Stirred Milling machine development and application extension

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metso

Contents

- Current technologies
- Efficiency and application range development
- Machine development and where we are going
- Key project updates

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Stirred milling

What is a stirred mill?

A mill by which the charge is agitated with stirring mechanisms within a static mill shell. (Vertical or horizontal)

The two distinct type of stirred mills – **gravity induced** and **fluidized** –

Stirred mills are generally recognized as cost saving technologies through:

- Higher energy efficiency
- Lower installation cost
- Lower operating cost

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Stirred milling

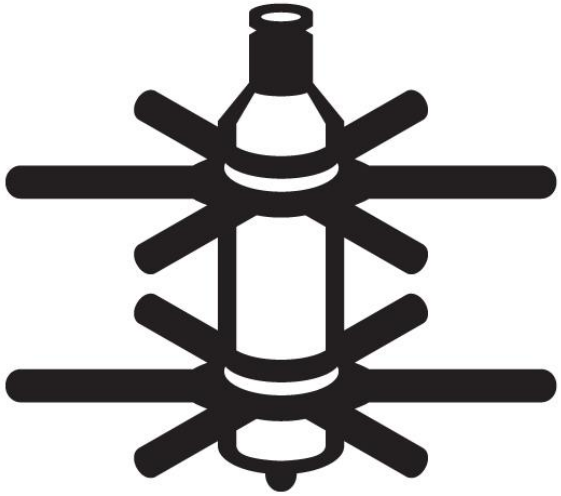
Gravity induced screw stirred mills

- Types
  - VERTIMILL® (VTM)
  - Eirich Tower mill™
- General characteristics
  - Gravity keeps media in the mill
  - Charge weight aids grinding
  - Low intensity, low tip speed
  - High density media
  - Media sizes 38 – 5 mm
  - Screw agitator to lift charge

Stirred milling

Fluidized mills

- Types
  - Stirred Media Detritor (SMD)
  - Xstrata Isamill™
  - FLS VXP Mill (formerly Deswik)
  - Outotec HIG
  - Metprotec, etc
- General characteristics
  - Fluidized media
  - Inert media, 1 - 6 mm
  - High rotational speed
  - Discs and pins



Stirred milling

Design goals

Lowest total cost of ownership

Process Design

Machine Design

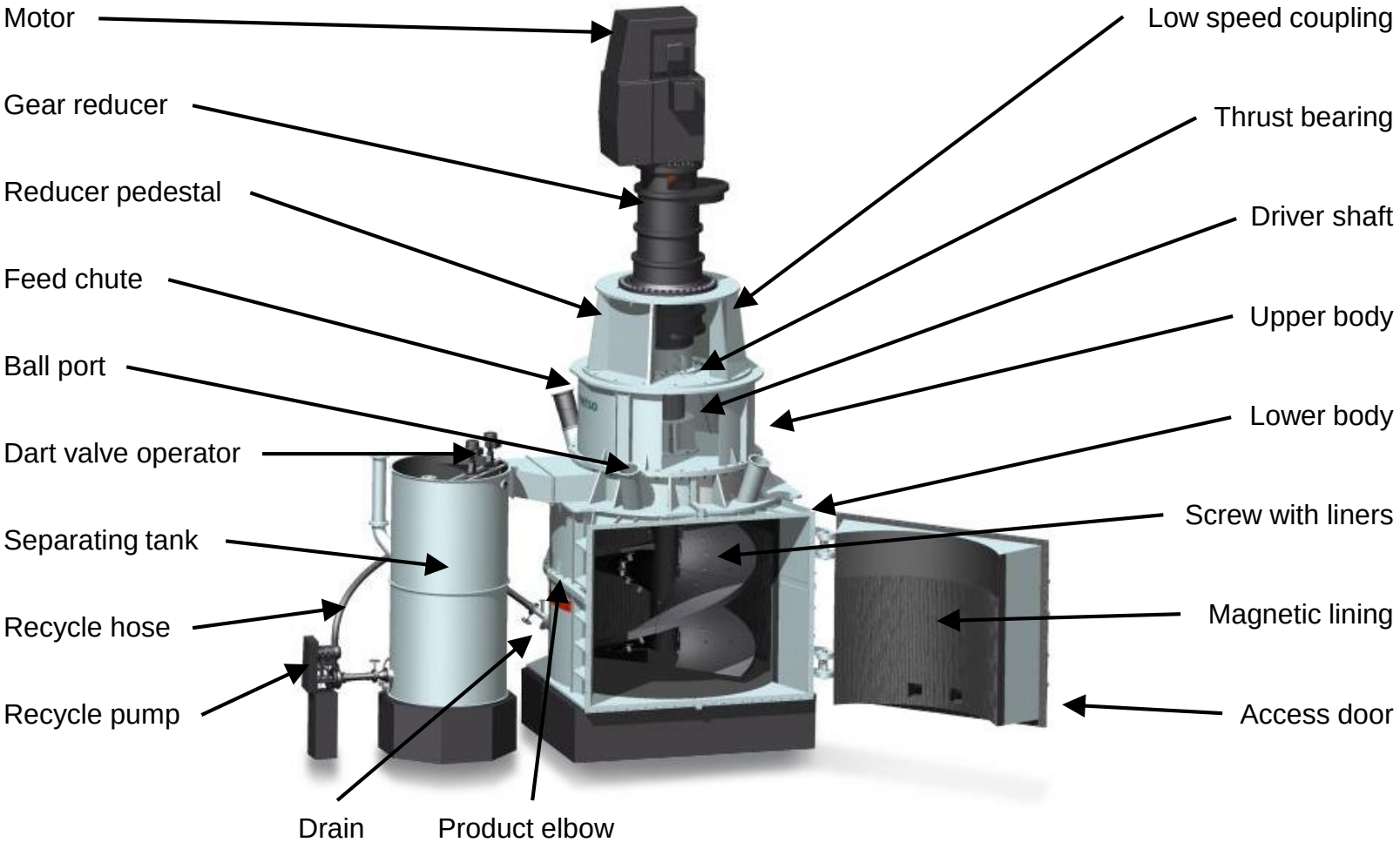
VERTIMILL® grinding mill

Overview

- Over 450 units worldwide
- Over 300,000 kW total power
- Unit sizes from 15 to 4500 hp
- Feed size from 6 mm
- Product sizes to <15 µm
- Low intensity = low wear
- High density media
- Media size matched with grind 38 – 5 mm

