IsaMill™
BREAKING THE BOUNDARIES

High intensity, energy efficient grinding providing versatile solutions to the minerals industry
The IsaMill™ is a large-scale, energy efficient grinding technology developed and proven in rugged metalliferous applications.

**About IsaMill™**

The IsaMill™ utilises more power per unit volume than ball and tower mills. This means a small footprint, simple installation and simple maintenance.

The horizontal configuration has enabled rapid scale up to large mills – 3MW and 8MW. For the first time the advantages of inert stirred milling are available to high tonnage, mainstream grinding.

The IsaMill™ reduces the energy cost, media cost and capital cost of grinding. Further, the intense inert attrition frequently improves metallurgical performance compared with conventional steel media. The IsaMill™ produces a steep particle size distribution in open circuit without needing internal screens or closed circuit cyclones. The horizontal plug-flow design prevents short circuiting, and provides for a robust and easy to operate technology. This means simple and easy to operate circuits.

Maintenance is safe, simple and quick – a team of 2 people can complete a disc and liner change in 8 hours.

The IsaMill™ is extensively used in base metals (copper, lead, zinc and nickel), PGM, iron ore, industrial applications and gold processing plants and is the optimum choice for:

- Regrinding Concentrates
- Fine/Ultrafine Grinding
- Mainstream Grinding

The IsaMill™ is currently available in the following models* (named according to net grinding volume in litres):

- M1000 (355–500kW)
- M3000 (800kW)
- M5000 (1120–1500kW)
- M10000 (3000kW)
- M15000 (3700kW)
- M50000 (8000kW)

* Smaller models are available on request.
IsaMill™ advantages

High throughput capacity, excellent availability, ease of maintenance, small foot print, low installation cost, high energy efficiency and improved downstream processing are the cornerstones of IsaMill™ technology.

1 Energy Efficiency
Simply, grinding efficiency is about media size. Smaller media has more surface area and higher media/particle collision frequency making it more efficient – as long as it can break coarse particles (<0.5mm). The high intensity in the IsaMill™ means small media can break coarse particles. The large scale of the IsaMill™ makes that efficiency available to mainstream grinding.

2 Improved Flotation/Leach Recovery
Inert grinding media produces clean, fresh mineral surfaces that often improves downstream processing performance. The steep particle size distribution also benefits flotation and leaching recovery as well as assisting material handling properties.

3 High Intensity – a smaller footprint and sharp product size distribution
This high intensity grinding technology (>300kW/m³) requires a much smaller footprint than conventional grinding technology – the grinding volume of the IsaMill™ is one tenth of the equivalent ball or tower mill. The high intensity means short residence times, preventing overgrinding and giving a sharp product size distribution.

4 Open Circuit configuration
Feed to the IsaMill™ passes through 8 consecutive grinding stages between the discs before it reaches the internal classifier. Other mills with just one grinding stage require closed circuit cyclones and high recirculating loads and still don’t produce product size distributions as steep as the IsaMill™.

5 Simple, Fast and Safe Maintenance
Maintaining an IsaMill™ is like maintaining a large pump. It is fully sealed with rubber lined replaceable components and a pressurised gland seal. A shut down for inspection and replacement of internal wear parts, including the liner, takes less than 8 hours.

6 Large Scale
Mills are available from 75kW to 8MW. This makes the efficiency and process benefits of inert grinding available to large and small tonnage applications.

7 Horizontal Design
The horizontal layout enables a plug-flow design. This avoids short circuiting and makes the mill far less sensitive to process disturbances. The horizontal design allows the mill to start under load and translates to simpler maintenance.

8 Low Installation Cost
Low height, small crane lifts and simple under-floor media system. Large scale mills and open circuit operation. This means less mills, less classification, simple circuit layout and lower installed cost.

