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

## QUARTERLY TECHNICAL PROGRESS REPORT 9

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# DISCLAIMER

TABLE OF CONTENTS

## LIST OF FIGURES

ABSTRACT


The advanced fine-coal cleaning techniques such as column flotation, recovers a low-ash ultra-fine size clean-coal product. However, economical dewatering of the clean coal product to less than 20 percent moisture using conventional technology is difficult. This research program objective is to evaluate a novel coal surface modification technique developed at the University of Kentucky Center for Applied Energy Research in conjunction with conventional and advanced dewatering technique at a pilot scale at the Powell Mountain Coal Company's Mayflower preparation plant located in St. Charles, VA.

During this quarter in the laboratory dewatering studies were conducted using copper and aluminum ions showed that for the low sulfur clean coal slurry addition of 0.1 Kg/t of copper ions was effective in lowering the filter cake moisture from 29 percent to 26.3 percent. Addition of 0.3 Kg/t of aluminum ions provided filter cake with 28 percent moisture. For the high sulfur clean coal slurry 0.5 Kg/t of copper and 0.1 Kg/t of aluminum ions reduced cake moisture from 30.5 percent to 28 percent respectively.

Combined addition of anionic (10 g/t) and cationic (10 g/t) flocculants was effective in providing a filter cake with 29.8 percent moisture. Addition of flocculants was not effective in centrifuge dewatering.

In pilot scale screen bowl centrifuge dewatering studies it was found that the clean coal slurry feed rate of 30 gpm was optimum to the centrifuge, which provided 65 percent solids capture. Addition of anionic or cationic flocculants was not effective in lowering of filter cake moisture, which remained close to 30 percent for both clean coal slurries.

## EXECUTIVE SUMMARY

Froth flotation technique is an effective and efficient process for recovering of ultra-fine (minus 74 $\mu$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 36 months beginning September 30, 1994. This report discusses technical progress made during the quarter from October 1 - December 31, 1996.


## 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 metal ions 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 0.1 kg/t $Cu^{2+}$ ions decreased cake moisture from 29.02 to 26.35% and increased solids recovery from 85.2 to 86.9%. Dosages of 0.2 kg/t or higher increased cake moisture without increasing solids recovery. On the other hand, use of 0.3 kg/t $Al^{3+}$ ions provided a cake moisture of 28.02% with about 80.3% solids recovery. Improved dewatering performance by use of metal ions was also observed with non-compliance coal slurry. For example, 0.5 kg/t $Cu^{2+}$ ions and 0.1 kg/t $Al^{3+}$ ions reduced cake moisture from 30.5 to 28 and 28.5%, respectively.

Vacuum and centrifugal dewatering tests were performed to study effects of combined flocculation with anionic and cationic flocculants using PMCC compliance coal slurry. The results have shown that a two-stage conditioning process with both flocculants improved vacuum filtration. Better results were produced when anionic flocculant was added in the first stage. Use of a combination of 10 g/t anionic flocculant and 10 g/t cationic flocculant provided 29.87% cake moisture, compared to 32.51% obtained when 20 g/t cationic flocculant alone was used. Combination of flocculant addition provided no significant improvement in centrifugal dewatering tests.

In the pilot scale studies on 18-inch diameter Decanter screen bowl centrifuge was utilized. Initially, studies were conducted on effect of slurry feed rate. It was found that a slurry feed rate of 30 ppm was optimum for the centrifuge. Using this feed rate a filter cake with 27 to 30 percent moisture was obtained and the solids capture was about 65 percent. Addition of anionic and cationic flocculants to the low and high sulfur clean coal slurries were evaluated. No significant decrease in filter cake moisture was observed with addition of either of the flocculants.

## 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% 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%) 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

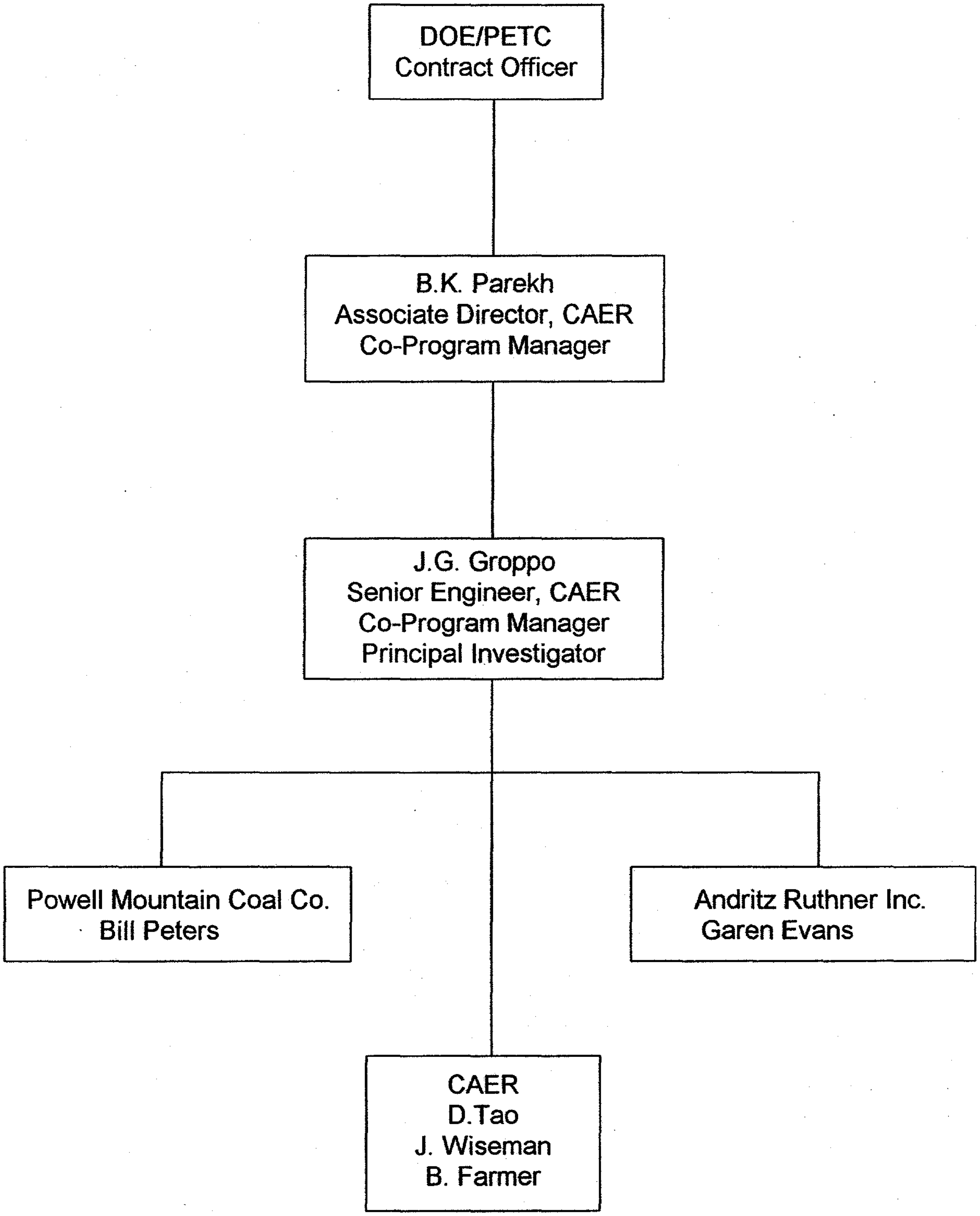


Figure 1. Project management organization chart

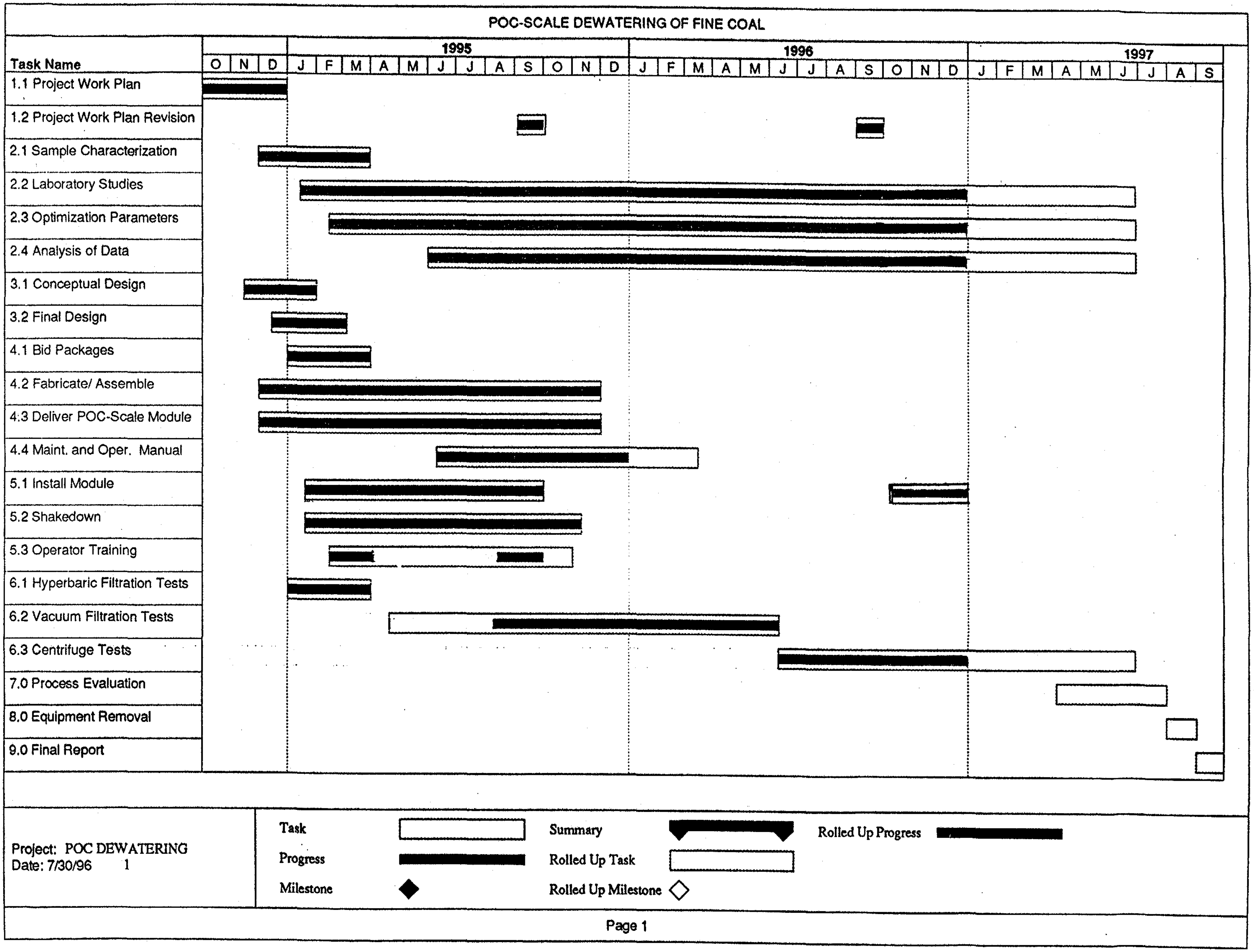


Figure 2. Up-to-date project schedule

pressure techniques to dewater the clean coal slurry to about 20% 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% 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.

