CENTER FOR ADVANCED SEPARATION TECHNOLOGIES
Update on the Latest Development from CAST

U.S.A.-India Coal Working Group, Washington, DC
November 18, 2005

by
Roe-Hoan Yoon
Virginia Tech
http://www.castconsort.org
## Separation Processes Used for Coal

<table>
<thead>
<tr>
<th>Size-Size</th>
<th>Solid-Solid</th>
<th>Solid-Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>Dense Media Vessel</td>
<td>Dewatering Screens</td>
</tr>
<tr>
<td>Raw Coal Screens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Dense Media Cyclone</td>
<td>Basket Centrifuges</td>
</tr>
<tr>
<td>Sieve Bends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine</td>
<td>Coal Spirals</td>
<td>Screen-Bowl Centrifuges</td>
</tr>
<tr>
<td>Classifying Cyclones</td>
<td></td>
<td></td>
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<tr>
<td>Ultrafine</td>
<td>Froth Flotation</td>
<td>Disc Filter</td>
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</tbody>
</table>
Organization

VT CE

Director & Support Staff

Technical Committee

Advisory Board

University Members

Affiliate Members

Charter Members

Members

Corporations

Government Agencies

Others

UTAH

NEVADA

NEW MEXICO

MONTANA

KENTUCKY

WVU

VT

Center for Advanced Separation Technologies
CAST Program

% effort

- Projects
  - Fundamental 50
  - Applied 50

- R&D Areas
  - Coal 50
  - Minerals 50

Roadmapping workshop:
Charleston, WV, August 14-15, 2002
67-page roadmap
Industry Advisory Board

- Richard Lawson,
  - Chairman, Energy, Environment and Security Group, Ltd.
- Bart Hyita,
  - Vice President, Operation, CONSOL Energy
- David Peugh,
  - Vice President, Arch Minerals
- John Marsden,
  - Vice President, Phelps Dodge Mining Company
- Edward Dowling,
  - Vice President, Cleveland Cliffs
Energy Policy Act 2005

(1) innovations for existing plants (including mercury removal);
(2) gasification systems;
(3) advanced combustion systems;
(4) turbines for synthesis gas derived from coal;
(5) carbon capture and sequestration research and development;
(6) coal-derived chemicals and transportation fuels;
(7) liquid fuels derived from low rank coal water slurry;
(8) solid fuels and feedstocks;
(9) advanced coal-related research;
(10) advanced separation technologies; and
(11) fuel cells for the operation of synthesis gas derived from coal.
Simplified Flowsheet

<table>
<thead>
<tr>
<th>Size-Size Separation</th>
<th>Solid-Solid Separation</th>
<th>Solid-Liquid Separation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Basket Centrifuge</td>
</tr>
<tr>
<td>Coarse</td>
<td>Raw Coal Screen</td>
<td>Heavy Media Cyclone</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Hydrocyclone</td>
<td>Spirals</td>
</tr>
<tr>
<td>Fine</td>
<td></td>
<td>Disc Filter</td>
</tr>
<tr>
<td></td>
<td>Froth Flotation</td>
<td></td>
</tr>
</tbody>
</table>

Increasing Difficulties

Center for Advanced Separation Technologies
Impoundments

- 3 billion tons of fine coal
  - In 713 impoundments
  - Mostly in Central Appalachia.

- Main cause
  - Lack of appropriate Separation Technologies
    - Solid-Solid (Fine particles)
    - Solid-Liquid (Dewatering)
Application of Advanced Separation Technologies

- Use of advanced separation technologies at Middle Fork
  - Recovered coal
  - Reuse of impoundment
    - No new impoundment
    - No new permits

Then...