9 Accurate Scale-up
Laboratory and Pilot results are scaled to commercial size with 100% accuracy. IsaMills have a proven 1:1 direct scale-up reducing project risk.
IsaMill™ operation and maintenance

IsaMill™ is designed to provide high intensity, energy efficient grinding. The product separator retains media and the horizontal configuration simplifies maintenance.

The IsaMill™ is a horizontal, high speed stirred mill that operates with very high power intensities (up to 300kW/m³) compared to ball or tower mills (with less than 40kW/m³).

This high power intensity enables the IsaMill™ to process coarse particles to fine product sizes with small media at high throughput. The result is large scale, efficient grinding for both coarse and fine particle sizes.

The IsaMill™ stirs media with rotating, rubber lined, disposable grinding discs mounted on a cantilevered shaft. The cantilevered shaft, coupled to the motor and gearbox, allows quick and simple removal of the grinding chamber to expose the mill internals for maintenance. A Liquid Resistance Starter (LRS) for the motor enables the IsaMill™ to be started under load. The feed and discharge flange and the IsaMill™ shell are rubber lined and easily maintained.

The motor and gearbox have individual lubrication and cooling systems. The shaft is sealed from atmosphere by a wet packed gland supplied with gland water (similar to a large pump). A separate water line supplies flushing water to keep media and slurry out of the gland area.

The IsaMill™ discs reach a tip speed of 19–22m/s depending on the application. The mill operates 70–80% full of small (1.5–6mm) grinding media. The discs agitate this media to grind the feed slurry. The patented product separator retains media in the IsaMill™ by first centrifuging it and then pumping it back towards the feed end of the mill. Feed particles have to pass through consecutive grinding discs – effectively 8 grinding stages in series before a particle reaches the product separator.

For maintenance, slurry is flushed from the IsaMill™ and the media is dumped through the scuttle valve into the media hopper below the mill. The IsaMill™ shell is then pushed back along rails using hydraulic rams providing easy access to all of the wear components.
IsaMill™ engineering

IsaMill™ technology includes not just the grinding mill – it incorporates the entire grinding system.

From design through to construction, commissioning and maintenance, our engineering resources have developed grinding systems that work. This reduces the risk to customers, both the end user and engineering firms.

IsaMill™ technology can be delivered to the customer under a variety of models to allow for maximum flexibility without compromising on quality or cost.

The scope includes process and engineering design, supply, and commissioning of a complete grinding system delivered to customer’s site for easy installation by a local contractor. This can incorporate auxiliary equipment that makes up the IsaMill™ technology package (associated tanks, hoppers, pumps, platforms and pipework).

The scope can be further expanded to supply the IsaMill™ technology package on a turn key basis or for extensive plants, an EPCM type solution where Glencore Technology works with others to also provide non-proprietary technologies, eg Flotation, CIL.

IsaMill™ specifications

<table>
<thead>
<tr>
<th>Grinding Chamber Volume</th>
<th>M1000</th>
<th>M3000</th>
<th>M5000</th>
<th>M10000</th>
<th>M15000</th>
<th>M50000</th>
</tr>
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<tbody>
<tr>
<td>litres</td>
<td>1000</td>
<td>3000</td>
<td>5000</td>
<td>10000</td>
<td>15000</td>
<td>50000</td>
</tr>
<tr>
<td>Drive capacity (kW)</td>
<td>355–500</td>
<td>800</td>
<td>1120–1500</td>
<td>3000</td>
<td>3700</td>
<td>8000</td>
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<tr>
<td>Total unladen mass (tonne)</td>
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<td>42</td>
<td>45</td>
<td>85</td>
<td>90</td>
<td>126</td>
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<td>Length (m)</td>
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<td>34</td>
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<tr>
<td>Width (m)</td>
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<td>3.5</td>
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<tr>
<td>Height (m)</td>
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<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>5.4</td>
</tr>
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</table>

1 Includes motor and gearbox. 2 Width approximated. TBC with motor. 3 Height approximated. TBC with motor.

Smaller models are available on request.
IsaMill™ grinding

The eight consecutive grinding chambers, patented product separator and short residence times mean the mill constantly delivers sharp product size distribution without external classification.