## RESULTS AND DISCUSSION

The project has been divided into tasks and subtasks listed in Table I. Each task and subtask has specific objective which can be inferred from its title. During this quarter (October 1 to December 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.

<u>Centrifugal Dewatering</u>

During the past quarter laboratory centrifugal dewatering tests were carried out with both PMCC compliance and non-compliance coals. The objective of this work is to develop new approaches to enhance dewatering of fine coal slurry using

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 |

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 of both coals 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.

Reagents tested using the centrifuge include anionic (sodium 2-ethylhexyl sulfate), nonionic (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 metal ions on centrifugal dewatering of PMCC compliance and non-compliance coal slurry samples of column flotation froth products. Metal ions were added to coal slurry to reach the point of zero charge (PZC) of coal surface at which coagulation of coal particles takes place. The coal slurry pH was controlled at 6.5 and 9.0 in the presence of $Al^{3+}$ and $Cu^{2+}$, respectively by adding dilute NaOH or HCl solutions.

*Effects of $Cu^{2+}$ Ions*

Figure 3 shows the effects of $Cu^{2+}$ ions on centrifugal dewatering of 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

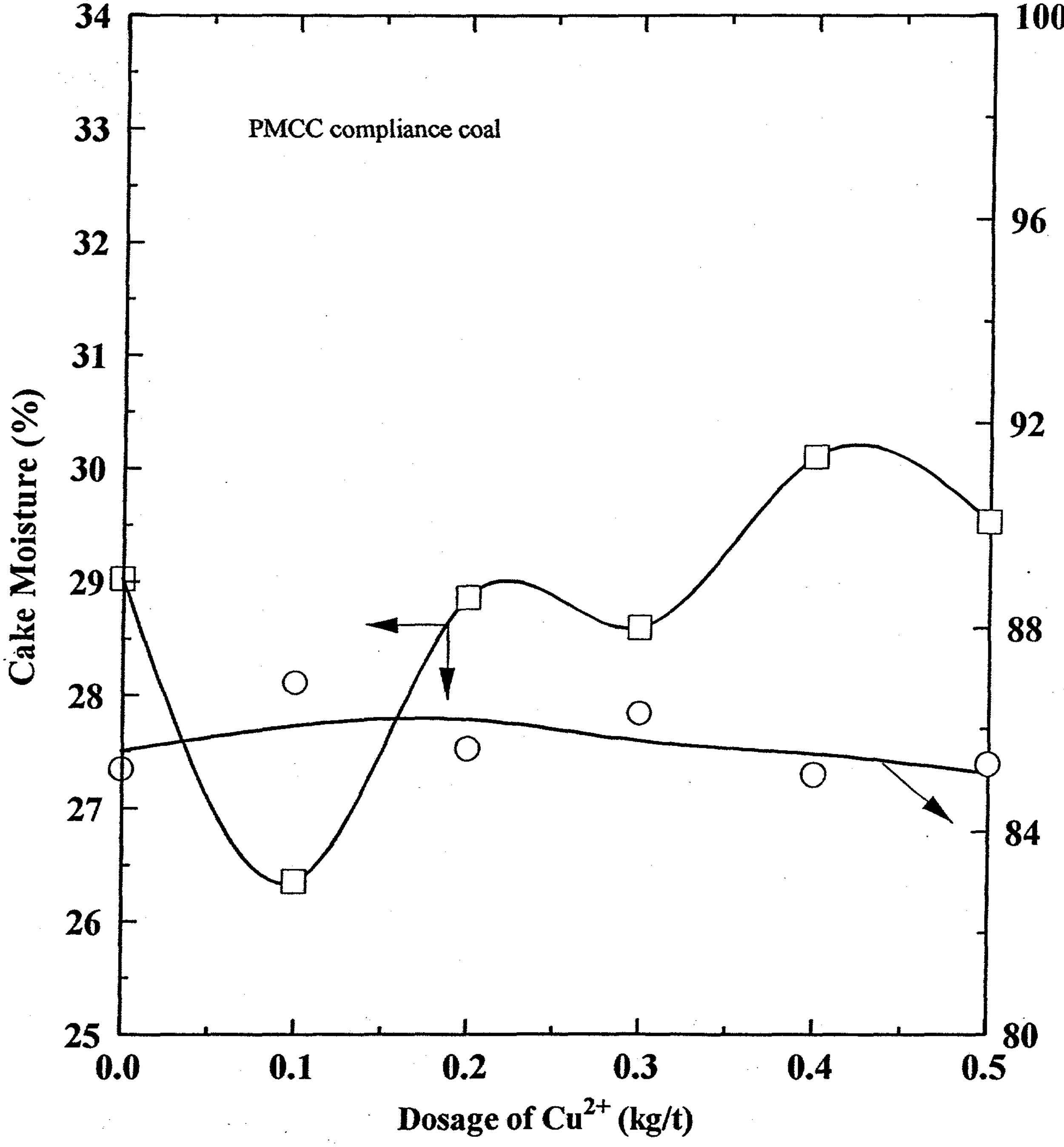


Figure 3. Effects of $Cu^{2+}$ ions on cake moisture and solids recovery with compliance coal.

that with compliance coal use of 0.1 kg/t $Cu^{2+}$ ions decreased cake moisture from 29.02 to 26.35% and increased solids recovery from 85.2 to 86.9%. Higher dosages of $Cu^{2+}$ ions had adverse effects on the cake moisture. For example, at a dosage of 0.2 kg/t cake moisture was about the same as that obtained in the absence of $Cu^{2+}$ ions. At dosages of 0.4 and 0.5 kg/t cake moisture was further increased. This indicated that excess quantity of $Cu^{2+}$ ions is detrimental to coal slurry dewatering, possibly due to reversal of surface charge or reduced surface hydrophobicity of coal particles at high concentrations of $Cu^{2+}$ ions. In addition, high dosages of $Cu^{2+}$ ions had no beneficial effects on solids recovery.

Figure 4 shows the effects of $Cu^{2+}$ ions on centrifugal dewatering of non-compliance coal. Use of $Cu^{2+}$ ions at dosages up to 0.2 kg/t reduced cake moisture from 30.5 to 29.35%. However, use of 0.3 or 0.4 kg/t $Cu^{2+}$ ions increased cake moisture to about 30.6%. At a dosage of 0.5 kg/t cake moisture was significantly lowered to 27.6%. Solids recovery was relatively constant over the dosage range except at 0.5 kg/t at which solids recovery was 90.3%, significantly higher than others. Better results obtained with the compliance coal slurry may be due to its finer particle size compared to the non-compliance coal slurry, because finer particles coagulate more effectively with the metal ions.

*Effects of* $Al^{3+}$ *Ions*

Figure 5 shows the effects of $Al^{3+}$ ions on centrifugal dewatering of compliance coal. Cake moisture and solids recovery were dependent on the dosage of $Al^{3+}$ ions. Use of 0.2 kg/t $Al^{3+}$ ions slightly increased cake moisture and solids recovery, from 29.02 to 29.63% and 85.2 to 85.69%, respectively. The lowest cake moisture of 28.0% and solids recovery of 80.3% were observed at 0.3 kg/t $Al^{3+}$ ions. Addition of

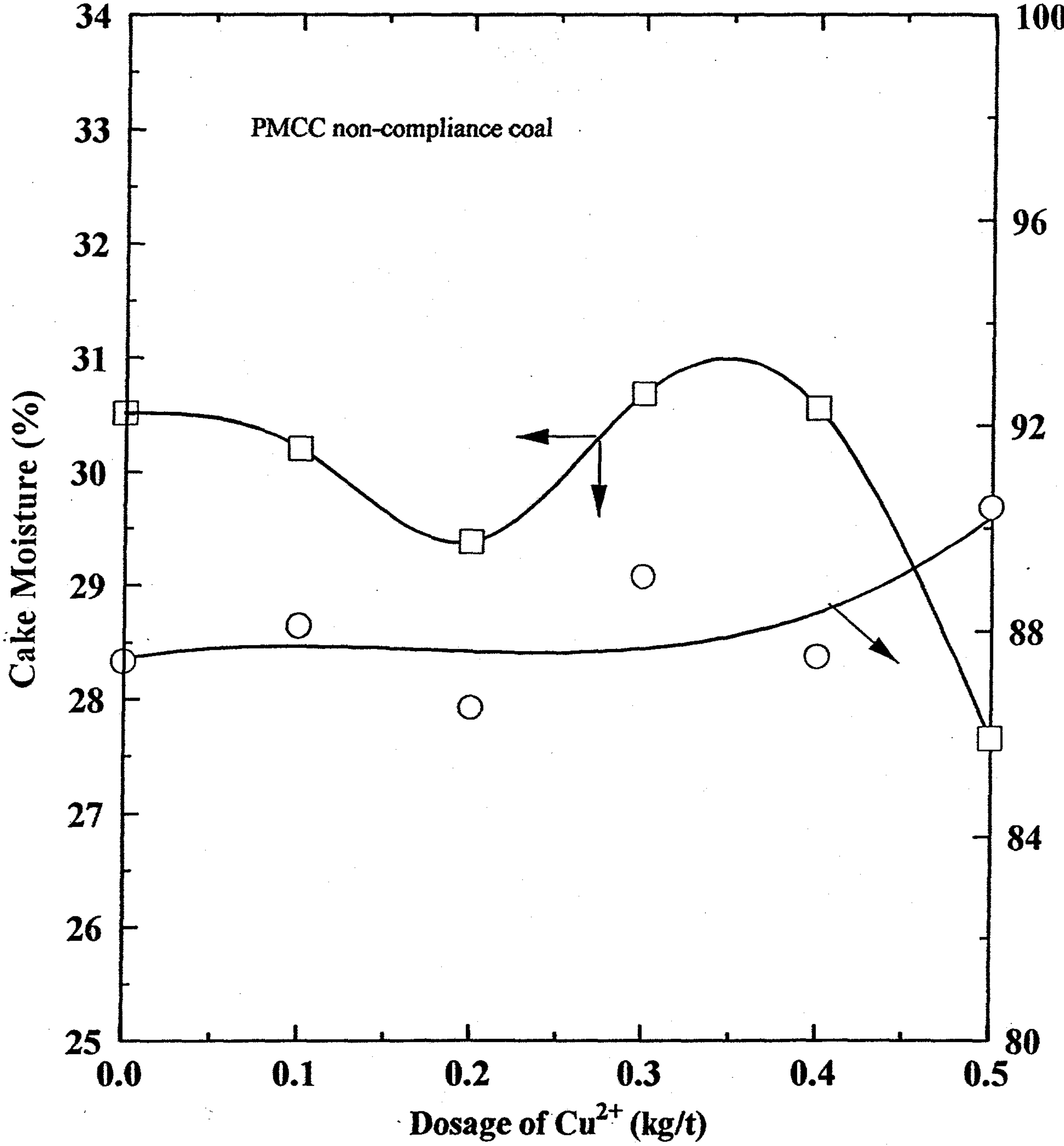


Figure 4. Effects of $Cu^{2+}$ ions on cake moisture and solids recovery with non-compliance coal.