Stirred milling – VERTIMILL® grinding mill

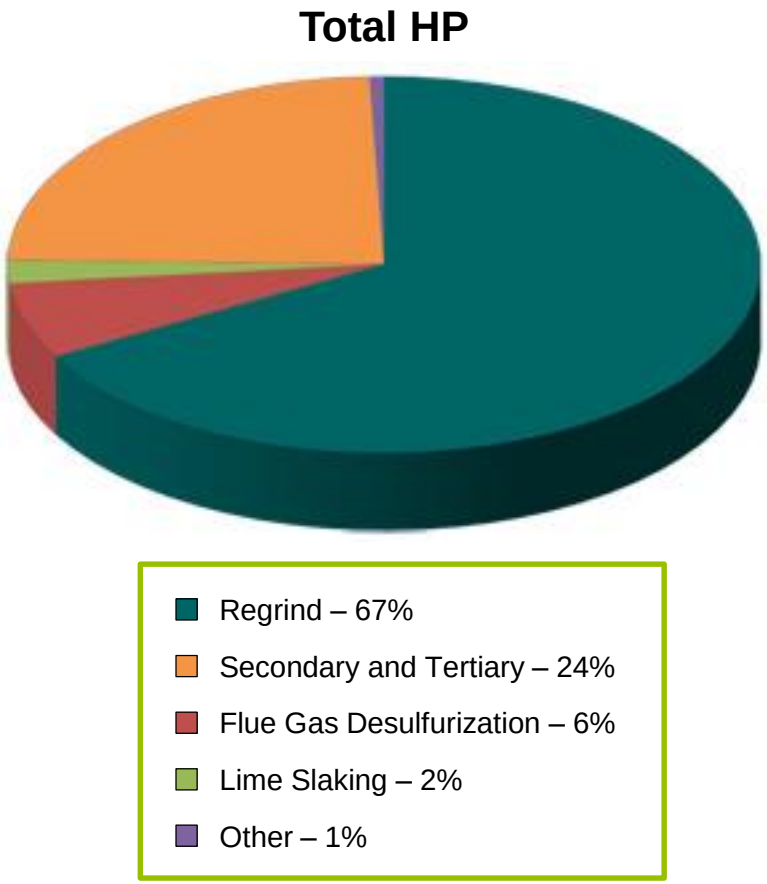
Components and features



VERTIMILL® grinding mill

Applications

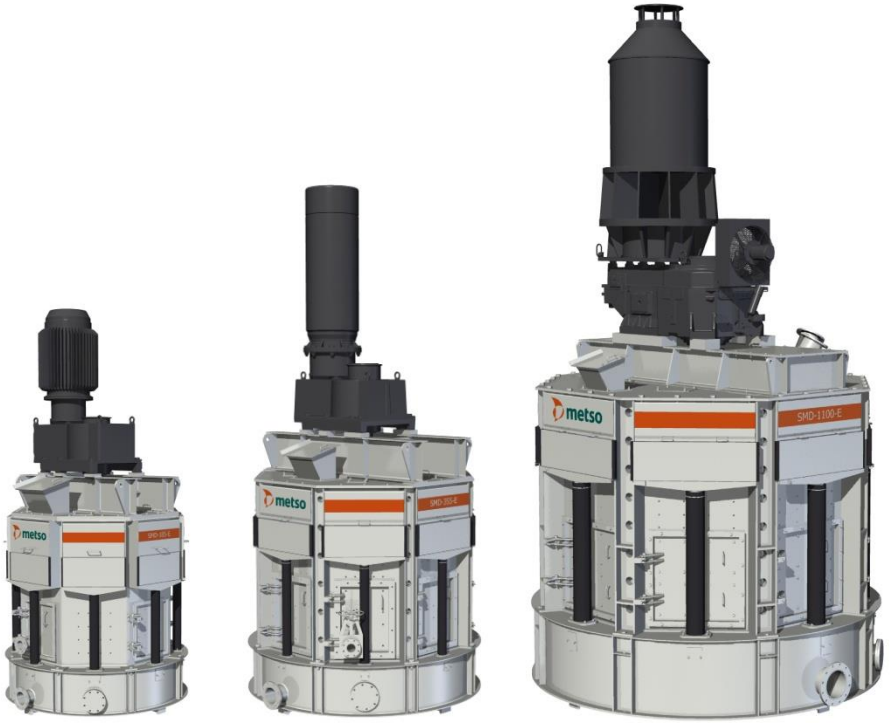
- Grinding
  - Secondary: 6 mm to 75 µm
  - Tertiary: 400 µm to 75 µm
  - Regrind: 200 µm to 15 µm
  - Flue gas desulphurization: 6 mm to 20 µm
- Lime slaking
  - Flue gas desulphurization
  - Acid neutralization
  - Additive



Stirred Media Detritor

Overview

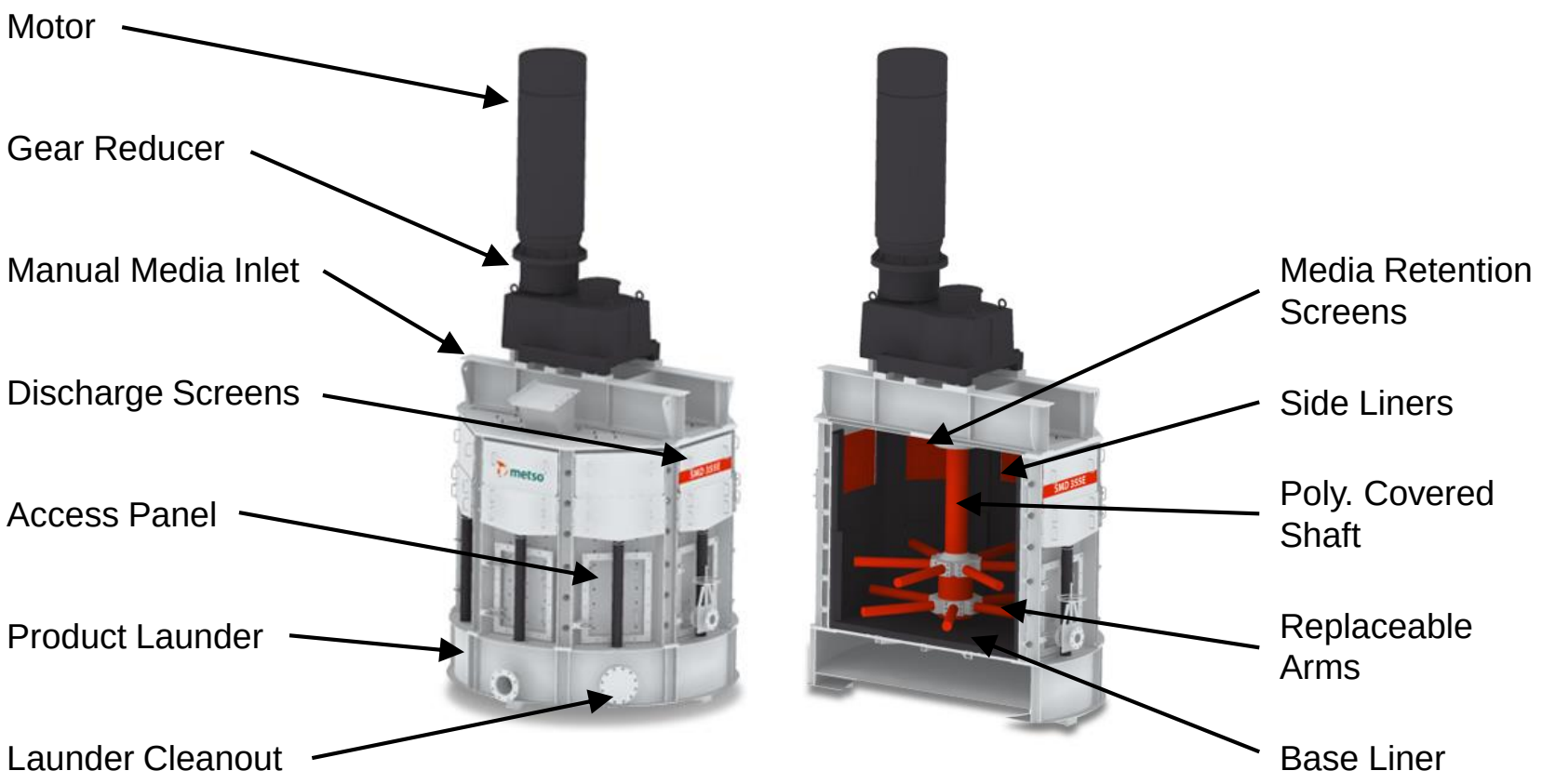
- Primarily for fine and ultra fine grinding
- Low density media: sand or ceramic
- Optimum grinding intensity for optimum wear life
- >170 units by Metso