Grinding Mechanism

The IsaMill™ is a closed mill. Slurry travels through the mill in a ‘plug’ flow pattern through consecutive grinding discs. Media recirculates between the rotating discs distributing grinding action throughout the IsaMill™. Grinding is by attrition and abrasion of the particles in contact with the high speed, small, circulating media.

At the discharge end of the IsaMill™, slurry and media reach the patented product separator. Media is centrifuged out to the shell and is pumped back with some of the slurry to the feed end of the mill. This action retains media in the IsaMill™ without the need for fine screens while the ground discharge slurry exits the centre of the product separator.

The high efficiency of the IsaMill™ comes from its ability to use small media, with high surface area and high media/particle collision frequency. Small media can still grind coarse feed because of its high speed – up to 22 m/sec. The high power intensity results in a small mill with short residence times – less than a minute – which avoids overgrinding.

This is one of the keys to the IsaMill™ energy efficiency – energy is directed to coarser particles and not wasted on fines, which leave the mill quickly.

Media Type

The ability to use small media is fundamental to the high efficiency of the IsaMill™. The intense inert attrition also produces fresh, clean mineral surfaces which can have significant benefits for downstream flotation or leaching.

The internal product separator retains media inside the mill without needing to use screens or cyclones. This feature means the IsaMill™ can use a wide range of media – including smelter slag, fine primary mill ore scats, silica sand or river pebbles and low or high density ceramics. Natural media is suitable for fine grinding but ceramics are normally needed for coarse grinding. Ceramic media is more efficient than natural media meaning lower installed power, lower media consumption and fewer mills for a specific application. The best media type for an application is a question of the ability of the media to break the top sized feed particles coupled with economics.

Glencore Technology can conduct a test program to compare the performance and economics of alternative media.
The shaft rotating at high speeds generates disc tip speeds of 19–22 m/s.

Recirculation of media occurs between discs due to variation in velocity profile across discs.

Media centrifuged to outside of grinding chamber by high centrifugal force generated inside mill.

Rotor pumps liquid back into chamber to retain media.

**Sharp Product Size Distribution**

The grinding mechanism of an IsaMill™ is fundamentally different from a ball mill. The impact mechanism and long residence times in ball mills cause indiscriminate grinding and poor size distributions. This generates slimes, wastes energy and increases reagent consumption. Furthermore, closed circuit cyclones used in ball and tower mill circuits use considerable amounts of energy to pump recirculating loads and still result in particles misreporting in the circuit. In contrast, the IsaMill™ produces a sharper size distribution in open circuit.

The plug flow, short residence time and product separator in the IsaMill™ results in a product size distribution that is always much sharper than the feed. While the IsaMill™ is more efficient at grinding to a particular P80 the sharp product size distribution and resulting reduced top size means that IsaMill™ technology often achieves the same process recovery at a coarser P80 than process flowsheets using alternative grinding technologies.

The “tight” product size distribution is ideal for subsequent flotation, resulting in improved coarse end liberation for a given P80 sizing. It is also crucial in leaching applications, where recovery is usually determined by the coarser end of the size distribution (best measured by P98 or P95, not P80).
Accurate design

With proven one-to-one direct scale up from laboratory testwork, installing IsaMill™ technology significantly reduces project risk.

Testing

Accurate testwork and scale up is essential for project performance. A test program must rigorously account for energy measurement, size measurement, media size, classification and batch testing versus continuous operation. While techniques like the Bond Work Index and "scale up factors" are useful for coarse grinding, they can significantly underestimate grinding needs below 100 microns.

Glencore Technology uses rigorous scientific design methods, and confirms the scale up on every plant. IsaMill™ installations always meet design.

