MASTER

SEPARATION OF PARTICLES FROM COAL-DERIVED LIQUIDS VIA SURFACE CHARGE PROPERTIES

Quarterly Progress Report
for the Period
September 15, 1977-December 15, 1977

by

D. Gidaspow, D. T. Wasan and C. Lee

Illinois Institute of Technology
Department of Chemical Engineering
IIT Center
Chicago, IL 60616

950 9142

Date Published:

Prepared for the Department of Energy
Under Contract No. FE-4324

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

REDA

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Objective and Scope of Work

Objective

The objective of this program is to develop an improved method of separation of coal-derived particles resulting from various liquefaction and solvent refined coal processes:

1. To measure electrophoretic mobility and streaming potential of coal and ash particles for real solid-liquid colloidal suspensions to be obtained from operating coal conversion plants.
2. To measure the settling rate of particles in coal-derived liquids and investigate various chemical additives to improve flocculation-agglomeration rates.
3. To determine the feasibility of separating micron size particles from synthetic oil mixtures as well as from "real" coal-derived liquids by the application of an electric field in a device such as the proposed cross-flow electrofilter.
4. To determine filtration rates from synthetic as well as real coal-liquid suspensions with a precoat filter at temperatures up to 650°F and pressures up to 1000 psi.

Scope of Work

The contractor shall provide the personnel, apparatus, and materials and other items necessary for the investigation of an improved method for the separation of coal-derived particles resulting from various liquefaction and solvent refined coal processes as described in Tasks I through VII below.

Task I.

A. Characterization of Coal-Derived Particles in Synthetic Oil-Particles Mixtures.

- a. consider different size particles ranging from 0 - 15 microns.
- b. particles of different chemical compositions, including oxides of alumina, silica, iron, etc., with and without carbon.
- c. various concentrations of particles: a typical coal liquefaction product will have solids content of from about 2 to 15 percent. The ash content of the clarified extract is about 0.2 weight percent.
- d. various coal-derived products including tetralin, anthracene, cresol, and dodecane.
- e. repeat of steps (a) through (d) at temperatures from ambient to 650°F under pressure in the presence of hydrogen to 1000 psi. Conduct at least 6 tests in this step.

B. Characterization of Filter Media Particles in Organic Liquid Suspension

Such characterization shall be made in terms of zeta potential and surface charges.

Task II. Collection and Supplemental Measurement of Selected Physical Data on "Real" Coal-Derived Liquids.

- A. A critical literature study shall be made to assemble published data and information on coal-derived liquid properties, having application to the present project.

Included in this survey will be available data on liquids produced in the H-Coal, Synthoil, and SRC processes.

- B. The collection of physical data assembled from the literature shall be supplemented, where deemed necessary, by actual physical measurements, using standard techniques. Measurements will be made on liquids resulting from the processes listed in II(A), above.

Task III. Modification of Surface Charge Characteristics of Both Synthesized and "Real" Coal-Derived Liquid-Solid Suspensions.

Surface charge characteristics of particles suspended in synthetic and coal-derived oils shall be modified by addition of small quantities of selected surfactants, both polymeric and non-polymeric (oleic acid, stearic acid, humic acid, etc.).

Task IV. Evaluation of the Stability of Suspensions of Particles in Coal-Derived Liquids.

- A. Settling times in batch systems shall be measured and correlated with Zeta potential measurements using methods of non-equilibrium thermodynamics. Onsager-type friction coefficients will be calculated in terms of the electrical properties of the suspensions. H-Coal, Synthoil, and SRC liquids will be studied.
- B. To establish flocculation-agglomeration rates in non-aqueous media, various chemical additives, and solid particles such as copper oleate, span 40, stearic acid,

aerosol OT, methyl alcohol shall be tried to establish the flocculation-agglomeration rates of coal particles in synthetic fuel oil and solvent refined coal processes.

Task V. Feasibility and Design of Laboratory Cross Flow Electrofilter for Particle Fluid Separation from Synthetic as Well as "Real" Suspensions in Coal-Derived Liquids.

(At the end of the first nine months of the first year of research, a summary progress report on Tasks I-V will be submitted to ERDA to serve as a basis for deciding on the justification of funding the second year of the project.)

Task VI. Construction, Testing, and Determination of the Comparative Merits of the Cross-Flow Electrofiltration Particle-Fluid Separation Technique.

- A. Construct a cross-flow electrofilter using materials such as porous carbon.
- B. Test several different configurations to determine an optimum design for large scale use.
- C. Compare this optimum design with the other particle-fluid separation techniques such as gravity settlers, hydroclones, precoat filters, etc.

