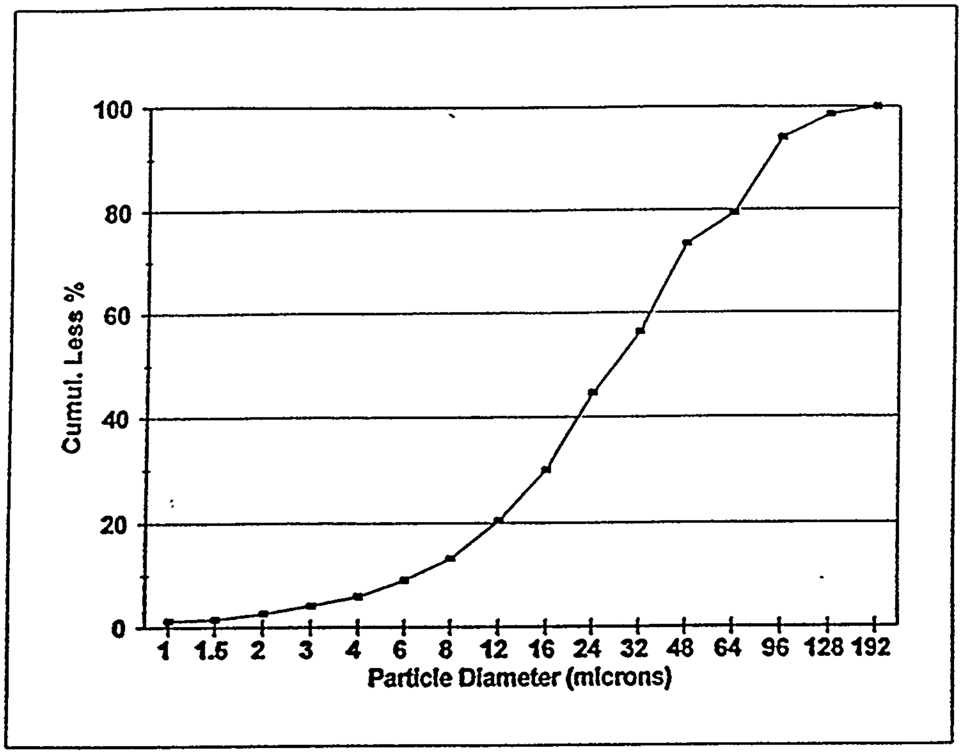


Figure 3. Particle size distribution of high sulfur (non-compliance) clean coal slurry

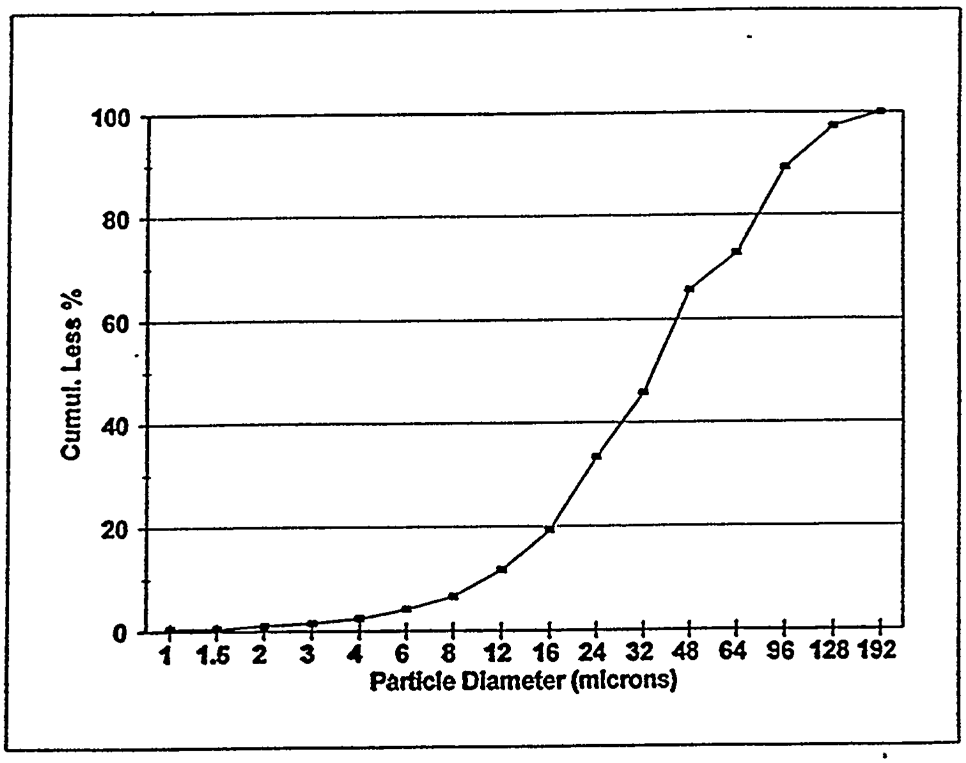


Figure 4. Particle size distribution of low sulfur (compliance) clean coal slurry

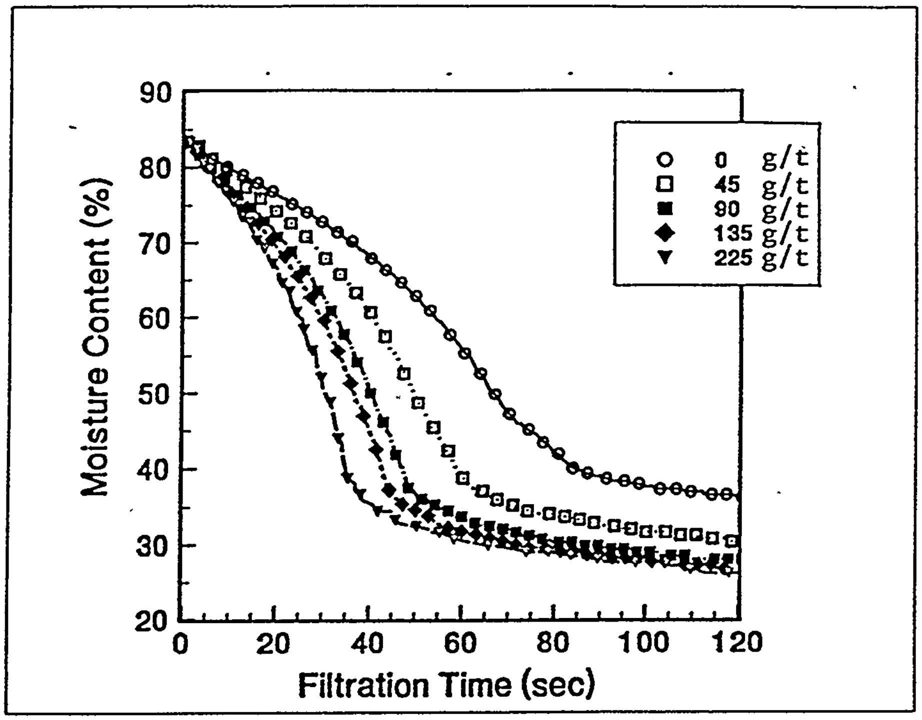


Figure 5. Effect of reagent dosages (XW-2) on the dewatering of the low-sulfur coal using vacuum filtration (cake thickness = 15 mm)

