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

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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 January 1 - March 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) 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

Laboratory centrifugal dewatering tests were conducted to study the effects of anionic and cationic flocculants on filtration of PMCC compliance (low sulfur) and non-compliance (high sulfur) ultrafine coal slurry. The results obtained with compliance coal indicated that use of 30 g/t anionic flocculant reduced filter cake moisture from 32.3 to 29.0 percent and increased solids recovery by two absolute percentage points. Use of cationic flocculant had no effects on solids recovery but lowered cake moisture to 27 percent at a dosage of 15 g/t. With the non-compliance coal slurry addition of 15 g/t anionic flocculant lowered cake moisture from 30 to 28.5 percent with marginal effects on solids recovery; addition of cationic flocculant reduced cake moisture by one absolute percentage point. Both flocculants showed marginal effects on solids recovery.

Laboratory vacuum filter leaf filtration studies showed that use of flocculants considerably increased filtration kinetics. For example, addition of 15 g/t anionic flocculant to the compliance coal slurry increased filtration kinetics by 10 times and addition of 15 g/t anionic flocculant to non-compliance coal slurry increased filtration kinetics by more than three times. More importantly, it has been found that cake moisture can be lowered significantly in the presence of flocculants, provided that other operating parameter, e.g., cake formation time, was modified to avoid high cake thickness commonly associated with the use of flocculants. Using this approach cake moisture was lowered by 12 to 15 absolute percentage points at the same cake thickness with the compliance coal. With the non-compliance coal cake moisture was reduced from 34 to 26 percent in a 12 mm thick cake and from 39.6 to 28.3 percent in a 22 mm thick cake.

Small scale continuous vacuum drum filter studies have confirmed that use of anionic flocculant considerably increased filtration kinetics and lowered cake moisture. With 20 g/t anionic flocculant added to the non-compliance coal slurry filter solids output increased from 9 to 45 $lb/ft^2/hr$ and cake moisture was reduced from 27 to 21 percent at the drum rotation speed 0.8 rpm.

Pilot scale studies conducted with the 18-inch diameter decanter screen bowl centrifuge showed that addition of surfactant was not effective for lowering product moisture of high sulfur clean coal slurry, however, for the low sulfur clean coal slurry addition of 0.5 Kg/t of a cationic surfactant lowered the product moisture from 36.7 to 34.5 percent. The solids capture in the equipment showed increase for the high sulfur clean coal slurry, whereas no improvement was seen with the low sulfur clean coal slurry.

Effect of metal ions (Cu^{+2}, Al^{+3}) additions to the high sulfur clean coal slurry was detrimental to the final product moisture, whereas for the low sulfur clean coal slurry addition of 25 mg/Kg of metal ion salt lowered the surface moisture from 36.7 to 33.5

percent. Solids capture showed an increase only with addition of $CuCl_2$, where it increased from 40.5 to 44 percent at a dosage of 50 mg/Kg.

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.

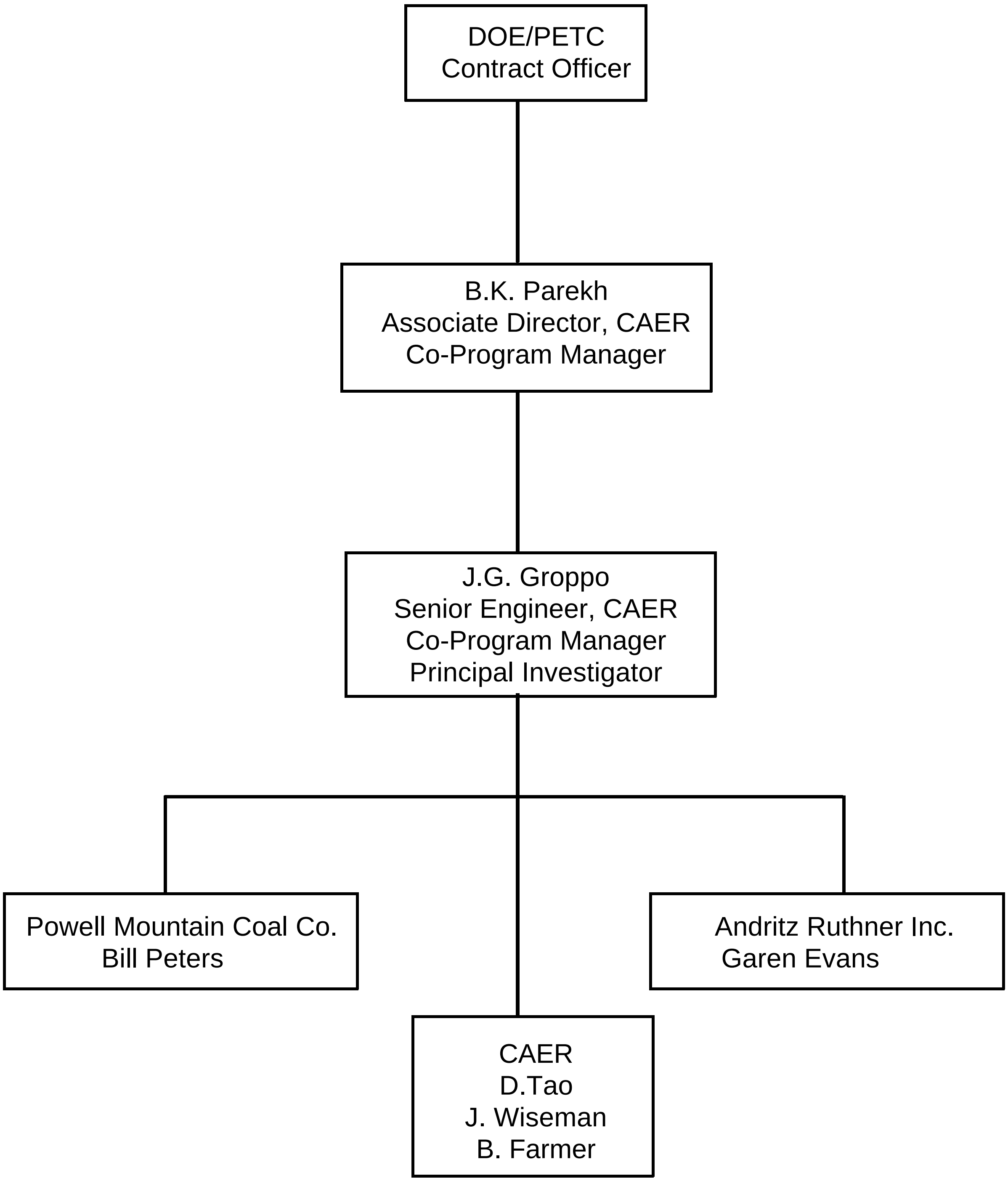

Figure 1. Project management organization chart

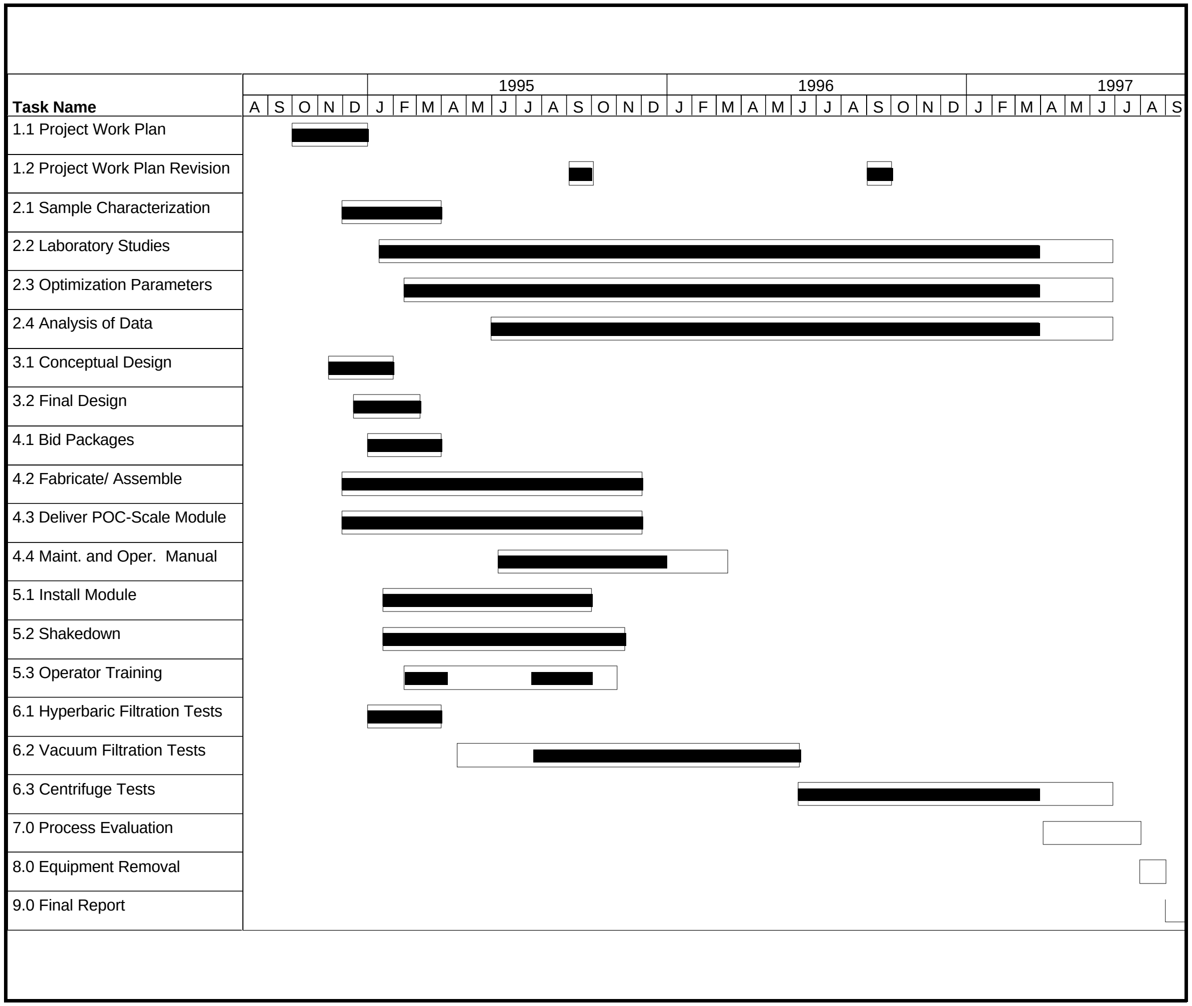

Figure 2. Project schedule

RESULTS AND DISCUSSION

The project has been divided into tasks and subtasks listed in Table 1. Each task and subtask has specific objective which can be inferred from its title. During this quarter (January 1 to March 31, 1996) work was done on Tasks 2, 4, and 6.