SMD-185-E SMD-355-E SMD-1100-E

Stirred Media Detritor

Components and features – SMD-E



Stirred Media Detritor

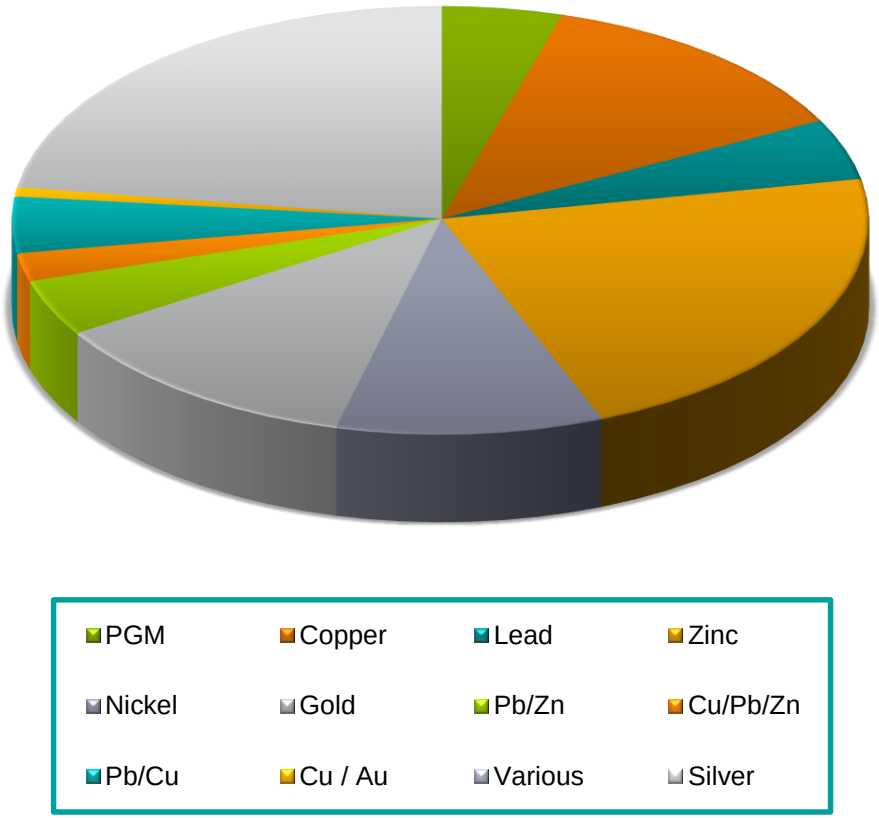
Typical operational parameters

Typical F_{80}	75 – 25 µm
Max. F_{80}	250 µm
Typical P_{80}	35 – 5 µm
Min. P_{98}	2 µm
Energy input	5 – 100 kWh/t
Grinding media	1 – 8 mm, matched with grind

Stirred Media Detritor

Applications

- Ores/concentrates with fine mineral intergrowth
- Bio-leaching and low pressure oxidation
- Flotation at sub 10 micron
- Leaching refractory gold ores



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Stirred milling

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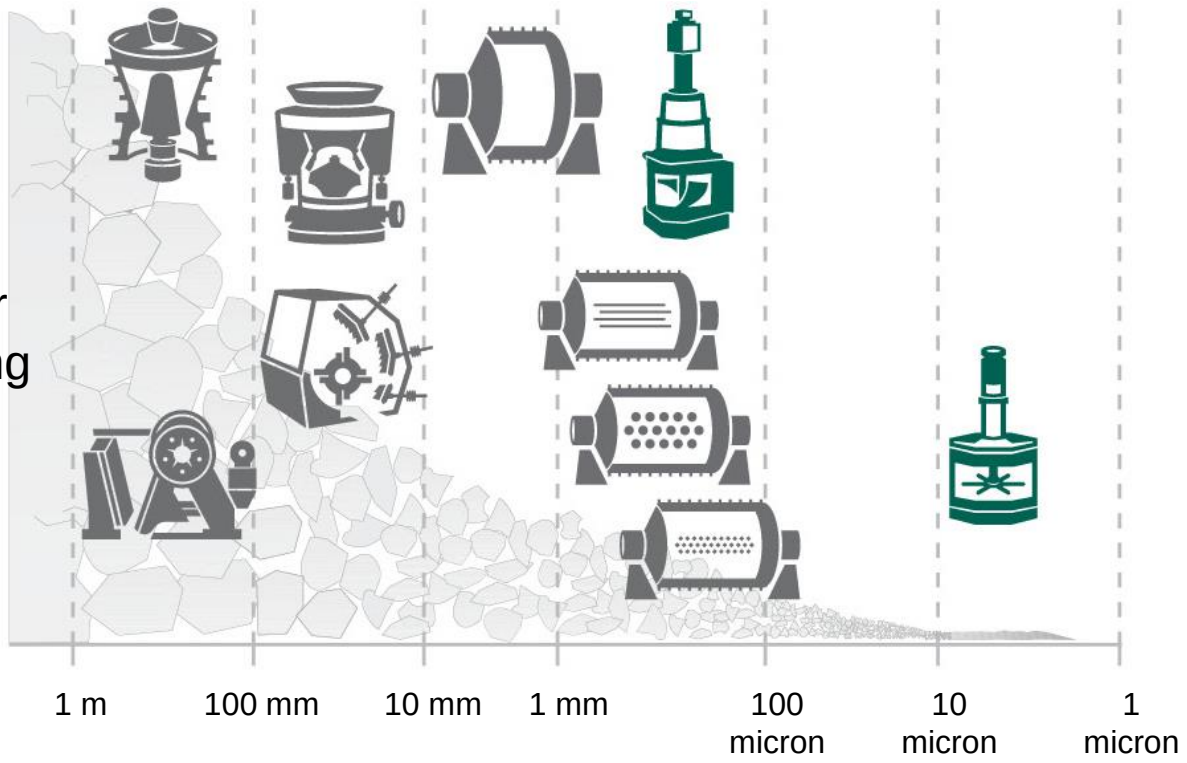
Metso stirred mills

