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POC-Scale Testing of Oil Agglomeration Techniques
and Equipment for Fine Coal Processing

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Table of Contents

	Page
1.0 Introduction	1
2.0 Summary of the Work Completed and in Progress	1
2.1 Work Plan for Continuous Bench-scale Testing (Subtask 2.4) ...	1
2.2 Preliminary Engineering and Design of POC Equipment (Task 3)	2
2.3 Batch-Scale Testing (Subtask 4.2)	5
2.3.1 Batch Testing of PBS Coal Fines and Results Evaluation ..	5
2.3.2 Batch Testing of CBDC Coal	10
3.0 Future Work	11

1.0 Introduction

This report covers the technical progress achieved from January 1, 1996 - March 31, 1996, on the POC-Scale Testing of Oil Agglomeration Techniques and Equipment for Fine Coal Processing, under PETC/DOE Contract No. DE-AC22-95PCPT 152.

The objective of this project is to develop and demonstrate a Proof-of-Concept (POC) scale oil agglomeration technology capable of increasing the recovery and improving the quality of fine coal streams. Two distinct agglomeration devices will be tested, namely, a conventional high shear mixer and a tubular (jet) processor.

To meet the overall objective an 11 task work plan has been designed. The work will range from batch and continuous bench-scale testing through the design, commissioning and field testing of POC-scale agglomeration equipment.

During the reporting period there were activities under the following tasks:

- Task 1 - Project Planning and Management
- Task 2 - Host Site Selection and Plan Formulation
- Task 3 - Preliminary Engineering and Design of POC Equipment
- Task 4 - Coal Characterization and Laboratory (Batch) and Bench-Scale Testing
- Task 9 - Process Evaluation

The work on the remaining tasks is scheduled for the next months.

2.0 Summary of Work Completed and in Progress

2.1 Work Plan for Continuous Bench-Scale Testing (Subtask 2.4)

During the reporting period a test plant for continuous bench-scale testing was developed and sent to DOE Project Manager for revision. The content of the plan covered the following topics:

- materials and equipment
- testing procedure

- high-shear mixer testing
- jet processor testing
- schedule
- quality assurance/quality control to be obeyed during testing

The DOE's suggestion/comments regarding more indepth descriptions of the proposed test matrices were included in the revised test plan and re-submitted to DOE.

2.2 Preliminary Engineering and Design of POC Equipment (Task 3)

During the reporting period the work on preliminary engineering and design of agglomeration equipment was completed.

Overall objective of this task was to develop a preliminary conceptual design for a 3 t/h system for recovery and cleanup of coal fines from cyclone overflow stream of the Shade Creek preparation plant owned and operated by PBS Coals Inc.

Specific objectives of the preliminary design were:

- determine the size of a high-shear agitator and jet processor for the 3 t/h system
- develop the 3 t/h system design with two processing options (high-shear agitator or jet processor)

Preliminary engineering and design of POC-scale equipment included the following:

- a) design criteria
- b) conceptual flowsheet
- c) material balance
- d) high-shear mixer design
- e) jet processor design
- f) plant layout
- g) list of equipment instrumentation and control system

High-shear Mixer

The POC-scale high-shear mixer is shown in Figure 1. Agitation in the mixer is provided by a four flat blade turbine impeller. Mixer is equipped with the 40 kW motor. Four vertical baffles inside the tank intensify slurry mixing. The power demand versus rotational speed (RPM) is shown in Table 1. The mixer operates at ambient pressure and temperature. The mixer is closed and sealed to prevent any emissions. The top of the mixer is equipped with a valve to release a possible pressure build-up.