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 particle size distribution and other properties of both coal slurries have been presented in the previous quarterly progress reports.

Centrifugal Dewatering

During the past quarter laboratory centrifugal dewatering tests were conducted with both PMCC compliance (low sulfur) and non-compliance (high sulfur) coals. The objective of this work was to develop new approaches to enhance dewatering of fine coal slurry using centrifugal filtration and provide guidelines for pilot-scale testing of these processes. This objective was accomplished by investigating the effects of various reagents on centrifugal dewatering performance with both coal slurry samples under predetermined operating conditions. The reagents used in this work are believed to enhance coal dewatering by modifying the coal surface to provide favorable dewatering characteristics such as:

high hydrophobicity

- low surface tension
- large aggregate size
- high permeability of filter cake, etc.

Table I. 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

Reagents tested using the centrifuge include anionic (sodium 2-ethylhexyl sulfate), non-ionic (octyl phenoxy polyethoxy ethanol), and cationic (1-hexadecyl pyridium chloride) surfactants; anionic Procol 156 and cationic Procol 371 flocculants; trivalent and divalent metal ions (Al^{3+} and Cu^{2+}). In the last quarter major efforts were devoted to investigation of the effects of different flocculants on centrifugal dewatering of PMCC compliance and non-compliance coal slurry samples of column flotation froth products. Flocculants were added to coal slurry prior to filtration to form large coal flocs and reduce cake resistance. A two minute conditioning time was used in all tests.

Effects of Flocculants with Compliance Coal

Figure 3 shows the effects of anionic Procol 156 flocculant on centrifugal dewatering of PMCC compliance coal. The results were obtained under the following operating conditions: 1000 ml slurry, 5000 rpm rotation speed, and 30 second filtration time. Figure 3 indicates that with the compliance coal cake moisture decreased with increasing dosage of anionic flocculant. In the absence of the flocculant, the cake moisture was 32.3 percent. Use of 30 g/t anionic flocculant lowered cake moisture to 29.0 percent. Use of anionic flocculant also slightly increased solids recovery.

Figure 4 shows cake moisture and solids recovery as a function of cationic Procol 371[*] flocculant with PMCC compliance coal. Use of cationic flocculant initially decreased cake moisture from 31 to 27 percent with increasing flocculant dosages to 15 g/t. However, further increase in cationic flocculant dosage increased cake moisture. Solids recovery, on the other hand, was essentially independent of the dosage of cationic flocculant.

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[*]supplied by Allied Colloids, Inc.

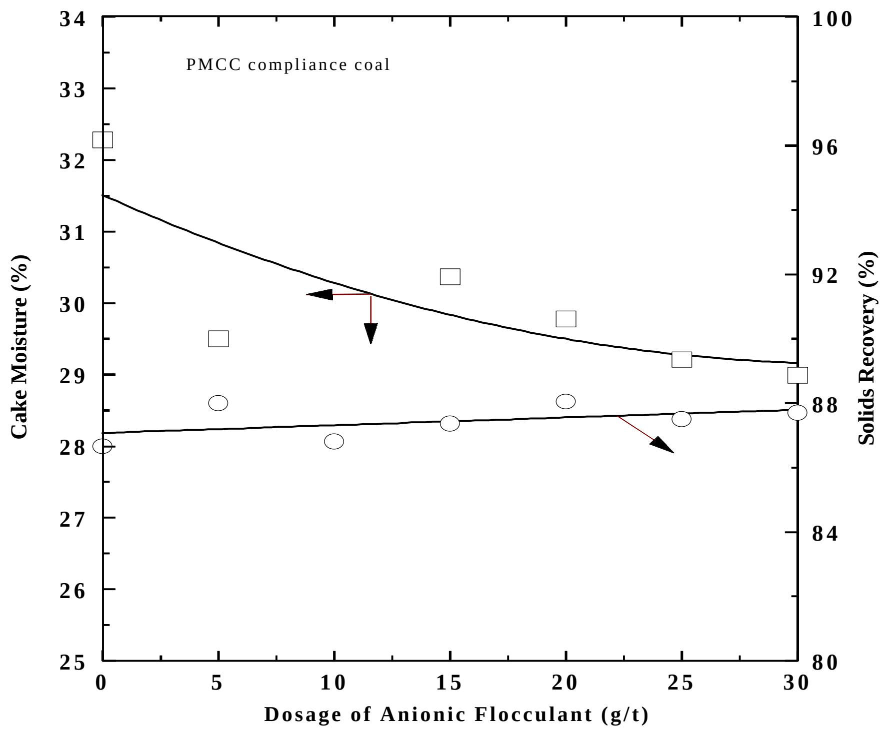

Figure 3. Effect of anionic flocculant dosage on filter cake moisture and solids recovery for the low sulfur clean coal slurry using laboratory centrifuge

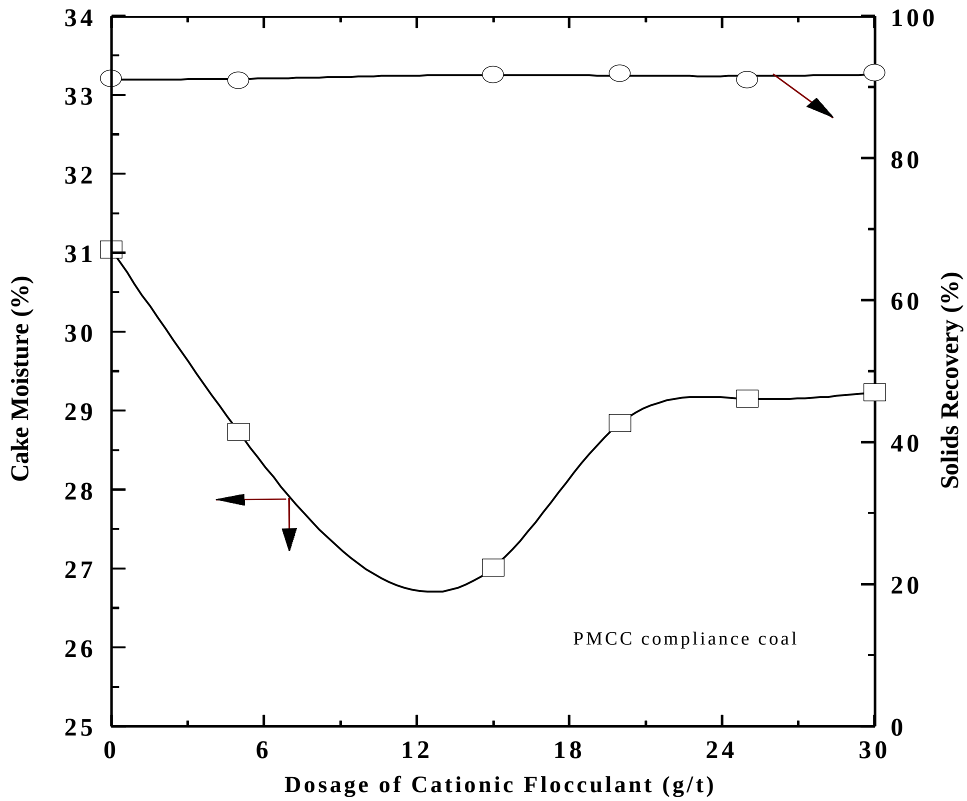

Figure 4. Effect of cationic flocculant dosage on filter cake moisture and solids recovery for the low sulfur clean coal slurry using laboratory centrifuge

Effects of Flocculants with Non-Compliance Coal

Figure 5 shows the effects of anionic Procol 156[**] flocculant on centrifugal dewatering of PMCC non-compliance coal. Use of anionic flocculant showed moderate cake moisture lowering effects with this coal. For example, the moisture was reduced from about 30 percent to 28.5 percent using 15 g/t anionic flocculant. In comparison with the compliance coal, anionic flocculant has less significant effects on cake moisture with the non-compliance coal. As to effects of anionic flocculant on solids recovery with the non-compliance coal, Figure 5 shows that use of this flocculant may have slight adverse influence on solids recovery.

Figure 6 shows effects of cationic flocculant Procol 371 on cake moisture and solids recovery. Use of the cationic flocculant with non-compliance coal reduced cake moisture from 29.9 to 29.0 percent at a dosage of 15 g/t. This reduction is not very significant compared with the results obtained with the compliance coal that showed maximum moisture reduction of about 4 absolute percentage points (shown in Figure 4). Solids recovery was slightly lowered in the presence of cationic flocculant, which is similar to results obtained with the anionic flocculant shown in Figure 5.

Previous vacuum filtration dewatering tests with flocculants showed that use of flocculants substantially increased cake thickness (throughput) by up to 5 times while cake moisture was maintained approximately the same or slightly lower. However, this type of substantial improvement was not observed in the centrifugal dewatering process. It is believed that the flocs formed by addition of flocculants were not strong enough to withstand the applied centrifugal force. As a result, flocs formed in the conditioning

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[**]supplied by Allied Colloids, Inc.