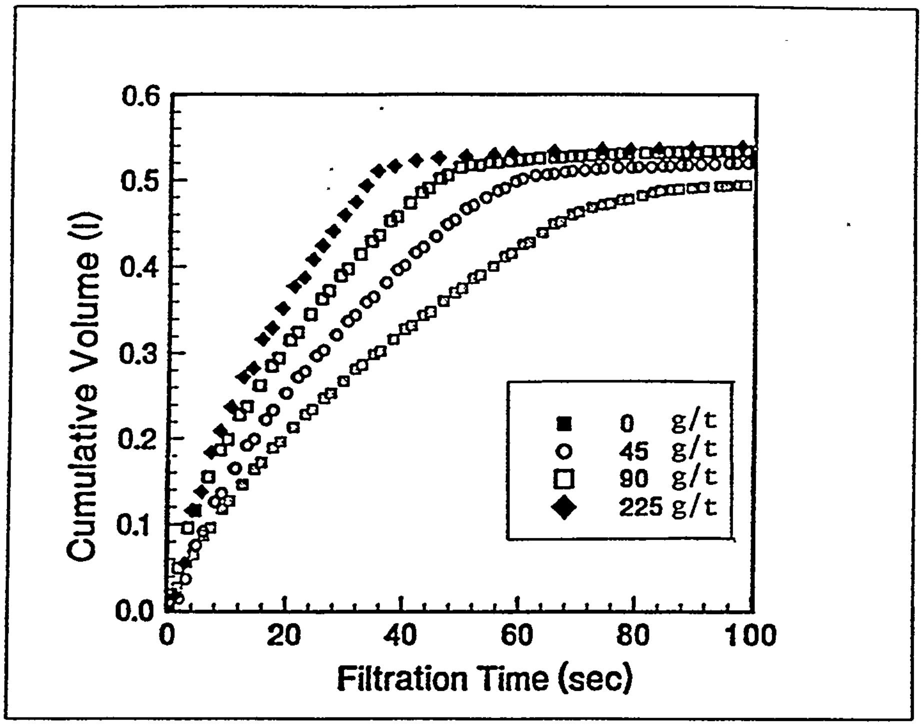


Figure 6. Vacuum filtration kinetics of low sulfur coal in presence of various dosage of flocculant dosages

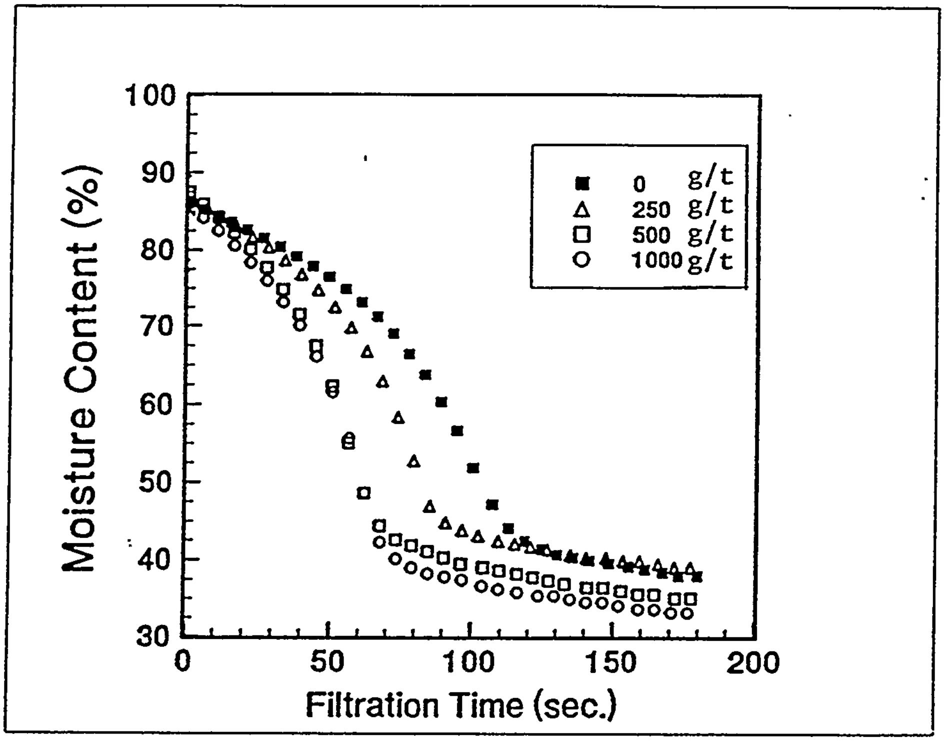


Figure 7. Effect of $FeCl_3$ dosage in dewatering kinetics for the PMCC low-sulfur coal using vacuum filtration (cake thickness = 15 mm)

moisture, however, it improves the filtration kinetics as shown in Figure 8. It shows that addition of $FeCl_3$ reduces the filter cake resistance indicating flocs formation. Figure 9 shows the filtration kinetics, i.e., filtrate volume accumulation as a function of filtration time. The filtration kinetics trend is very similar to that observed in Figure 8, i.e., addition of $FeCl_3$ increased filtration rate.

Effect of another synthesized reagent SIOT dosages on the filter cake moisture is shown in Figure 10. Note, that this reagent is very effective in lowering the filter cake moisture. Addition of less than 100 g/t of SIOT provided filter cake with moisture less than 20 percent. Figure 11 shows the filtration kinetics comparison using 500 g/t of $FeCl_2$ and 200 g/t and 300 g/t of SIOT for the low sulfur clean coal slurry. Note, that SIOT provided much less filter medium resistance than $FeCl_3$, indicating its superior performance.

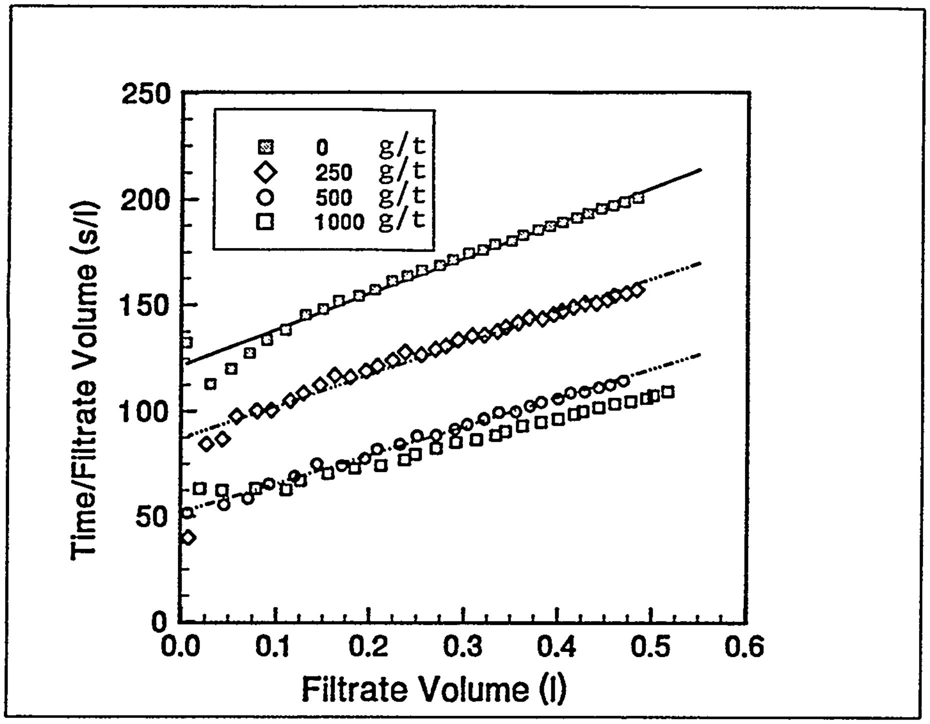


Figure 8. Darcy Kozney plot diagram showing filtration kinetics of low sulfur coal in presence of various dosages of $FeCl_3$

