Up-grades and Optimization of Crushing and Grinding Plants
HPGRs for hard rock applications

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POLYCOM – High Pressure Grinding Roll (HPGR) Design and Principle
Growth of HPGR's in the Minerals Industry

- Iron Ore
- Diamonds
- Hard Rock

No. Installed

Polycom – High Pressure Grinding Roll (HPGR) Applications and References
## Polycom – High Pressure Grinding Roll (HPGR)
**Reduction of Bond Work Index and OPEX**

<table>
<thead>
<tr>
<th>Material</th>
<th>Bond Index Wi</th>
<th></th>
<th></th>
<th>Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HPGR Feed</td>
<td>HPGR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>Product</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>Copper Ore</td>
<td>Material 1:</td>
<td>15.84</td>
<td>13.94</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td>Material 2:</td>
<td>17.02</td>
<td>15.36</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>Material 3:</td>
<td>17.30</td>
<td>13.70</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>Material 4:</td>
<td>19.13</td>
<td>15.60</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td>Material 2:</td>
<td>16.71</td>
<td>15.59</td>
<td>6.7</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>Material 1:</td>
<td>14.40</td>
<td>13.40</td>
<td>6.9</td>
</tr>
</tbody>
</table>

### Micro-Cracks

![Micro-Cracks Image](image)

### Particle Size Distribution

![Particle Size Distribution Graph](image)
Stage Crushing – Still a Common Flowsheet

- Fine gap setting limits throughput
- Batteries of crushers are needed to reach a certain throughput
- Ball/Rod mill feed fineness is limited
Up-grades and Optimization of Crushing and Griding Plants
HPGR at Tertiary Stage

- Reduction of Bond Work Index (BWI)
- Reduction of energy consumption of ball mill
- Increase of throughput capacity

**Freeport**

Cerro Verde I, Copper ore, 108.000 tpd
4 x POLYCOM 24/17
5.0 MW each
In operation since: 2006

Cerro Verde II, Copper ore, 240.000 tpd
8 x POLYCOM 24/17
In operation since: 2015
Up-grades and Optimization of Crushing and Griding Plants
HPGR at Quaternary Stage

- Reduction of Bond Work Index (BWI)
- Reduction of energy consumption of ball mill
- Increase of throughput capacity

Freeport
PTFI Grasberg, 35.000 tpd,
copper/gold/silver ore
2 x POLYCOM 20/15
3.6 MW each
20 % plant capacity increase in total
In operation since: 2007
Up-grades and Optimization of Crushing and Griding Plants
Comparison of Different Flowsheet (Case Study)

<table>
<thead>
<tr>
<th>Option</th>
<th>Energy Index ($P_{80} = 250 \mu m$)</th>
<th>New throughput of ball mills</th>
<th>Required POLYCOM</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>actual kWh/t</td>
<td>relative %</td>
<td>relative %</td>
</tr>
<tr>
<td>Current</td>
<td>6,0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Option 1</td>
<td>4,6</td>
<td>77</td>
<td>130</td>
</tr>
<tr>
<td>Option 2</td>
<td>5,2</td>
<td>87</td>
<td>115</td>
</tr>
<tr>
<td>Option 3</td>
<td>4,0</td>
<td>67</td>
<td>150</td>
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</tbody>
</table>
What is the Economic Potential?

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>19 % increase</th>
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</thead>
<tbody>
<tr>
<td>Plant capacity</td>
<td>tpd</td>
<td>51.000</td>
</tr>
<tr>
<td>Flotation feed fineness</td>
<td>µm</td>
<td>200</td>
</tr>
<tr>
<td>Recovery</td>
<td>%</td>
<td>90</td>
</tr>
<tr>
<td>Copper production</td>
<td>t</td>
<td>275</td>
</tr>
</tbody>
</table>

Value of production

- daily \(^{(1)}\) million US$ /d 1,50 1,79
- yearly million US$ /y 549 653

Additional value million US$ /y + / - 104

\(^{(1)}\) @ 0.6 % copper grade and a copper price of 5460 US$/t

Source: LME July 31\(^{st}\), 2015

Copper grade and price as well as capacity increase are mainly effecting the economics.

51,000 tpd copper plant
@ 0.6 % copper and 90 % recovery

19 % production increase

1 POLYCOM 24/17 operated in single pass mode

Total investment: Approx. 50 million US$

Value of additional production: 104 million US$ per year
Conclusions of Up-grades and Optimization by HPGR

- HPGR retrofits proved ability to increase plant production by higher throughput and metal recovery!
- Single pass HPGRs as quaternaries are easiest to implement!
- Up to 30 % higher ball mill throughput by single pass HPGRs!
- Relative low cost projects but highly profitable!
- Reduction of operating costs!
- Return Of Investment roughly 1 year for individual projects!
POLYCOM - Dry Finish Grinding System
The Next Step for Grinding Efficiency

- Only 1 grinding stage from secondary crusher product to flotation or magnetic separator feed
- Incorporates the most energy efficient comminution devices
- Closes the “gap” between HPGRs and stirred media mills
- Lowers energy consumption
- Lowers process water consumption

**Vasavadatta Cement, Limestone (~ 95 %)**
- Bond Index: 15 – 16 kWh/t
- Feed F99: < 50 mm
- Product P80: 65 – 90 µm
- Throughput: 320 – 370 tph
- Energy input: 10.7 – 11.5 kWh/t

(POLYCOM, fan, separator, bucket elevators)
Thank you for your attention!

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