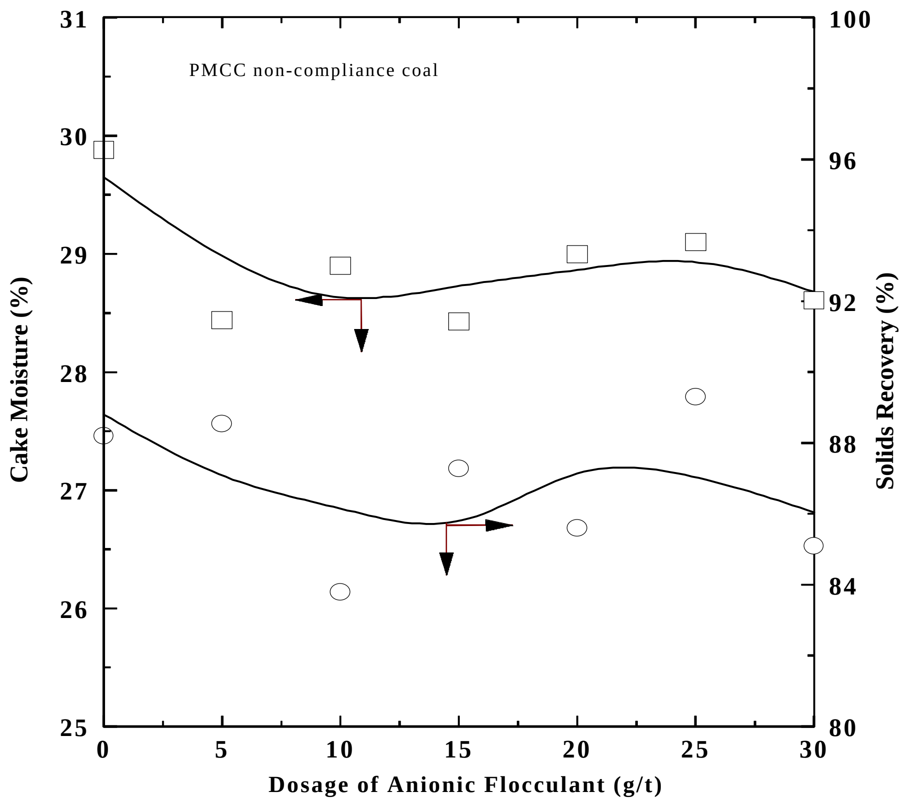

Figure 5. Effect of anionic flocculant dosage on filter cake moisture and solids recovery for the high sulfur clean coal slurry using laboratory centrifuge

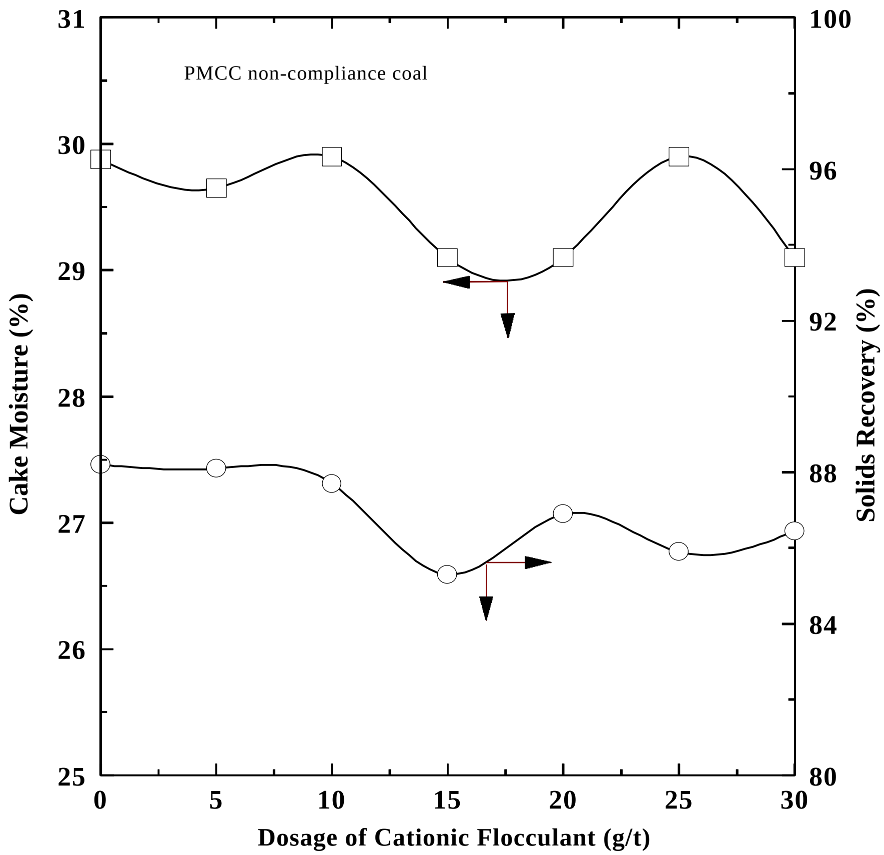

Figure 6. Effect of cationic flocculant dosage on filter cake moisture and solids recovery using laboratory centrifuge for the high sulfur clean coal slurry

stage broke up in the centrifuge. This minimized potential benefits of using flocculants in the fine coal centrifugal dewatering process.

New Approaches to Improving Vacuum Filtration Dewatering Using Flocculants

During the last quarter considerable efforts were made to develop new vacuum filtration dewatering approaches to improving dewatering performance by use of flocculants. Previous vacuum dewatering tests with flocculants have shown that use of flocculants greatly increased cake thickness. However, cake moisture was not lowered significantly, and in some cases moisture increased with the addition of flocculants. A number of tests were designed and conducted during the last quarter to study possible methods for increasing vacuum dewatering throughput and lowering cake moisture simultaneously with the use of flocculants. Tests were conducted using the laboratory filter leaf filtration set up described in the sixth quarterly report.

It was postulated that lack of pronounced cake moisture lowering effects with the use of flocculant was associated with the substantially increased cake thickness. This was because in previous vacuum filtration tests cake formation time was kept constant with and without flocculants. To study effects of cake thickness on cake moisture, a series of filter leaf vacuum filtration tests were carried out in which cake formation time was varied while cake drying time was maintained constant at 40 seconds. Figure 7 shows cake thickness and cake moisture obtained with PMCC compliance coal as a function of cake formation time in the presence and absence of 15 g/t anionic flocculant. Due to drastic difference in cake formation time required to produce approximately the same cake thickness with and without the flocculant, two different cake formation time scale were used in the figure. Cake thickness increased with cake formation time in the

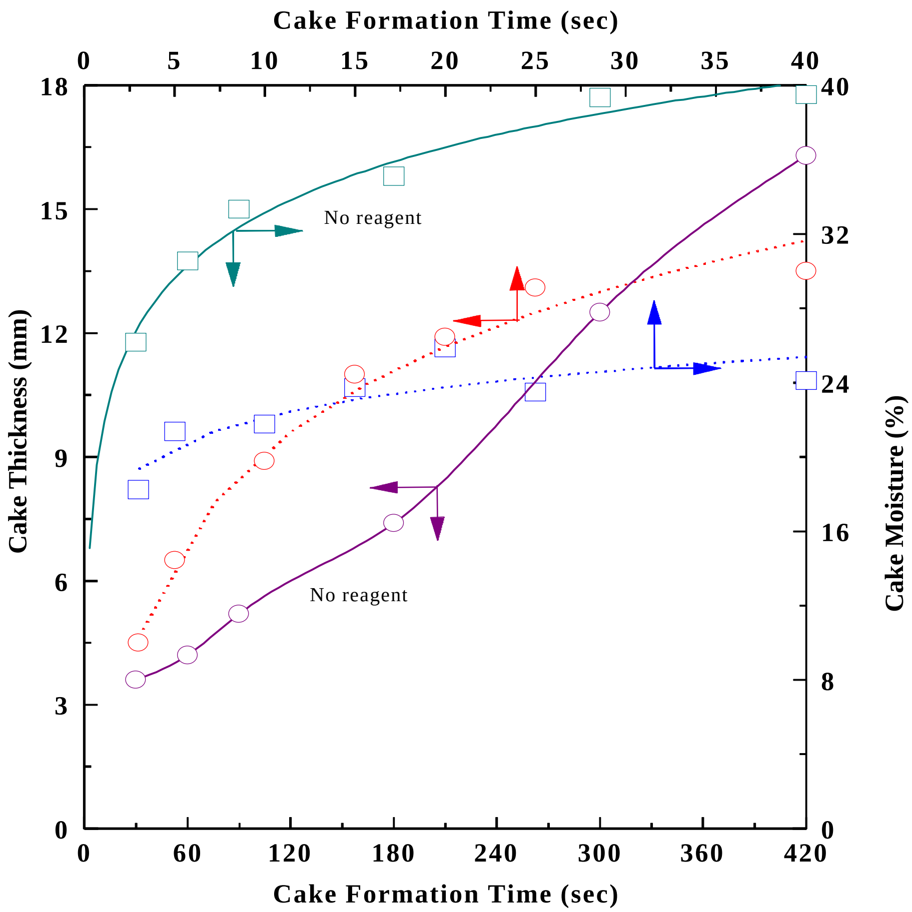

Figure 7. Effect of cake formation time in vacuum dewatering of low sulfur clean coal slurry with respect to cake thickness and moisture, with and without using 15 g/t of an anionic flocculant (cake drying time 40 sec)

presence of flocculant than in the absence of flocculant. Without the flocculant, it took 330 seconds (5.5 minutes) to produce a cake thickness of 13.5 mm. With the flocculant the same cake thickness was achieved in about 32 seconds. This indicated that use of 15 g/t anionic flocculant increased vacuum filtration kinetics by about 10 times. Figure 7 also shows that the cake moisture increased with cake formation time and was lower in the presence of the anionic flocculant than in its absence. A better way to show the effects of the flocculant on cake moisture is to compare cake moisture obtained with and without flocculants at the identical cake thickness. Therefore data of cake moisture was plotted as a function of cake thickness in Figure 8. Note, in this figure a given cake thickness was obtained using different cake formation time. The figure shows that cake moisture was consistently and considerably lower at the same cake thickness with use of the flocculant. Use of the anionic flocculant reduced cake moisture by twelve absolute percentage points (from 30 to 18 percent) with a 4.5 mm thick cake and by fifteen absolute percentage points (from 39 to 24 percent) with a 13 mm thick cake.