Testwork facilities

The best way to accurately size an IsaMill™ is by testwork on a representative feed sample. Glencore Technology has its own facilities and has also authorized a number of independent laboratories to conduct IsaMill™ tests. IsaMill™ test procedures consistently achieve one-to-one scale up, because the test rig configuration is the same as a full scale mill – continuous feed, internal classifier, same grinding action and same grinding media.

Initial testing uses an M4 IsaMill™ to accurately determine the relationship between specific power draw and product size – the “signature plot”. Alternatively, fully self-contained M20 plant pilot rigs are available for on-site campaigns. M20 pilot rigs can determine power requirements while investigating media consumption and downstream processing performance on real plant streams.

Net Energy Consumption

Testwork determines the Net Energy Consumption to grind to the target size. This is the primary design variable and extreme care is needed to measure it directly and correctly. The net energy must be converted to gross energy for full scale to allow for losses in the motor and gearbox.

Media

For any given ore, grinding energy efficiency is determined primarily by media size and type. Glencore Technology’s procedures use the same size media as the full scale IsaMill™ – essential for accurate scale up. These procedures test first with a benchmark media and then with other media types if nominated by the client.

Particle Size Measurement

Like energy measurement, particle size measurement is not a trivial matter. Glencore Technology has considerable experience in using reliable and repeatable methodology for this crucial measurement.

Classification, Continuous vs Batch, Particle Segregation

Scale-up methods must accurately predict real-plant continuous operation and classification effects. The test procedure must ensure steady state and no “hold-up” of coarse particles in the test mill – a particular issue with vertical mills. IsaMill™ test procedures use the same continuous feed and classification as full scale, and specifically confirm that steady state has been reached.
Technology partnership concept

IsaMill™ technology is a major advance in processing. It was developed over a long period in Glencore operations and at our client sites. This has resulted in a technology package that is more than just a mill. The technology package includes all aspects needed to design and incorporate high intensity grinding into a flowsheet.

Our Technology Partnership concept is the vehicle that makes this body of knowledge and experience available to you, enabling your company to achieve the full potential benefits of IsaMill™ Technology.

» Glencore Technology has an ongoing technical relationship with all users.
» We facilitate interchange of learnings between users.
» Glencore operations have been using IsaMill™ Technology as a core part of their processing operations since 1994. This commitment continues to grow with 25 IsaMills™ operating at various Glencore concentrator facilities in Australia, South America and Africa.

» Our extensive operating experience combined with the latest equipment and process development produces a package that delivers rapid technology transfer to your operation.
» IsaMill™ users are invited to participate in regular international technology meetings to share learnings and latest developments.

Reducing your carbon footprint

Due to the energy efficiency of IsaMill™ technology operators may be in a position to generate carbon credits to meet their current or future emission reduction obligations. Alternatively, the credits could be sold on global carbon markets.

There are two main pathways for this under the Kyoto Protocol, the Clean Development Mechanism (CDM) and Joint Implementation (JI). Under the CDM, companies can generate credits by investing in Greenhouse Gas (GHG) reduction projects in countries that are classified as ‘developing’. This includes mineral-rich countries of Africa, South America and Asia.

Under the JI, companies can generate carbon credits from GHG reduction projects implemented in countries who have ratified the Kyoto protocol and are classified as developed or with an economy in transition. This includes projects in countries such as Russia and the Ukraine.

To ensure that projects qualify for and realise carbon trading opportunities, it is important that the carbon considerations are included in the earliest stages of project planning and decision making. Glencore Technology and its carbon partner Sigma Global can ensure that you derive the maximum carbon benefit from IsaMill™ technology. This includes the investigation of suitable carbon credit schemes for the project site, approval and verification of the project by the relevant authorities and expert advice on the most appropriate strategy for your company.
Manufacturing to mining

The development of IsaMill™ technology is a case study in applied research. It started at Mount Isa in the 1970s and 1980s when it was clear that future ores would need much finer grinding.

Conventional Ball and Tower Milling were not economic to grind below 25 microns, due to low energy efficiency, low power intensity and high media consumption.