Product role

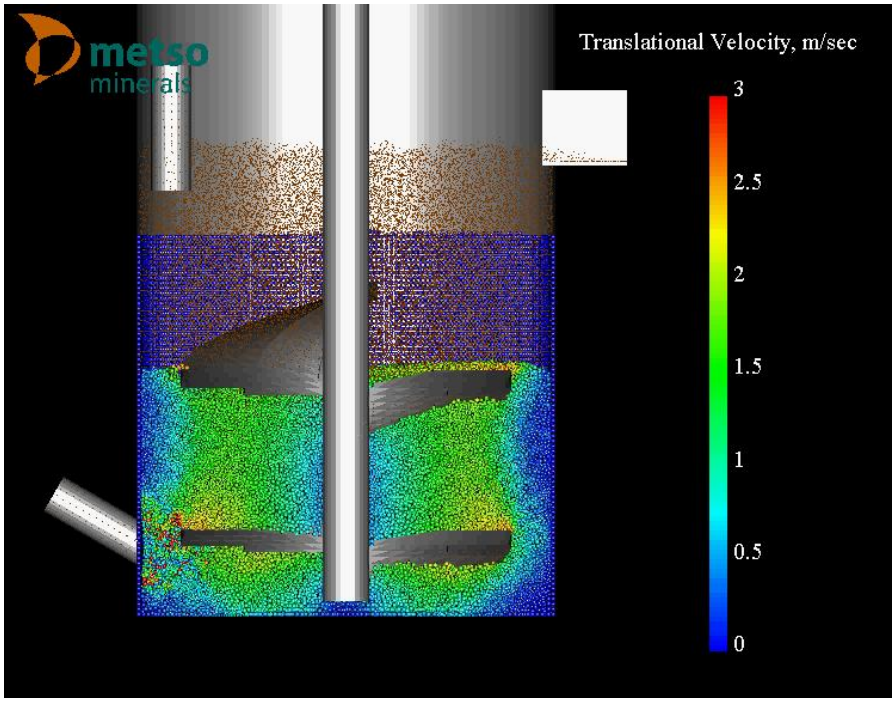
The VERTIMILL® and SMD applied correctly can provide improved grinding efficiency, reduced media consumption, and lower installation and operating costs when applied in the right application. There appears to be significant overlap with ball mills



Vertimill Energy Efficiency

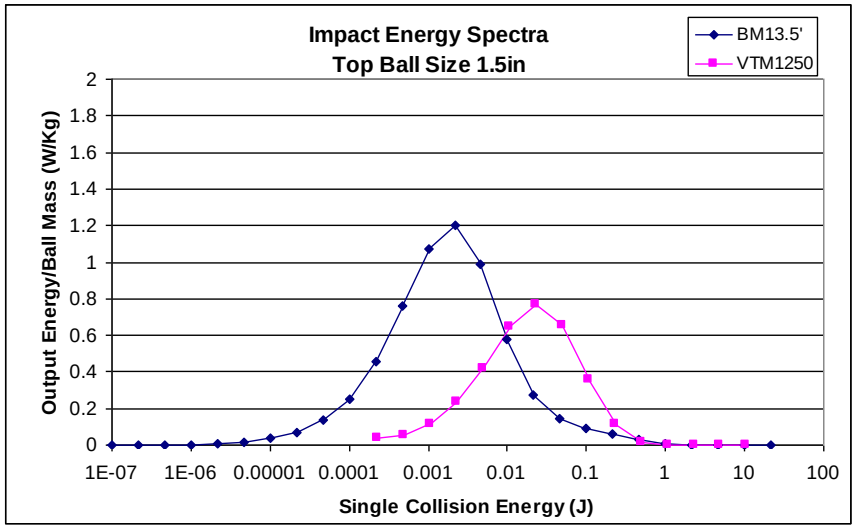
Primary Reasons

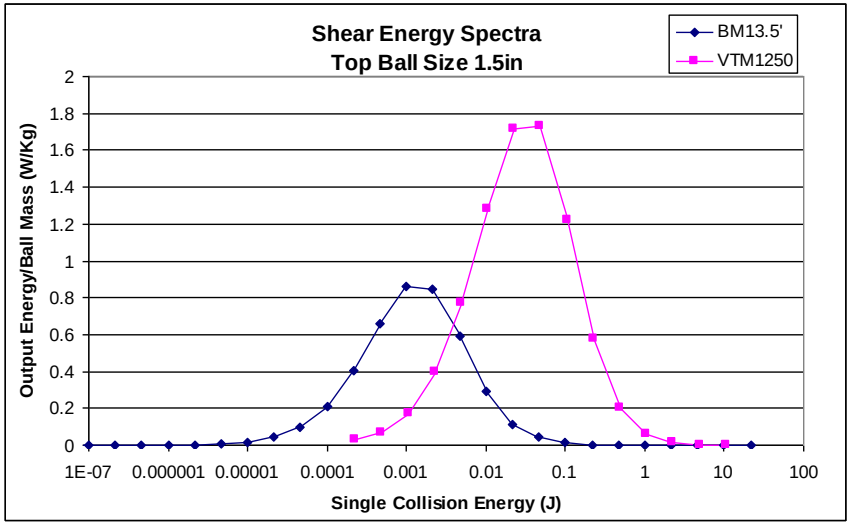
- High Shear Energy
  - Generally accepted to be more efficient
- Minimal Impact
  - Wasted ball mill energy with balls impacting balls and balls impacting liner
  - Also contributes to higher ball wear
- Retention of Fine Media
  - Vertical arrangement keeps the fines in the mill
  - Fine media will float out of a ball mill (will wear out pumps and screens fast too)