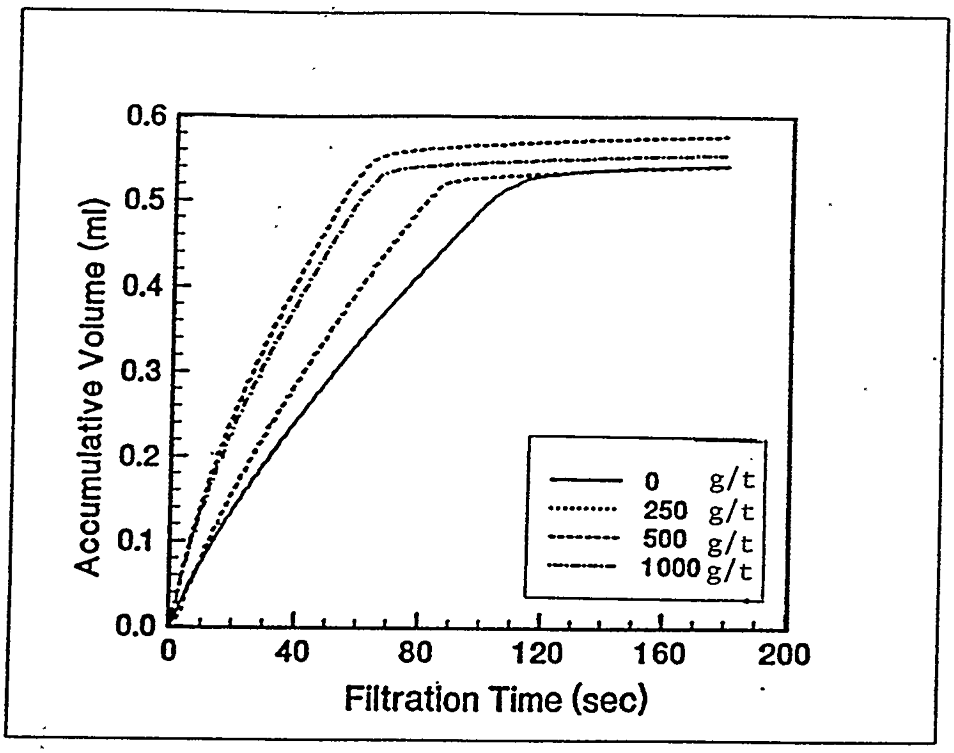


Figure 9. Filtration kinetics of low sulfur clean coal slurry in presence of various dosages of $FeCl_3$

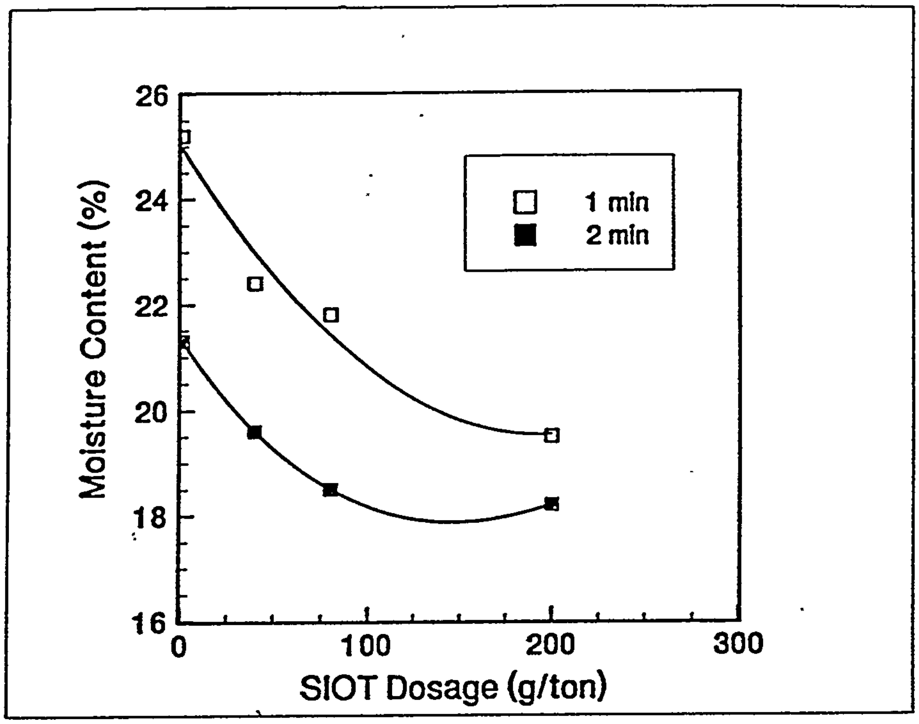


Figure 10. Effect of SIOT reagent dosage on moisture content of filter cake for two different time periods using vacuum filtration (low sulfur coal, cake thickness = 15 mm)

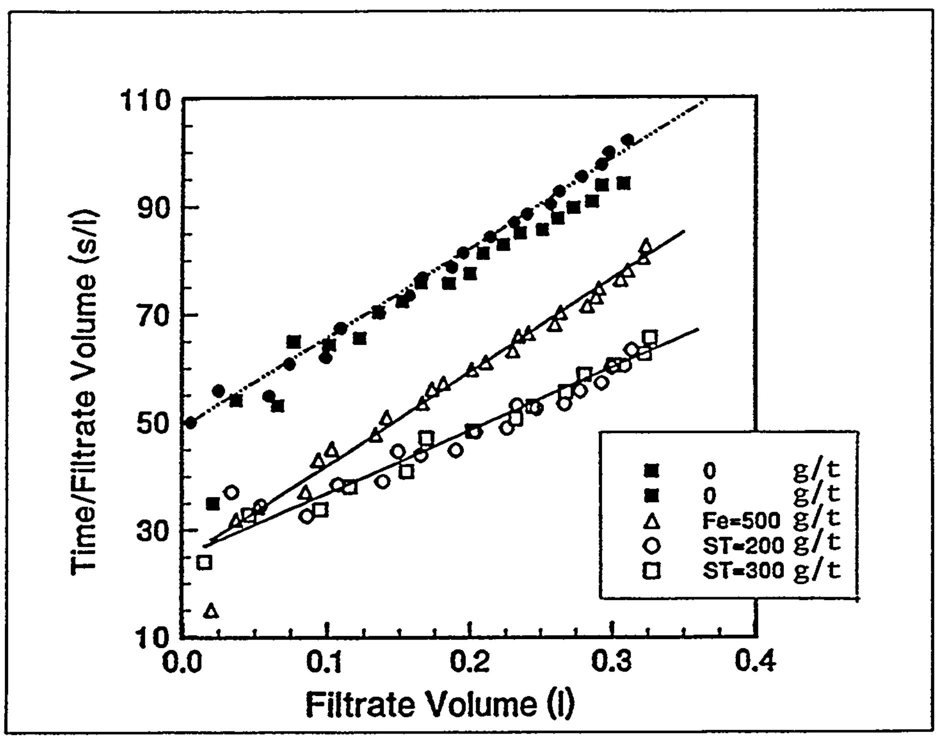


Figure 11. Comparison of addition of 500 g/t $FeCl_3$, and 200 g/t and 300 g/t SIOT on the filtration kinetics of PMCC coal using vacuum filtration (cake thickness = 15 mm)

Effect of addition of new flocculant #s 3670 and 3480 are shown in Figures 12, 13, 14, and 15, respectively. Note, that flococulant #3670 (Figures 12 and 13) shows an improvement in filtration kinetics of the low sulfur clean coal slurry; however, addition of flocculant #3480 (Figures 14 and 15) shows a remarkable improvement in filtration kinetics.

A comparison of SIOT, 3670, and 3780 reagents for the low sulfur clean coal slurry is shown in Figure 16. It shows that of all the three reagents, 3480 performed better. SIOT and 3670 were very similar in performance.