Figure 9 shows cake thickness and cake moisture obtained with PMCC non-compliance coal as a function of cake formation time with and without 15 g/t anionic flocculant. For this high sulfur clean coal slurry, it appears that the filtration kinetics were slower than the low sulfur clean coal slurry (Figure 7). For example, a 12 mm thick cake was formed in 30 seconds in the presence of 15 g/t anionic flocculant and in 90 seconds in the absence of the flocculant, which represented only a three-fold increase in filtration kinetics compared to ten-fold increase obtained for the low sulfur clean coal slurry. This can be attributed to the difference in particle size between these two different coal slurry samples. It has been reported previously that the non-compliance coal contained

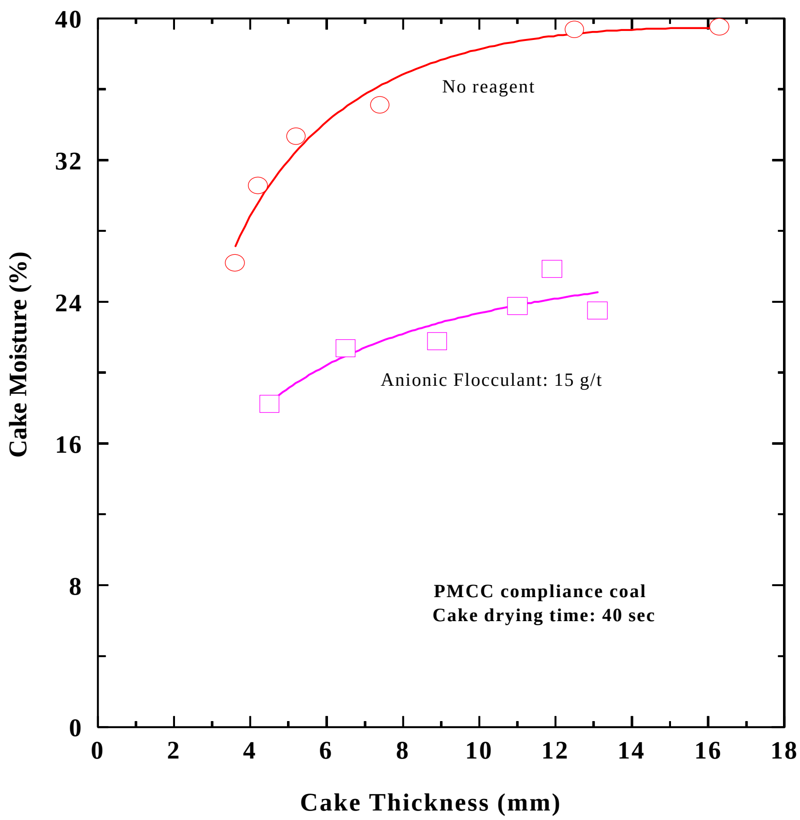

Figure 8. Effect of cake thickness on cake moisture using vacuum filter for the low sulfur clean coal slurry with and without the addition of 15 g/t of an anionic flocculant (cake drying time 40 sec)

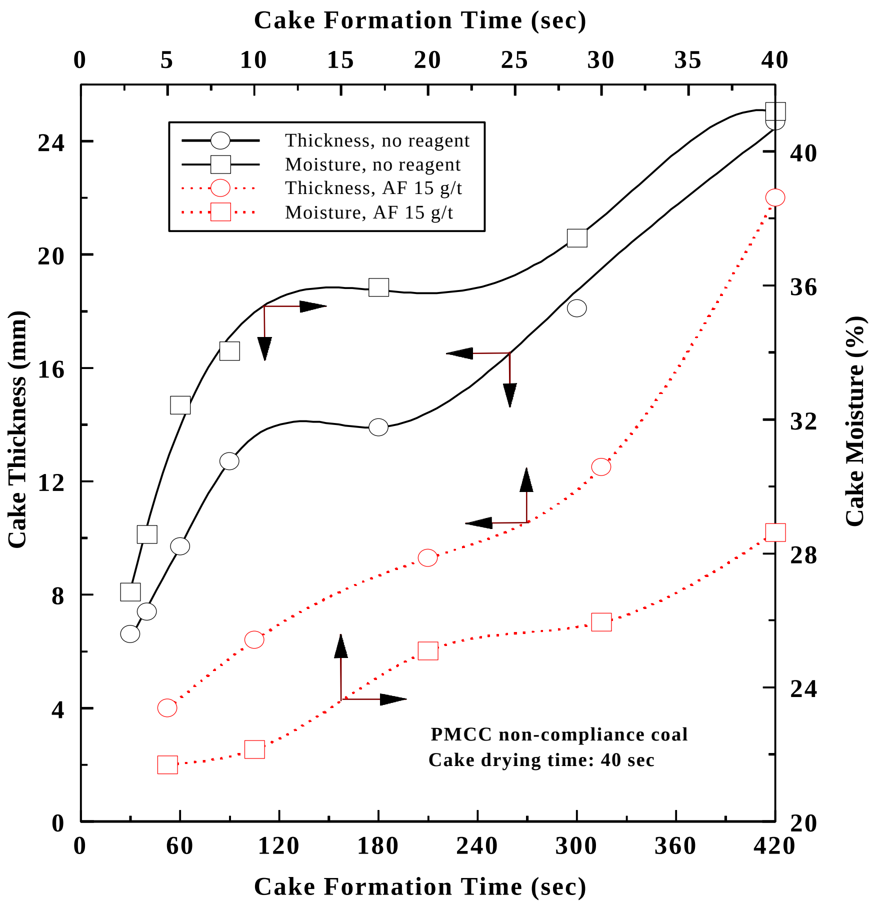

Figure 9. Effect of cake formation time on cake thickness and moisture using vacuum filtration for the high sulfur clean coal slurry, with and without the addition of 15 g/t of an anionic flocculant (cake drying time 40 sec)

coarser particles than the compliance coal. As a result, use of flocculants would have less significant effects on the non-compliance coal.

Figure 9 also shows that use of the anionic flocculant had significant effects on cake moisture. To better show the effects of flocculant on cake moisture data of cake moisture was plotted as a function of cake thickness in Figure 10. A significant lowering of cake moisture was observed with the use of flocculants, especially at higher cake thickness. With a 12 mm thick cake, use of 15 g/t anionic flocculant lowered cake moisture from 34 to 26 percent; with a 22 mm thick cake, it lowered cake moisture from 39.6 to 28.3 percent. Use of the cationic flocculant (Procol 371) appeared to have less substantial effects on cake moisture than the anionic flocculant, possibly due to its lower molecular weight.

The above results obtained with the continuous vacuum filter leaf filtration set up clearly indicate that use of flocculants can not only increase vacuum filtration kinetics by several times, but also lower the cake moisture drastically, provided that the cake thickness in the presence of flocculant can be maintained at approximately the same as in the absence of flocculant, for example, increasing rotation speed of the drum filter. The previous work conducted by the present investigators and other workers failed to reveal this important feature because of increased cake thickness with the addition of flocculants. This finding could have significant influence on industrial vacuum filter operations since it suggested a feasible approach to increasing filtration kinetics and reducing cake moisture.

To confirm the above results obtained with use of flocculants using the filter leaf filtration system, a small scale continuous vacuum drum filter available at CAER was

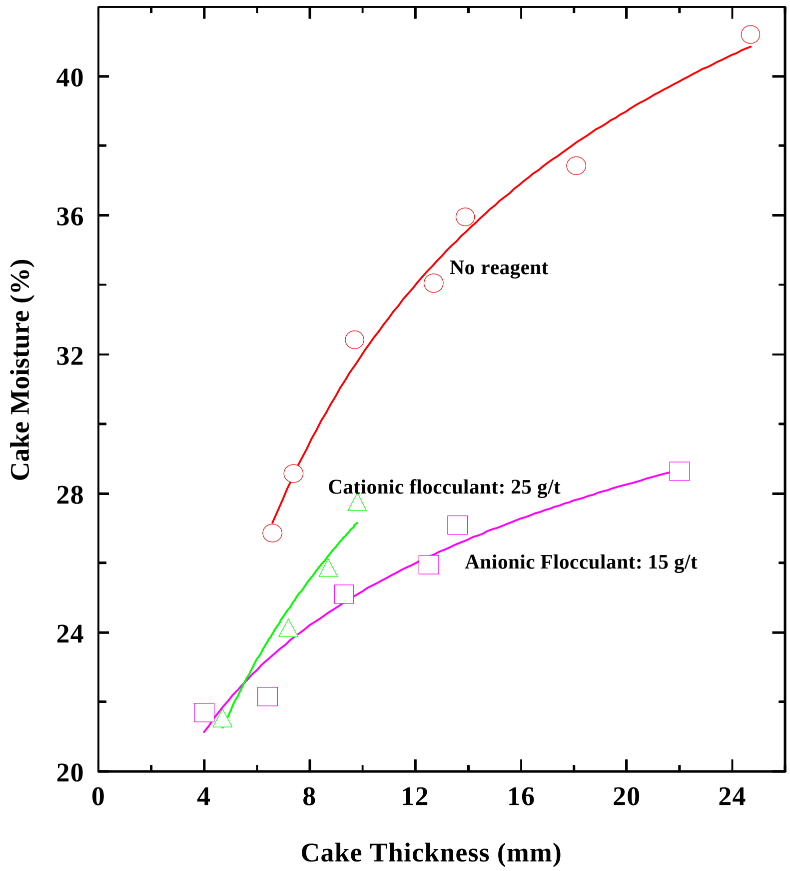

Figure 10. Effect of cake thickness on cake moisture with and without flocculants

employed to perform several dewatering tests with the PMCC non-compliance coal slurry. The filter drum is of 7-in. diameter and 3-in. width. The cake formation time was approximately equal to the cake drying time and both were dependent on the rotation speed. For example, if the rotation speed was 0.8 rpm, the cake formation and cake drying time was approximately 37.5 seconds each, which was close to the cake drying time, 40 seconds, used in the filter leaf filtration tests. The feed flow rate to the drum filter was modified in each test to keep the filtration chamber full of slurry. The results of solids output and cake moisture are shown in Figure 11 as a function of drum rotation speed. The drum rotation speed was varied to control cake formation time, and consequently cake thickness. Two series of tests were conducted: the first series without the addition of anionic flocculant as baseline tests and the second series with the anionic flocculant. It should be pointed out that there is a major difference between the filter leaf filtration system and the drum filter. With the drum vacuum filter, the cake formation time and cake drying time can not be varied independently. Changes in the drum rotation speed affect both cake formation and cake drying times. Figure 11 shows that use of 20 g/t anionic flocculant increased solids throughput and reduced cake moisture. In the absence of the flocculant, the maximum solids throughput was approximately 9 lb/ft^2/hr obtained at 0.8 rpm. Use of the flocculant improved the solids throughput to more than 45 lb/ft^2/hr, a 5-fold increase. This is in reasonable agreement with the results obtained with the filter leaf system. Without the flocculant, the cake moisture varied from 27 to 32 percent, depending on the rotation speed. Use of 20 g/t anionic flocculant produced cake moisture between 21 to 23.5 percent, considerably lower than that obtained without the flocculant.