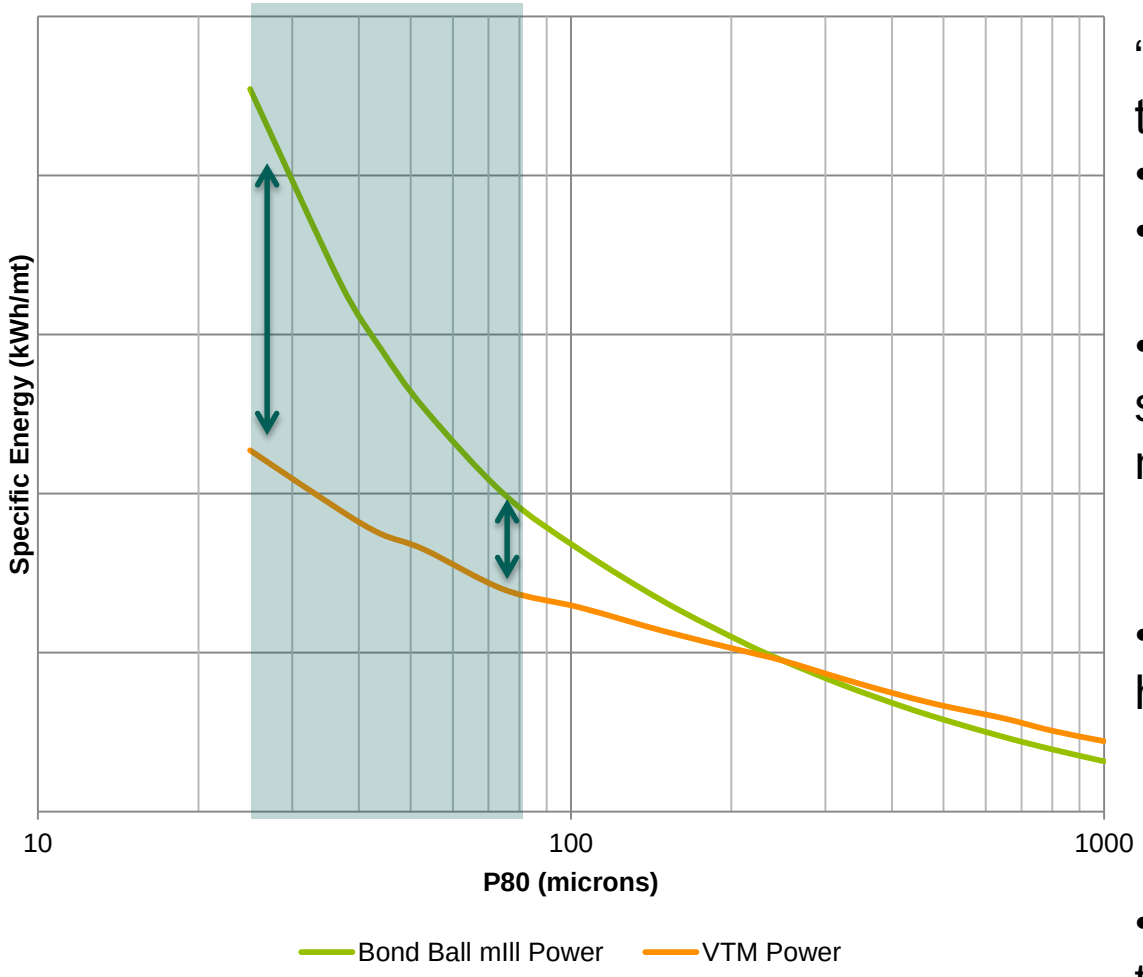
Vertimill Energy Efficiency

Energy Spectra





Striving to full understanding of the VERTIMILL and ball mill power relationship



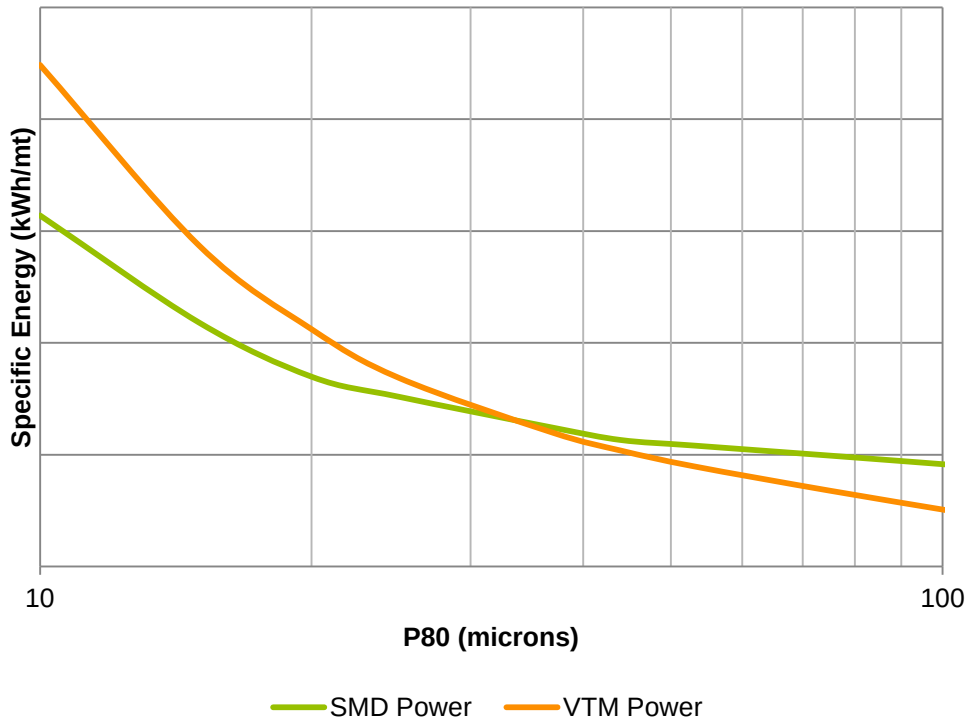
"30-50% more efficient than a Bond Ball Mill"
- True in most cases
- Over simplification

- Function of the feed size, product size, and material grindability

- How far coarse and how fine can we go?
  - Efficiently
  - Practically

- How do we determine this relationships for all ore types?

the VERTIMILL and SMD power relationship



Fluidized mills are generally more efficient to finer product sizes than Vertimills

This is highly depend on the feed size

Largely a function of the efficient use of media

Our collaboration with the JKMRC is a big part of getting there

Metso is in the midst of a 3 year, $2 million program with the Julius Kruttschnitt Mineral Research Centre

- Validate current selection methodologies
- Develop better testing methodologies
- Create a model for Vertimill performance
- Gather extensive field data
  - Process performance
  - Operation practice
  - Wear data

SMI JKMRC
Julius Kruttschnitt Mineral Research Centre

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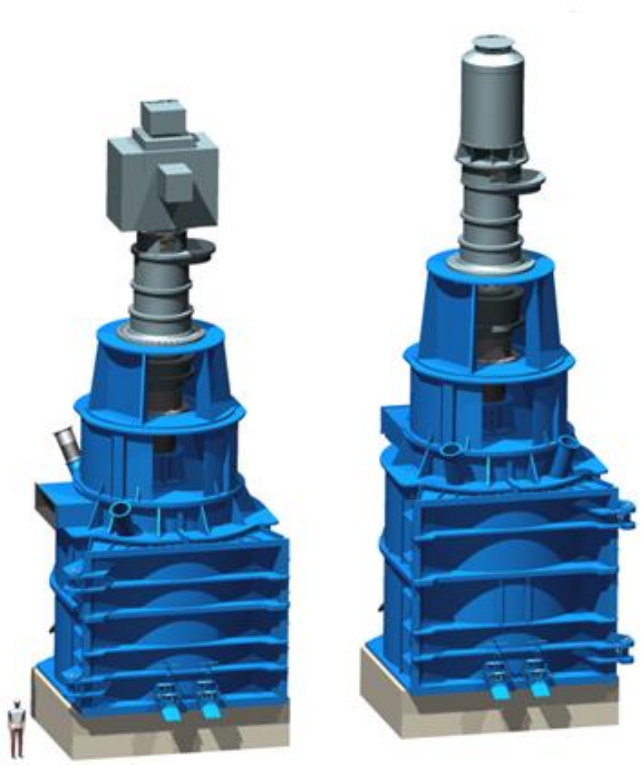
Current/Planned Development Activities

Vertimill

VTM-6000 (or larger!)	• Bigger mills at economical prices • Enable secondary grinding
VTM-10 Pilot Unit	• Create multiple VTM Pilot units to be distributed into third party facilities • Looking partner to take a unit
Stirred Milling Bench Scale Equipment	• New Test in development with the JKMRC • Jar mill continued development
Intermediate VTM Sizes	• Fill in our product offering for improved project economic • VTM-2250-WB and VTM-3750-C
VTM-75-WB Portable Pilot Plant	• Available for Extensive field trials
VTM Liner Handler	• Integral device for faster liner handling • Included features to remove grinding media
Automated Media Discharge	• Hydraulic Actuated valve • Integrate water flush lines
SMART Equipment	• Condition Monitoring and advanced process control • Standard unit supervisory control to reduce installation cost and time
Automated Media Reloading	• Faster media addition during operation and after mill relining
Standard Layouts	• Reduce project engineering cost • Incorporates beset practices in maintenance and operation

VTM-4500-C

Size Comparisons



Key Figures	VTM-3000-WB	VTM-4500-C
Length (m)	6.92	6.92
Width (m)	6.36	6.36
Height (m)	17.59	18.91
Mill Mass (mt)	343	400*
Charge Mass (mt)	260	325
Screw (mt)	23.6	30.5
Screw End Liner (mt)	8.4	8.4
Screw Flight Liner (mt)	4.5	4.5

Metso Innovations
VTM-4500-C and Beyond

- We need to lower CAPEX to allow for broader application => lower $/kW
- Change the Total Cost equations (there is no free lunch, but we can make it cheaper) = > Sacrifice wear life (OPEX) to reduce CAPEX

	Capacity	Wear life	CAPEX ($)	CAPEX ($/kW)	CAPEX + OPEX
VTM-4500-C relative to the VTM-3000-WB	+50%	-30%	+30%	- 15%	-7%

