Fine Coal Cleaning by Froth Flotation

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Outline

- Coal Preparation
- Froth Flotation
- Flotation Machine
- Bubble Size
- Froth Phase
- Jameson Cell
Coal Preparation

General

- Desliming screen: 1.4 mm
- Dense medium circuit
- Clasifying cyclones
- 2 Stage spirals
- Flotation
- Co-disposal
- Dewatering
- Product
Froth Flotation

General

• Surface chemistry based separation technique.
  – Pulp consists of hydrophobic and hydrophilic species
  – Air bubbles are introduced into an agitated pulp
  – Hydrophobic particles attach to air bubbles and are carried to the surface
  – Laden bubbles overflow the flotation cell into the collecting launder
  – Hydrophilic particles remain in continuous phase
Coal is hydrophobic and ash is hydrophilic
Froth Flotation

Hydrophobic and hydrophilic species

Coal particles attach to air bubbles
Froth Flotation

Background

Ore
- Mineralogy
- Liberation
- Particle Size
- Variability

Dynamic

Chemistry
- Particle hydrophobicity and contact angle
- Selectivity
- Water chemistry
- Pulp pH, Eh
- Reagents: collector, frother, depressants, dispersants

Levers of flotation

Fixed
- Features of the technology

Machine
- Type
- Design
- Bubble size
- Gas hold up
- Carrying capacity
- Lip length
- Mixing intensity
There exist many different techniques and devices to disperse air

- Shear action of a metallic surface moving at high speed in a relatively stationary liquid (rotor in mechanical cells)
- Jetting of air through small holes in a porous material (laboratory flotation columns)
- Jetting of air through a single hole (jetting spargers)
- Jetting of liquid into a liquid surface (Jameson cell)
- Shear action of a high velocity liquid striking a stationary metallic surface (in-line mixers and contact cells)
Froth flotation needs to be performed on machines that are designed for:

- Generation and distribution of bubbles
- Suspension and distribution of particles
- Generation of a “clean” froth phase
Flotation Machine

Ultimate goal

Coal is collected from the concentrate stream
Bubble Size

Fine bubbles are better for the whole size range

Bubble size:
- 1.13 mm
- 1.64 mm
- 1.99 mm

Rate Constant (1/min) vs. Particle size (μm)
Bubble Size

Fine bubbles are better for the whole size range

Bubble size depends on the flotation technology
**Bubble Size**

Fine bubbles are better for the whole size range

Small bubbles means higher throughput

- Why do we need small bubbles?

<table>
<thead>
<tr>
<th>Total Vol, mm$^3$</th>
<th>Bubble Diam, mm</th>
<th>No Bubbles</th>
<th>Bubble surface area mm$^2$</th>
<th>Particle Diam, mm</th>
<th>Particle surface area, mm$^2$</th>
<th>No particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.5</td>
<td>46</td>
<td>36</td>
<td>0.25</td>
<td>0.20</td>
<td>180</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>2</td>
<td>12</td>
<td>0.25</td>
<td>0.20</td>
<td>60</td>
</tr>
</tbody>
</table>
Non-Selective recovery of coal and ash

Coal

Ash

Air bubble

wake:
water carried by bubble
Froth Phase

Water entrainment

Coal

Ash

Froth phase

Low ash

Medium Ash

Same ash as feed

Liquid phase (slurry)
Froth Phase
Water entrainment

Ash particles prefer to stay in water (hydrophilic)

Drainage

Low liquid content
Medium liquid content
High liquid content
Froth Phase

Removal of entrained ash by wash water

After a few minutes, water sprayed in via this ring with wash water on.
Jameson Cell

- Pressurized slurry enters downcomer through a nozzle at high velocity
- The jet entrains air from the atmosphere
- Jet plunges into slurry surface causing the air to shear into fine bubbles
- High intensity mixing leads to high probably of bubble-particle collision and contact
- Slurry and collected particles exit downcomer
- Particle laden bubbles are separated from the pulp
Jameson Cell

• To account for fresh feed flow fluctuations, a portion of tailings are re-circulated

• Downcomer always operates at constant feed pressure and flow rate which provides consistent:
  • Jet velocity
  • Air entrainment
  • Mixing intensity
Jameson Cell

Split slurry-air distributor
Washwater tray
Separation tank
Air intake
Cross lauder
External launder outlet
Internal launder outlet
Downcomer feed inlet
Tailings outlet
Jameson Cell

Three 2.5 m x 16 m columns

Two 1.9 m Jameson Cells
Each Jameson Cell has the same capacity as one column
Coal Flotation

- Need to characterize the flotation response of each coal seam: Standard tree test, release analysis or another procedure
Plant Performance

![Graph showing Combustibles Recovery (%) vs Ash (%)]

- **Combustibles Recovery (%)**
- **Ash (%)**

Legend:
- Red circles: Jameson Cell
- Blue diamonds: Wemco Cells
Plant Performance

- Performance depend on the selected operating variables
Questions?