...and Now

Center for Advanced Separation Technologies
Microcel Flotation

Recovery: 60.1% vs. 79.9%
Yield: 38.9% vs. 47.8%
Tonnage: 38.9 vs. 47.7 tph (8.9 tph gain)
Value: $1.86 MM/yr
Microcel Flotation
Cleaner Coal at BHP Billiton

- Ash (%)
- Time (hours)

Target
Advanced Coal Cleaning Technologies

- Microcel flotation
- Dewatering
  1. **Dewatering aids**
     - Licensed to Nalco
     - Pinnacle pond recovery plant
     - Due to completion in January 2006
  2. **Hyperbaric centrifuge**
     - Licensed to Decantor
     - Pilot-scale tests is being carried out
  3. **Hyperbaric horizontal belt filter**
     - Pilot-scale tests planned in 2005
  4. **Dewatering by displacement**
     - An engineering company is exploring commercialization potential
  5. **Polymer injection system for Screen-bowl centrifuges**
     - 18 installations
Pond recovery at Pinnacle Mine  
Wyoming County, WV

- **Pilot-scale tests**
  - *Moisture reduction*
    - From 29% to 16%
  - *Throughput*
    - 2-3 times higher
  - 200 tons/hr plant is being built by Beard Technologies
Dewatering Aids (2)

Pinnacle plant flowsheet
(due to completion in January 2006)

Feed

+1 mm Sizing

Waste

-100 M

Primary Cyclones

Clean Cyclones

Two-Stage Spirals

Screen-Bowl Centrifuge

Coarse Clean

Waste

100 x 325 M

Clean Columns

Waste

Reagent Conditioner

Ultrafine Disc Filter

Ultrafine Clean

Deslime Cyclones

Waste

Reagent Conditioner

Fine Disc Filter

Fine Clean

Ultrafine Columns
## Hyperbaric Centrifuge

### Table 60: Effect of Using Compressed Air for the Centrifugal Filtration of a Pittsburgh Coal

<table>
<thead>
<tr>
<th>Drying Cycle or Centrifugation Time (sec)</th>
<th>Cake Moisture (wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air Pressure (^1) Alone</td>
</tr>
<tr>
<td>30</td>
<td>27.5</td>
</tr>
<tr>
<td>60</td>
<td>25.8</td>
</tr>
<tr>
<td>120</td>
<td>23.8</td>
</tr>
</tbody>
</table>

\(^1\) 100 kPa of air pressure; \(^2\) 2000 G; \(^3\) 0.45 inch cake thickness.

Air pressure
Semi-continuous unit

Cross Section A-A

- 0.1 mm Opening
- Screen Panel Bars
- Rotation
- Filter Cake
- Feed Inlet

- Cake Port
- Drain Ports
- Pressure Chamber
- Cake
- Sealing Edge
- Scraper
- Wedge Bars
- Cake Discharge
- Drain Discharge

- Housing
- Pneumatic Cylinder
- Air
- Timed Rotary Valve
- Slurry
- Seal
- Drive Motor
- Belt
- Scraper

Center for Advanced Separation Technologies (CAST)
Hyperbaric Belt Filter (1)

*Filtration at 30 psi (2 bar) gives <10% moisture.*

![Graph showing moisture percentage vs. reagent dosage.](image-url)
Dewatering by Displacement (2)
Butane Dewatering Test Results and Potential Impact on U. S. Coal Reserve

Results show that dry coal can be obtained without thermal drying.

<table>
<thead>
<tr>
<th>( M_b/M_c ) Ratio</th>
<th>Percent Moisture at Specified Feed Solids Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5% Solids</td>
</tr>
<tr>
<td>0.5</td>
<td>---</td>
</tr>
<tr>
<td>0.75</td>
<td>---</td>
</tr>
<tr>
<td>1.0</td>
<td>12.5</td>
</tr>
<tr>
<td>1.5</td>
<td>5.5</td>
</tr>
<tr>
<td>2.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

By decreasing the top size of the coals cleaned from 1.5 inches to 14 mesh, US can double its reserve for compliance coal (DOE report by Cavallero, et al. 1991)
Indian Coal

The graph shows the cumulative yield (%) over flotation time (minutes) for Indian coal separated based on mesh size. Two conditions are compared:

- **Float Separately**
- **Float Together**

The graph includes lines for two mesh size categories:

- >65 mesh
- <65 mesh

The data indicates that:

- >65 mesh solids yield a higher cumulative percentage at shorter flotation times compared to <65 mesh solids.
- The cumulative yield for both sizes increases with flotation time, with >65 mesh generally reaching a higher cumulative yield at a given time.

This suggests that >65 mesh solids may be more efficiently separated at shorter times compared to the smaller size fraction.
A Solution for Indian Coal