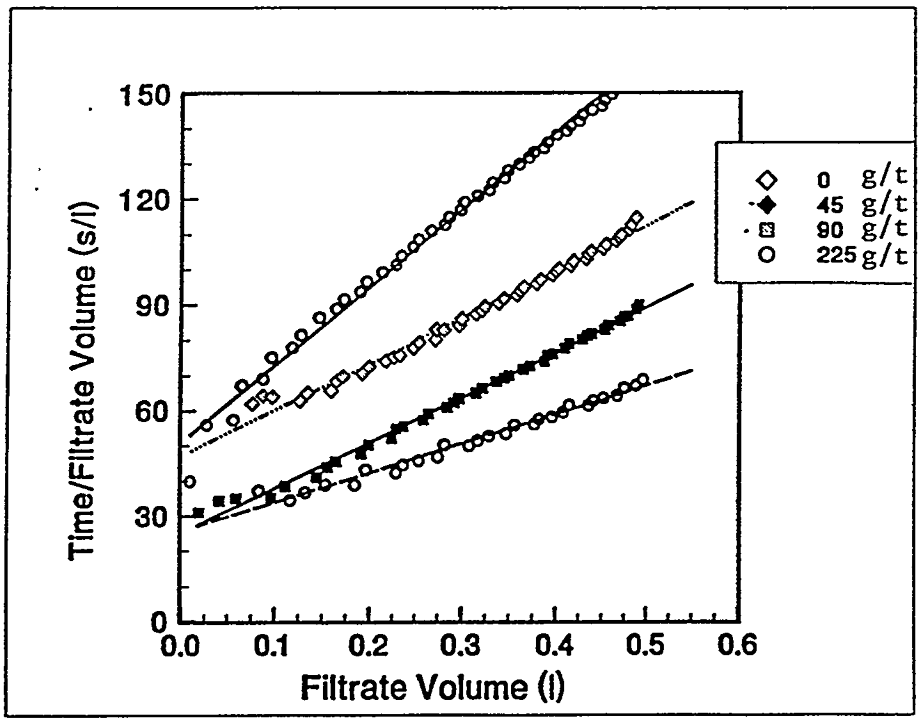


Figure 12. Effect of dosage of flocculant #3670 on filtration kinetics of PMCC coal using vacuum filtration

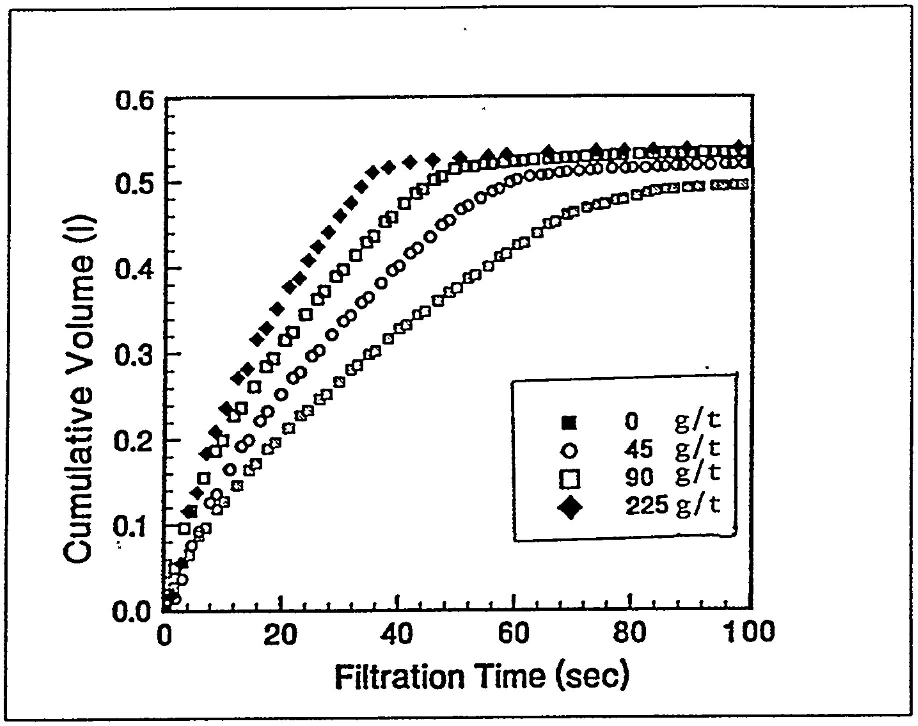


Figure 13. Filtration kinetics of low sulfur coal using various dosages of flocculant #3670

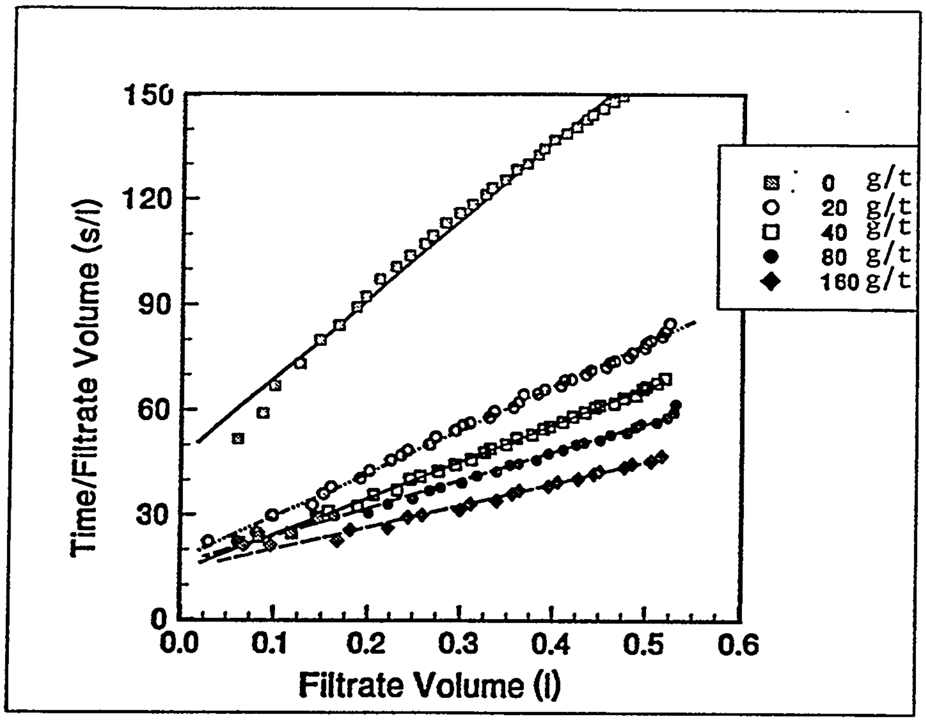


Figure 14. Effect of flocculant #3480 dosage on dewatering of low sulfur clean coal slurry using vacuum filtration

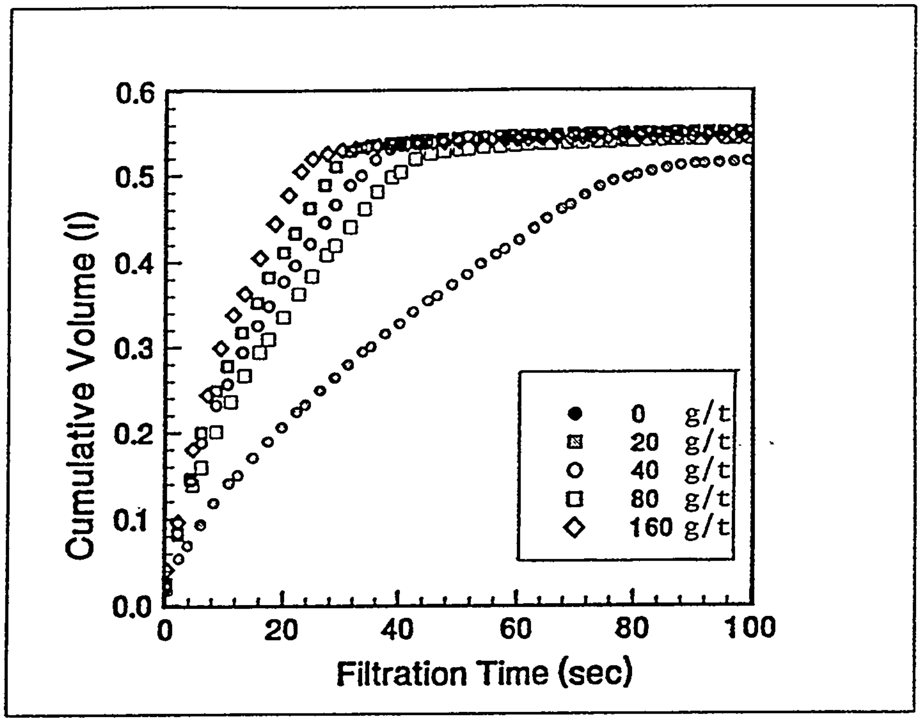


Figure 15. Effect of flocculant #3480 dosage on the filtration kinetics of low sulfur clean coal slurry

