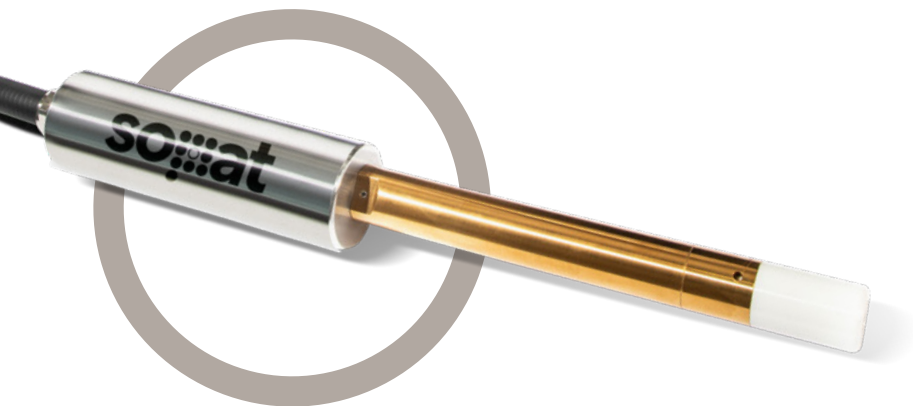


Inline Characterization of Particles in the Mining Industry

MADE IN GERMANY



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Main challenges

The technical challenges in the mining industry are numerous. Some of them are listed in the following categories:

Mineral Liberation and Extraction:

Efficient release of valuable minerals from the ore matrix and their recovery is a fundamental challenge. Factors such as ore composition, mineralogy, and particle size distribution can influence the release and recovery rates.

Grinding and Crushing:

Achieving the desired particle size for the concentrate can be challenging. The balance of energy consumption, equipment wear, and the need for fine grinding to release minerals can affect the efficiency of the process.

Energy Consumption:

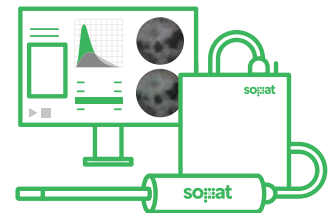
The production of concentrate can be energy intensive, especially in the grinding and comminution processes. Reducing energy consumption and finding more energy-efficient methods are constant challenges.

Flotation:

Froth flotation is a common process for producing ore concentrates. Challenges in flotation include maintaining the stability of the froth, controlling pH, controlling froth depth, and optimizing the use of reagents.

Selection and Optimization of Reagents:

In flotation and leaching processes, the selection and optimization of the right chemicals (reagents) is crucial for achieving high recovery rates and concentrate quality. This requires continuous testing and adjustments.





The Solution: The SOPAT MiningScope

- **Inline measurement despite abrasive environment.** The system is absolutely robust and has been adapted to the conditions in the mining industry in intensive test trials.
- **Accurate measurement of particle size to avoid over-milling:** Over-milling leads to slime formation, reduced throughput, and high milling costs. With SOPAT, the milling process is optimized - inline and automated.
- **Robust measurement of particle size to ensure efficient separation in the flotation cells.** Measurement before the particles enter the flotation cells will ensure the correct size distribution before problems occur in the flotation cell. The SOPAT solution distinguishes between particles and bubbles and measures both separately.
- **Easy implementation and low manpower requirements.** No moving parts, 24/7 installation, direct insertion of the probe into the process and thus no more sampling and dilution. This makes the expensive infrastructure with its sampling and dilution equipment obsolete.
- **Lower maintenance costs.** Compared to other particle size process solutions, maintenance costs are reduced by 80%.

MiningScope

Particle Size Range Field of View (diag.)	1 – 1,200 µm 750 µm or 2,500 µm
Dimensions & Weights Housing	Length: 240 mm Diameter: 72 mm
Protection Tube	Wetted length: 320 mm Wetted tube diameter: 38.1 mm (1.5")
Weight	8 kg
Materials Housing	1.4404
Protection Tube	1.4404 with TiN coating
Probe Tip Window	<i>Tip:</i> Ceramic (proprietary Yttrium stabilized Zirconia) <i>Window:</i> Sapphire
Solder	Au/Sn
Cable	Adaptaflex cable protection; type SPLHC; flexible; liquid resistant; IP67; black
Technical Data Permissible Process Temperature	10 – 130°C
Permissible Ambient Temperature	0 – 50°C
Permissible Process Pressure	0.01 – 10 bar (higher pressure ratings on request)
Camera	5.1 Megapixel Machine Vision Camera with GigE Interface, 18 fps
Power Supply	141 VA (50–60 Hz)
Approvals Protection Compliance	IP 65 rated RoHS conform according to 2011/65/EU