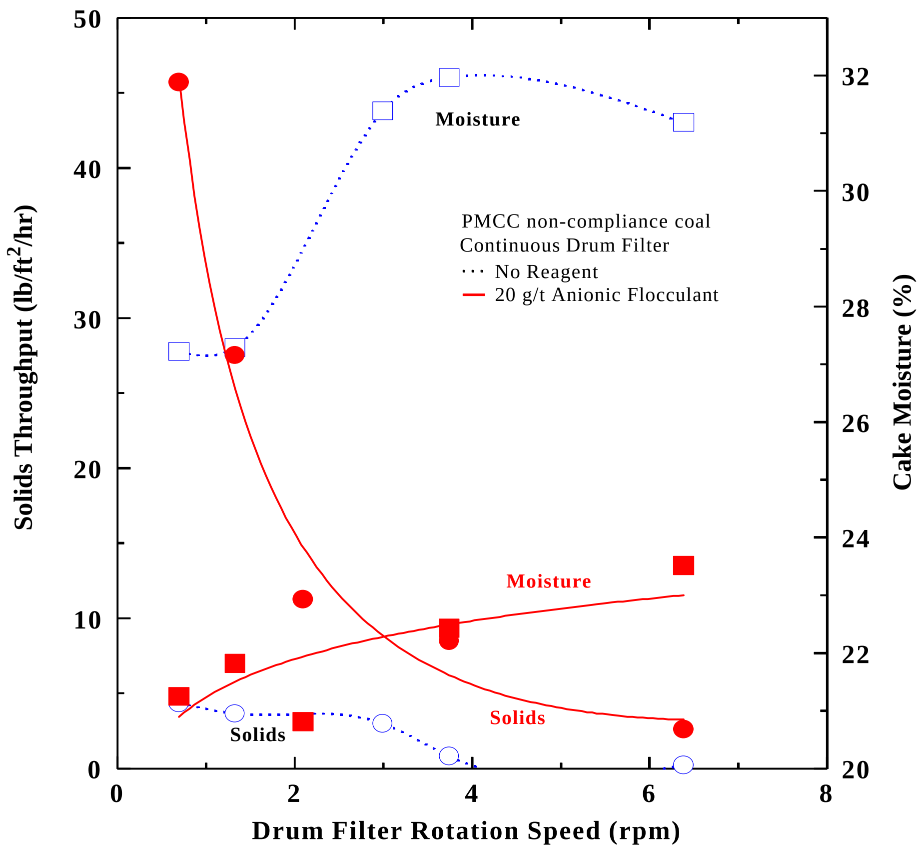

Figure 11. Effect of vacuum drum filter speed on cake moisture and solids throughput with and without addition of 20 g/t of an anionic flocculant

Figure 11 also indicates that increasing drum rotation speed from 0.8 rpm (the lowest speed possible with the device) to 6.3 rpm increased cake moisture and decreased solids output with or without the anionic flocculant. The cake moisture increased with increasing the rotation speed can be attributed to the reduced cake drying time associated with increased rotation speed. The decreased solids output is believed to be a result of decreased filter cake thickness observed in the experiments.

Task 4. Procurement and Fabrication:

The ceramic disk filter, manufactured by Otokumpu, has been installed. The unit was dry-run tested with slurry, after connecting to the power. It appeared to be working satisfactorily. Because of our lack of experience with the machine, we were not able to activate the ultrasonic system on the machine, which is a critical operation unit, in order for the filter to operate satisfactorily. Otokumpu company personnel were contacted for assistance, however, they were reluctant to provide any assistant.

Task 6. Operation:

For the pilot scale studies, additional tests using the 18-inch diameter Decanter screen bowl centrifuge were conducted. The speed of the centrifuge was 1000 rpm. The screen bowl opening was 28 mesh (0.5 mm). The main and screen bowl effluents samples were collected for a given length of time for analysis and to determine the amount of coal present in it. The dewatered coal product discharged on a small conveyor belt installed under the centrifuge. Samples of dewatered coal were collected for one minute time period and weighed. For each set of conditions the centrifuge was operated for 15 minutes before samples were collected.

Figures 12 and 13 show effect of various dosage of three surfactant namely, cationic, anionic, and non-ionic on dewatered product moisture and solids capture, for the high sulfur clean coal slurry, respectively. Note, that the product moisture and solids capture increased with increase in surfactant dosage. The most notable solids capture increase was observed with non-ionic and cationic surfactant, where solids captured increased from 64 to 72 percent at a dosage of 0.5 Kg/t.

Figures 14 and 15 show the effect of surfactant dosages on dewatering and solids capture of the low sulfur clean coal slurry, respectively. For this coal slurry, addition of all three surfactant showed lowering of product moisture. A dosage of 0.5 Kg/t of cationic surfactant lowered the moisture from 36.7 to 34.5 percent. Similarly, for the anionic and non-ionic surfactants the moisture was lowered to 35.3 percent and 35.4 percent, respectively. The solids capture in the centrifuge, however, did not show any improvement. In fact, for the anionic surfactant solids captured was reduced from 42 to 37 percent at a dosage of 1 Kg/t.

Effect of addition of Cu^{+2} and Al^{+3} metal ions on dewatering and solids capture of the high sulfur clean coal slurry is shown in Figures 16 and 17, respectively. Note, that addition of both metal ions increased the product moisture. The solids capture in the centrifuge increased from 63 to 68 percent at a dosage of 25 mg/Kg of the $CuCl_2$. However, for the $AlCl_3$ the solids capture increased to 71 percent at a dosage of 50 mg/Kg. The product moisture data are very similar to that obtained with surfactant for the high sulfur coal.

Figure 18 shows the product moisture and solids capture as a function of metal ion dosage for the low sulfur clean coal slurry. As seen with the surfactant addition, the

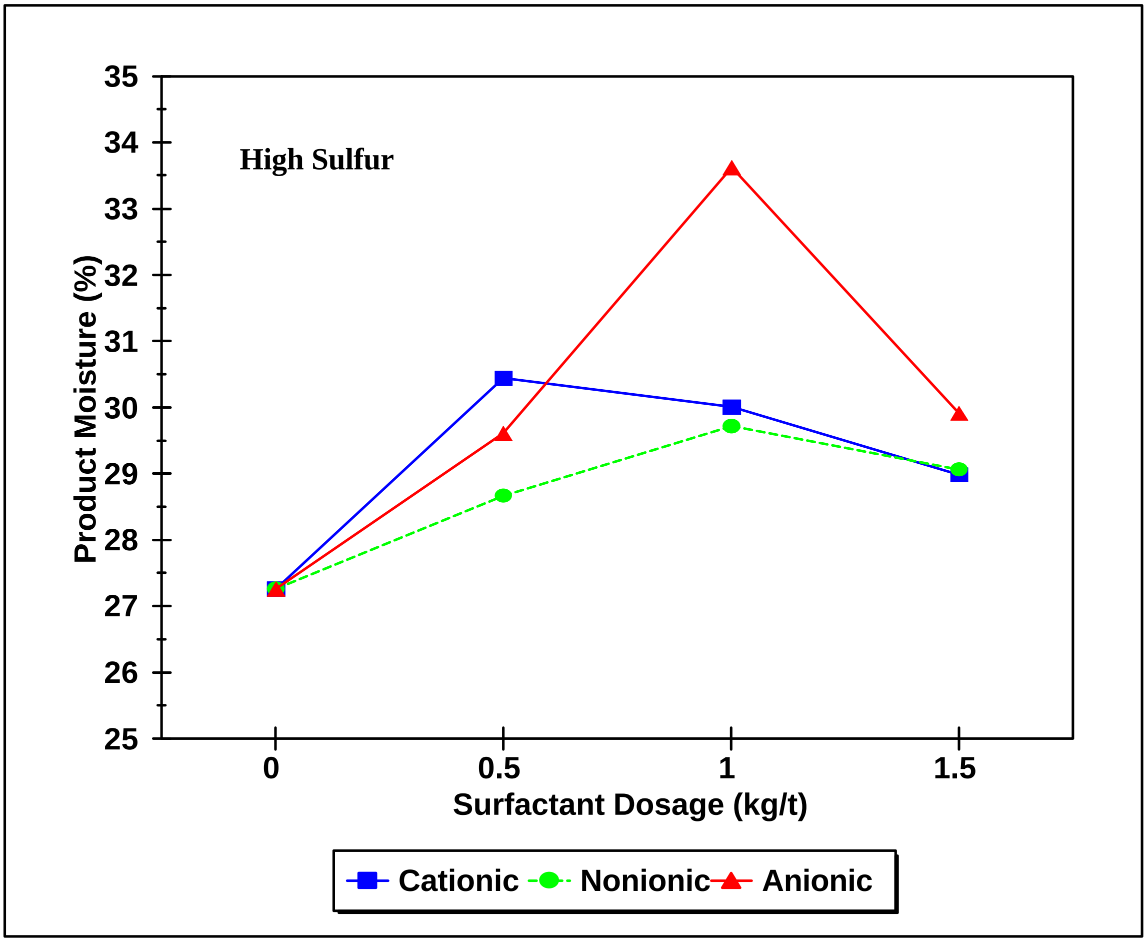

Figure 12. Effect of surfactant dosage on product moisture of the high sulfur clean coal slurry using the pilot scale centrifuge

