High Pressure Grinding Rolls (HPGR)

In Comparison to SAG Milling Technology

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Jake Alexander, MBA
• HPGR Process/Overview
• HPGR vs. SAG
• The Manufacturers
• Mine Operations using HPGR
• Projects by Wardrop/Tetra Tech
• Economic Benefits
• Questions
The Process

Major Parts:

- Counter-rotating Rolls
- One fixed roll, one moving roll
The Process

Major Parts:

• Hydraulic pressure applied
• Nitrogen accumulator provides optimum interparticle crushing pressure
Main Operating Parameters

- Press Force (N/mm²)
- Roll Speed (m/s)
- Moisture Content (%)
- Feed Particle Size Distribution

Specific throughput

\[ M^* = \frac{\text{throughput}}{D \times L \times V} \quad (\text{ts/hm}^3) \]

Flake thickness/strength in balance with the compressing force (floating roll situation)
HPGR Assembly from the workshop, view the hydraulic side
HPGR Installations
Cerro Verde Maintenance Shop
The Manufacturers

Krupp Polysius (Germany)
- Favours a high aspect ratio design, i.e. large diameter, small width
- Use of studs for wear protection on rolls surface

KHD (Germany)
- Favours a low aspect ratio, i.e. small diameter, large width
- Use of studs for wear protection on rolls surface

Koppern (Germany)
- Favours a low aspect ratio, i.e. small diameter, large width
- Use of studs and hexadur wear protection linings

Others (Metso, FLS, Outotec, CITIC)
HPGR vs. SAG

Advantages

- Significant energy cost savings
- Reduced grinding media consumption
- Reduced overall operating costs
- Reduced footprint
- Higher mechanical availability
- Faster Equipment Delivery
- More Environmentally Friendly

Disadvantages

- Can increase initial capital costs
- Increased material handling
- Increased dust
Mine Operations Using HPGR

- Freeport McMoran, Cerro Verde, Peru
  - 2.4 m Dia x 1.7 m wide, 5 MW (2x2.5), processing 2,500 tph
- Freeport McMoran, Grasberg Mine, Irian Jaya, Indonesia
  - 2.0 m Dia x 1.8 m wide, 3.6 MW, processing 1,450 tph
- Nurkazgan Gold, Kazakhstan
  - 1.7 m Dia x 1.4 m wide, 2.3 MW, processing 1,000 tph
- Zapadnoe Gold, Russia
  - 1.0 m Dia x 0.9 m wide, 0.8 MW, processing 320 tph
- Newmont, Boddington Copper/Gold, Australia
  - 2.4 m Dia x 1.7 m wide, 5.6 MW (2x2.65), processing 2,100 tph
- Spinifex Ridge Moly/Copper, Australia
  - Three HPGR units (2x2.65 MW each)
Mine Operations Using HPGR

- Anglo Platinum, Mogalakwene Platinum Mine, South Africa
  - 2.2 m Dia x 1.6 m wide, 5.6 MW (2x2.8), processing 2,400 tph
Projects

Adanac Moly Corporation
Ruby Creek Project, Feasibility Study
20,000 tpd Moly Ore

Imperial Metals Inc.
Mount Polley Project, Scoping Study
Expansion from 20,000 to 30,000 tpd
Copper Gold Ore
Projects

International Molybdenum PLC
Malmbjerg Project, Trade-off Study + Feasibility Study
30,000 tpd Moly Ore

Pacific Booker Minerals Inc.
Morrison Project, Trade-off Study + Feasibility Study
30,000 tpd Copper/Gold/ Moly Ore
Projects

Russian Project, Trade-off Study
60,000 tpd Copper Gold Ore

Seabridge Gold Inc.
Courageous Lake Project
Trade-off Study
25,000 tpd Gold Ore
Projects

China Project
HPGR Study
40,000 tpd Copper/Gold Ore

Seabridge Gold Inc.
KSM Project
Trade-off Study + Pre-Feasibility
120,000 tpd Copper/Gold/ Moly Ore
Projects

Abacus Mining & Exploration Corp.
Ajax Project
Trade-off Study + Feasibility Study
60,000 tpd Copper/Gold Ore
SAG Mill

Primary Crusher → Stock Pile → Cone Crusher → SAG Mill → To Process

Ball Mill
## Economic Benefits

<table>
<thead>
<tr>
<th>Power</th>
<th>SAG</th>
<th>HPGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adanac Moly Corp</td>
<td>4.53 $/t</td>
<td>3.83 $/t</td>
</tr>
<tr>
<td>Imperial Metals Inc.</td>
<td>n/a</td>
<td>0.13 $/t*</td>
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<tr>
<td>International Moly</td>
<td>2.35 $/t</td>
<td>1.95 $/t</td>
</tr>
<tr>
<td>Russian Project</td>
<td>0.78 $/t</td>
<td>0.53 $/t</td>
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<tr>
<td>Seabridge Gold Inc.</td>
<td>3.59 $/t</td>
<td>2.47 $/t</td>
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<tr>
<td>Pacific Booker Minerals Inc.</td>
<td>0.63 $/t</td>
<td>0.56 $/t</td>
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<tr>
<td>Abacus Mining &amp; Exploration</td>
<td>0.60 $/t</td>
<td>0.47 $/t</td>
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* Additional costs for expansion project
## Economic Benefits cont.’d