The full system: SOPAT Hardware

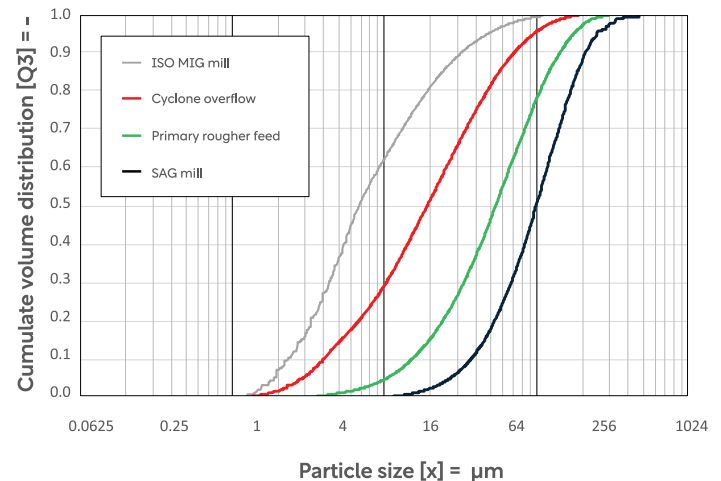
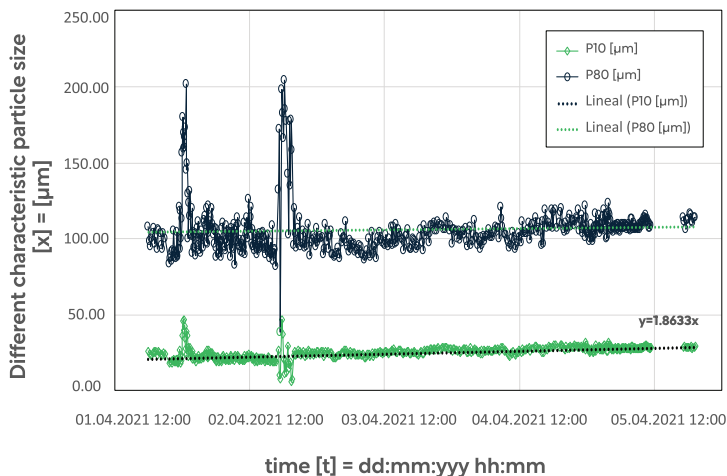
The SOPAT MiningScope. A robust inline solution for abrasive slurries in mining applications.



The full system: SOPAT Software



- In combination with our hardware, our software provides real-time analysis of particle size distribution.
- Distinguishing particles from bubbles is made possible with the photo-optical analysis.
- Connect the SOPAT equipment to your process control system, including long distances -up to 10kms.
- With the integrated Probe Control you have a powerful tool to generate live images using different control functions to manipulate the image quality. Acquire images directly from your process and store them on the hard disc drive of the reliable SOPAT workstation for immediate image analysis and/or later use.



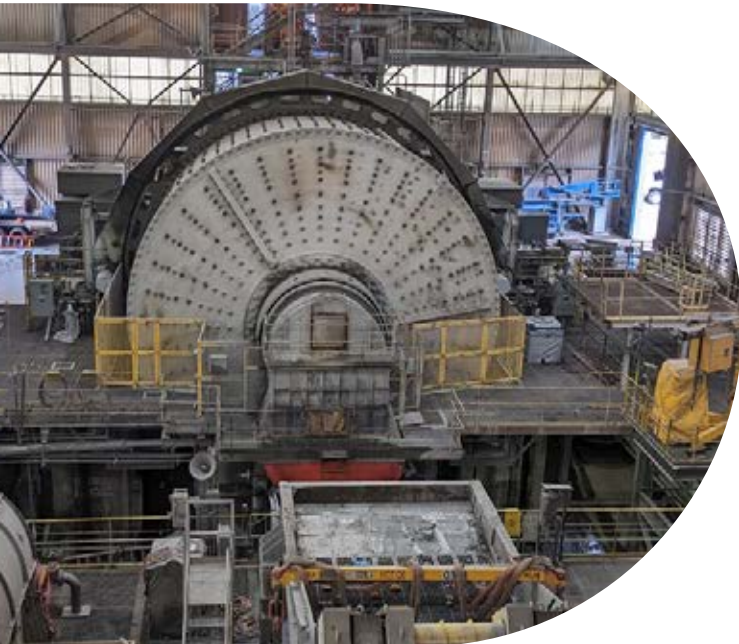
Challenges due to over- and under-milling in production of mining concentrate

