Project Title: Improvements in Fundamentals of Foam and Column Separation of Fine Coals

ICCI Project Number: 87/1.1D-3

Principal Investigator: Professor John C. Slattery, Department of Chemical Engineering, Northwestern University, Evanston, Illinois 60208

Other Investigators: Professor Joseph A. FitzPatrick, Department of Civil Engineering, Northwestern University, Evanston, Illinois 60208

Project Monitor: Dr. John M. Lytle, CRSC

ABSTRACT

Two related tasks have been proposed that are relevant to the design of flotation processes for the separation of fine and ultrafine Illinois coal from pyrite and ash.

We have completed initial design algorithms for both the staged flotation column and the packed flotation column. The WEMCO/Leeds column may operate as a limiting case of the cleaning section of a staged flotation column. There are no published data for either the WEMCO/Leeds column or a packed flotation column that are sufficiently complete to allow a test of these algorithms.

On the basis of sample computations for staged flotation columns, we recommend the use of reflux, the return of a portion of the purified product to the column with the washing solution. Product grade is improved at the expense of more stages in the scavenging section of the column required to maintain recovery and a larger column diameter required to accommodate the increased flow rates in the column. The results are expected to be qualitatively the same for open and packed columns.

Given the manpower constraints of this project, we are focusing our experimental study on packed flotation columns. A 4" prototype column with no reflux has been constructed and operated with no unexpected instabilities. This column is currently being revised to minimize wall effects and to permit the use of reflux. We expect this revised column to be in operation during the first quarter of 1988-89.

Pages 5 through 25 contain proprietary information.
EXECUTIVE SUMMARY

We have proposed two tasks that are relevant to the design of flotation processes for improved separation of pyrite and ash from Illinois coals.

TASK 1: A NEW APPROACH TO THE DESIGN OF FLOTATION COLUMNS

We have completed initial design algorithms for both staged flotation columns and packed flotation columns (see Appendices A and B of our third Technical Report for 1987-88). A revised paper describing our algorithm for staged column design is currently being prepared and will be submitted for publication shortly. A revised paper describing our algorithm for packed column design will be submitted for publication with the results of our first experimental study.

The WEMCO/Leeds column may operate as a limiting case of the cleaning section of a staged flotation column. To our knowledge, there are no other flotation equipment that corresponds to a staged flotation column.

There are no data from packed flotation columns that have been published which are sufficiently complete to allow a test of this algorithm. We are looking forward to being able to study our own packed column in 1988-89.

An interesting aspect of our design algorithms for staged and packed flotation columns is the use of reflux, the return of a portion of the purified product to the top of the column mixed with the washing solution. This does not appear to have been previously suggested in the context of flotation. It is common practice in the context of distillation, liquid-liquid extraction, and gas adsorption.

Reflux appears to be beneficial for improving product grade or purity for a given number of stages in the cleaning section. Additional stages in the scavenging section are required to maintain recovery as reflux is increased.

For a given reagent system, an optimal design of a staged flotation column must be based upon a design algorithm such as ours as well as experimental data, in order to balance the conflicting effects of the number of stages, the excess interfacial area available for flotation, the efficiency of washing, and the reflux ratio upon capital costs as well as product grade and recovery. As the number of stages is increased, product grade and recovery are increased, but capital costs also increase. As the excess interfacial area available for flotation in increased, product recovery increases, but product grade decreases and both capital and operating costs can be expected to increase. As the efficiency of washing increases, product grade increases, but we increased capital expenses may result from increased attention to tray design. As the reflux ratio increases, product grade increases, but capital and operating costs also increase with more stages in the scavenging section required to maintain recovery, with a larger column...
diameter required to handle the increased flow of pulp down the column, and larger volumes of fluid circulated.

Our expectation is that reflux should be used with open and packed columns as well as staged columns. The effects should be qualitatively the same.

The implication of our staged column computations is that the optimal design of open columns and packed columns, particularly when reflux is employed, must also be based upon design algorithms in addition to experimental data. The same complications observed with the design of staged flotation columns can be expected with open and packed columns as well.

TASK 2: EXPERIMENTAL STUDY OF PACKED FLOTATION COLUMNS

Given the manpower constraints of this project, we are focusing our experimental study on packed flotation columns.

A prototype 4" packed column with no reflux has been constructed and operated. No unexpected instabilities were observed.

This column is currently being revised to minimize wall effects and to permit the use of reflux. We expect to have it in operation during the first quarter of 1988-89.
OBJECTIVES

The objective of this project is to improve our fundamental understanding of flotation processes, in order that they may be designed and operated to achieve maximum cleaning of fine and ultrafine Illinois coals. We have sought both to enhance our understanding and modeling of governing mechanisms and to take advantage of proven concepts for the design of open, packed, and staged columns.

This project consists of two complementary tasks that are relevant to the design of flotation columns for the separation of coal from undesirable minerals.

TASK 1: A NEW APPROACH TO THE DESIGN OF FLOTATION COLUMNS

Our first objective is to extend the established methods for the design of foam separation columns and of distillation columns to the design, scale-up, and control of open, packed, and staged flotation columns.

TASK 2: EXPERIMENTAL STUDY OF PACKED FLOTATION COLUMNS

Our second objective is to construct a small scale packed flotation column. A design algorithm for a packed column must be based upon experimental data from an operating column.

INTRODUCTION AND BACKGROUND

An extensive introduction and review is given in our annual report for 1987. Detailed introductions to staged flotation columns and to packed flotation columns are given in Appendices A and B of our third Technical Report for 1987-88. Papers based upon these appendices are in preparation.

PROCEDURES

Our approach to these tasks is as follows.

TASK 1: A NEW APPROACH TO THE DESIGN OF FLOTATION COLUMNS

Our approach to the design of an open, staged, or packed column is to develop an algorithms, which we can test with data from operating columns. For staged and open columns, we will rely upon data from the literature or from outside sources. We intend to construct and test our own packed column.