Further, the high steel media consumption in these mills was severely detrimental to flotation performance.

Our engineers studied other industries which used ultra fine grinding commercially – pigments, inks, pharmaceuticals and foodstuffs (e.g. chocolate). These high value products used small scale mills, high cost media, and often batch grinding. But they demonstrated the principle that stirring fine media at high speed was highly efficient.

The challenge was transferring this concept to continuous, high tonnage and lower-value streams in the minerals industry. Mount Isa Mines worked in partnership with Netzsch-Feinmahltechnik GmbH of Germany, a specialist in stirred milling for over 50 years. After 7 years of development and testing of prototypes in the Mount Isa operations, the IsaMill™ evolved. It was large scale, continuous, and most importantly robust because it was developed by operators. The crucial breakthrough was the perfection of the internal product separator – this allowed the mill to use cheap natural media (sand, smelter slag, ore particles) and to operate in open circuit. These are significant advantages for operating cost and circuit simplicity.

Moving stirred milling “from ink to zinc” was the hard part. The next challenge was to apply the same energy and processing advantages to mainstream grinding.

This needed two further developments – an even bigger mill and low-cost, competent ceramic media. The first M10,000 IsaMill™ was installed in South Africa in 2003, and Magotteaux developed KERAMAX® – MT1™ ceramic media specifically for IsaMill® in 2005. Since then, the 3MW M10,000 has become the most commonly installed IsaMill™. The power installed in regrind and coarse grinding applications has quickly outstripped that used in ultra fine grinding. This remarkably rapid adoption in coarse grinding reflects the robustness and simplicity of IsaMill™ technology.

Glencore Technology

Glencore Technology develops, markets and supports technologies for the global mining, mineral processing and metals extraction industries. It has offices in Australia, South Africa, Europe, Russia, China, Canada and Chile, and is a wholly owned subsidiary of Glencore, a major global diversified mining group.

For further information please visit www.glencoretechnology.com.
Case Study:
Mount Isa Mines George Fisher Regrind Circuit

Fine grinding to a P80 of 7 microns in the zinc retreatment circuit was necessary for the economic development of the George Fisher deposit. Every one micron size reduction in the zinc retreatment circuit below a P80 of 10 microns improves the overall plant zinc recovery by 1%.

The existing concentrator was modified to suit the new ore type primarily by the introduction of eight 1.1MW IsaMills™, two to regrind lead cleaner feed and six to regrind intermediate zinc flotation streams.

The figure below shows these changes increased zinc recovery from 70% to 75% after all IsaMills™ were commissioned in November (the initial drop, in 1999, was due to temporary removal of grinding and flotation during the brownfields installation).

While the recovery improvement was expected due to better liberation, what wasn’t expected was a significant drop in reagents and circulating loads. Fine minerals are expected to consume more reagent due to their higher surface area. But improved liberation dropped circulating loads, and clean fresh surfaces from inert attrition increased flotation rates and selectivity, significantly reducing the need for collector and depressant.

% Zinc Recovery

Prominent Hill

OzMinerals’ Prominent Hill copper-gold concentrator began commercial production in 2009. A 3MW M10000 IsaMill™ operating with 3.5mm ceramic media was installed to liberate the fluorine bearing gangue minerals from the rougher concentrate. Liberated fluorine minerals could then be rejected in the cleaner flotation circuit to produce a commercial quality copper-gold concentrate. The IsaMill™ regrind circuit was designed to produce a cleaner circuit feed P80 of 20–25µm ensuring adequate liberation. The inert grinding environment in the IsaMill™ prevents contamination of the mineral surfaces giving optimum flotation performance.

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Installations

From the installation of the first M3000 IsaMill™ at Mount Isa in 1994, IsaMills are now operating in major mining operations around the globe.

For a current installation list please visit our website www.isamill.com
Glencore operates mines throughout the world. Tough testing grounds that make our process technologies the best on earth.

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