<table>
<thead>
<tr>
<th>Consumables</th>
<th>SAG</th>
<th>HPGR</th>
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<tbody>
<tr>
<td>Adanac Moly Corp</td>
<td>0.77 $/t</td>
<td>0.73 $/t</td>
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<tr>
<td>Imperial Metals Inc.</td>
<td>n/a</td>
<td>0.55 $/t*</td>
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<tr>
<td>International Moly</td>
<td>2.03 $/t</td>
<td>1.29 $/t</td>
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<tr>
<td>Russian Project</td>
<td>1.46 $/t</td>
<td>1.10 $/t</td>
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<tr>
<td>Seabridge Gold Inc.</td>
<td>1.39 $/t</td>
<td>1.15 $/t</td>
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<td>Pacific Booker Minerals Inc.</td>
<td>2.03 $/t</td>
<td>1.47 $/t</td>
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<tr>
<td>Abacus Mining &amp; Exploration</td>
<td>1.83 $/t</td>
<td>1.38 $/t</td>
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</table>

* Additional costs for expansion project
### Economic Benefits cont.’d

<table>
<thead>
<tr>
<th>Overall Operating Costs</th>
<th>SAG</th>
<th>HPGR</th>
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<tbody>
<tr>
<td>Adanac Moly Corp</td>
<td>5.30 $/t</td>
<td>4.56 $/t</td>
</tr>
<tr>
<td>Imperial Metals Inc.</td>
<td>n/a</td>
<td>0.73 $/t*</td>
</tr>
<tr>
<td>International Moly</td>
<td>4.66 $/t</td>
<td>3.52 $/t</td>
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<tr>
<td>Russian Project</td>
<td>2.24 $/t</td>
<td>1.63 $/t</td>
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<tr>
<td>Seabridge Gold Inc.</td>
<td>4.98 $/t</td>
<td>3.62 $/t</td>
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<tr>
<td>Pacific Booker Minerals Inc.</td>
<td>2.66 $/t</td>
<td>2.03 $/t</td>
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<tr>
<td>Abacus Mining &amp; Exploration</td>
<td>2.48 $/t</td>
<td>1.92 $/t</td>
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</table>

* Additional costs for expansion project
Capital Costs

Capital Costs

- Adanac Moly Corp: -6.4%
- Imperial Metals Inc.: $35 mln*
- International Moly: -9.6%
- Seabridge Gold Inc.: -8.2%
- Pacific Booker Minerals Inc.: -9.6%
- Abacus Mining & Exploration: -10.2%

*S Additional costs for expansion project
## Power Consumption Greenland Project

<table>
<thead>
<tr>
<th>Plant Concept</th>
<th>SAG Circuit</th>
<th>HPGGR Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment</strong></td>
<td>1 x SAG Mill 9.8 MW</td>
<td>1 x Secondary Crusher 750 kW</td>
</tr>
<tr>
<td></td>
<td>1 x Pebble crusher 450 kW</td>
<td>1 x HPGGR 4.0 MW</td>
</tr>
<tr>
<td></td>
<td>2 x Ball Mills 5.6 MW each</td>
<td>2 x Ball Mills 5.6 MW each</td>
</tr>
<tr>
<td></td>
<td>Screens and conveyors 0.5 MW</td>
<td>Screens and Conveyors 1.5 MW</td>
</tr>
<tr>
<td><strong>Total drive capacity installed</strong></td>
<td>21.95 MW</td>
<td>17.45 MW</td>
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</tbody>
</table>
Power Savings

Installed Power Savings MW

- Adanac Moly Corp 4.1
- Imperial Metals Inc. -4.4
- International Moly 4.5
- Seabridge Gold Inc. 8.1
- Pacific Booker Minerals Inc. 4.0
- Abacus Mining & Exploration 14.0
Environmental Benefits

Estimation of CO₂ reduction based on EIA*

Reduction of \[ \text{TPY, CO}_2 \]

- Adanac Moly Corp \[ 21,000 \]
- Imperial Metals Inc. \[ n/a \]
- International Moly \[ 23,000 \]
- Seabridge Gold Inc. \[ 41,000 \]
- Pacific Booker Minerals Inc. \[ 20,000 \]
- Abacus Mining & Exploration \[ 71,000 \]

* Energy Information Administration

** Based on data for EIA USA, IMWH = 0.606 t CO₂
Thank You