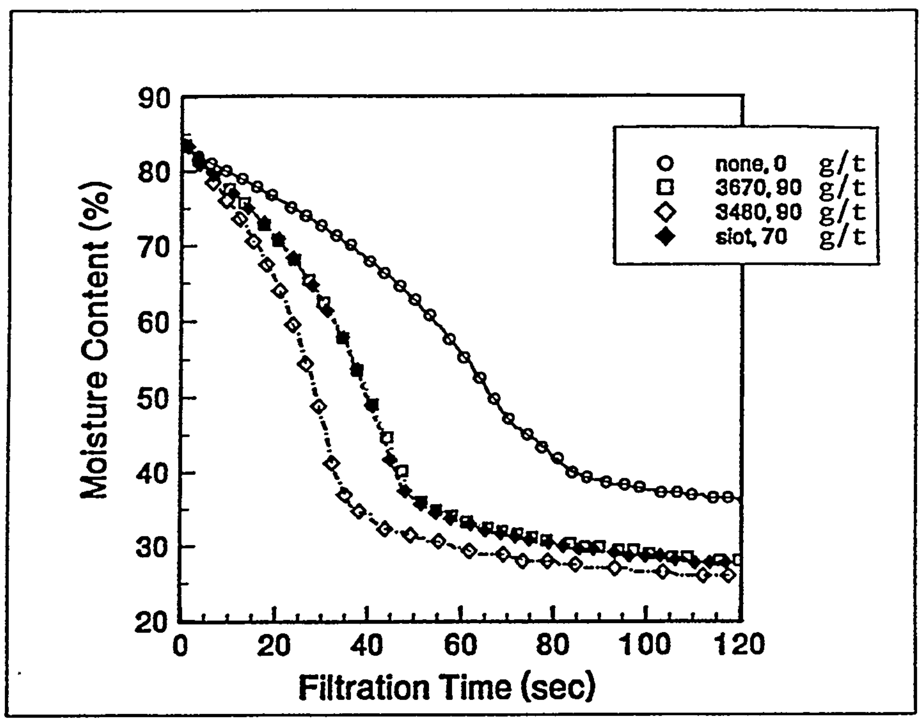


Figure 16. Comparison of vacuum dewatering characteristics of low sulfur clean coal slurry in presence of 709 g/t SIOT, 90 g/t #3670 and #3480 (#3670 and #3480 are reagents from the ISP

Task 4. Procurement and Fabrication

The WesTech Engineering Inc. of Salt Lake City, Utah, who is also cost sharing the project, refurbished the 3-ft. diameter vacuum drum filter to meet the safety standard of the PMCC plant. PMCC personnel installed the power and water lines for the unit.

Task 5. Installation and Shakedown

The POC-Scale vacuum drum filter was delivered and-installed as shown in the layout Figure 17. The unit was installed below the slurry tank so that the unit can be gravity fed.

Initial shakedown tests on the unit were conducted to check the vacuum, speed of the drum filter, tub level, and cake discharge mechanism. It was found during the shakedown that the unit has to be in horizontal mode to operate smoothly. Some minor problems encountered in smooth rotation of drum were fixed using special grease supplied by WesTech.

Three staff members from the UKCAER were trained to operate the unit. This involved immediate shutdown procedure, and regular maintenance of the machine.

Task 6. System Operation

The POC-Scale vacuum drum filter setup is shown in Figure 18. The filter unit consists of a 3-ft (9.91 m) diameter by 2-ft (0.61 m) wide rotary vacuum drum. The skid mounted unit was rented from WesTech Engineering in Salt Lake City, Utah and installed at the Mayflower Preparation plant during this quarter.

The feed tank and piping used for the previous phase of testing with the Andritz hyperbaric filter are being used in this phase as well. A stream of column flotation concentrate is diverted into a stirred 500 gallon feed tank and fed by gravity into the