Milling optimization

The cost of the grinding process accounts for about 50% of the total production cost, as the quality of the final product is directly influenced by the separation ratios and the efficiency of downstream operations. Ball mills are known for their low energy efficiency, which can often be 1% or even less. The SOPAT MiningScope helps to optimize the throughput of the SAG mill during operation by avoiding over- and under-milling, resulting in significant energy savings and lower maintenance costs.

Poor Recovery Rates

Under-milling can lead to poor recovery rates as the coarse particles may not be fully released, resulting in lower recovery rates in the flotation process. Over-milling, on the other hand, can also lead to lower recovery rates, as the fine particles cannot be effectively recovered in the flotation process. Moreover, the grinding process runs without adding any value to the process. In addition, the throughput is lower due to the product's higher residence time in the mill. Over-milling also leads to slime formation and excessive wear of the grinding equipment



With the help of the SOPAT MiningScope, the operation of the SAG mill and its throughput is optimized by mitigating over- and under-milling, leading to significant energy savings.

Challenges due to over- and under-milling in production of mining concentrate



Bubble size in flotation cells

Froth flotation is the predominant technique for mineral processing and has achieved great economic success. Its high process efficiency is often limited to a narrow particle size range of about 10-100 μm . Considerable efforts have been made to extend this size range beyond both ends of the size distribution. To achieve this, the bubble size distribution must be controlled and optimized. The SOPAT inline system provides real-time monitoring not only at the surface but also within the large-scale flotation cells. This improves performance in this most critical step of the entire production process.

The flotation cell and the hydrocyclone are further important application areas of the SOPAT MiningScope where process optimizations and cost savings can be realized.

Cyclone overflow

In mining, wet particle classification in water is necessary for efficient size control of particles in the range of 10-100 μm . In this range, hydrocyclones are often the best choice. Problems may arise further downstream due to improperly separated slurries. The MiningScope can be positioned in the cyclone overflow. Its output data is then used to optimize process parameters such as pressure and throughput in the hydrocyclones to achieve an optimal particle size for the following flotation step.



Inline Process Control

PHASE 1

Inline particle measurement

- Direct contact between probe and process.
- Our inline particle analysis requires neither sampling nor any preparation such as dilution, filtration, or even dispersing.