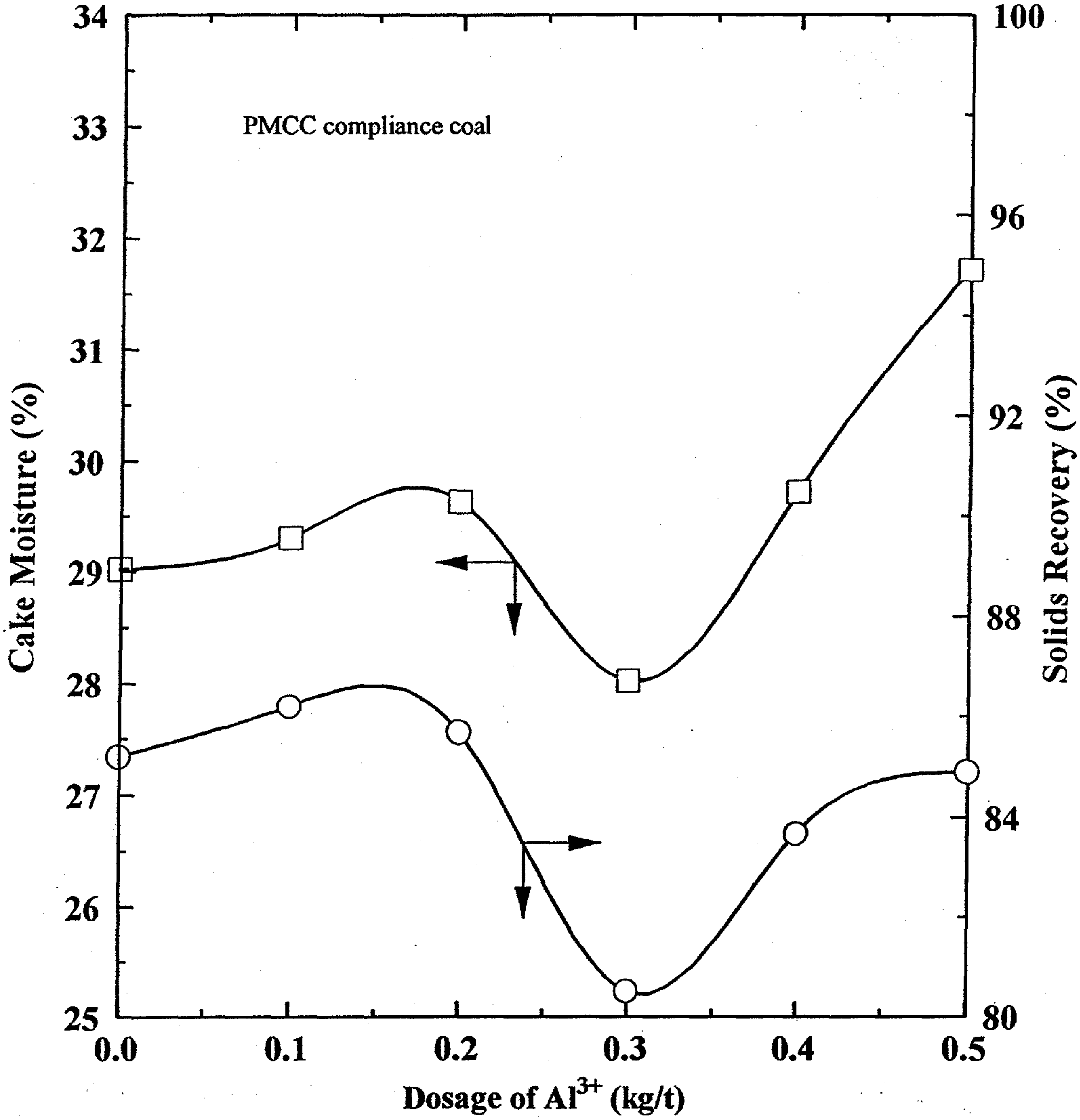


Figure 5. Effects of $Al^{3+}$ ions on cake moisture and solids recovery with compliance coal.

more than 0.3 kg/t $Al^{3+}$ ions did not further reduce cake moisture. Instead it increased cake moisture and solids recovery. Comparing results shown in Figures 3 and 5 indicates use of $Cu^{2+}$ ions was more effective than $Al^{3+}$ ions in lowering cake moisture.

Figure 6 shows the effects of $Al^{3+}$ ions on centrifugal dewatering of non-compliance coal. Cake moisture was reduced from 30.5 to 28.5% at a dosage of 0.1 kg/t. But use of 0.2 kg/t $Al^{3+}$ ions increased cake moisture to 31.4%. Increasing the dosage to 0.3, 0.4 kg/t lowered cake moisture back to about 29.5%. The moisture was increased to 30.5% with the addition of 0.5 kg/t $Al^{3+}$ ions. On the other hand, solids recovery was only slightly increased in most cases in the presence of $Al^{3+}$ ions, except at 0.4 kg/t $Al^{3+}$ ions it was remarkably increased to 90.5%.

Effects of Combining Anionic and Cationic Flocculants

During the last quarter both vacuum and centrifuge dewatering tests were conducted to study combined effects of anionic and cationic flocculants on filtration dewatering of fine coal. The tests were performed with the PMCC compliance coal under different conditions. It was expected that combined use of cationic and anionic flocculants will produce larger and stronger flocs that are more readily dewatered.

Figure 7 shows vacuum dewatering data (cake moisture and thickness) as a function of dosage of anionic and cationic flocculants for the compliance coal slurry. In all these tests the total dosage of flocculants was kept constant at 20 g/t. Anionic flocculant was first added to the slurry and conditioned for 2 minutes before cationic flocculant was added and conditioned for another 3 minutes. As the dosage of anionic flocculant was increased the dosage of cationic flocculant was decreased by the same amount. As can be seen in the figure, increasing the dosage of anionic flocculant increased cake thickness consistently. This may be due to high molecular

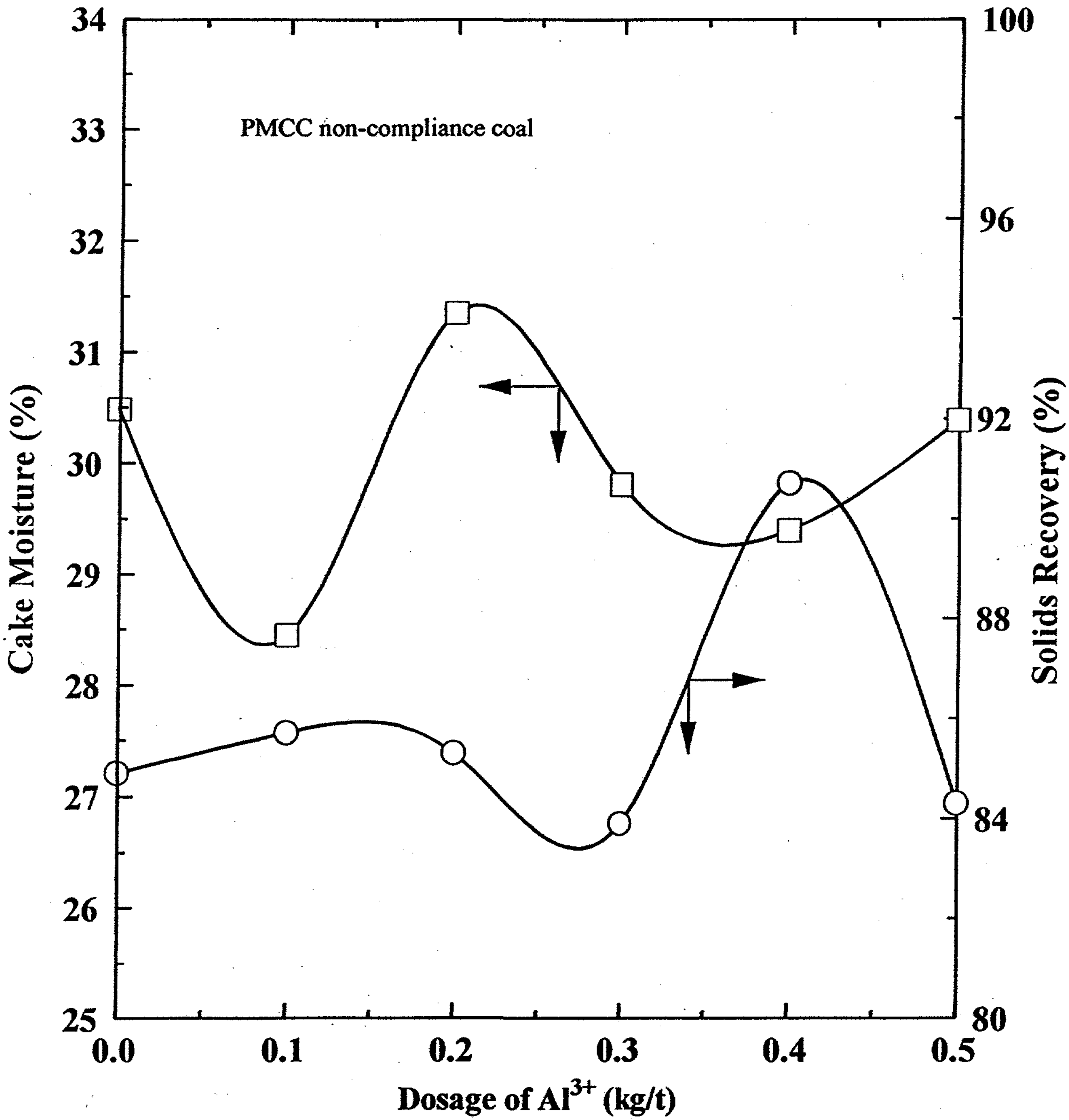


Figure 6. Effects of $Al^{3+}$ ions on cake moisture and solids recovery with non-compliance coal.