- First VTM-4500-R (Retrofit of VTM-3000) will be started by in November at Northlands Resources in Sweden
- Two (2) VTM-4500-C mills start up in June 2014 at Altai Polymet
- VTM-6000 in development, ready for offer by January 2014

VTM-6000-C

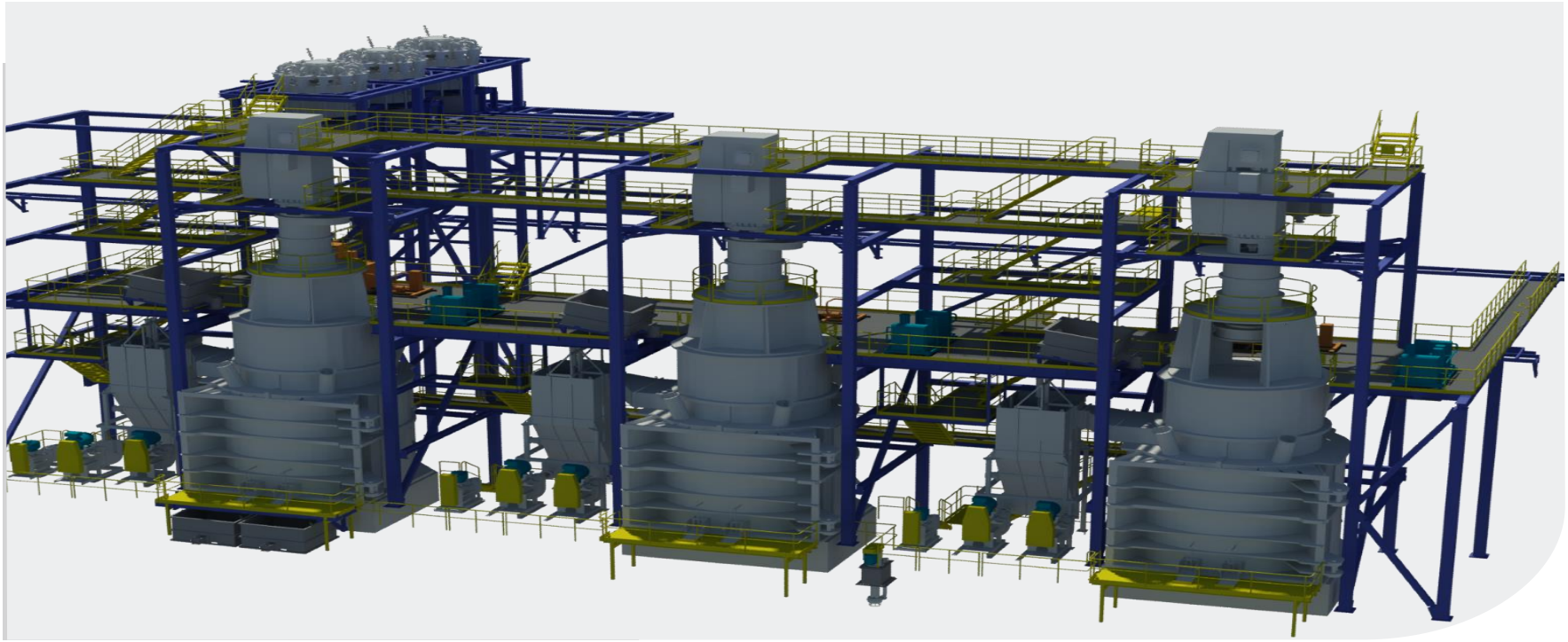
And beyond

- What we want to provide
  - Lower CAPEX, enable use of large machines
  - VTM-4500 equal or better OPEX
  - Shorter mill deliveries
  - Smaller wear components
- Will likely use innovative and new to metallic mineral processing drive concepts
- Will be shorter overall height than VTM-4500-C
- Ready to offer by Dec 2013, target delivery of 1Q15

VERTIMILL® grinding mill

Standard Layouts

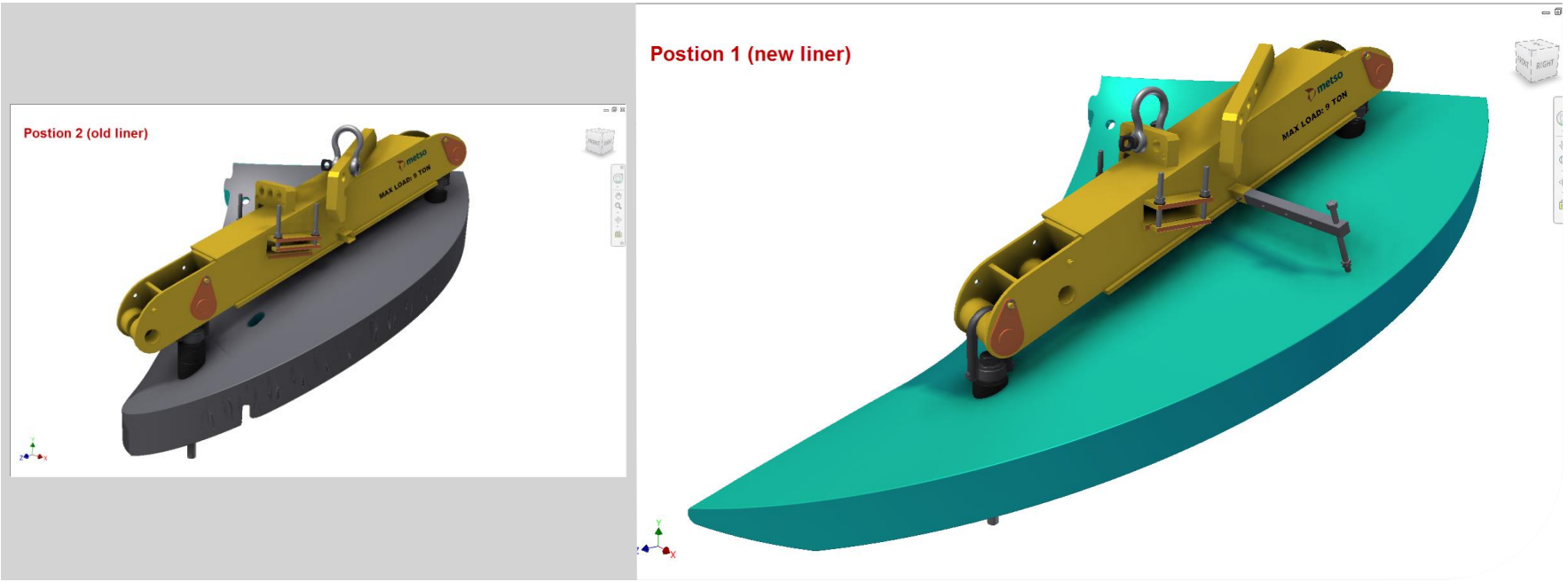
- Takes the full experience of the Metso team
- Incorporates different strategies for maintenance
- Saves times and cost