PHASE 2

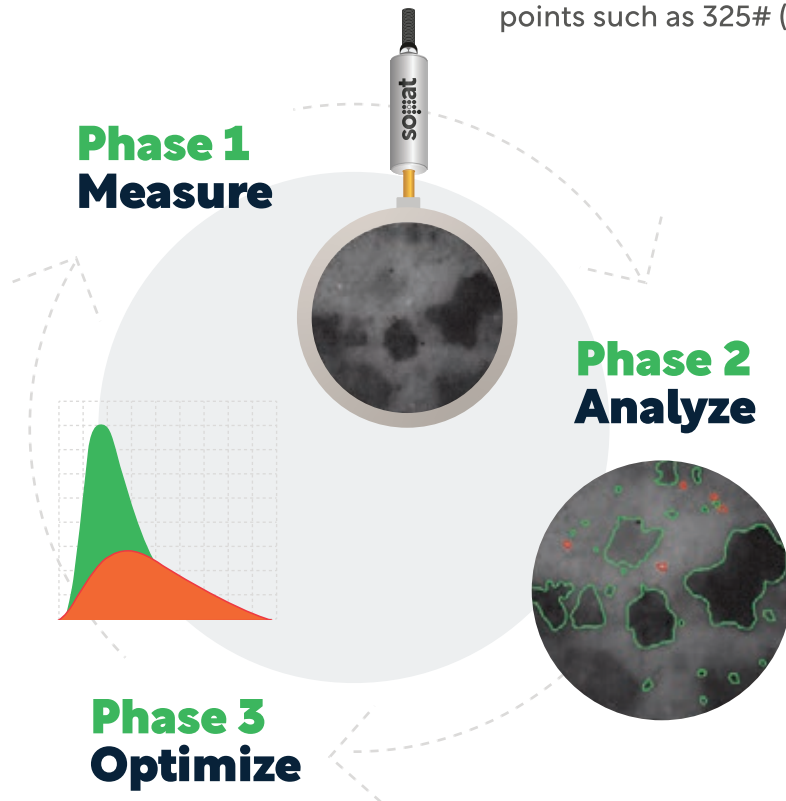
Real-time analysis

- Analyze bright and dark particles individually and get quantitative results.
- Track the variation of particle size distribution and shape to obtain characteristics such as P75, P80, Dv50 (all in μm) circularity and/or particular points such as 325# (mesh, %).

PHASE 3

Process optimization

- Avoid over-milling and reduce slime formation and energy costs.
- Stabilize the separation in the flotation step.
- Avoid under-milling to increase throughput and ensure that the precious metals are separable in the flotation.



Integrate SOPAT's MiningScope directly into your production line.

Characterizing particle size in the slurry and bubble size in the flotation cell



IMAGING

Imaging: Photo-optical techniques are capable of identifying different types of particles based on their optical properties.

Visualization: With its real-time information, the MiningScope provides information about the condition of the ore slurry. The size and shape of the different materials are measured, and the number of bubbles in the stream is counted. Different components of the ore can be identified separately based on differences in reflectivity.

Quantification: The MiningScope combines the visual information with quantitative results from automated image analysis.

DATA ACQUISITION

Data Treatment: Starting from the original image, various steps of pre-filtering and background subtraction bring out the individual particles.

Analysis: The underlying algorithms can distinguish particles according to their grey value, size and shape (see figure below).

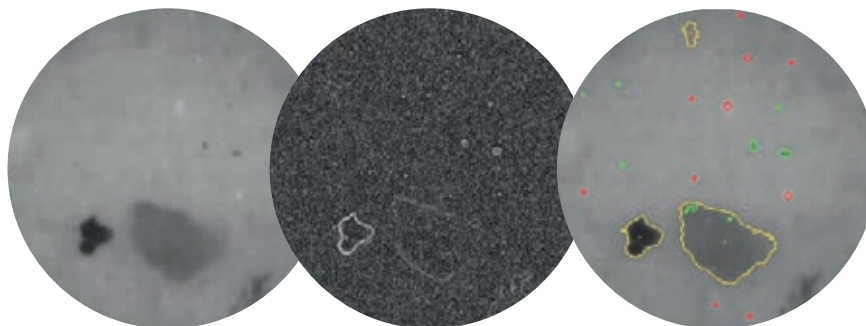
An Example: In the image below, three particle fractions were analyzed individually: small dark (marked in green), large dark (marked in yellow) and bright particles (marked in red).

PROCESS CONTROL

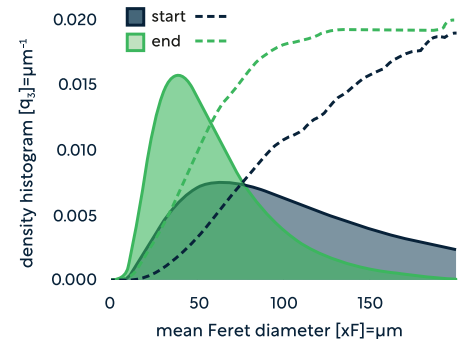
Interpretation: Particle size distributions can be obtained inline by analyzing the images.

Process Control: SOPAT's combination of stroboscopic image acquisition and simultaneous analysis enables a continuous process control using the MiningScope.

Standardized: SOPAT's automated image analysis detects particles and quantifies size and shape according to ISO standards: ISO 13322-1-2014, ISO 12322-2-2006.