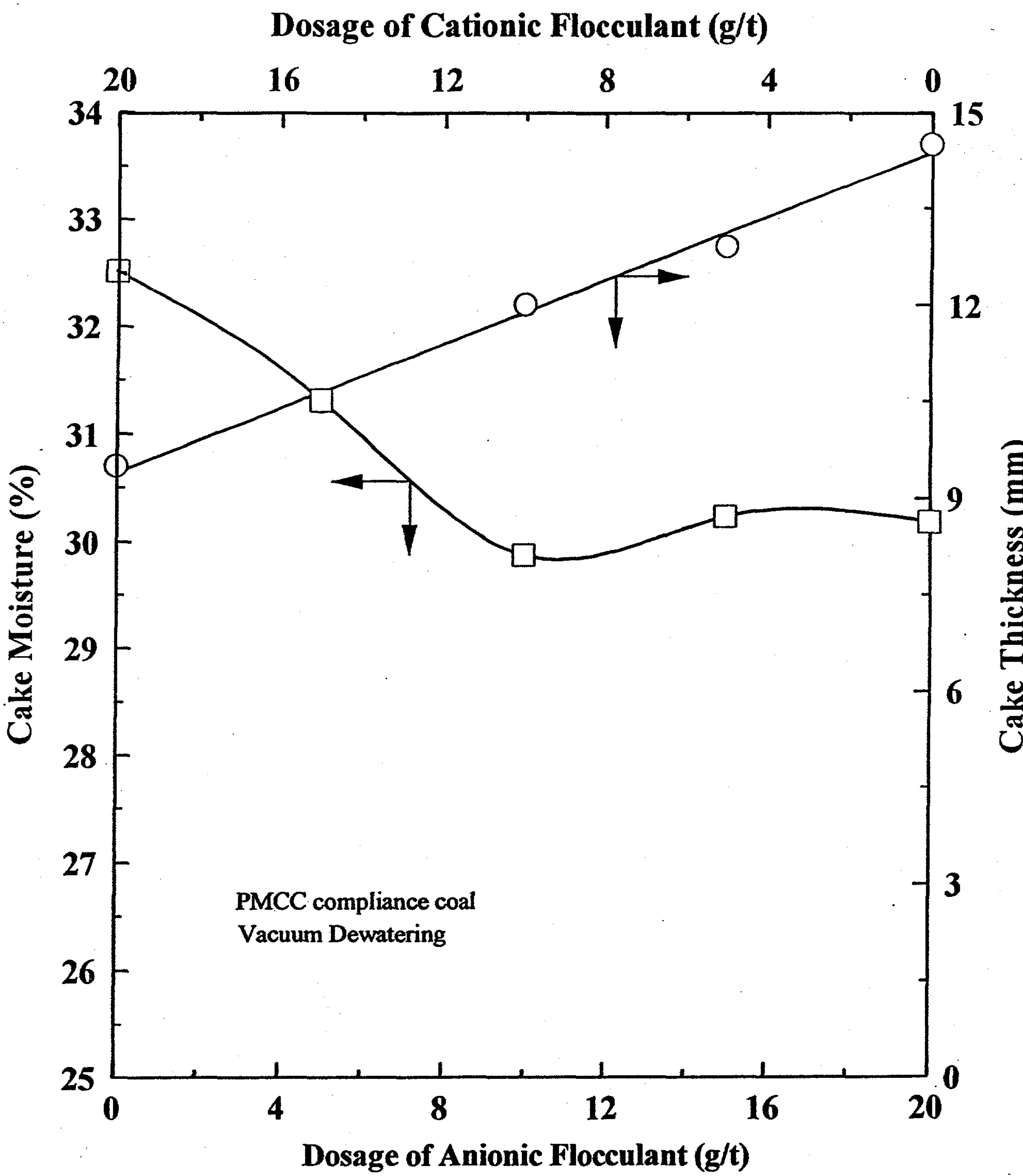


Figure 7. Effects of co-use of anionic and cationic flocculants on cake moisture and thickness in vacuum filtration with compliance coal.

weight of the anionic flocculant which produced larger flocs than cationic flocculant. However, cake moisture was not reduced with increasing the dosage of anionic flocculant. Interestingly, cationic flocculant dosage higher than 10 g/t or anionic dosage flocculant lower than 10 g/t generated higher cake moisture. The lowest cake moisture of 29.8 percent was achieved at approximately equal dosage of anionic and cationic flocculant, i.e., about 10 g/t for each. The results suggested that there is a synergetic effect between cationic and anionic flocculants that could lower cake moisture. It is possible that co-existence of anionic and cationic flocculants of opposite charge produced larger and stronger flocs due to interactions of polymer molecules.

Figure 8 shows effects of cationic flocculant addition time on cake moisture and thickness for the compliance clean coal slurry. In these tests the total conditioning time was kept constant at 5 minutes and 10 g/t anionic flocculant was added first to the slurry at zero minute. Cationic flocculant (CF) in a dosage of 10 g/t was added to the slurry at different times in different tests. The CF addition time of 2 minutes means that cationic flocculant was added 2 minutes after the conditioning process started. It seems that the best dewatering results providing filter cake with 29.4 percent moisture when cationic flocculant was added about 2 minutes later than anionic flocculant. Adding cationic flocculant too early may interfere the interaction between anionic flocculant and coal particles and adding it too late may limit its own interactions with anionic flocculant and particles.

Figure 9 shows effects of use of anionic and cationic flocculants on centrifugal dewatering of PMCC compliance coal. In these tests anionic flocculant was added first and the total dosage was maintained at 20 g/t by varying dosages of both

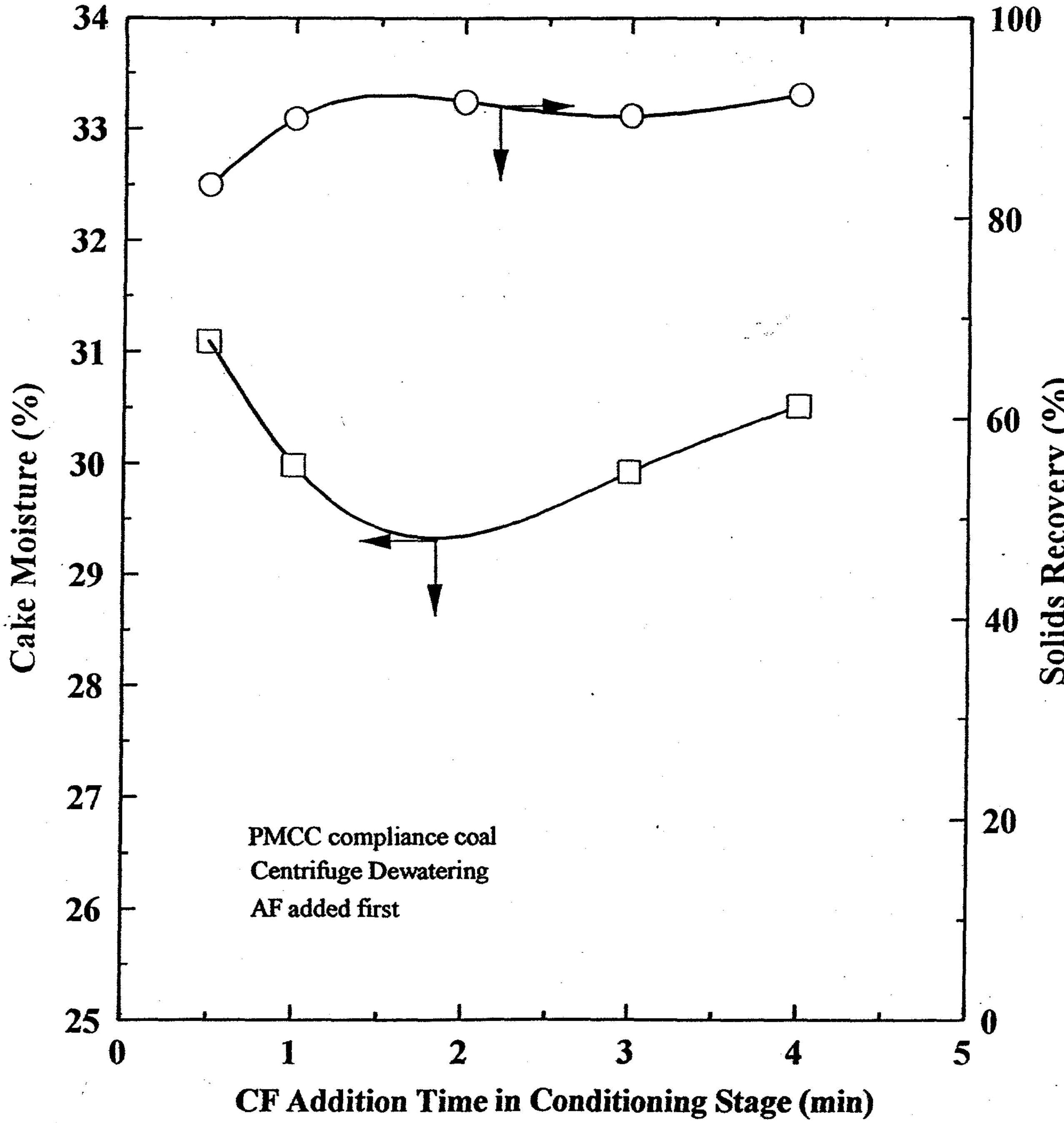


Figure 8. Effects of cationic flocculant (CF) conditioning time on cake moisture and thickness in vacuum filtration with compliance coal.

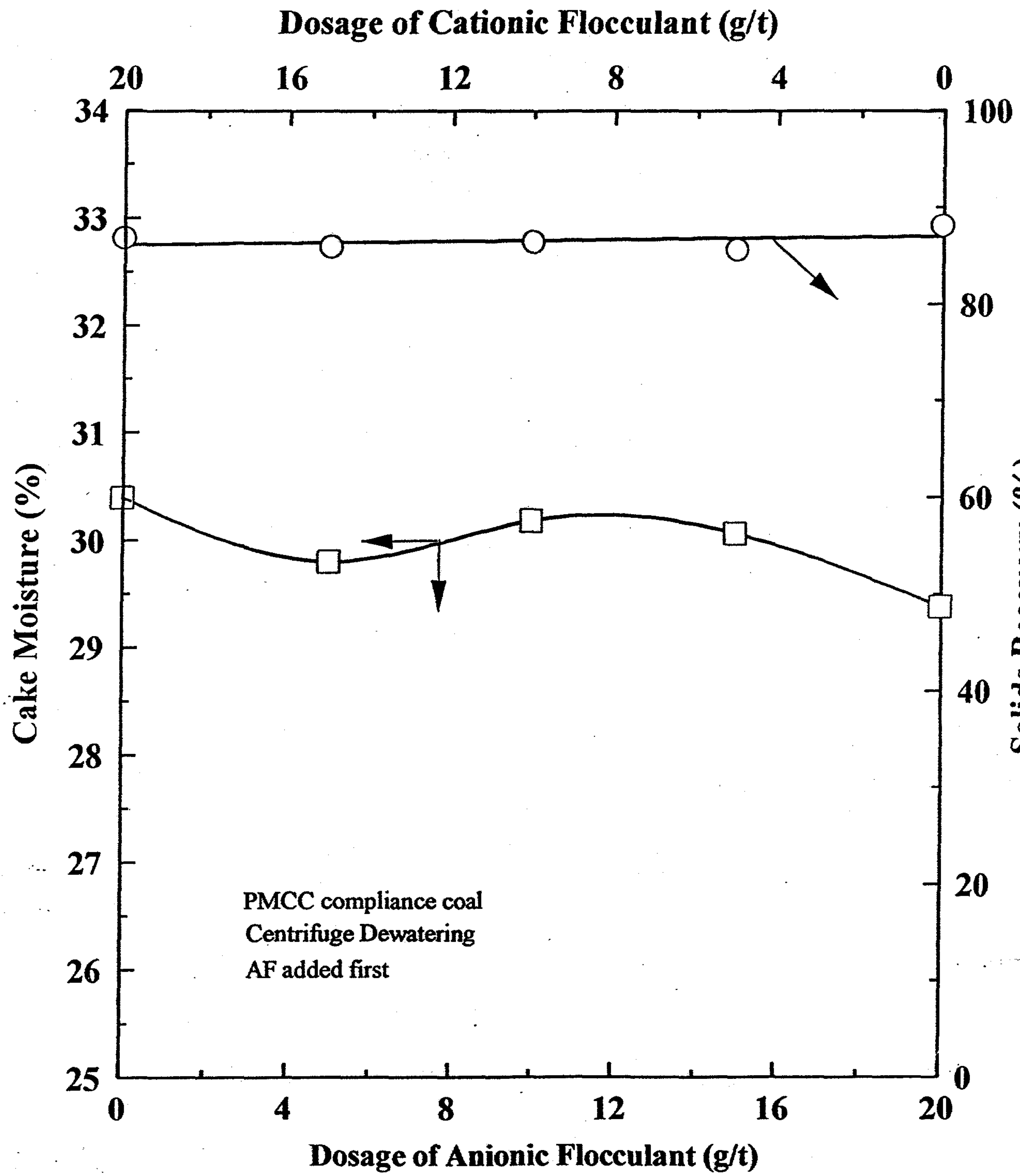


Figure 9. Effects of co-use of anionic and cationic flocculants on cake moisture and solids recovery with compliance coal. Anionic flocculant added first.

