Fine Coal Beneficiation and Recovery

Workshop on Coal Beneficiation and Utilization of Rejects Initiatives, Policies and Practices
August 22-24, 2007

by

Roe-Hoan Yoon, Director
Center for Advanced Separation Technologies
## Separation Processes Used for Coal

<table>
<thead>
<tr>
<th></th>
<th>Size-Size</th>
<th>Solid-Solid</th>
<th>Solid-Liquid</th>
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<tbody>
<tr>
<td><strong>Coarse</strong></td>
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<td>Froth Flotation</td>
<td>Disc Filter</td>
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Increasing Difficulties
## Separation Processes Used for Coal

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**Size-Size**

- Raw Coal Screens
- Sieve Bends
- Classifying Cyclones
- Dense Media Vessel
- Coal Spirals
- Screen-Bowl Centrifuges

**Solid-Solid**

- Dense Media Vessel
- Dense Media Cyclone
- Coal Spirals

**Solid-Liquid**

- Dewatering Screens
- Basket Centrifuges
- Screen-Bowl Centrifuges
Deslime Flotation Circuit

FEED → Hydrocyclone → 100 mesh x 0

→ 100 x 325 mesh → Flotation Bank → 325 mesh x 0 → ULTRAFINES

→ Reagents

→ 100 x 325 mesh → REJECT

→ Centrifuge → CLEAN COAL

→ effluent → To Other Processing Circuits
Fine Coal Impoundment

- 2.5 to 3 billion tons of fine coal
  - In 713 impoundments
  - Mostly in Central Appalachia.
Effect of Particle Size on Flotation

(Gaudin, 1931)

Plant Practice

Model Prediction

(Sherrell, Do and Yoon, 2005)
Cost of Dewatering

Ref: Hucko, 1990

Cost of Dewatering ($/t)

Particle Top Size (mm)
Advanced Coal Processing (1)

- Advanced Flotation
  - Microcel Flotation

- Advanced Dewatering
  - Dewatering Aids
    - Licensed to Nalco Chemical
    - Commercialized at Pinnacle
  - Hyperbaric Centrifuge
    - Licensed to Decanter Machine
    - Pilot-scale tests ongoing
  - Novel Dewatering Technology
    - Can produce <5% moisture
Bubble Generation in Microcel

Microcel Spargers

In-Line Mixer Bubble Generator

Pump
Benefits of Using Microcel at Peak Downs

Before and After Installation
## Ongoing Microcel Projects in Australia

### Summary of Microcel Projects

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of Cells</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collinsville</td>
<td>1</td>
<td>Xstrata</td>
</tr>
<tr>
<td>Millennium</td>
<td>4</td>
<td>Excel</td>
</tr>
<tr>
<td>Gregory</td>
<td>5</td>
<td>BMA</td>
</tr>
<tr>
<td>Dawson</td>
<td>6</td>
<td>Anglo Coal</td>
</tr>
<tr>
<td>Blackwater</td>
<td>6</td>
<td>BMA</td>
</tr>
<tr>
<td>Lake Lindsay</td>
<td>2</td>
<td>Anglo Coal</td>
</tr>
<tr>
<td>Sonoma</td>
<td>1</td>
<td>BMA</td>
</tr>
</tbody>
</table>

*From Eriez Manufacturing*
Advanced Coal Processing (2)

- **Advanced Flotation**
  - *Microcel Flotation*

- **Advanced Dewatering**
  - **Dewatering Aids**
    - Licensed to Nalco Chemical
    - Commercialized at Pinnacle
  - **Hyperbaric Centrifuge**
    - Licensed to Decanter Machine
    - Pilot-scale tests ongoing
  - **Novel Dewatering Technology**
    - Can produce <5% moisture
Novel Dewatering Aids
Dewatering Aids

![Graph showing the relationship between cake moisture and reagent dosage. The graph compares laboratory and in-plant data.](image)

- **Laboratory**
- **In-Plant**

Center for Advanced Separation Technologies (CAST)
Hyperbaric Filter Centrifuge

Pilot-Scale Prototype

1500 RPM
0.15 mm x 0
13 mm cake

Moisture (%) vs. Spin Time (sec)

Center for Advanced Separation Technologies
Effect of Particle Size on the Flotation of Indian Coal

