HRC™: taking HPGGR efficiency to the next level by reducing edge effect

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Introduction to HPGRs

Operating principles:

- Two counter-rotating tires (one fixed and one floating)
- Hydraulic cylinders apply force to the floating tire
- The counter-rotating tires draw in a bed of material
- This bed of material is crushed via inter-particle comminution
Industry Use of HPGR Technology

- Industry trends
  - Lower ore grades: more processing for less product
  - Rising energy costs: deposits more remote, power transmission or generation is more expensive
  - Finer liberation sizes
- Sites looking to energy efficient technologies to stay profitable
- Gradual acceptance of HPGR as viable technology option
Edge Effect

Edge Effect is the impaired comminution performance at the edges of the HPGR tires due to a reduction in crushing pressure.

This results in:

- Coarser product size
- Uneven wear on the tire surface
- Decreased energy efficiency
Comparison of HPGR Tire Designs

Traditional HPGR

- High Wear Area
- Cheek Plate
- Crushing Zone

HRC™ HPGR

- Flange
- Top View
- Crushing Zone

Cutaway Side View
Comparison of HPGR Tire Designs

Proposed advantages of flanges:
- Moving with the material through the crushing zone
- Higher crushing forces at the tire edge
- Greater total wear surface area utilized at high wear crushing zone
Traditional HPGR

Segregated feed = *Uneven* gap setting

Metso’s HRC™ HPGR

Segregated feed = *Even* gap setting

- Torsion tube
- Bearing housing
HPGR Pressure Profile

![Graph showing HPGR Pressure Profile with Traditional Cheek Plates and Flanged Tire Design.](image-url)
Morenci Pilot Plant

A collaborative research & development program between Metso and Freeport-McMoRan Copper & Gold.

Major Equipment:
- Metso HRC™ HPGR
- Metso VTM-650-WB Vertimill
- 10’ x 10’ Horizontal Ball Mill

<table>
<thead>
<tr>
<th>Operating Hours*</th>
<th>Processed Tons *</th>
<th>Process Surveys</th>
<th>Controlled Process Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,500</td>
<td>530,000</td>
<td>114</td>
<td>11</td>
</tr>
</tbody>
</table>

* through August 2013
Morenci Pilot Plant – Edge Effect Testing Series

A total of twelve (12) tests were completed, varying:

- Presence of flanges or cheek plates
- Relative wear of flanges/cheek plates
- HPGR specific force (N/mm$^2$)

For each test, the HPGR circuit was surveyed under steady state conditions, including fractional samples of the HRC discharge (edge, center, edge).
Morenci Pilot Plant – HPGR Circuit
Edge Effect Testing – Sampling Points
Cheek Plate Test
P80 = 7.5 mm

Flange Test
P80 = 6.0 mm

F80 = 11.5 mm
<table>
<thead>
<tr>
<th>Test number</th>
<th>Test Z2B</th>
<th>Test Z8A</th>
<th>% change</th>
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</thead>
<tbody>
<tr>
<td>Test description</td>
<td>Cheek plates - new</td>
<td>Flanges - new</td>
<td></td>
</tr>
<tr>
<td>HPGR specific force (N/mm^2)</td>
<td>4.49</td>
<td>4.51</td>
<td>+0.3%</td>
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<tr>
<td>HPGR tire speed (RPM)</td>
<td>23.2</td>
<td>22.3</td>
<td>-3.7%</td>
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<tr>
<td>Plant feed tonnage (dry MTPH)</td>
<td>35.3</td>
<td>42.8</td>
<td>+21%</td>
</tr>
<tr>
<td>HPGR throughput (dry MTPH)</td>
<td>57.7</td>
<td>61.7</td>
<td>+6.9%</td>
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<tr>
<td>HPGR specific throughput (t·s/m^3·hr)</td>
<td>216</td>
<td>240</td>
<td>+11%</td>
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<tr>
<td>HPGR net circuit specific energy (kW·hr/tonne)</td>
<td>3.04</td>
<td>2.72</td>
<td>-11%</td>
</tr>
<tr>
<td>Circulating load (%)</td>
<td>111%</td>
<td>87%</td>
<td>-22%</td>
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<tr>
<td>HPGR feed F80 (microns)</td>
<td>11,577</td>
<td>11,502</td>
<td>-0.7%</td>
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<tr>
<td>HPGR product P80 (microns)</td>
<td>7,491</td>
<td>6,004</td>
<td>-20%</td>
</tr>
<tr>
<td>HPGR circuit product P80 (microns)</td>
<td>1,700</td>
<td>1,697</td>
<td>-0.1%</td>
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</table>
### Net Circuit Specific Energy (kW-hr/MT)

<table>
<thead>
<tr>
<th>Wear Condition</th>
<th>Specific Force (N/mm²)</th>
<th>Traditional HPGR</th>
<th>Flanged-Tire Design</th>
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</thead>
<tbody>
<tr>
<td>New</td>
<td>3.5</td>
<td>3.00</td>
<td>2.80</td>
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<tr>
<td></td>
<td>4.5</td>
<td>3.30</td>
<td>3.10</td>
</tr>
<tr>
<td>Half-Worn</td>
<td>3.5</td>
<td>3.00</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>3.30</td>
<td>3.10</td>
</tr>
<tr>
<td>Fully-Worn</td>
<td>3.5</td>
<td>3.00</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
<td>3.30</td>
<td>3.10</td>
</tr>
</tbody>
</table>
Specific Throughput (t/s/m³/hr)

<table>
<thead>
<tr>
<th>Specific Force (N/mm²)</th>
<th>Wear Condition</th>
<th>Traditional HPGR</th>
<th>Flanged-Tire Design</th>
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</thead>
<tbody>
<tr>
<td>3.5</td>
<td>New</td>
<td>150</td>
<td>225</td>
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<tr>
<td>4.5</td>
<td>Half-Worn</td>
<td>175</td>
<td>250</td>
</tr>
<tr>
<td>3.5</td>
<td>Fully-Worn</td>
<td>200</td>
<td>275</td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td>225</td>
<td>300</td>
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</tbody>
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Future Work

Additional work in this area includes:

- Normalize data across case study relative to feed ore properties
- Scale up of the flanges’ performance on larger size units
- Incorporate these effects into computer models

In addition, future work will highlight the results from the various other aspects of the Morenci Pilot Plant testing program.
Conclusions

The presence of flanges has been shown to yield better particle breakage at the edges of the HPGR tire. At the 750mm diameter pilot scale, the flanged tire design has been shown to:

- Reduce specific energy by 13.6%
- Lower circulating load by 24%
- Increase the specific throughput by 19%

These results have significant implications for the design and operation of HPGR circuits.
Thank You
Muchas Gracias

Morenci Pilot Plant, Arizona, USA