flocculants. The results indicated that use of more anionic flocculant tended to reduce cake moisture more significantly. However, use of 5 g/t anionic flocculant and 15 g/t cationic flocculant also produced low cake moisture. Solids recovery was not significantly affected by the relative amount of anionic and cationic flocculants. Compared with the results obtained in vacuum dewatering tests, less significant effects of combined use of anionic and cationic flocculants may be attributed to strong centrifugal force that tends to destroy flocs.

Figure 10 shows the centrifugal dewatering results of the compliance coal slurry with the addition of both cationic and anionic flocculants. In these tests the cationic flocculant was added first. The results indicated using 5 g/t cationic flocculant and 15 g/t anionic flocculant a filter cake with 34 percent moisture was obtained, which was much higher than that obtained when 20 g/t anionic flocculant alone was used. Increasing cationic flocculant dosage and decreasing anionic flocculant dosage lowered cake moisture using 20 g/t of cationic flocculant alone provided a filter cake with 29.5 percent moisture filter cake. There was not significant synergetic effects observed between two different flocculants that can be taken advantage of to improve centrifugal filtration of fine coal.

**Task 4. Procurement and Fabrication:**

In this program, it was decided to include evaluation of a ceramic disk filter, which was available for testing from Coal Technology Inc., Bristol, VA. The ceramic filter pilot scale unit, manufactured by Outokumpu Mintec U.S.A. Inc., weighing about 7000 lbs., was moved to the University of Kentucky Center for Applied Energy Research. The pilot scale unit could be operated with four feet diameter disk filters.

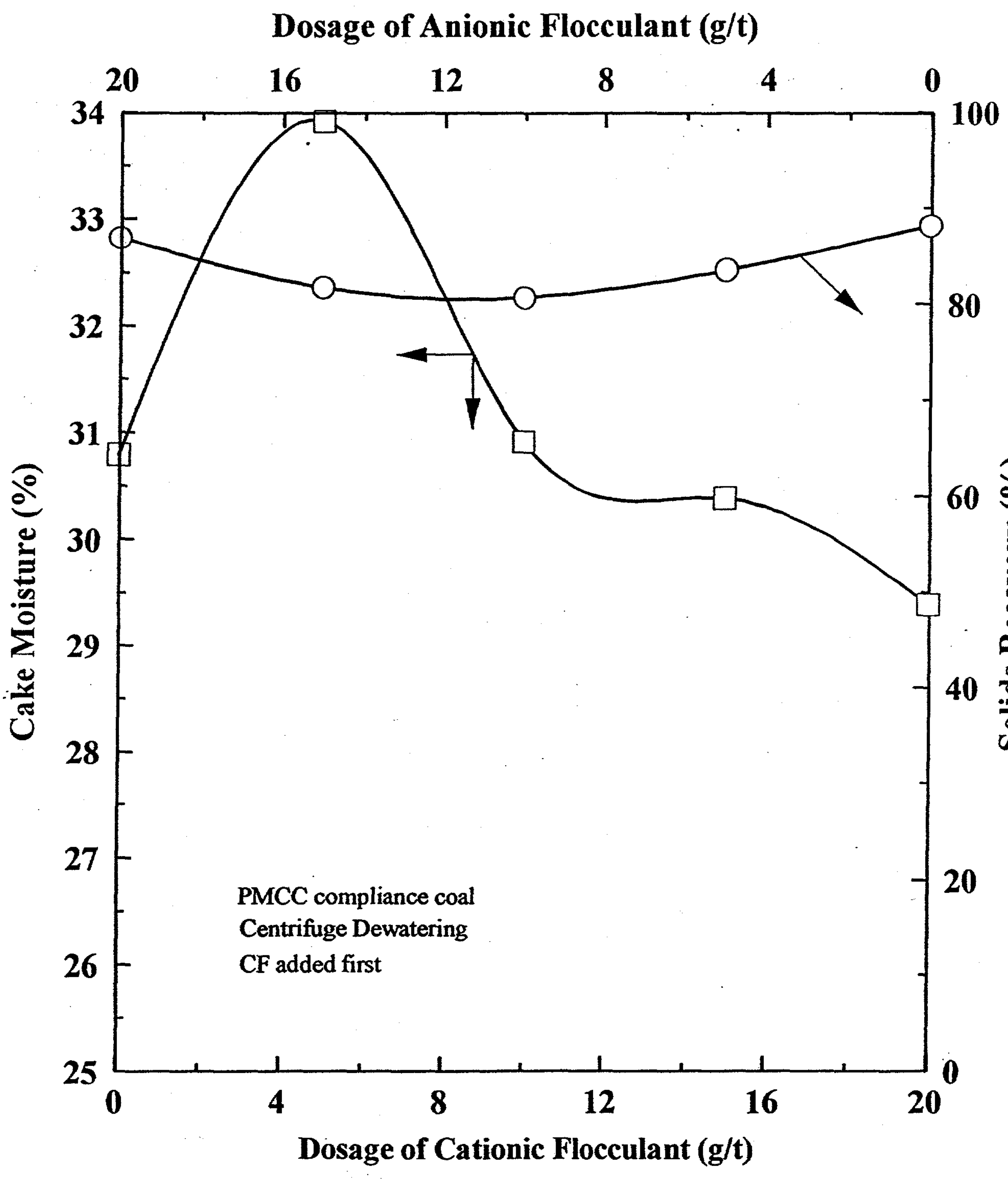


Figure 10. Effects of co-use of anionic and cationic flocculants on cake moisture and solids recovery with compliance coal. Cationic flocculant added first.

However, it has been equipped with only one ceramic disk, which should be sufficient for the pilot scale studies. The unit was installed and connected to the power.

**Task 6. Operation:**

For the pilot scale centrifuge dewatering studies, a 18-inch diameter Decanter screen bowl centrifuge was used. Figure 11 shows the centrifuge mounted on a trailer. The speed of the centrifuge was fixed at 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 to determine the amount of coal lost in them. The dewatered coal product was discharged using a small conveyor belt installed under the centrifuge. Samples of dewatered coal were collected for about one minute time period (Figure 12). The dewatered coal sample collected was weighed to determine amount of coal produced. For each set of conditions the centrifuge was operated for 15 minutes before samples were collected.

Figure 13 shows the effect of the slurry feed rate on the product moisture for the high and low sulfur clean coal slurries. It shows that for both the slurries as the feed rate increased the filter cake moisture decreased. For the high sulfur coal 21 percent moisture filter cake was obtained using 60 gpm of slurry. The higher feed rate correlates directly to solids throughput as shown in Figure 14. At 60 gpm the solids feed rate was about 1.5 tons per hour of dry solids. However, as shown in Figure 15, that the solids captured in the centrifuge decreases with increasing slurry feed rate. For the high sulfur coal slurry the solids capture was about 45 percent using 60 gpm feed rate, and for the low sulfur clean coal slurry the solids capture was only 25 percent using 43 gpm feed rate. The lower solids capture with the low sulfur clean coal slurry was due to finer size of particle in the slurry compared to the

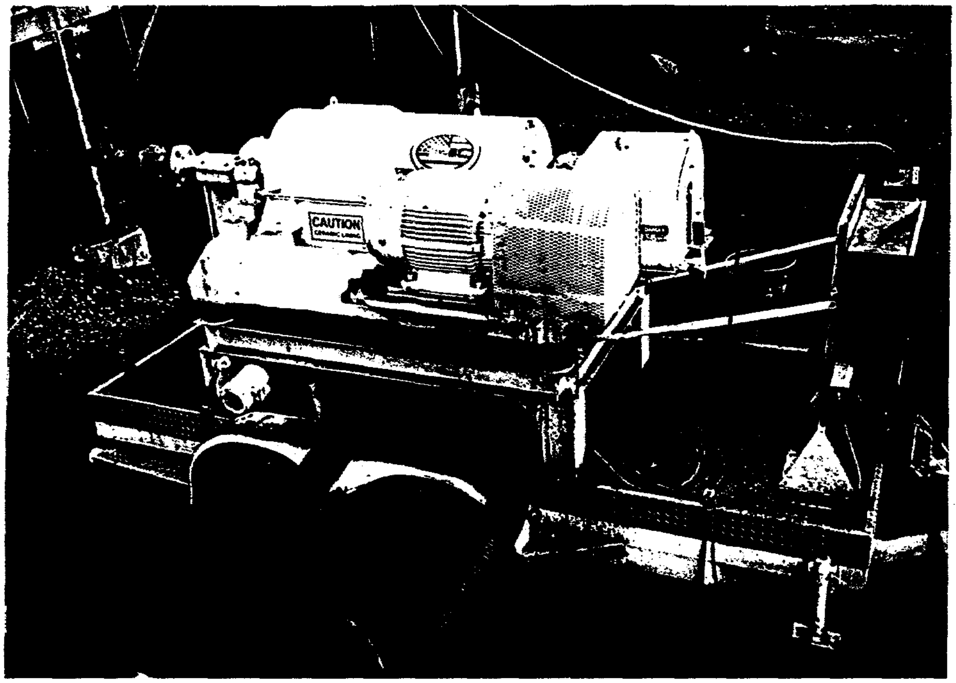


Figure 11. The 18-inch diameter Decanter Centrifuge.