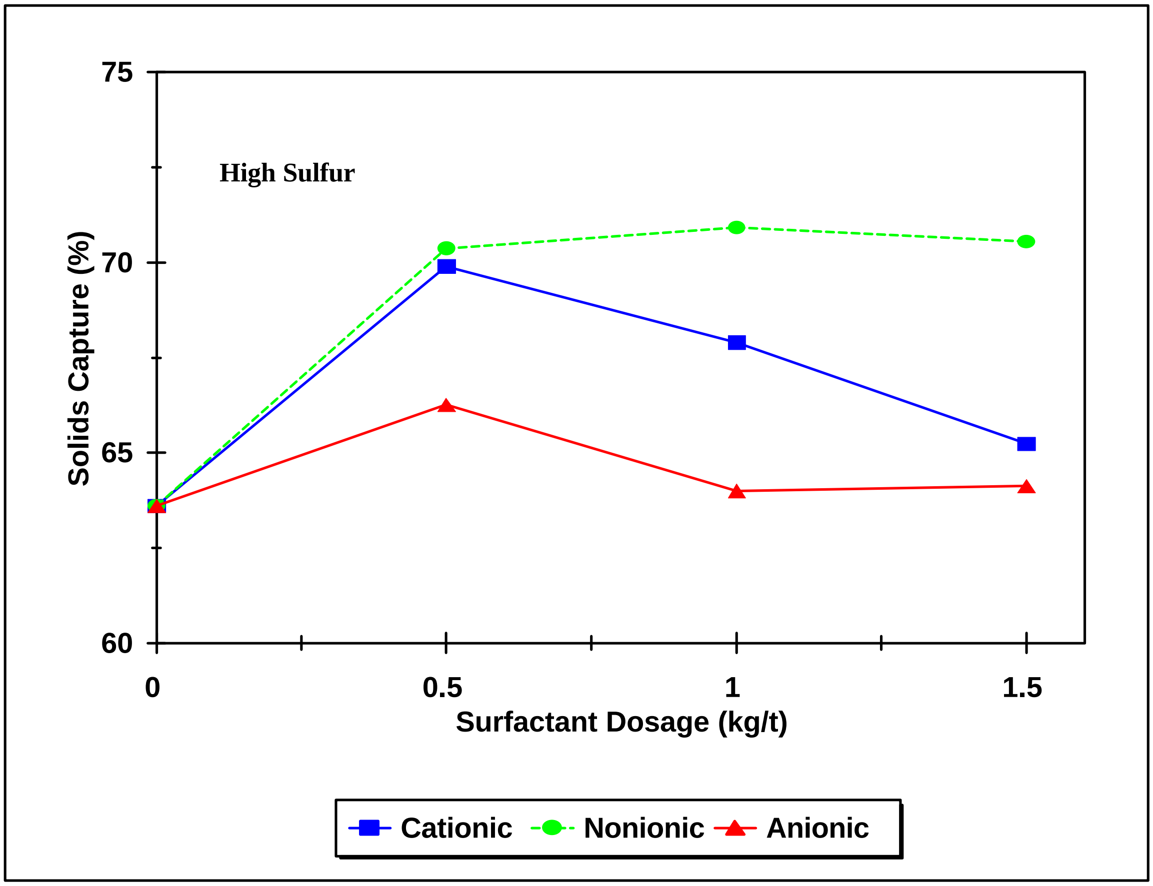

Figure 13. Effect of surfactant dosage on solids capture for the high sulfur clean coal slurry

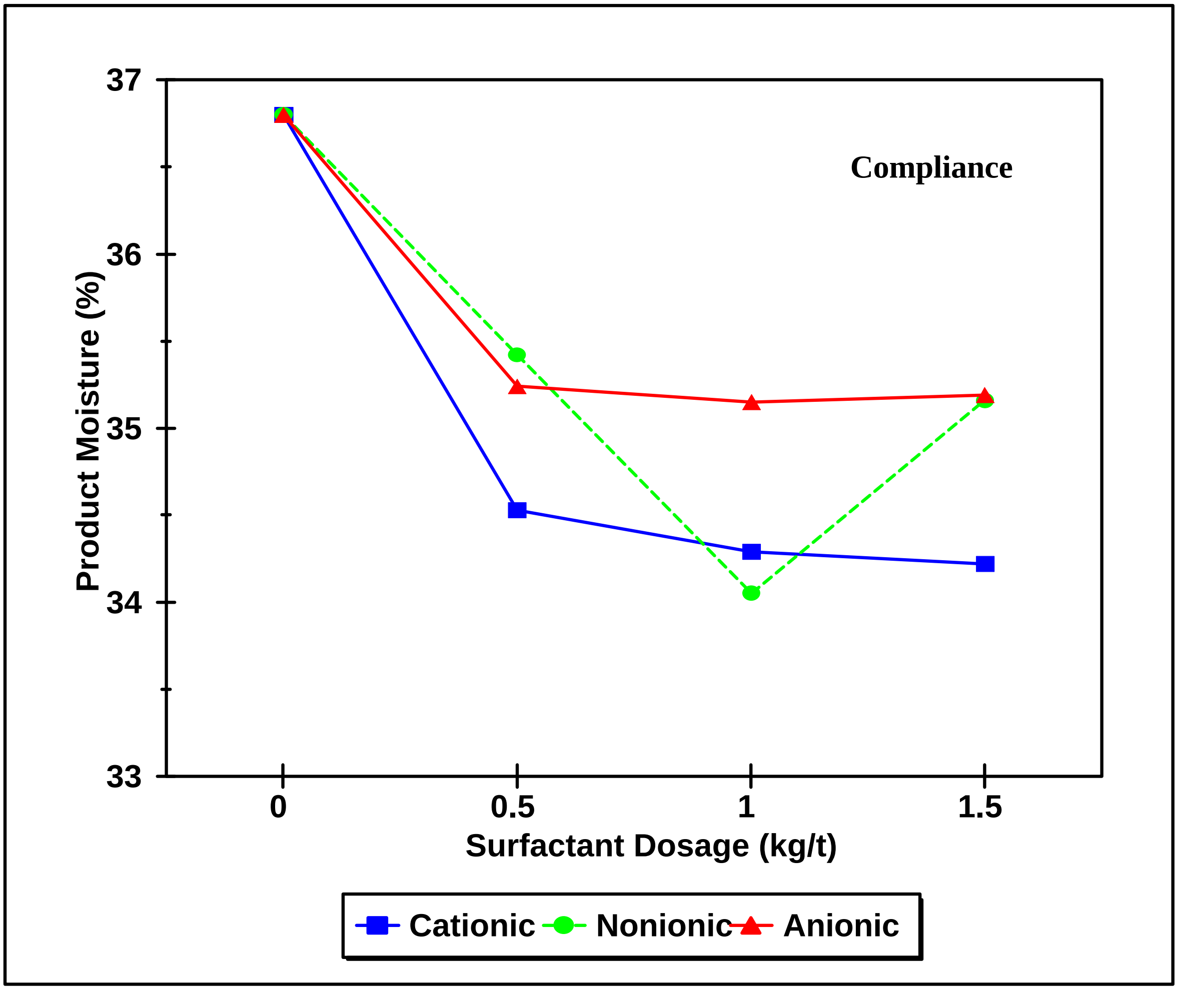

Figure 14. Effect of surfactant dosage on product moisture of the low sulfur clean coal slurry using the pilot scale centrifuge