VERTIMILL® grinding mill

Liner lifting fixture

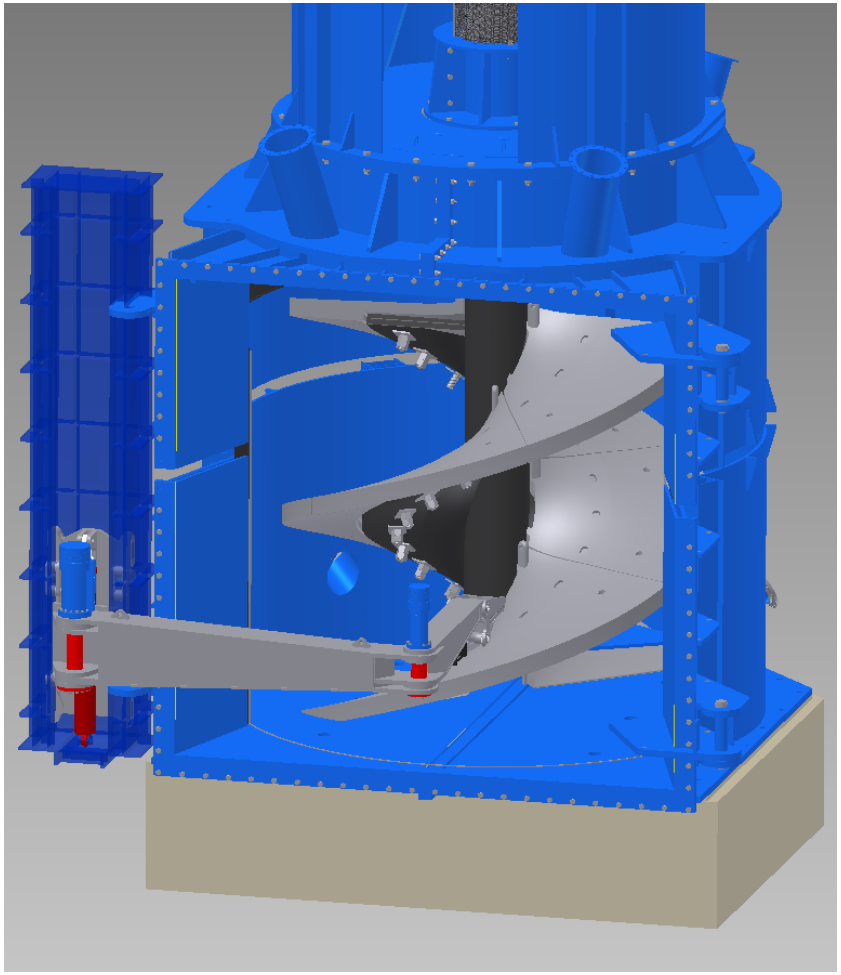
New lifting tool to aid in the installation and removal of screw liners. Enables single point pick up over the CG of the component (both worn and new) to hold the liner in the correct configuration



VERTIMILL® grinding mill

NEW Liner handler

- To be completed in March 2014
- Attached to and supported exclusively by the mill.
- Five axis of movement for precise and remote control
- Can be attached while the mill is in operation
- Functions and feature include:
  - Man lift to unbolt the door
  - Scrapper to remove media from the mill
  - Lifting fixture to hold liner in place



Current/Planned Development Activities

Stirred Media Detritor

SMD-E	• Completion of the E Series Product Line • E series improves wear life, maintainability and reduces cost
SMD-3300-E	• Next Larger size SMD • Ready for the market in 1Q 2014
Simulation and Modeling	• DEM and PEPT Work to further optimize the SMD operation
SMD-1100- E Field Trials and Validation	• Extensive field program jointly with Anglo Platinum to put the SMD-1100-E through its paces
SMD Impeller Arm wear materials	• Continued development on impeller material for specific applications • Bench scale impeller wear test rig • Advantage of pin is new machines immediately test various materials

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Northland Resources Kaunisvaara Operations

Line 1 – Two (2) VTM-3000-WB & One (1) VTM-4500-R

Kaunisvaara Design Considerations

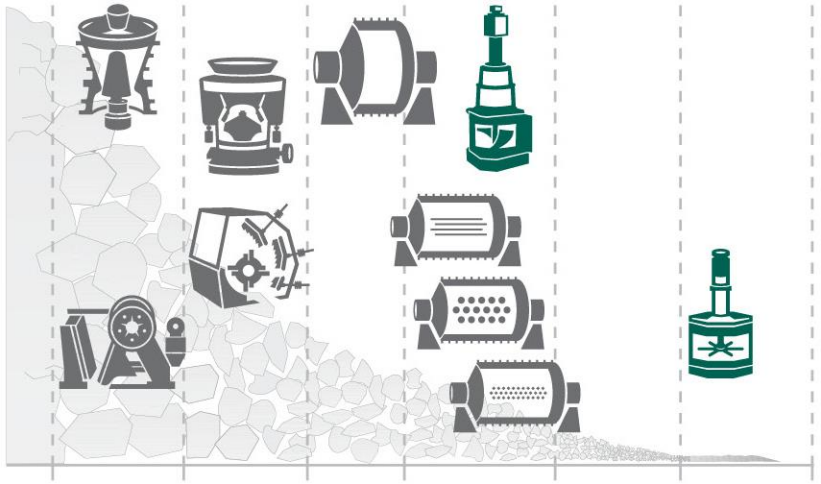
Grinding Circuit

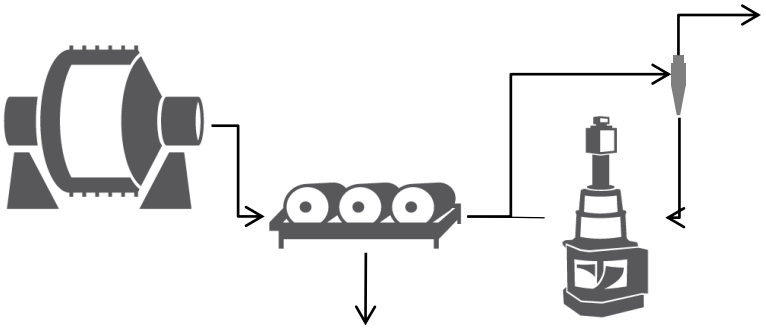
- Two different ore bodies
  - Tapuli
  - Sahavaara
- Want to:
  - Minimize risk
  - Quickly move into operation (fast and accurate selection with minimal testing)
  - Improve profitability

Kaunisvaara Design Considerations

Grinding Solutions Considered

- Multiple Comminution options available
- Multi stage crushing, HPGR
- AG – Pebble
  - Low OPEX
  - High Risk process
- SAG – Ball Mill
  - High CAPEX
  - Process Flexibly
- Decided to consider AG and Vertimill
  - Low OPEX
  - Process Flexible





Vertimill Multi Unit Arrangement

Kaunisvaara Advantage

- Trend is for single stage ball mill to save CAPEX, but this limits flexibility
- Additional space has been left for a 5th Vertimill in the Sahavaara Line
- Only the Mills that are required will be run, saving:
  - Energy – each mill operated at optimum efficiency
  - Wear and Parts
- Vertimills Enabled a change in Mining Schedule
  - Original Plan was to have line 1 with Tapuli Ore, line 2 with Sahavaara Ore
  - All ore now planned to be tapuli, delayed delivery of one mill
  - Conversion of one unit to VTM-4500-R to have greater capacity than plan
- Design = F80 300 microns to a P80 of 34 microns.
- Schedule for Review by JKMRC