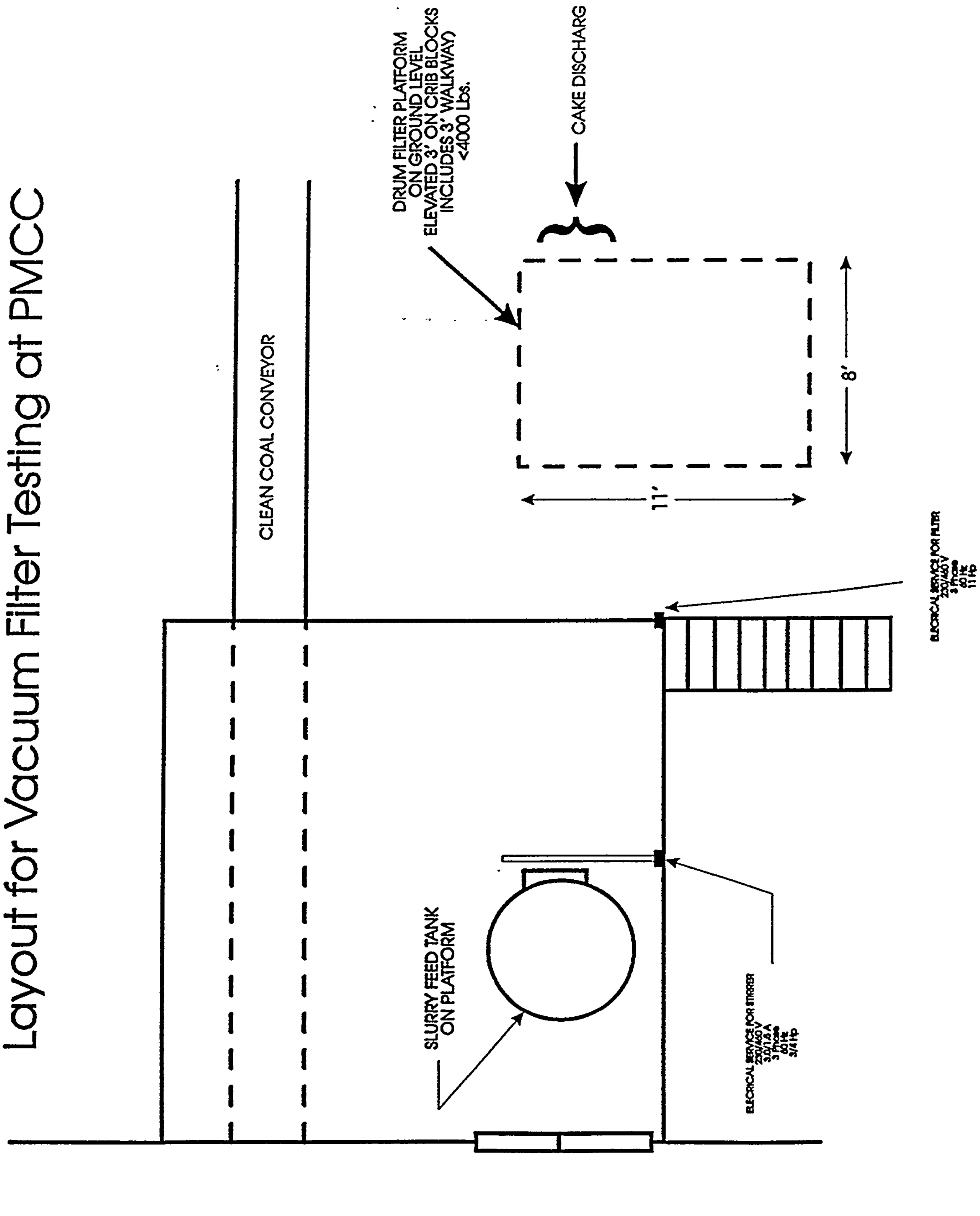
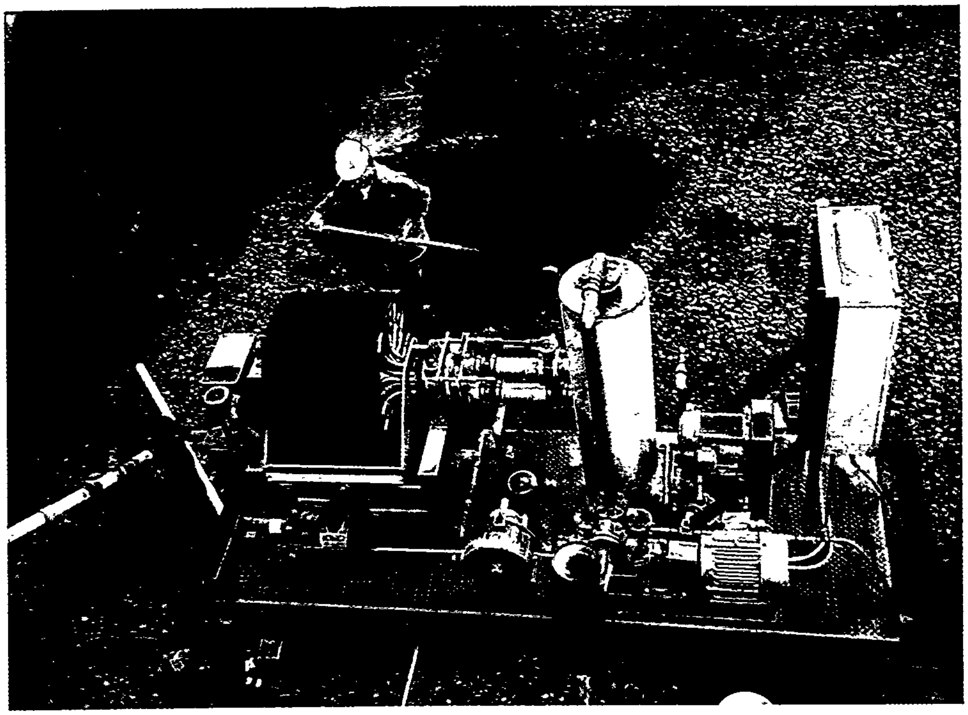


Figure 17. POC-Scale vacuum drum layout



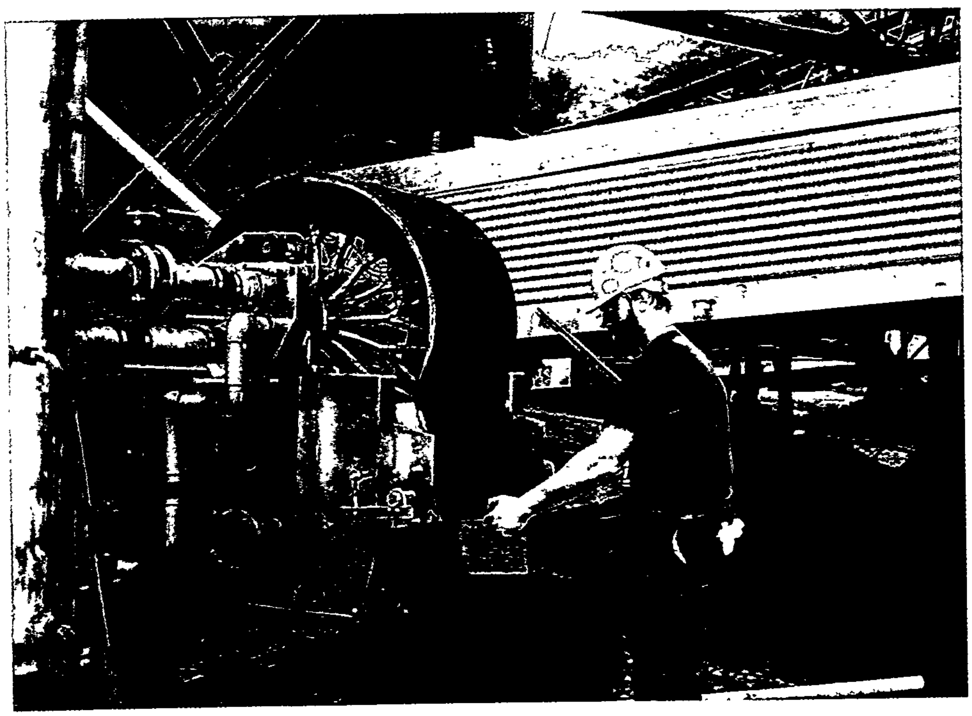


Figure 18. POC-Scale vacuum drum filter setup

vacuum filter. Feed rate control is maintained by a gate valve and tub overflow which is recycled back to the plant. The filter feed rate is approximately 5 gallons of slurry per minute; filter cake is discharged continuously with a snap-blow mechanism and scraper blade arrangement.

Baseline Testing: Baseline testing was conducted with the WesTech vacuum drum filter at the Mayflower Preparation Plant using the column flotation froth product as the filter feed. Filter operating parameters were evaluated using both high sulfur and compliance coals. The primary operating variables that were evaluated in baseline testing were drum speed and submergence level. The drum speed was varied from 0.2 to 1.5 rpm. The submergence level refers to the slurry level maintained in the filter tub which is controlled by an overflow weir. Three different submergence levels were evaluated; full tub, -1 inch (2.5 cm) and -2 inches (5.0 cm). The slurry feed rate was increased or decreased to maintain the desired submergence level.

The effect of drum speed on cake moisture for both high sulfur and compliance coals is shown in Figures 19 and 20, respectively. With both substrates, increasing drum speed increased cake moisture. For the compliance coal, cake moisture increased from 22 to 31 percent moisture over the drum speed range tested. There were minor differences in the results obtained with the three submergence levels tested. Similar results were obtained with the high sulfur coal feed although the cake moistures were slightly higher (24 to 32% moisture).