Dimensions and technical data of the PBS-3 high-shear mixer are as follows:

- Total volume 2.7 m³
- Working volume 2.5 m³
- Tank diameter 1.34 m
- Tank height 2.00 m
- Impeller diameter 635 mm
- Distance of impeller from the bottom 425 mm
- Motor power 40 kW
- RPM up to 280
- Coal slurry flow rate 83 m³/h

Table 1
Power demand for the PBS-3 slurry mixer

RPM	80	100	120	140	160	180	200	220	240	260	280
Power, kW	1.14	2.22	3.84	6.10	9.1	13.0	17.8	23.7	30.7	39.0	48.8
Sp. Power, kW/m ³	0.433	0.847	1.46	2.32	3.47	4.94	6.77	9.01	11.7	14.9	18.6

Volume	2.7 m ³
Operational Volume	2.5 m ³
Tank Diameter	1.34 m
Tank Height	2.0 m
Motor Power	40 kW
Max. rpm	280

Figure 1. High-shear mixer with a four flat-blade turbine impeller

Jet Processor

The two-stage jet processor for the 3 t/h system for fine coal recovery and cleanup is shown in Figure 2.

In the first stage, the oil emulsification takes place and oil-in-water emulsion is formed. In the second stage, a jet of oil-in-water emulsion is intensively mixed with coal slurry, depositing the oil droplets on coal particle surfaces (conditioning and generating microagglomerates). The microagglomerates are recovered by froth flotation.

The two-stage jet processor consist of a water tank with high pressure water pump, an oil tank equipped with measuring high pressure pump, emulsifying orifice and injection nozzle. The injection nozzle is inserted into the coal slurry line.

Compared to the high-shear mixer, application of the jet processor should result in:

- shortening the time required for coal surface conditioning
- lowering the energy consumption
- reducing space requirements
- savings in capital and operating cost

2.3 Batch-Scale Testing (Subtask 4.2)

2.3.1 Batch Testing of PBS Coal Fines and Results Evaluation

The major objective of batch testing was to demonstrate that the Aglofloat process can perform well with PBS coal fines and produce clean coal at high yields. Specific objectives were as follows:

- select bridging oil and its concentration
- evaluate effect of solids concentration on process performance, and
- compare the Aglofloat process performance versus standard froth flotation

Selected results from batch evaluation are presented in Tables 2 and 3.

Figure 2. Diagram of the jet processor for the 3 t/h system

Table 2 presents the results of Aglofloat testing performed with diesel oil as a bridging liquid, while in Table 3 the results obtained using blends of diesel/Fuel No. 6 oil are shown. Analysis of the test results show that:

- both bridging liquids perform well at specific oil addition and provide high clean coal yields
- increase in diesel addition from 0.05% (typical for froth flotation) to 0.25% has a significant impact on clean coal yield and coal matter recovery
- for solids concentration of 3.6% (typical for cyclone overflow at Shade Creek plant) and 20% (recommended for Aglofloat) similar results were achieved
- for diesel oil/Fuel No. 6 blend an increase in Fuel No. 6 content to the ratio 1:4 significantly reduced process performance
- clean coal quality was very similar for both bridging liquid:
 - ash content in the range of 7.2 to 7.6%
 - sulfur content in the range of 0.75-0.9%

Based on the presented results the following conclusion and recommendation can be made:

- Aglofloat performs very well with PBS coal fines
- by using Aglofloat the recovery of combustible material exceeds 95%
- blend of diesel oil/Fuel No. 6 at the range ratio 1:1 to 3.7 are recommended as a bridging oil and are used for preliminary material balances and process economics

Figure 3 and Table 4 present mass balances (short tons) of the fine coal circuit for the existing system and preliminary balances after system modification.

Assumption taken into account are as follows:

- For the existing fine coal circuit:
 - cyclone overflow contains 21 TPH of coal fines
 - half of the overflow stream is fed to a flotation cell and the yield of clean coal is about 65%
 - the other half of the stream is directed for disposal via thickener
- For the modified system the whole overflow stream is subjected for processing using Aglofloat procedure and equipment.