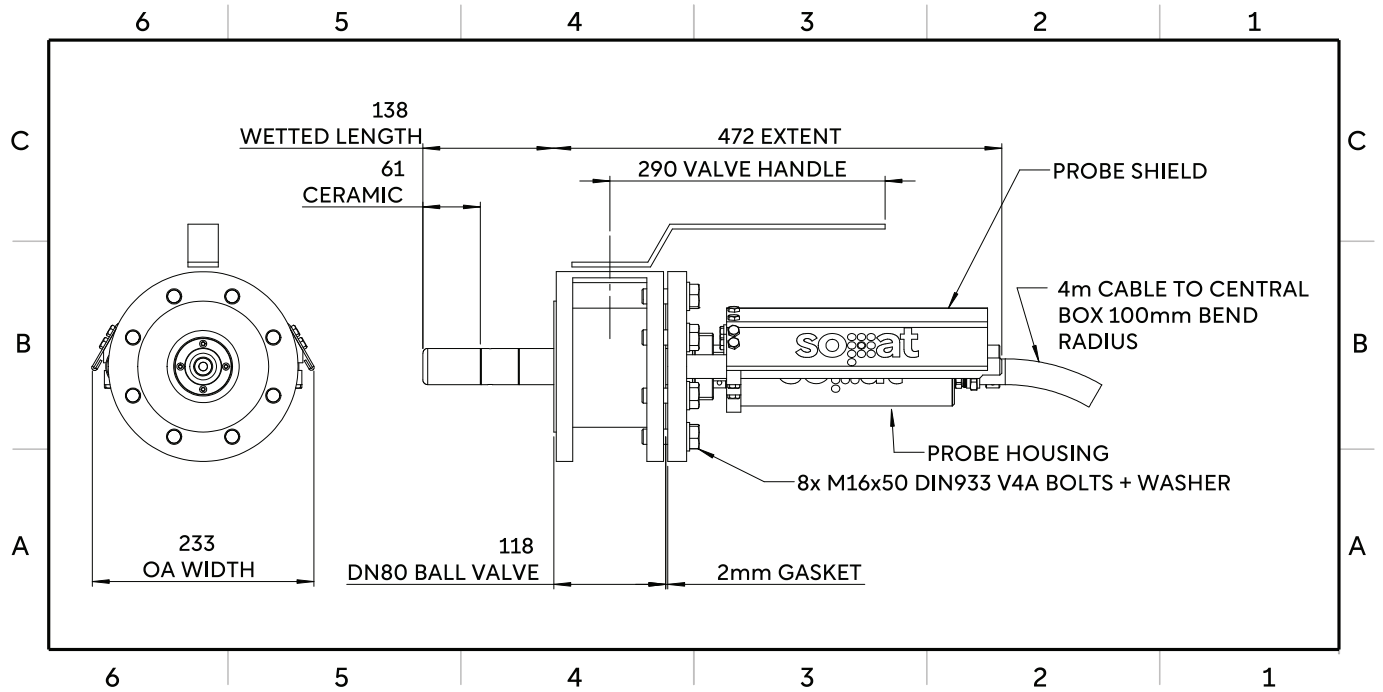


1 Original picture 2 Prefilter, normalize 3 Object classification



4 Particle size distribution

Integration into Production Line



The MiningScope right before inserted into the process. The technical drawing above shows the final measurement position.

Integration into Production Line



The MiningScope can be used at several points in the production line, depending on the individual production conditions and the need for on-site real-time measurements.



The design of the probe with a tip diameter of 38.1 mm and a special ceramic material makes it extremely robust despite the strong abrasion potential of the slurry.

The replaceable probe tip in combination with our compact process flanges allows convenient maintenance every 12 to 18 months, even while the plant is in operation.

Maintenance time is less than one hour. The probe's front window is made of sapphire.



Easy connection to your process control system (PCS) via Modbus TCP/IP, OPC UA or others is given.



The modular design of the individual components (probe, Centralbox, computer) allows an easy handling.



SOPAT is the only supplier worldwide to offer complete particle size distribution measurement in the original concentration directly in the entire product stream.



The MiningScope provides you with highly reliable data because the underlying method, microscopy, allows you to distinguish between particle types and bubbles based on their optical properties.

Therefore, bubbles are measured and reported as bubbles and no longer interfere with your particle data!



Time-efficient measurements:

- No dilution
- No sample extraction
- No human factors involved
- No delay between process & analysis



R & D An Essential Part of Our Company's Philosophy

New approaches are constantly being tested to improve the SOPAT system. We maintain many cooperations with universities and are active in many research projects. In addition, we support the next generation of young scientists.

SOPAT sees itself as a research partner, system supplier and employer for young people and maintains a close relationship with a number of international research institutes. SOPAT is proud to work with the new generation of emerging scientists.



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