Assam Coal 2

Release Analysis
Assam Coal II

-100 mesh
-325 mesh
Effect of Particle Size on the Flotation of Indian Coal

Assam Coal 1

Release Analysis
Assam Coal

- 28 x 100 mesh
- -100 mesh
- -325 mesh
Advanced Fine Coal Beneficiation (4)
for Indian Metallurgical Coal

Note: Not all clarified and process water streams are shown.
Effect of Particle Size on Flotation

(Gaudin, 1931)

(Sherrell, Do and Yoon, 2005)
Coarse Coal Flotation (1)

Ofori, Brien, Firth, Jenkins (2005)

Fig 3 - Component recovery as a function of particle size.
Coarse Coal Flotation (2)

Ofori, Brien, Firth, Jenkins (2005)

MACE™ 300 images on Bowen basin coal
Coarse Coal Flotation (3)

Less hydrophobic coals drop off.
Coarse Coal Flotation (5)

*Indian coal may need a more powerful collector.*
Advanced Fine Coal Beneficiation (6)

Split Flotation helps Indian coal.

![Graph showing the effect of flotation time on cumulative yield for different coal sizes.](image-url)
# Coarse Particle Flotation (7)

*How hard do we float?*

<table>
<thead>
<tr>
<th>Froth Product</th>
<th>Individual</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mass (%)</td>
<td>Ash (%)</td>
</tr>
<tr>
<td>C1</td>
<td>10.95</td>
<td>6.55</td>
</tr>
<tr>
<td>C2</td>
<td>15.26</td>
<td>6.88</td>
</tr>
<tr>
<td>C3</td>
<td>34.35</td>
<td>9.07</td>
</tr>
<tr>
<td>C4</td>
<td>10.76</td>
<td>17.32</td>
</tr>
<tr>
<td>T</td>
<td>28.68</td>
<td>91.70</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>33.05</td>
</tr>
</tbody>
</table>

**Conclusion:** Incremental ash <20-25% in flotation, so always pull float cells “hard” (produce grey tails).
# Maximizing Yield

*Operation at Constant Incremental Ash*

<table>
<thead>
<tr>
<th>SG Value</th>
<th>Dense Medium Cyclone</th>
<th>Dense Medium Bath</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mass (%), Ash (%)</td>
<td>Mass (%), Ash (%)</td>
</tr>
<tr>
<td>1.30</td>
<td>31.12, 4.44</td>
<td>5.32, 4.51</td>
</tr>
<tr>
<td>1.35</td>
<td>28.27, 7.65</td>
<td>11.32, 7.50</td>
</tr>
<tr>
<td>1.40</td>
<td>13.41, 13.74</td>
<td>16.32, 13.52</td>
</tr>
<tr>
<td>1.45</td>
<td>1.71, 19.40</td>
<td>4.32, 19.54</td>
</tr>
<tr>
<td>1.50</td>
<td>0.90, 24.67</td>
<td>2.35, 25.11</td>
</tr>
<tr>
<td>1.55</td>
<td>0.64, 29.60</td>
<td>1.23, 30.14</td>
</tr>
<tr>
<td><strong>1.60</strong></td>
<td><strong>0.87, 34.22</strong></td>
<td><strong>1.03, 34.14</strong></td>
</tr>
<tr>
<td>1.65</td>
<td>1.03, 38.55</td>
<td>1.24, 39.01</td>
</tr>
<tr>
<td>1.70</td>
<td>1.26, 42.63</td>
<td>1.92, 41.95</td>
</tr>
<tr>
<td>1.80</td>
<td>1.45, 48.30</td>
<td>2.21, 47.69</td>
</tr>
<tr>
<td>2.00</td>
<td>2.95, 58.30</td>
<td>3.28, 59.23</td>
</tr>
<tr>
<td>Feed</td>
<td>16.38, 87.22</td>
<td>49.46, 86.54</td>
</tr>
</tbody>
</table>

Cumulative Mass (%): Cum Mass

Cumulative Ash (%): Cum Ash
Summary

- Advanced fine coal beneficiation technologies have been developed.
  - *Microcel flotation column*
    - *Eriez Manufacturing*
    - *Metso Minerals*
  - *Fine coal dewatering technologies*
    - *Nalco*
    - *Decanter*
  - *Coarse coal flotation collector*
    - *Nalco*

- For Indian coals
  - *Fine coal flotation can produce low-ash products.*
  - *Coarse coal flotation can help increase yield.*