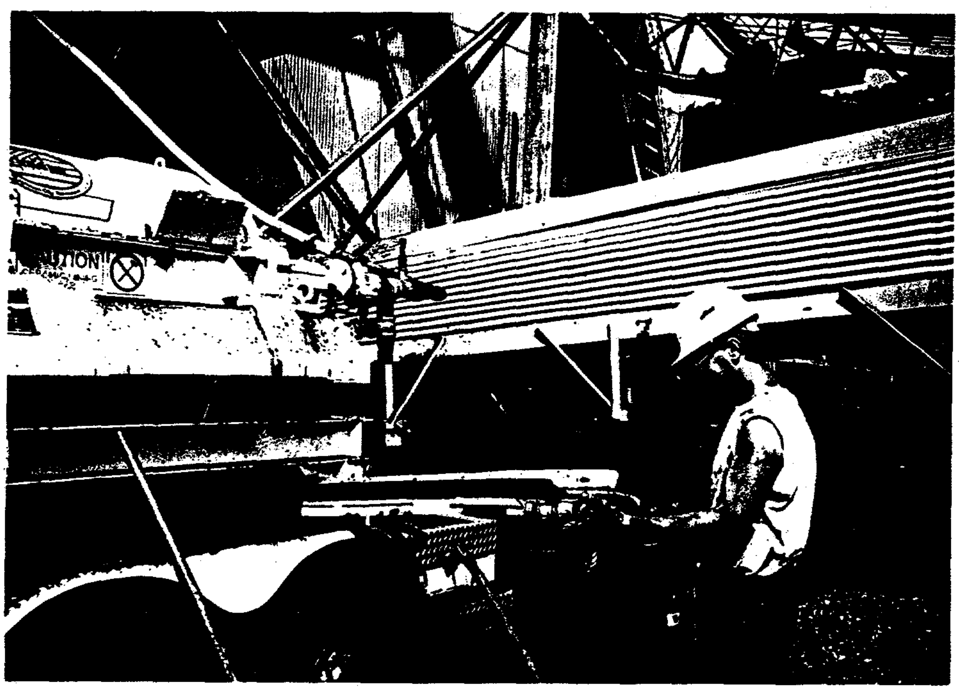

Figure 12. Dewatered coal sample collection from the Centrifuge.

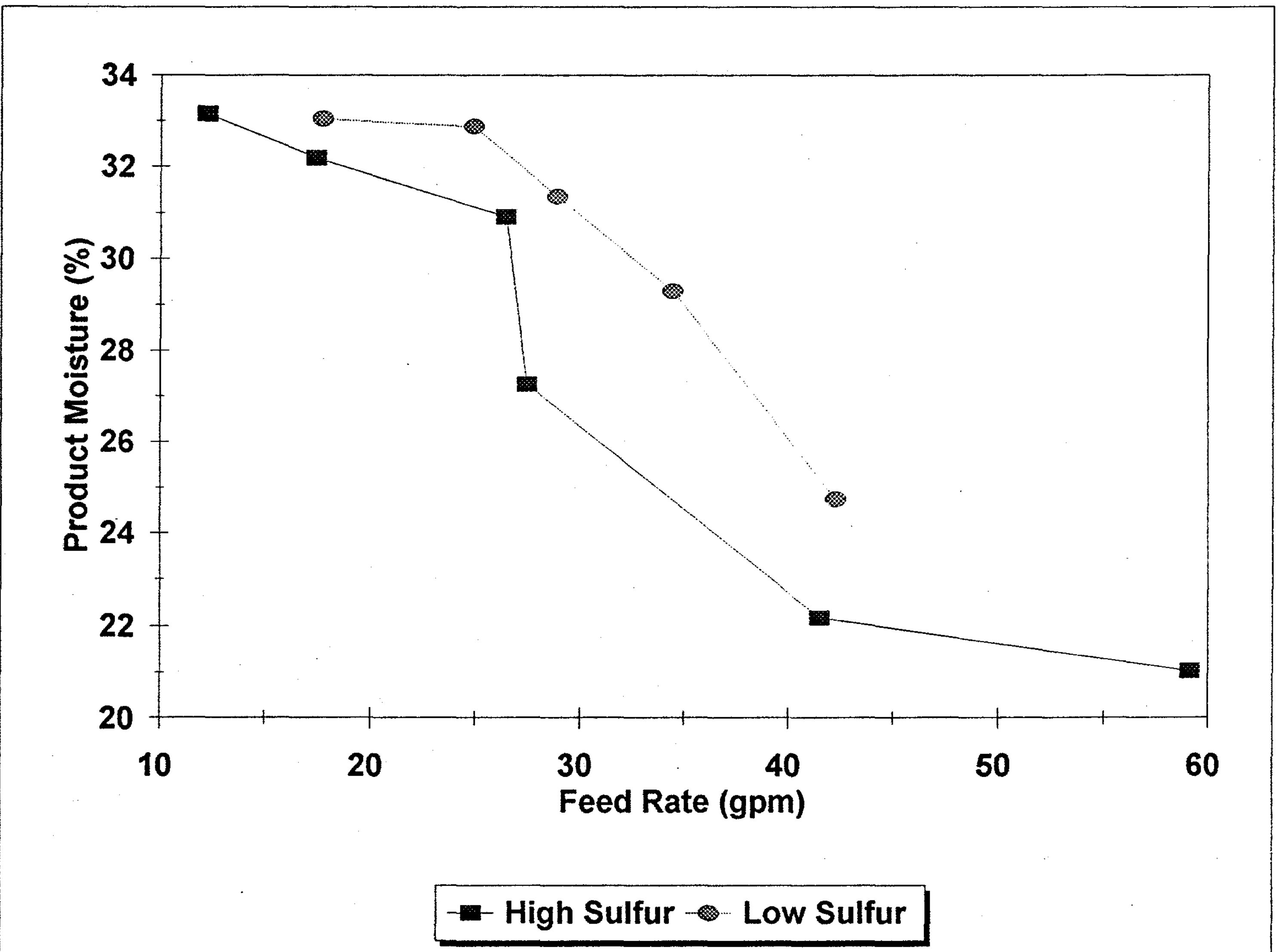


Figure 13. Effect of slurry feed rate to the centrifuge on filter cake moisture of high and low sulfur coal slurries.

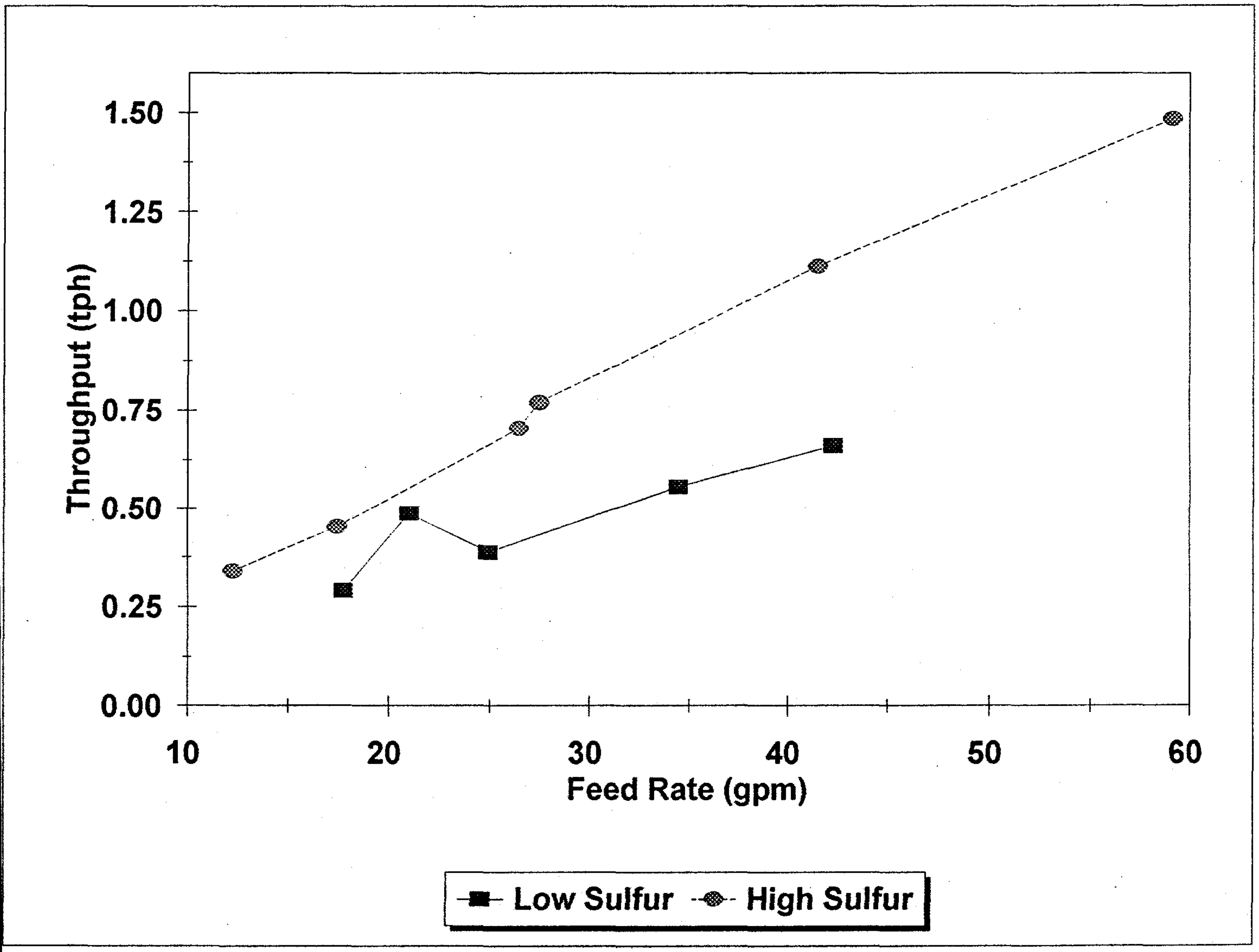


Figure 14. Correlation of slurry feed rate to solids throughput in the centrifuge for the high sulfur and low sulfur clean coal slurries.

