Outotec HIGmills™

High Intensity Grinding

Global ore grades are declining while commodity demand continues to increase. Ore bodies are getting increasingly complex requiring finer grind for maximum mineral recovery.

The demand for finer grind has set new challenges for grinding technology. Energy efficiency is one of the major topics, targeted in the quest for sustainability and project viability.

Outotec HIGmills™ provide an advanced, energy efficient, fine and ultra fine grinding solution utilizing existing, well proven technology.

Benefits
- Excellent energy efficiency
- Largest industrial units in operation up to 5000 kW
- Online particle size optimization to maximize downstream process efficiency
- Compact, simple installation and process
- Operational flexibility
- Long maintenance intervals
Outotec HIGmill for ultra fine grinding

The HIGmill comprises a mill body, shaft with grinding discs, shell mounted counter rings, gearbox and drive. The grinding chamber is filled up to 70% with grinding beads. Rotating discs stir the charge and grinding takes place between beads by attrition. The number of discs (grinding stages) depend on the application and can be up to 30. Feed slurry is pumped into the mill via bottom connection. When the flow transfers upwards, it passes all consecutive grinding stages. Final product discharges at open atmosphere at the top of the machine.

Because of the tall, narrow, vertical mill body arrangement, grinding media is evenly distributed and mineral particles remain in constant contact, significantly increasing grinding efficiency.

In a typical application, the circuit feed is pumped to a scalping cyclone upstream of the mill. The overflow bypasses the mill and the underflow is fed into HIGmill. The pulp density of the mill feed is also controlled in the cyclone. The mill shaft speed is adjusted in order to generate the required energy to reach the target fineness. In typical cases the process is single pass and no external classification is needed. The cyclone overflow and mill discharge are the circuit’s products.

Over 200 HIGmills have been put into service; the total installed motor power is over 400 MW.

Outotec HIGmill benefits

Energy efficiency
Gravity keeps the media compact during the operation ensuring high intensity inter-bead contact and efficient, even energy transfer throughout the volume. The disc configuration and the whole chamber geometry have been optimized for efficient energy transfer to the bead mass, internal circulation and classification.

Largest industrial units in operation up to 5000 kW
The Outotec HIGmill comes in various drum diameters. The Mill heights can be varied to optimize the media load and power input for specific applications. Chamber volumes range from 5 to 20 000 liters with corresponding drives from 5 to 5000 kW. The HIGmill is the only ultrafine grinding technology in commercial use that can use small size high density grinding media in mill sizes above 3000 kW.

Online particle size optimization to maximize process efficiency
HIGmill offers a unique opportunity to optimize product fineness on-line. The control principle is to measure scalping cyclone feed quantity and adjust the mill shaft speed to reach target energy per total feed flow. Alternatively, particle size distribution is measured by Outotec PSI® on-line particle analyzer and the shaft speed adjusted to maintain constant product size.

Compact, simple installation and process
HIGmill has a less complex and more compact process layout and flow sheet than other stirred media mills. The process comprises only a scalping cyclone, feed tank and pump and the mill itself. The benefit of high power intensity and vertical installation is a very small foot print. The head room over the mill is small and the flanged, split shell construction reduces the space needed for maintenance. The top supported, hanging arrangement keeps the floor and sides clear, simplifying maintenance and emptying the beads.

The mill is not a pressure vessel and there is no need for shaft seals. Gravity keeps the grinding media in the mill and no external screens are needed.
The throughput can vary in a wide range and there is no need to circulate material in order to keep the flow inside a narrow band. Instrumentation level is minimal and, for optimal process control, it is suggested to measure at least scalping cyclone feed (flow and density), mill feed pressure, mill discharge temperature and density as well as final product PSD.

**Operational flexibility**
Outotec HIGmill can be used for a wide range of grinding applications and it has also an excellent flexibility to adapt to fluctuating process conditions.

There are two product configurations: Standard (ST) and High Efficiency (HE). Basic design is similar but details are optimized per application. ST is utilized in the coarser range where the feed \( f_{80} \) is \( >100 \mu m \) and product \( p_{80} \) \( > 40 \mu m \). HE is designed for fine or ultra fine grinding where the feed \( f_{80} \) is \( <100 \mu m \) and \( p_{80} <40 \mu m \). During process design, mill volume and diameter, bead charge, disc tip speed range as well as bead size and material are optimized.