The effect of drum speed on solids throughput for compliance and high sulfur coals is shown in Figures 21 and 22, respectively. For the compliance slurry, the throughput increased from approximately 5 to 12 lb/sq. ft/hr. As the drum speed was

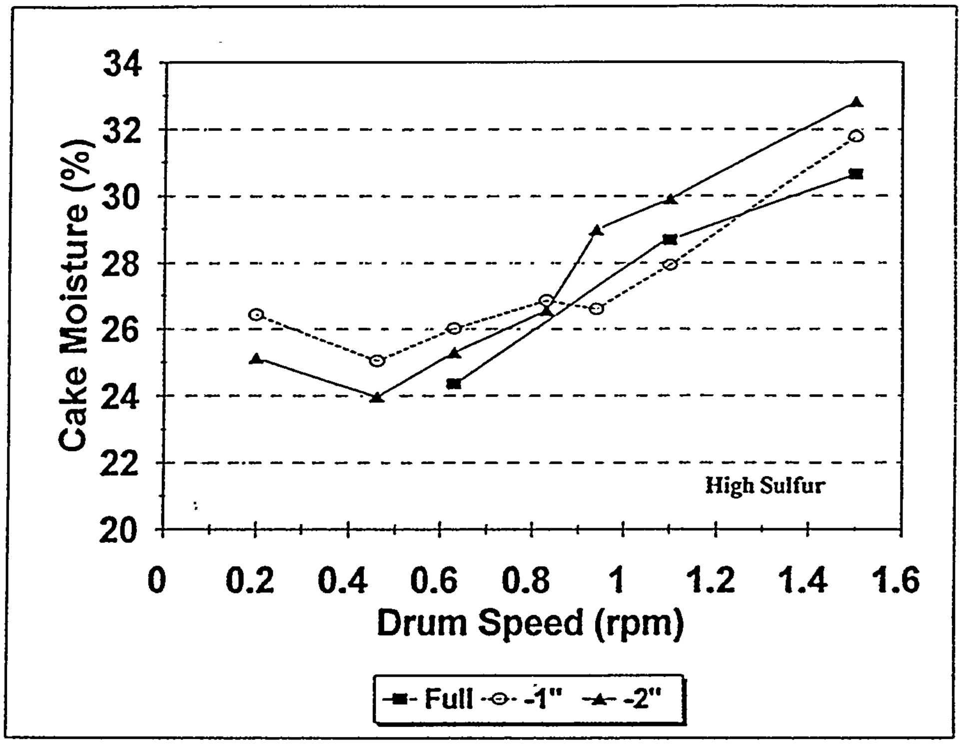


Figure 19. Effect of vacuum drum filter speed on filter cake moisture for three different tub levels for the high sulfur coal

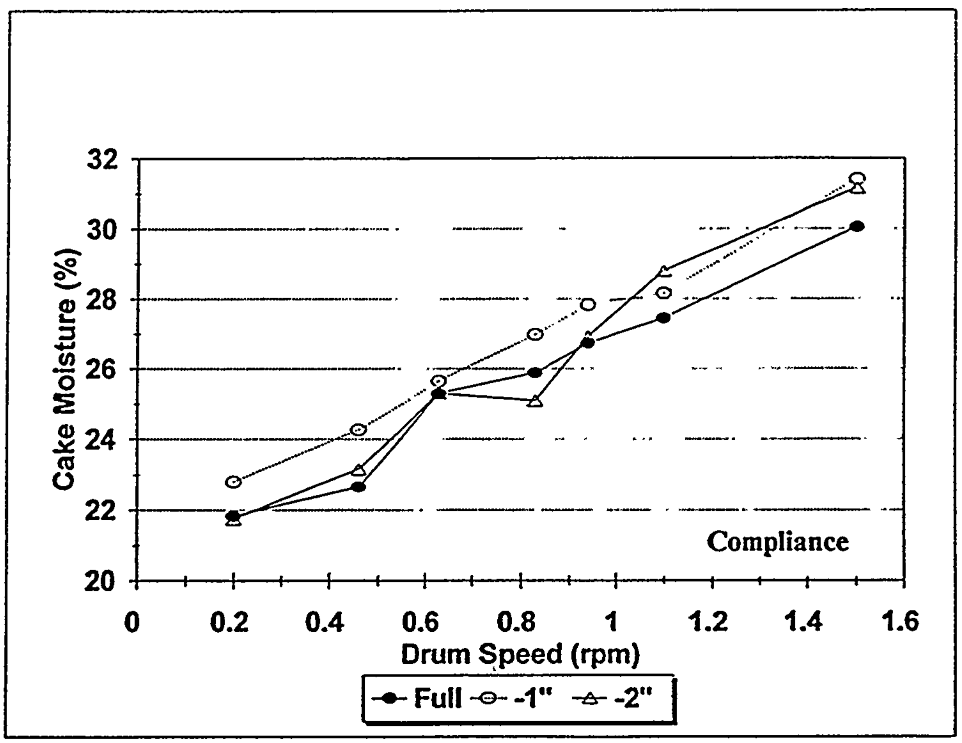


Figure 20. Effect of vacuum drum filter speed on filter cake moisture for three different tub levels for the low sulfur coal

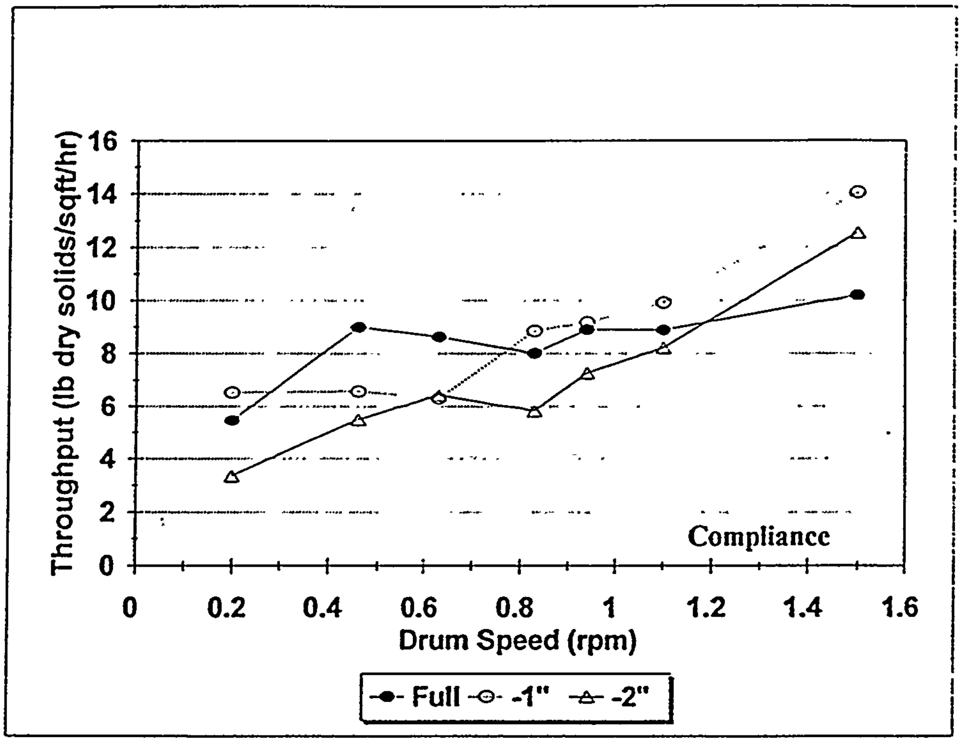


Figure 21. Effect of drum filter speed on solids throughput for three different tub levels for the compliance coal slurry