Task VII. Construction and Testing of a High-Temperature, High-Pressure Precoat Filtration Apparatus

An apparatus shall be built to filter coal-derived particles resulting from various liquefaction and solvent refined coal processes. The filtration parameters will be correlated in terms of the basic measurements on Zeta potential.

Summary of Progress to Date

Preliminary data obtained under proposed Tasks I, III and V has shown us that our original concept of the proposed novel separation method "Cross Flow Electrofiltration" was feasible. We therefore proceeded to the design of the cross flow electrofilter. The data used for this design is reported in our attached paper.

"Settling of Non-Aqueous Liquid Slurries with a High Voltage Electric Field" by C. Lee, D. Gidaspo and D. Wasan. Pages 34 to 37 refer to coal derived slurries. While data obtained so far is meager, it was sufficient for design and construction of our electrofilter.

The cross-flow electrofilter was tested with synthetic (not yet coal derived) slurries. The performance was so good that we expect to report data obtained with a coal derived slurry in the next report.

In conclusion, we believe we have invented a novel method of separating particles from coal derived slurries. We hope to present data in the next quarterly report.

Detailed Description of Technical Progress

- A. Progress to date on Tasks I, III and IV is given in detail in the attached paper.
- B. The description of the cross flow electrofilter and tests conducted follows.

B. CROSS FLOW ELECTROFILTER

Description of Filtration System:

The electrofiltration system consists of a feed pump unit, a high DC power supply unit and of a tubular electrofilter (Figure A). The electrofilter was constructed of a porous stainless steel tube with a 5 cm pore opening. The dimensions of the tube are 7/8" ID x 1.3" OD x 12"L. (See Fig. B1) This porous cylinder is used as an electrode. A platinum rod passing through the center of the tube as the second electrode. The slurry is pumped to flow through the central filter tube. The clear liquid is pushed into the annular space of the outer shell. The filtrate is collected from the upper end of tube. The slurry pump unit (See Figure C) is composed of two pistons seated in the cylinders, a worm, worm gear units, change gears, a synchronous motor and an automatic reversing switch box. The power is transmitted from the motor to the change gear. The reciprocating speed is adjusted by replacing the gears in the change gear box. This slurry pump has the capacity of delivering pressures of about 1000 psi.

The power supply unit was built from high d voltage capacitor and has the capacity of 15,000 DC volt supply.

Experimental Data

Figure D shows the results of our recent experimental test of the electrofilter using the system tetralin with α -alumina particles of a size of 0.3 to 2 μm . It shows that the rate of filtration is dependent on the pressure difference across the filter wall, and on the electric field strength. As is shown, the filtration rate increases, as Δp is increases.

Then for a given Δp , the rate of filtration reaches an asymptotic value.

It was observed that the particles were plugging the filter pores to give no clear filtrate when the polarity of the electrodes was reversed. By reversing it again, the plugged pores were cleared to give clear permeate. This indicates the feasibility of pore-plugging control by applying an electric field.

In Figure D, the solid line indicates the boundary of the clear filtrate and the dotted line the electrophoretic velocity of the particles obtained independently using the Zeta meter.

CONCLUSIONS

A novel device called a cross flow electrofilter was constructed and tested with a synthetic slurry. Preliminary data indicate that it should be an alternate device for removing particles from coal derived slurries and be able to compete with pressure precoat filters and hydroclones in its ability to remove particles from liquefaction and solvent refined coal process streams.

PROJECT PLAN & PROGRESS REPORT

As of Date: September 15, 1977

EVAL.	TASK NO.	SCHEDULE	SEPT.	OCT.	NOV.	DEC.
	I	Characterization of Coal Derived Particles in Synthetic Oil-Particle Mixtures
	II	Physical Data on Coal Derived Liquids				
	III	Modification of Surface Charge Characteristics
	IV	Stability of Suspensions of Particles in Coal Derived Liquids
	V	Design of Cross Flow Electrofilter	Task Completed
	VI	Construction, Testing and Determination of Merits of Cross Flow Electrofilter

Legend

Progress

Early Start

Fig. A Flow Diagram of Cross Flow Electro-Filtration

FIG. B ELECTRO-FILTER

Fig. C CONSTANT VOLUME PUMP

System : Tetralin + α - Al_2O_3 (0.3 ~ 2 μm)

Mobility of Particles : 0.05 ($\mu\text{m}/\text{s}/\text{V}/\text{cm}$)

Filter Pore size : 5 (μm)

Feed Rate : 4.762 (cm^3/s)

Particle Cont. : 1 % by wt.

Conductance : 1.25×10^{-7} (mho)

Fig. D. Cross Flow Electrofiltration Data