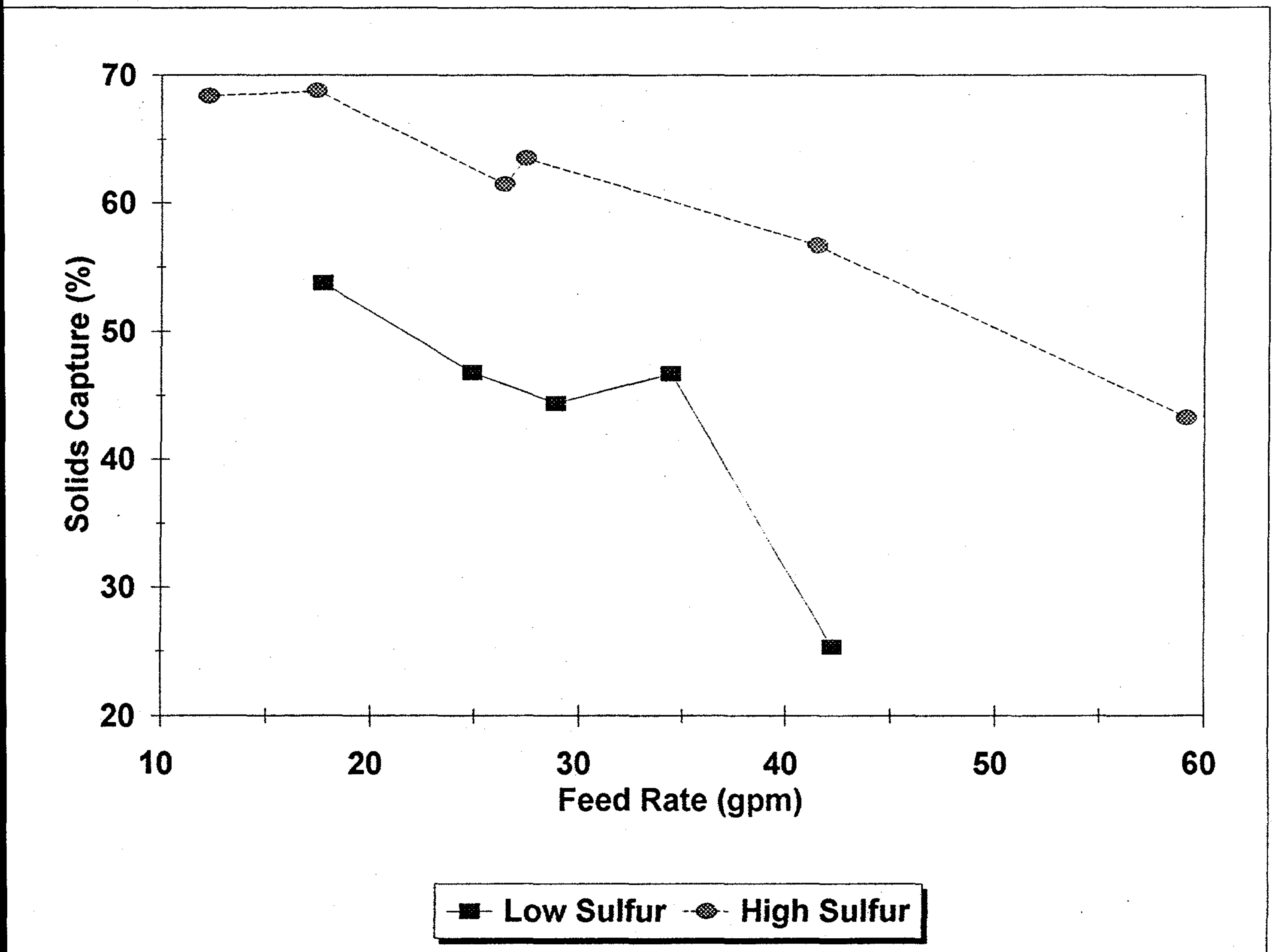


Figure 15. Effect of slurry feed rate on solids capture in the centrifuge for the low and high sulfur clean coal slurries.

little coarser size in the high sulfur clean coal slurry. Based on the above-mentioned data, a feed rate of 30 gpm slurry feed rate was selected for the study.

Flocculant Addition:

For the pilot plant studies, three different flocculants supplied by Allied Colloid Company and listed below were used:

| | | |
|---|---|---|
| Cationic flocculant | - | Procol |
| Anionic flocculant | - | Procol 156 |
| Non-Ionic flocculant | - | Procol 371 |

Figure 16 shows the effect of the cationic flocculant dosage on filter cake moisture. As expected, the flocculant was not effective in lowering the moisture content of the filter cake. For the high sulfur clean coal slurry addition of the flocculant increased the moisture. Figure 17 shows the solids capture with respect to the cationic flocculant dosage. For both the coal slurries, no significant improvement in solids capture was observed. It was anticipated that with the addition of flocculant because of the particle size increase more solids will be captured.

Figure 18 shows the effect of anionic flocculant dosage on the filter cake moisture for both the coal slurries. Note, that addition of this flocculant had no significant effect on filter cake moisture contents. Figure 19 shows effect of the anionic flocculant dosage on solids capture in the centrifuge. For the high sulfur coal, the solids capture increases with increase in flocculant dosage, reaching a maximum at 10 ppm dosage. However, for the low sulfur coal a slight decrease in solids capture was observed at 10 ppm dosage.

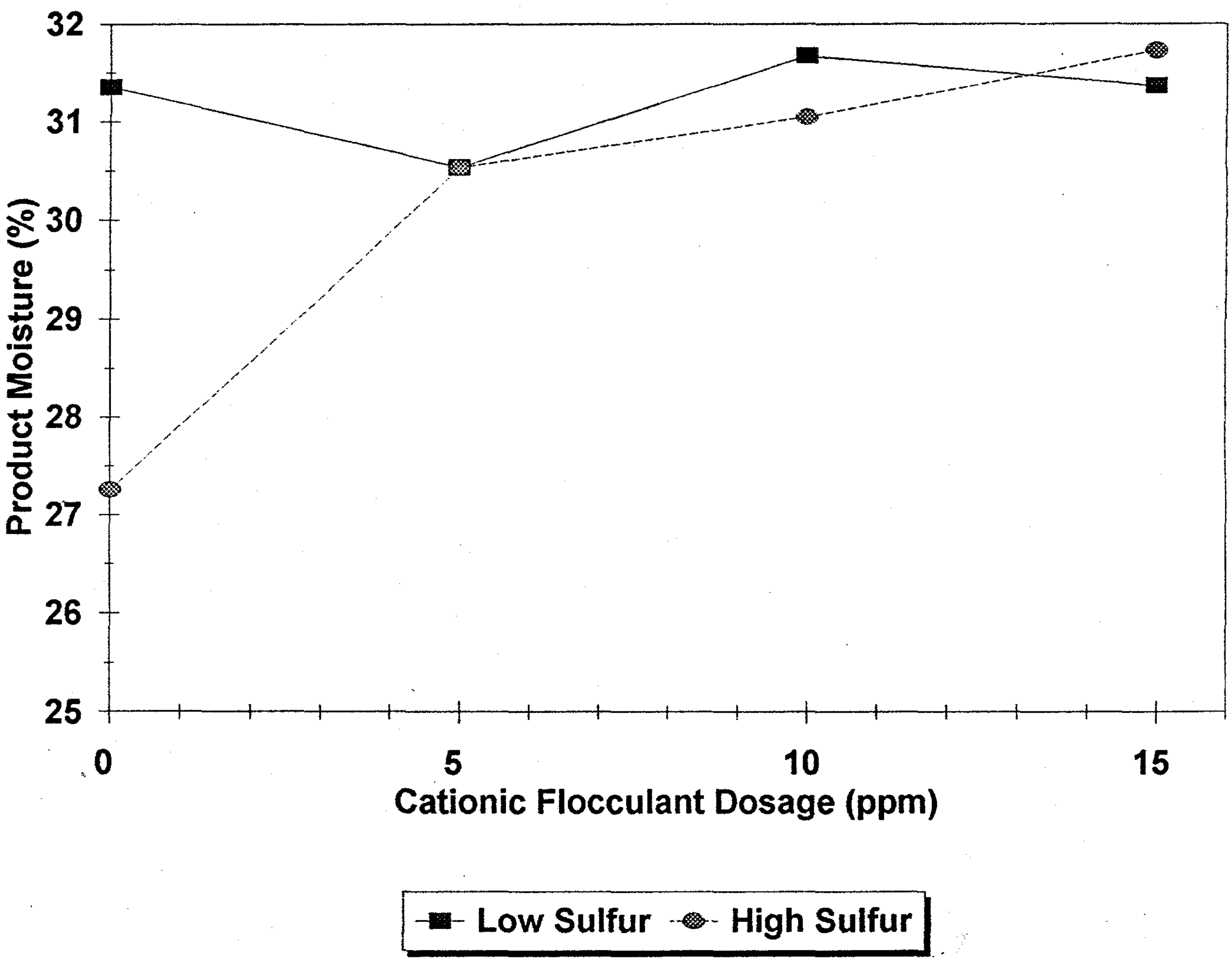


Figure 16. Effect of the cationic flocculant dosage on filter cake moisture using the centrifuge filter for the high and low sulfur clean coal slurries.

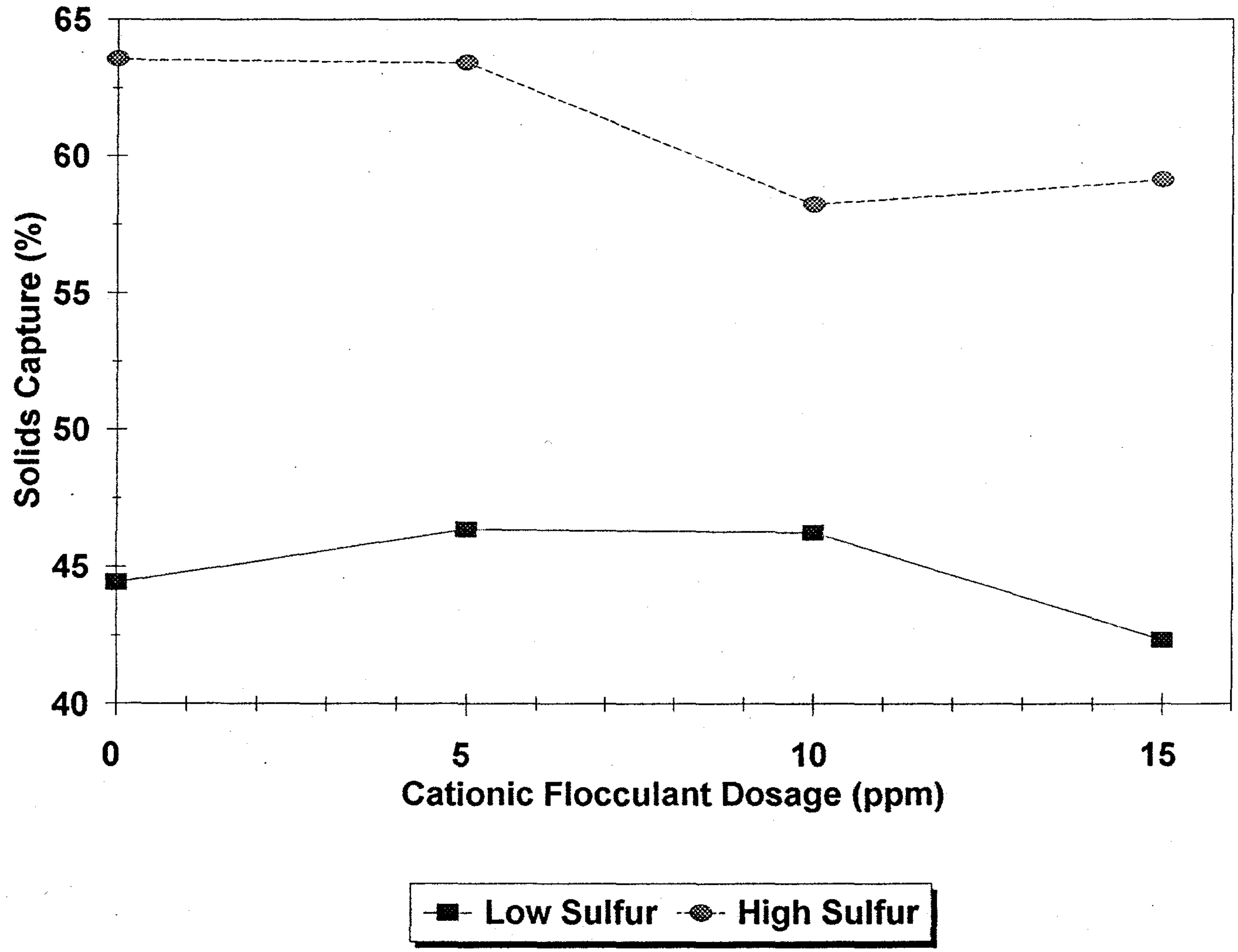


Figure 17. Effect of the cationic flocculant dosage on solids capture in the centrifuge for the high and low sulfur clean coal slurries.