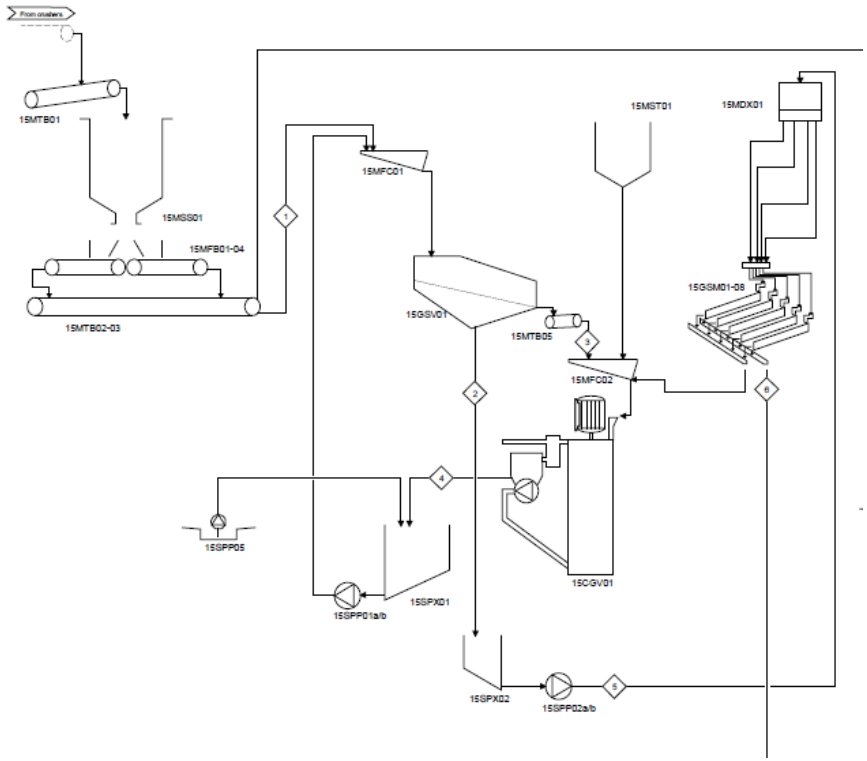
Northlands Screw

8 months of operation

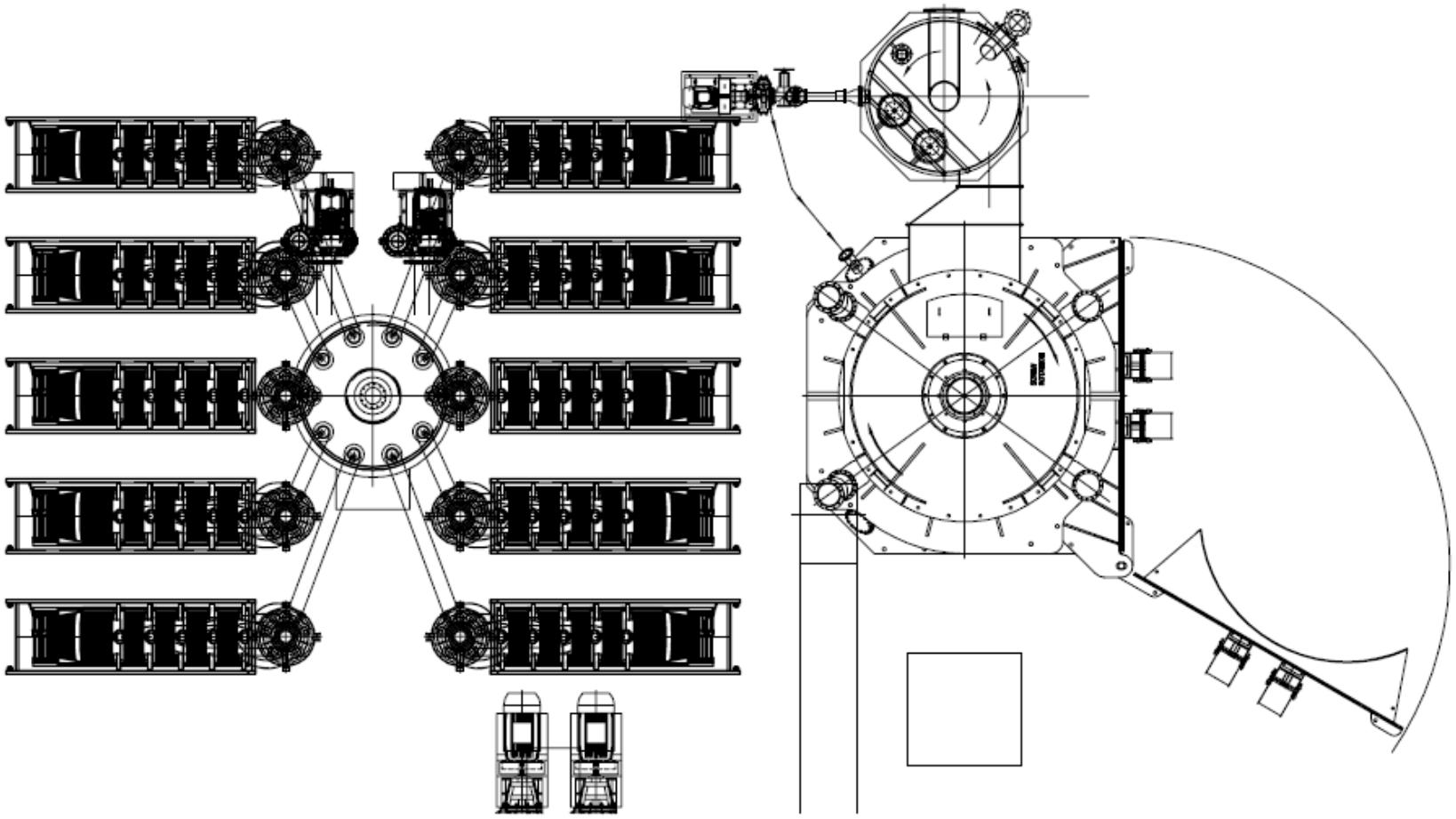
Altai Polymet

Two (2) VTM-4500-C

- Bwi of 19.56 kWh/mt for sulphide ore;
- Bwi of14.14 kWh/mt for oxide ore
- F90 of 3 mm
- 200 mtph of Sulphide, 245.5 mtph of Oxide ore per line
- P80 of 63 microns
- CC with Derrick Screens
- Protection screen for Derricks
- Schedule for operation June 2014



Altai Polymet VTM layout



VERTIMILL® and HRC™

Developmental pilot plant

- A VTM-650-WB operating in the southwest USA
- The VTM is operating downstream of a Metso HRC™ HPGR in a secondary grinding duty accepting a feed F80 ranging from 1.3 mm to 3.4 mm
- P80 = 114 microns on average
- 8300 hours, producing over 400,000 tonnes of porphyry copper ore
- Plant feed has a Bond Work Index of 13.5 kW-hr/st on average

Samarco

VTM-1500-WB in Iron ore Regrind

- F80 = 80 microns
- P80 = 34 microns
- Mill Power Draw: 980 kwh
- Original production rate: 156 t/h
- current production rate: 210 t/h
- net specific energy : 6.28 kwh/t
- media consumption: 35 g/kw
- media size:25mm
- power saving: VTM 1500 X parallel ball mill = power saving for same capacity 33,4 %

Samarco

Batch Jar Mill to Industrial Comparison

- the Jar Mill required 9.39 kWhr/mt, with 0.65 Vertimill efficiency factor estimated Vertimill Specific energy of 6.10 kWh/mt.
- Very close alignment, especially considering different media used
- Questions:
  - The jar mill was conducted on sample received 2 years ago; Was the sample representative?
  - How great is the media impact?
  - Was the mill operating optimully?

	SE	F80	P80	Media	Owi
Jar Mill	6.1	100	42	19	11.2
Lab Pilot	5.06	100	42	19	9.32
Actual	6.28	80	34	25	10.5


Thank You