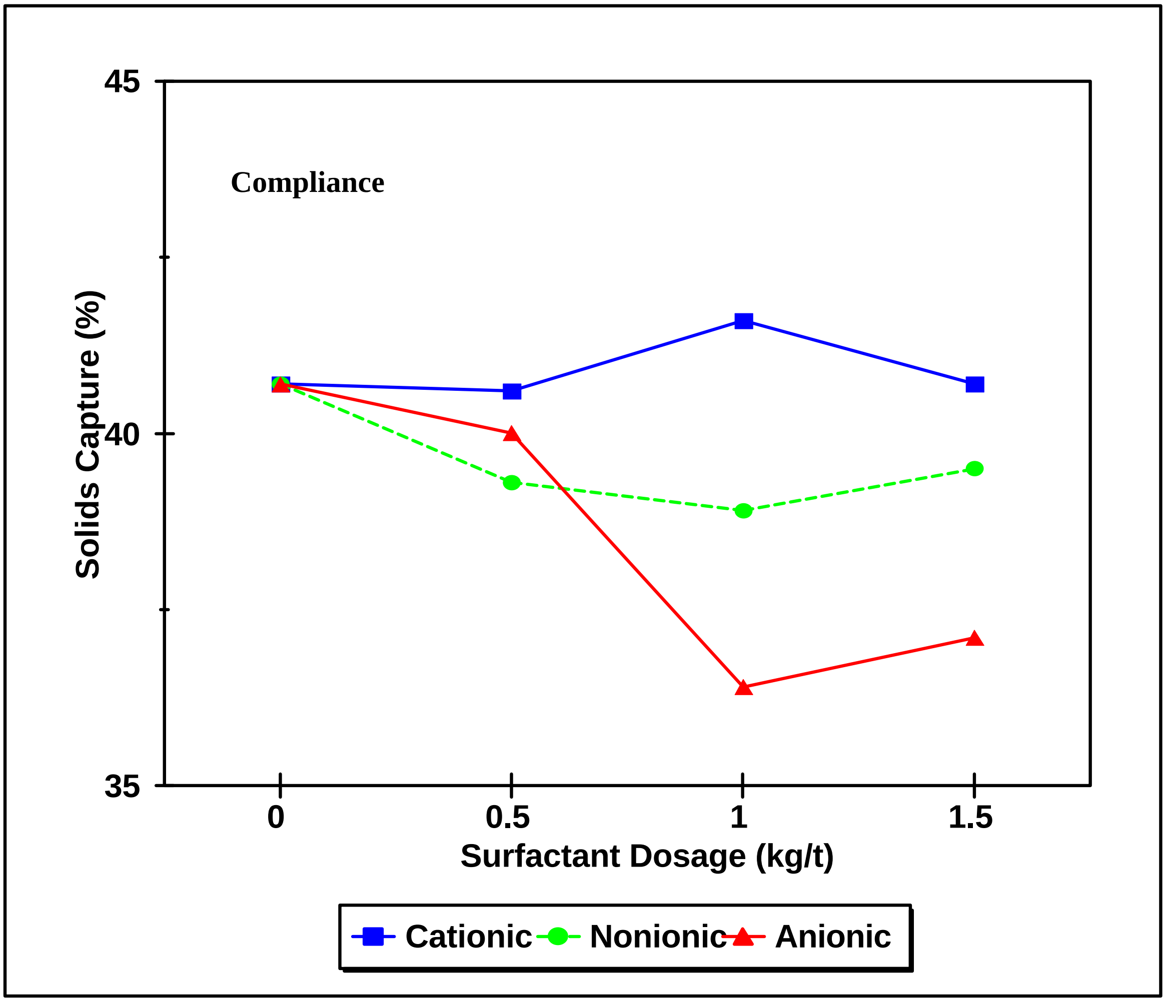

Figure 15. Effect of surfactant dosage on solids capture of the low sulfur clean coal slurry

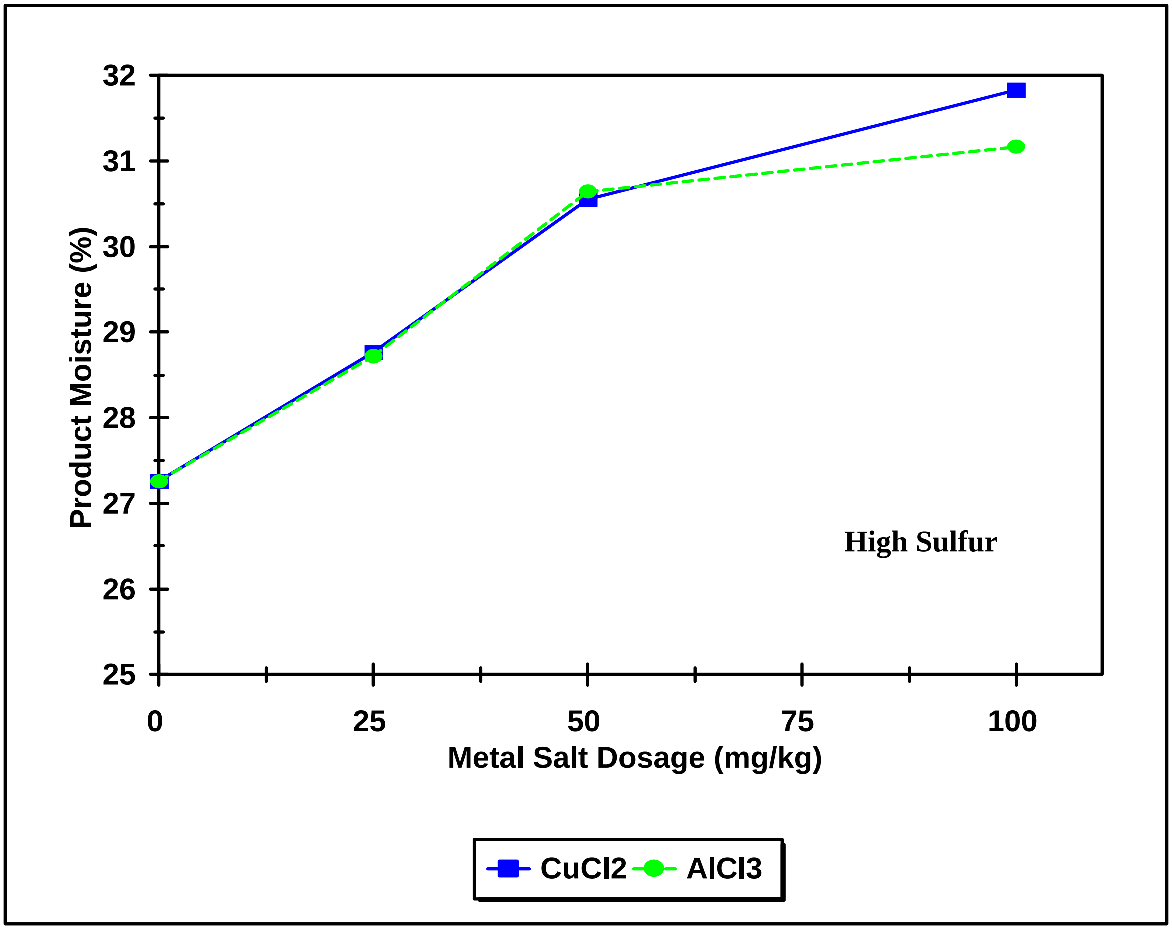

Figure 16. Effect of metal salt dosage on product moisture for the high sulfur clean coal slurry using the pilot scale centrifuge

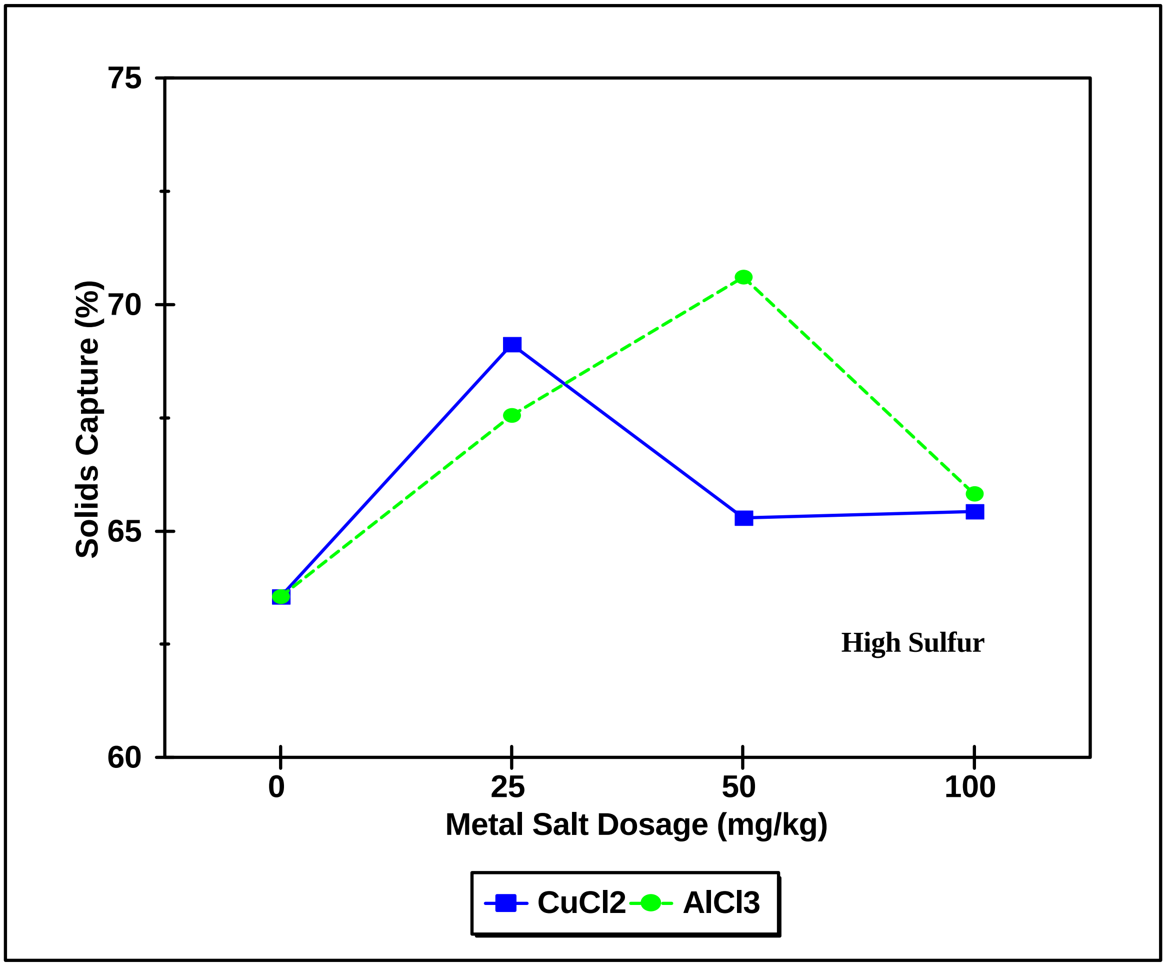

Figure 17. Effect of metal salt dosage on solids capture for the high sulfur clean coal slurry