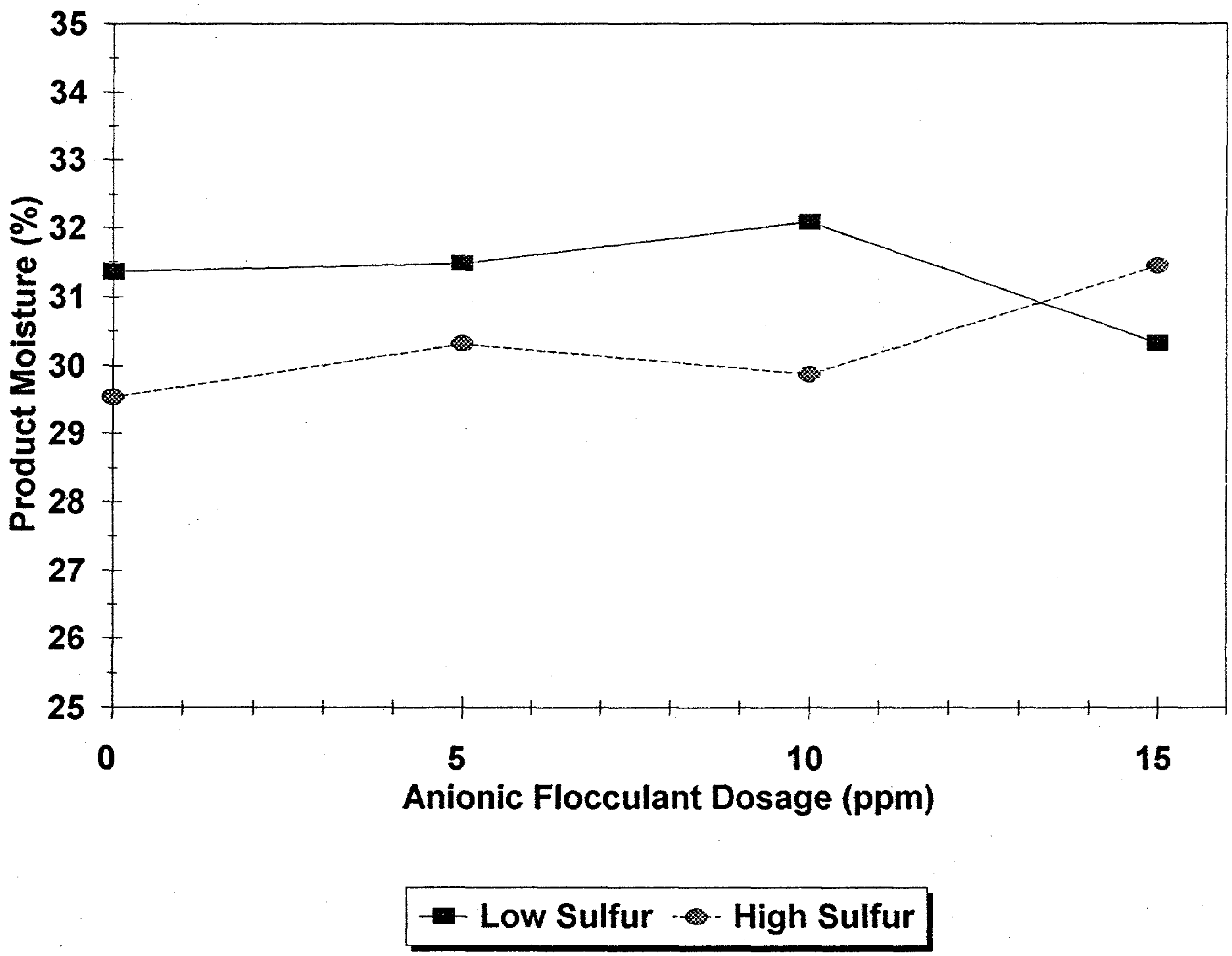


Figure 18. Effect of anionic flocculant dosage on filter cake moisture using the centrifuge for the high and low sulfur clean coal slurries.

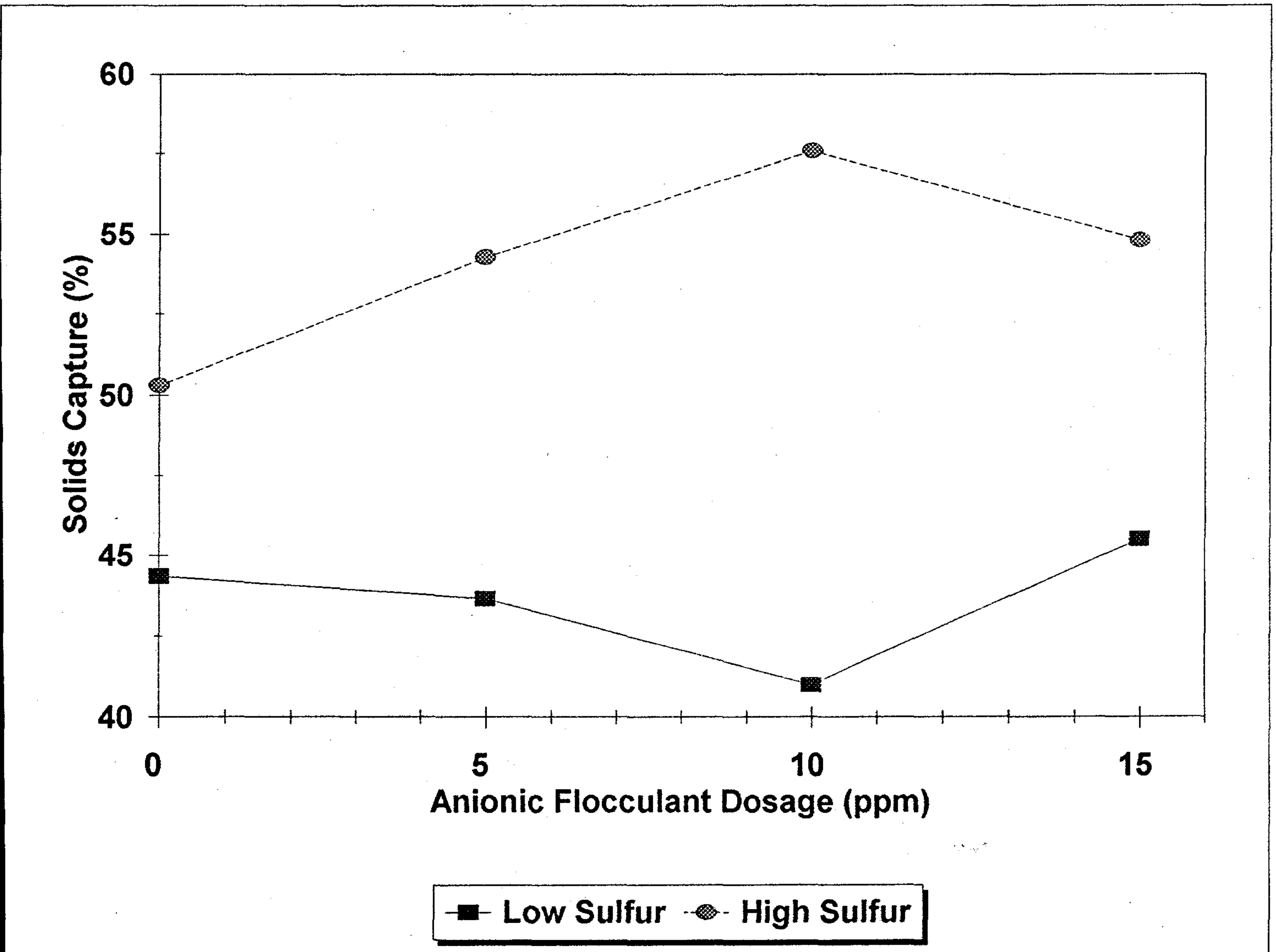


Figure 19. Effect on anionic flocculant dosage on solids captured in the centrifuge for the high and low sulfur clean coal slurries.

## CONCLUSIONS

Based on the results obtained this quarter, the following conclusions are made:

- In laboratory centrifugal dewatering studies, addition of 0.1 Kg/t of copper ions to low sulfur clean coal slurry lowered the filter cake moisture from 29.0 percent to 26.3 percent and increased solids recovery from 85.2 percent to 86.9 percent.

  For the high sulfur clean coal slurry addition of 0.2 Kg/t of copper ions reduced filter cake moisture from 30.5 percent to 29.3 percent. Using 0.5 Kg/t of copper ions reduced the cake moisture to 27.6 percent. Solids recovery in this case was about 90 percent.

- Addition of 0.3 Kg/t of aluminum ions to the low sulfur clean coal slurry provided 28 percent filter cake moisture with 80 percent recovery of solids.

  For the high sulfur clean coal slurry addition of 0.4 Kg/t of aluminum ions provided filter cake with 29.5 percent moisture with 90 percent recovery of solids.

- In vacuum dewatering, a combination of 10 g/t of anionic and 10 g/t of cationic flocculant provided filter cake with 29.7 percent moisture for the low sulfur clean coal slurry.
- In centrifugal dewatering studies, addition of combination of flocculants did not provide any lowering of filter cake moisture.
- In pilot scale screen bowl centrifuge dewatering studies for the high sulfur clean coal slurry, a high feed rate of 60 gpm provided filter cake with 21 percent moisture; however, the solids captured were about 45 percent. For

both the clean coal slurries a feed rate of 30 gpm was found to be ideal providing about 65 percent solids capture.

- Addition of anionic flocculant had no significant effect on filter cake moisture content. However, solids captured increase at 10 ppm dosage.
- Addition of cationic flocculant was also not effective in lowering the moisture content of the filter cake.

For both the coal slurries, no improvement in solids captured was observed.

## ACTIVITIES FOR NEXT QUARTER

More laboratory centrifugal dewatering tests will be conducted in the next quarter. Systematic investigation on dosage, conditioning time, conditioning method of different flocculants will be performed with both PMCC compliance and non-compliance coal. Flocculants to be investigated include two types of hydrophilic flocculants, two types of hydrophobic flocculants. In addition, synergetic effects between two metal ions and three surfactants will be studied.

The pilot scale centrifuge dewatering tests will be completed with surfactants. A series of tests will be conducted using the DOE/PETC Granuflow Process.