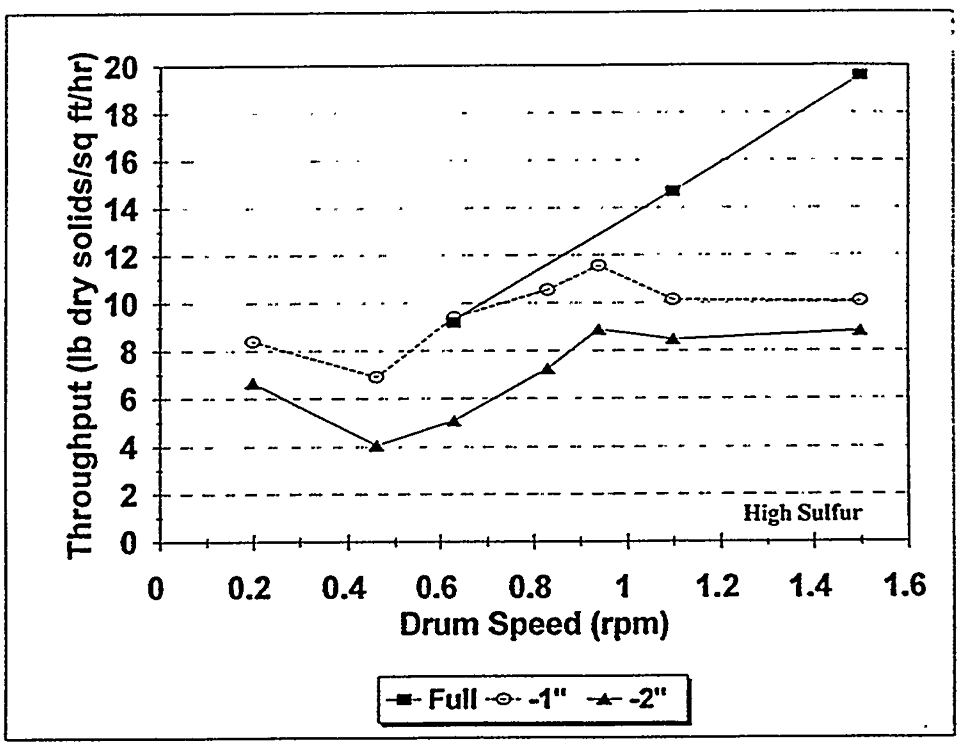


Figure 22. Effect of drum filter speed on solids throughput for three different tub levels for the high sulfur clean coal slurry

increased from 0.2 to 1.5 rpm. As with cake moisture, there were minor differences in the throughput achieved with the three submergence levels tested. For the high sulfur slurry, the throughput was similar to that obtained with the compliance coal with one notable difference. At the full submergence level, the throughput increased to nearly 20 lb./sq. ft./hr.

A comparison of the cake moistures obtained with high sulfur and compliance coals at -1" submergence is shown in Figure 23. Note that there is essentially no difference in cake moisture at drum speeds higher than 0.5 rpm. The solids throughput resulting from these tests are summarized in Figure 24 which shows that the high sulfur coal provided slightly higher throughput at most drum speeds. This is attributed to the thicker cake produced with the high sulfur coal slurry as shown in Figure 25. There were marginal differences in the slurry feed rates for the two coal slurries evaluated, however, the high sulfur coal slurry contained a higher solids content than the compliance coal (18 vs. 13% solids) which produced the thicker cake and resulted in higher throughput.

ACTIVITIES FOR NEXT QUARTER

Analysis of the test data obtained with the WesTech vacuum drum filter unit will be continued. Laboratory dewatering tests using vacuum drum filter will be continued.

We are in the process of contacting Bird Centrifuge Company to conduct filtration tests using their laboratory centrifuge.

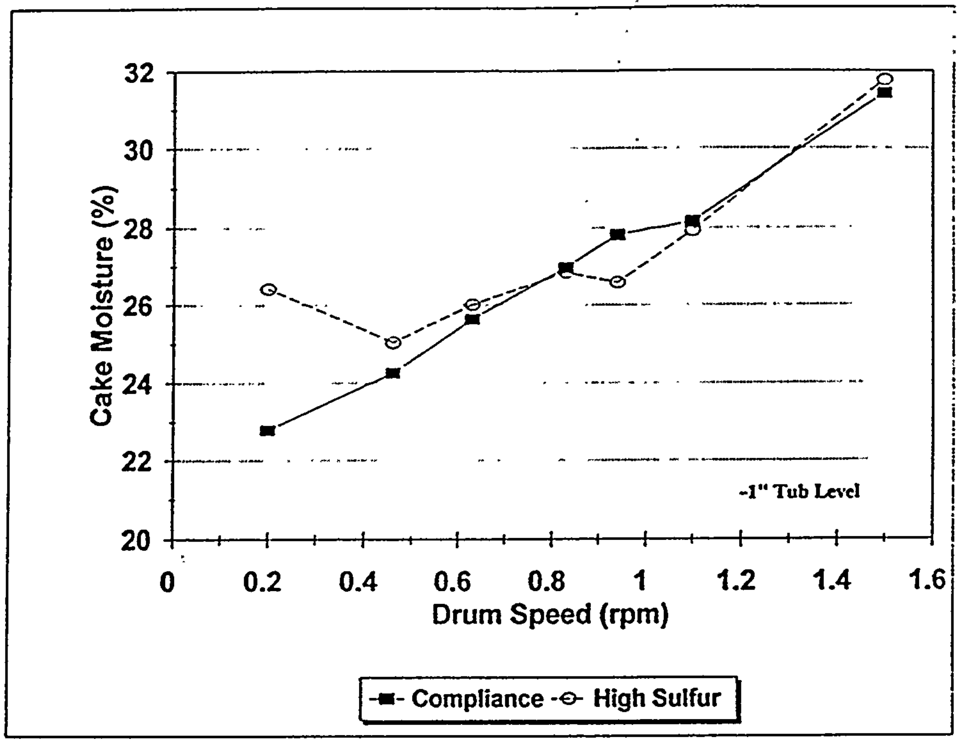


Figure 23. Comparison of filter cake moisture for the compliance and high sulfur clean coal slurry as a function of drum filter speed using 1 in. tub level

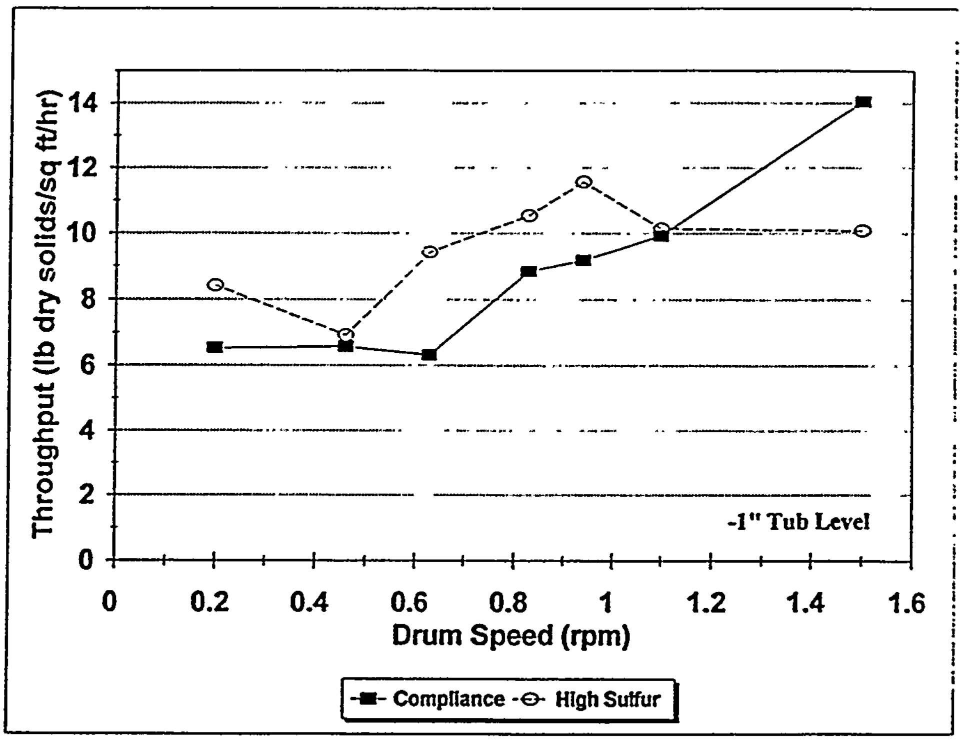


Figure 24. Comparison of solids throughput for the compliance and high sulfur clean coal slurry as function of drum filter speed