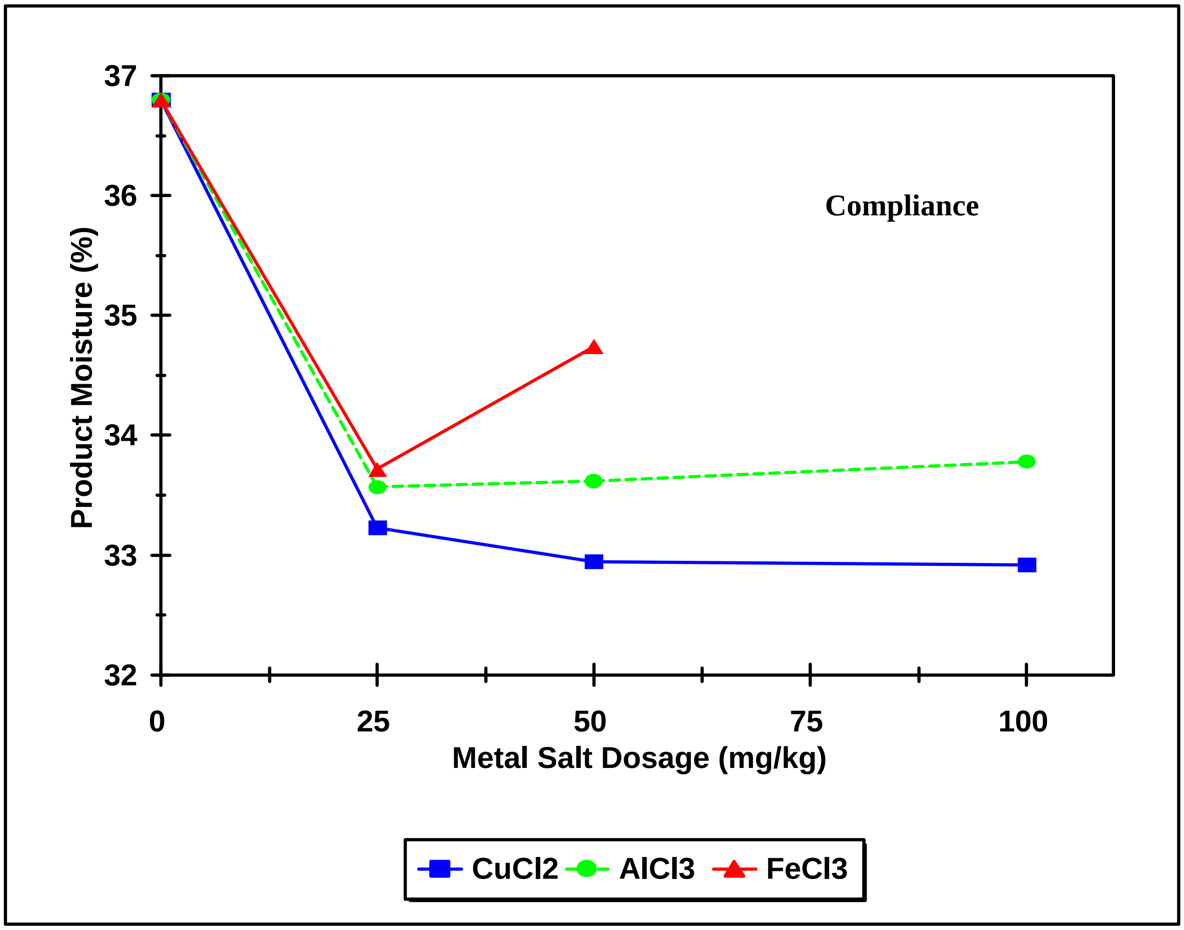

Figure 18. Effect of metal salt dosage on product moisture for the low sulfur clean coal slurry using the pilot scale centrifuge

product moisture reduced from 36.7 to 33.5 percent for all the three i.e., $AlCl_3$, $FeCl_3$ and $CuCl_2$ salts addition at a dosage of 25 mg/Kg. Increasing metal ion dosage was not effective in lowering the product moisture. The solids capture (Figure 19) shows an increase for the $CuCl_2$ salt, for example, at a dosage of 50 mg/Kg the solids capture increased from 40.5 to 44 percent.

CONCLUSIONS

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

- In laboratory centrifugal dewatering studies, use of 30 g/t anionic flocculant with the compliance (low sulfur) coal slurry reduced filter cake moisture from 32.3 to 29.0 percent and increased solids recovery by two absolute percentage points. Use of cationic flocculant had no effects on solids recovery but lowered cake moisture to 27 percent at a dosage of 15 g/t.

  With the non-compliance (high sulfur) coal slurry addition of 15 g/t anionic flocculant lowered cake moisture from 30 to 28.5 percent with marginal effects on solids recovery; addition of cationic flocculant reduced cake moisture by one absolute percentage point with negligible effects on solids recovery.

- Laboratory vacuum filter leaf filtration studies showed that increased filtration kinetics and lowered cake moisture can be achieved simultaneously in the presence of flocculants, provided thick filter cake formation is prevented with the addition of flocculants; which can be achieved by reducing cake formation time. It has been found that addition of 15 g/t anionic flocculant to the compliance coal slurry increased filtration kinetics by 10 times and lowered cake moisture by 12 to 15 absolute percentage points at the same cake thickness. Addition of 15 g/t anionic flocculant

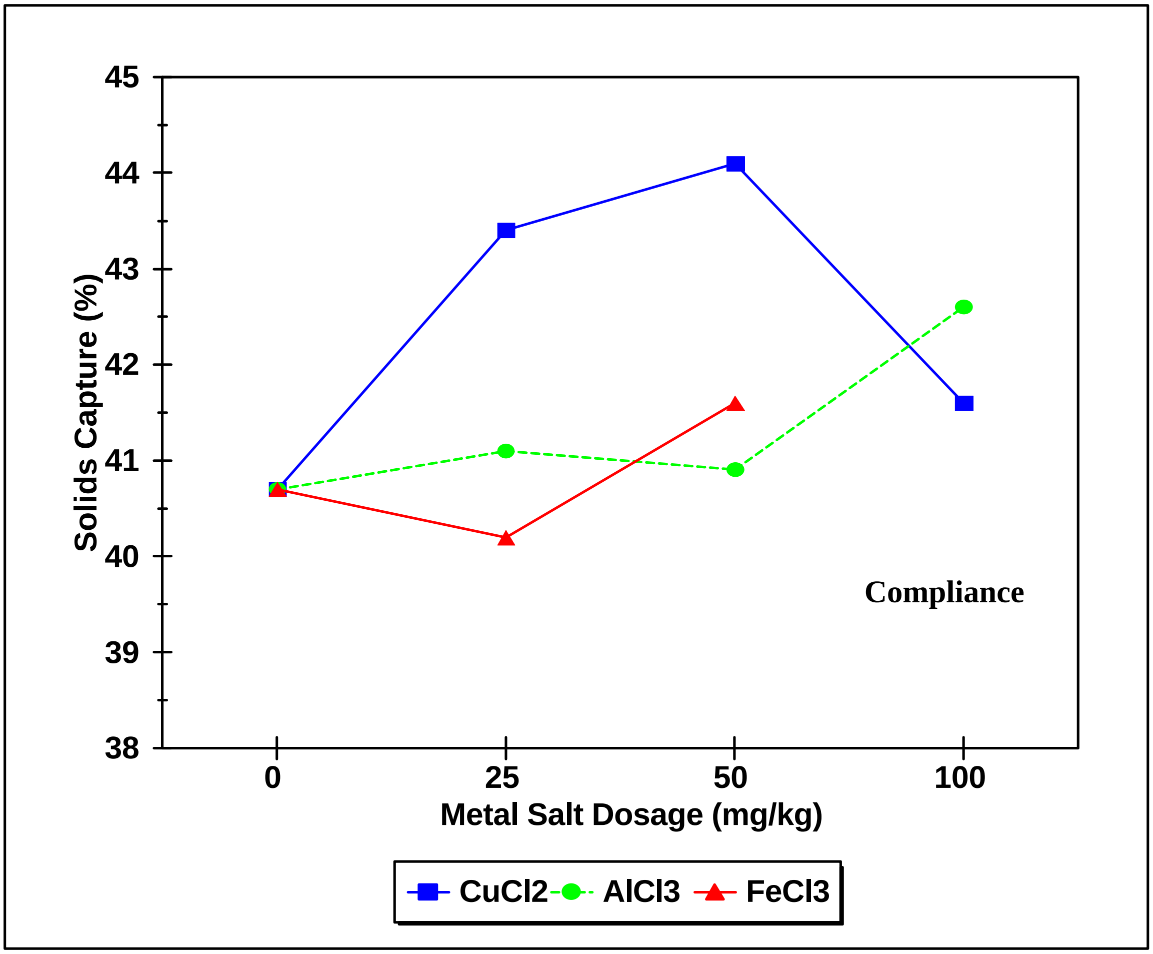

Figure 19. Effect of metal salt dosage on solids capture for the low sulfur clean coal slurry using the pilot scale centrifuge

to non-compliance coal increased filtration kinetics by more than three times. It also reduced moisture in a 12 mm thick cake from 34 to 26 percent and that in a 22 mm thick cake from 39.6 to 28.3 percent.

- Small scale continuous vacuum drum filter studies have confirmed that use of anionic flocculant increased filtration kinetics and lowered cake moisture. With 20 g/t anionic flocculant added to the non-compliance slurry filter solids output increased from 9 to 45 lb/ft^2/hr and cake moisture was reduced from 27 to 21 percent at the drum rotation speed 0.8 rpm.
- Pilot scale centrifuge tests conducted with addition of various surfactants showed that filter cake moisture of low sulfur clean coal reduced from 37 to 34 percent as a dosage of 0.5 Kg/t of the surfactant. However, for the high sulfur clean coal slurry, the filter cake moisture increased with increase in surfactant dosage.

  The solids capture in the centrifuge increased with surfactant dosage for the high sulfur clean coal, whereas it remained constant for the low sulfur clean coal slurry.
- Addition of 25 mg/Kg of metal ion salt ($CuCl_2$ or $AlCl_3$) lowered the filter cake moisture from 37 to 33.5 percent for the low sulfur clean coal slurry, however, for the high sulfur clean coal slurry it increased the filter cake moisture with the addition of metal ions.

ACTIVITIES FOR NEXT QUARTER

More laboratory centrifugal dewatering tests will be conducted in the next quarter. The efforts will be focused on studies of synergetic effects between two metal ions and three surfactants. The metal ions to be investigated are: trivalent ions (Al^{3+}) and divalent ions (Cu^{2+}); surfactants to be studied are: anionic surfactant (sodium 2-ethylhexyl sulfate), non-ionic surfactant (octyl phenoxy polyethoxy ethanol), and cationic surfactant (1-

hexadecyl pyridium chloride). In addition, some new reagents that can be used to substitute surface water on coal will be investigated for their applicability to fine coal dewatering processes.

Pilot scale dewatering tests will be conducted in collaboration with USDOE/FETC personnel to evaluate the `Granu-flow' process using the centrifuge.