Typical application for the HIGmill is regrinding of concentrates (e.g. magnetic, flotation). The flow from upstream processes can vary remarkably due to fluctuations in ore grade and quality. Also the target fineness can vary because of variations in the ore mineralogy. Flow fluctuations in the HIGmill can be dampened by maintaining the net energy constant via control of the mill shaft speed. Product fineness is also controlled by adjusting the shaft speed and thus power input.

If the conditions permanently change so that the current operational range is no longer optimal, the range can be optimized by changing volumetric media filling, bead size and/or bead material. Both ceramic and steel beads can be used. In ultrafine grinding the typical bead diameter is 1-3 mm and in coarser grinding 3-6 mm.

Tip speed and thus power input can be adjusted in a very wide range. A special feature of the HIGmill is that energy efficiency remains constant through a wide tip speed range.

**Long maintenance intervals**
The drum segments and wear components have been specifically designed to make maintenance simple and quick. The casing is flanged vertically so that it can be split down the center into two halves that can be moved apart on a railing system. After exposing the internals, changing of discs and liner segments can be done individually by a team of two skilled mechanical trade personnel.
Wear of the discs is even around the circumference. The wear is faster in the bottom part of the mill and typically the lowest discs have to be replaced a few times before the total set is changed. For total set change, a spare shaft, ready for installation, is an option. Wear components can be lined with polyurethane, metal hard facing or natural rubber depending on application. The critical components of the mill and gears can be delivered in short time.

**HIGmill delivery**

The HIGmills are available with or without the mounting frame. The mills in brown field projects are typically supplied with a frame, while the mills in green field projects are integrated into the concentrator building.

Typical delivery includes:
- Scalping cyclone with feed pump
- Feed, mixing and storage tanks
- Feed pump
- Media addition systems for grinding media
- Motor and drive components
- Gearbox and oil supply system
- All instrumentation, controls and the motor control centre
- PLC control with human machine interface (HMI)
- Vertical process package engineering and plant model

### Testing

Outotec has two sizes of test units. HIG 5 is a 5 liter/7.5 kW unit for defining specific grinding energy (SGE) to reach the target PSD. The ideal sample quantity is from 100 kg upwards. A simple batch test with one set of parameters and constant SGE can be performed with a 50 kg sample. HIG 5 results give a reliable basis for full scale design.

HIG 25 (25 liter/30 kW) is available for continuous pilot runs. Sample amount is from 1000 kg upwards. This unit is applicable for on-site campaigns, too.

Minimum of a single parameter basic test is required for process sizing. In an optimal case, a larger sample is required so that more basic parameters can be tested. Test parameters are slurry milling density, retention time, tip speed, mill internal geometry, media charge, bead size/distribution and bead material.

The HIGmills are available in a fixed range of body diameters. Overall height can be varied to optimize the media load and power input for each application. Mill volumes range from 400 litres to 20,000 litres with corresponding drives ranging from 130 kW to 5000 kW. The ability to provide small capacity increments. Outotec can optimize the mill size to match project requirements: optimizing Capex and operating costs.

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<thead>
<tr>
<th>Type</th>
<th>HIG 130</th>
<th>HIG 200</th>
<th>HIG 500</th>
<th>HIG 700</th>
<th>HIG 1100</th>
<th>HIG 1500</th>
<th>HIG 2000</th>
<th>HIG 3000</th>
<th>HIG 3500</th>
<th>HIG 4000</th>
<th>HIG 5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed power (kW)</td>
<td>130</td>
<td>200</td>
<td>500</td>
<td>700</td>
<td>1100</td>
<td>1500</td>
<td>2000</td>
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Outotec develops and provides technology solutions for the sustainable use of Earth’s natural resources. As the global leader in minerals and metals processing technology, Outotec has developed over decades several breakthrough technologies. The company also offers innovative solutions for the chemical industry, industrial water treatment and the utilization of alternative energy sources. Outotec shares are listed on the NASDAQ OMX Helsinki.