Table 2
PBS Coal Fines - Aglofloat Processing
Bridging Oil - Diesel Oil

Solids Concentration ^a wt%	Bridging Oil Concentration wt%	Ash wt%	Yield wt%	CMR ^b wt%
Feed Coal Fines		11.1	-	-
3.6/3.6	0.05	7.3	72.4	75.3
	0.25	7.2	91.6	95.5
	0.50	7.3	92.4	96.3
20.0/6.5	0.05	6.9	62.7	65.6
	0.25	7.6	93.1	96.7
	0.50	7.4	92.7	94.6
	1.00	7.5	95.1	96.8

^aHigh- shear solids concentration/flotation concentration

^bCMR - Combustible Matter Recovery

High-shear mixing:

- Solids concentration - 3.6% or 20%
- Mixing intensity - 2000 RPM
- Residence time - 1 min.

Two-stage flotation:

- Solids concentration - 3.6% or 6.5%
- Mixing intensity - 1,100 RPM
- Residence time - 3.5/3.0 min.
- Froth - MIBC at 0.045 kg/tonne (first stage only)

Table 3
PBS Coal Fines - Aglofloat Processing
Bridging Oils - Fuel No. 6/Diesel Oil Blends

Diesel/Fuel No. 6 Ratio	Ash wt%	Yield wt%	CMR ^a wt%
1:1	7.4	93.7	97.6
3:7	7.6	92.5	96.2
1:4	7.8	71.1	73.7

^aCMR - Combustible Matter Recovery

High-shear mixing:

- Bridging liquid concentration - 0.5%
- Solids concentration - 20%
- Mixing intensity - 2000 RPM
- Residence time - 1 min.

Two-stage flotation:

- Solids concentration - 6.5%
- Mixing intensity - 1,100 RPM
- Residence time - 3.5/3.0 min.
- Froth - MIBC - 0.045 kg/tonne (first-stage only)

Figure 3. Mass Balances

a) *System as it is now*

b) *System after modification (Diesel /Fuel Oil No 6 - 1:1)*

c) *System after modification (Diesel/Fuel Oil No 6 - 3:7)*

Table 4
Annual Production and Clean Coal Quality for
the Existing and Modified Fine Coal Circuit

	Annual Production	Clean Coal Quality	
		Ash	Sulfur
Existing System	48,320	~7	~0.75
Modified System	140,858-142,590	7.2-7.6	0.75-0.9
Difference	92,538-94,270	not significant	not significant

2.3.2 Batch Testing of CBDC Coal

The batch testing was carried out with minus 150 μm (100 mesh) classifying cyclone overflow. The fines sample was extracted from a sample shipment from DBDC's mine using CANMET's coal preparation plant. The plant was operated using flowsheet similar to that of Victoria Junction preparation plant. The coal was crushed and then screened to remove fraction minus 600 μm (28 mesh). The minus 600 μm (28 mesh) fraction was then processed using compound water cyclone and classifying cyclone. The overflow of the classifying cyclone was a feed for batch testing.

Determination of coal fines size distribution revealed that almost 100% of fines are below cyclone size cut. The mass median diameter determined by laser granulometry is about 27 μm .

Following are the selected properties of project coal fines:

- ash 13.8%
- total sulfur 1.74% of which 1.03% is pyritic, 0.15% is sulfatic and 0.56% is organic

The main objective of batch testing was to obtain a primary product (metallurgical grade) containing less than 1.25% sulfur with a yield of approximately 50% of the total product, while maximizing total coal matter recovery by extracting a secondary product (thermal grade) higher in sulfur.

Preliminary Aglofloat experiments with CBDC's fines showed that:

- The Aglofloat process can produce metallurgical and thermal grade coals within required specifications.
- For bridging liquid (diesel oil) addition of 0.5% about 93% of coal matter is recovered in clean product with the sulfur content lower than the maximum allowed for metallurgical grade coal

Detailed results from batch testing of CBDC's coal will be presented in next technical report.

3.0 Future Work

Future work to be performed and/or completed in the next reporting period is as follows:

- continue batch testing
- commence bench scale testing of agglomeration equipment using bulk sample of coal fines submitted by PBS Coals Inc.
- final engineering and design of POC scale equipment