Particle Density Meter (PDM)

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What is Particle Density?

- Particle Density
- Bulk Density
- Slurry Density

- Particle Density – Density of the actual particles only
- Bulk Density – Density of the particles and air
- Slurry Density – Density of the slurry = particles + water
## Common Particle Densities

<table>
<thead>
<tr>
<th>Material</th>
<th>Particle Density (t/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haematite</td>
<td>5.2</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>4.2</td>
</tr>
<tr>
<td>Galena</td>
<td>7.4</td>
</tr>
<tr>
<td>Sphalerite</td>
<td>4.0</td>
</tr>
<tr>
<td>Spodumene</td>
<td>3.1</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>4.7</td>
</tr>
<tr>
<td>Clean Coal</td>
<td>1.4</td>
</tr>
<tr>
<td>Coal Reject (Silica, shale, dolomite, etc)</td>
<td>2.4</td>
</tr>
<tr>
<td>Silica</td>
<td>2.7</td>
</tr>
<tr>
<td>Calcite</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Table 1 Approximate particle density for some common minerals.*
Why measure particle density?

• Geologists use particle density (Apparent Relative Density or ARD) as a primary quality measure.
• The amount of dilution in plant feed can be determined by measuring the particle density of the feed and the knowing the coal quality from bore-core information.
• Reconciliation with mine models.
• Better determination of in-situ density and stockpile bulk density.
• Allows the preparation plant to operate more efficiently.
Particle density can be used as a means of measuring quality of feed, product and reject.

- This can and should be used now.

- Samples currently sent to laboratories for “ash” value, SE, etc. should also be tested for particle density and this particle density used as a control value.

- In many cases the particle density determination will be much quicker than the other analysis.

- With the PDM, the particle density can be determined online every 1 s.

- First International Coal Preparation Congress (Paris, 1950)
• Many unit processes use particle density as the basis for separation

• Therefore, it makes sense to use particle density as a means of controlling the processes.

• Even those processes that don’t use particle density for separation (e.g. flotation) can still use particle density as a means of control

• Determination of cut-point online? This is a particle density driven term.
What is currently used for CHPP monitoring?

• Stockpile sampling – manual, highly inaccurate.

• Existing conveyor belt sampling systems.
• In-plant sampling.
• Manual sampling – stopped belt type.

• Conveyor Samples and in-plant samples are often composited over a shift (12 hours) and analysed by the laboratory, giving results with a long delay.
• Give no indication of quality variation within the sampling time period.
• Large times between sample increments can also reduce accuracy.

• Online monitoring devices (nucleonic devices) have been installed and use with varying levels of success.
PDM - What is it?

• Monitors average particle density

• Tracks changes in stream quality.

• Allows trends to be seen during plant operation & optimisation.

• Now installed at Bloomfield, Ashton and Moranbah North. Unit under construction for Kestrel. Unit for spiral control awaiting re-installation.
Possible **online** outputs:
- Flowrate of actual solids - when PDM combined with flow meter
- Particle density (quality) of each stream
- Mass Yield
- Tonnage of coal lost to tails ($$)
- Tonnage of coal produced ($$)
PDM on Plant Feed (also for coarse product/reject)

- Working with Quality Handling Systems (QHS) to produce a modular system for plant feed sampling, preparation and analysis using the CleanProTech PDM.

- Improved conveyor belt sampling.
- More accurate
- More primary increments
- Less sampling waste disposal problems
- Containerised and more standardised sampling stations
PDM on Plant feed – Lab Trials

• Plant Feed + Product
PDM on Plant feed – Lab Trials

- Plant Feed + Reject

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Particle Density (Lab)</th>
<th>Particle Density (PDM)</th>
<th>Ash (Lab)</th>
<th>Ash (PDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.20</td>
<td>1.50</td>
<td>40.00</td>
<td>45.00</td>
</tr>
<tr>
<td>2</td>
<td>1.40</td>
<td>1.70</td>
<td>45.00</td>
<td>50.00</td>
</tr>
<tr>
<td>3</td>
<td>1.60</td>
<td>1.90</td>
<td>50.00</td>
<td>55.00</td>
</tr>
<tr>
<td>4</td>
<td>1.80</td>
<td>2.10</td>
<td>55.00</td>
<td>60.00</td>
</tr>
<tr>
<td>5</td>
<td>2.00</td>
<td>2.30</td>
<td>60.00</td>
<td>65.00</td>
</tr>
<tr>
<td>6</td>
<td>2.20</td>
<td>2.50</td>
<td>65.00</td>
<td>70.00</td>
</tr>
<tr>
<td>7</td>
<td>2.40</td>
<td>2.70</td>
<td>70.00</td>
<td>75.00</td>
</tr>
<tr>
<td>8</td>
<td>2.60</td>
<td>2.90</td>
<td>75.00</td>
<td>80.00</td>
</tr>
</tbody>
</table>
• Plant Feedrate (capacity)
  • All equipment (conveyors, pumps, screens, dense-medium cyclones, classifying cyclones, spirals, etc.) is designed on volumetric throughput. An **assumed particle density** is then used to convert this volumetric throughput to a mass throughput as mass can be measured with weightometers on plant feed, product and reject conveyor belts.
  • By measuring the plant feed particle density and knowing the mass flowrate, the volumetric feedrate to the plant can be measured online.
  • If the plant feed particle density increases, then the volumetric feedrate will decrease, for the same mass flowrate. This means that the plant may be underutilised (reject capacities have to be checked as well).
  • Significant increases in plant feed capacity (10 to 20 %) may be able to be realised by measuring the feed particle density online.

• Determine flow to the different circuits in the plant (Combination of PDM and magnetic flowmeter)
  • From this know the size distribution of the feed
Particle Density Monitor

- Proven
- Accurate
- Non-Nucleonic
- Australian Invention
- Used on slurries in-plant
- Combined with QHS Conveyor Belt Samplers allow for Particle Density Measurement of any stream on a conveyor belt.

- Thank you to AusIMM for organising today.