Crushers - An Essential Part of Energy Efficient Comminution Circuits

Ted Bearman¹
Scott Munro²
Magnus Evertsson³

¹ Director, Bear Rock Solutions Pty. Ltd.
² Director, Met Dynamics Pty. Ltd.
³ Assoc. Professor, Chalmers University, Gothenburg, Sweden.
Energy in Comminution

Source: ETSU, 1996

MetPlant 2011 Conference, 8 – 9 August 2011, Perth WA

Source: ETSU, 1996
Crushing Efficiency

• Crushers can achieve 60-70% machine efficiency, based on the percentage of input applied to breakage
• In many cases overall circuit efficiency is much lower
• Efficiency controlled by a variety of factors related to:
  – Machine configuration,
  – Operational parameters, and,
  – Overall circuit considerations.

How can we use the efficiency of crushing to relieve the use of energy in milling?
Crushing Efficiency - Factors

- Mechanical Design Variables (MDV),
- Feed Material Variables (FMV),
- Machine Operating variables (MOV),
- Machine limits,
  - Volumetric (maximum feed size, capacity),
  - Power,
  - Force, and
- Flowsheet design and interaction with other equipment.
Crushing Efficiency - Factors

- Mechanical Design Variables (MDV),
- Feed Material Variables (FMV),
- Machine Operating variables (MOV),
- Machine limits,
  - Volumetric (maximum feed size, capacity),
  - Power,
  - Force, and
- Flowsheet design and interaction with other equipment.
Mechanical Design Variables

- Cone head pivot point,
- Cone head angle,
- Eccentric throw,
- Eccentric speed, and,
- Chamber and liner design.

Factors controlled by manufacturers.

Operator has some control over liners and potentially options exist for speed control.
Machine Operating Variables

- Closed Side Setting (CSS)
- Feed presentation

- CSS control is well known and options to automate have existed for many years.
- Feed presentation is often the “invisible” detractor.

Segregated

Non-Segregated

MetPlant 2011 Conference, 8 – 9 August 2011, Perth WA
Main Efficiency Controls

• Energy distribution in the crushing chamber
  – Chamber design
  – Impact of liner wear
  – Ability to maintain effective crushing and control of product size

• Recirculating load and near-size
Initial Chamber Selection

- Critical to match chamber to the feed size distribution
- Position of crushing force dictates design of bushes, bearings, mainshaft and eccentric
- Consequences of mis-match:
  - Inability to achieve required CSS
  - Poor product size distribution
  - High crushing forces induced
  - Development of poor wear profiles
  - Early close-off of feed opening
  - Reduced MTBF for components
  - Energy wasted.

‘Coarse’ Liner

‘Medium’ Liner

MetPlant 2011 Conference, 8 – 9 August 2011, Perth WA
Liner Wear

New liner
- Evenly distributed pressure and power draw
- Effective particle capture and breakage

Worn liner
- Pressure, power draw and particle capture concentrated at closed edge
- Excessive crushing forces, reduced throughput and poor product sizing
Liner Wear

- Wear on crusher liners can dramatically change performance over the life
- Operational life should be determined on process impact – not on thickness or in order to minimize replacement cost
Near-Size

- Build-up in recirculating load due to:
  - Ineffective crushing
  - Performance drift with liner wear
  - Overloading of screens leading to increased undersize reporting to oversize

- Bottlenecking of plant

- Crushing energy used in re-treating recirculated material
Energy Improvement Scenario

• Multi stage crushing plant feeding milling circuit

• Improvements in crushing via:
  – Feed presentation
  – Selection of crushing chambers
  – Wear profiles
  – Product size control
  – Liner change-out strategy
## Scenario Outcome

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crushing</td>
<td>0.8kWh/t</td>
<td>1.03kWh/t</td>
</tr>
<tr>
<td>Milling</td>
<td>13.5kWh/t</td>
<td>12.4kWh/t</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>14.3kWh/t</td>
<td>13.43kWh/t</td>
</tr>
<tr>
<td><strong>Yearly Consumption</strong></td>
<td>215GWh</td>
<td>201GWh</td>
</tr>
</tbody>
</table>

- Overall decrease of 6.5% in total energy use
- Crushing and screening circuit not optimized.
- Transfer size from crushing to grinding can be reduced using:
  - Newer crushing equipment, or,
  - Addition of other forms of comminution, i.e. HPGR.
Crushing – Milling Transfer Size

Improved crushing equipment/circuit

Extension of crushing envelope into newer technologies ie HPGR

Graphs showing energy consumption (kWh/t) for different transfer sizes (2-5mm, 5-10mm, 10-30mm)
Widescreen Test Pattern (16:9)

Aspect Ratio Test
(Should appear circular)