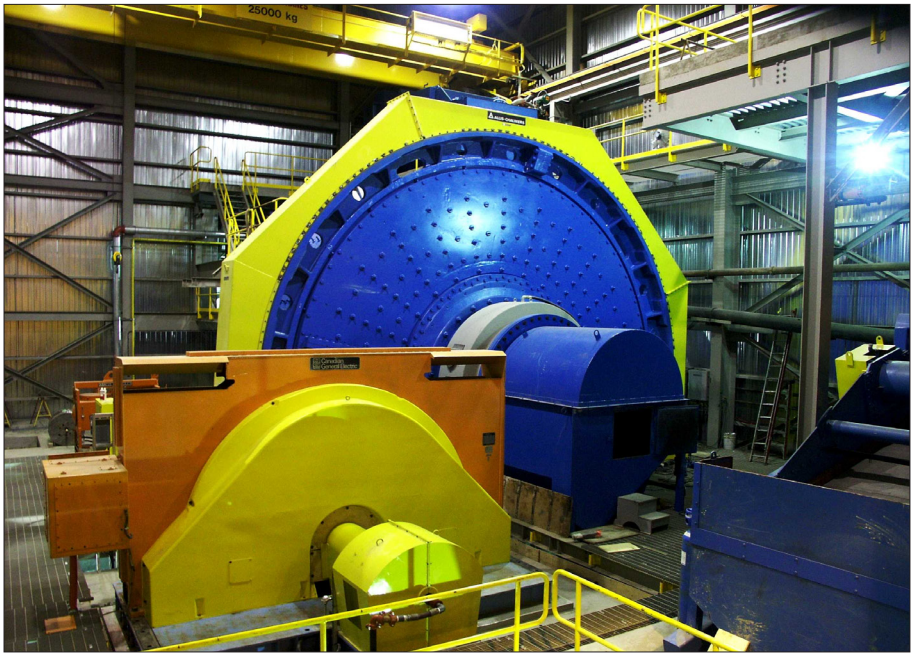
COMMINUTION SERVICES

GRINDING CIRCUIT DESIGN, OPTIMIZATION AND PRODUCTION FORECASTING

INTRODUCTION

In most processing plants, the grinding circuit represents the largest capital investment. With the emergence of low grade – high tonnage operations, this is especially true now that economics dictate the use of the largest milling equipment to take advantage of economy-of-scale. Today, the presence of a single large grinding train would allow the project to proceed, but two trains, with the entire added infrastructure, can kill the project. It is important to be confident in your greenfield design without the crutch of arbitrary "safety margins" or design "fat", because too much fat can mean the project does not get off the ground.

SGS brings a true best-of-breed solution to grinding circuit design, optimization and production forecasting. In the early stages of a project SAG Power Index (SPI®), Bond, SMC and JK Drop Weight Tests are used to characterize ore samples. For subsequent design simulations CEET® and JK SimMet are used. At the bankable feasibility stage, or for production forecasting, a more rigorous model of the orebody is created using the geometallurgical methodology pioneered by SGS' metallurgical group. Using this design, uncertainty is quantified using statistical techniques. With our approach, you will truly optimize the comminution design for your orebody and maximize your return. You will know exactly what the uncertainty is in your design and you will be able to add just the right amount of safety margin – and no more.



OUR EXPERIENCE AND PHILOSOPHY

SGS mineral processors have operated many SAG plants and have conducted over 500 Lakefield SAG pilot plants. Our processors have designed the largest installation base of advanced control (expert systems) for comminution circuits in the world. Our reference list speaks to our global experience and includes grinding circuits, both large and small, including the largest circuit in the world, the Collahuasi Rosario 40 foot grinding plant.

Our philosophy is to understand the variability in your ore and then design, optimize, or forecast from this knowledge. We bring proven technology from the geological and processing disciplines, relying on not one methodology but several, to provide a bankable solution that is unmatched in its rigor.

BENCH-SCALE TESTING

- The SAG Power Index (SPI®) Test is a measure of the hardness of the ore from a SAG or AG milling perspective. Conducted in a bench-scale SAG mill, the SPI® test measures the energy needed to perform a standard size reduction (expressed as an index). All four breakage mechanisms found in the industrial SAG mill are represented in the SPI® test , which is the key to its scale-up applicability and its widespread international success. The SPI® test, in combination with Bond ball mill data, are used in the advanced CEET® grinding simulation system for design, optimization, and production forecasting studies. Over 9,000 SPI® tests have been conducted on ore samples from deposits across the world.

1 Impact breakage, single particle nipping, abrasion breakage and autogenous compression

- The Bond Ball Mill Grindability Test determines the Bond Ball Mill Work Index used to determine net power requirements when sizing ball mills. The test is a closed-circuit, dry grindability test. It is run in a standard ball mill and can be performed at mesh sizes ranging from 48 mesh to 400 mesh. Bond Ball Mill Work Index (and modified Bond Work Index) data can be used in the CEET® grinding simulator.
- The Bond Rod Mill Grindability Test determines the Bond Rod Mill Work Index which is used to determine net power requirements for sizing rod mills. The test is a closed circuit, dry grindability test, run in a standard rod mill. It can be performed at mesh sizes ranging from 4 mesh to 65 mesh.
- The Bond Impact Test determines the Bond Impact Work Index which is used to calculate net power requirements for sizing crushers.
- The Abrasion Test determines the Abrasion Index, which can be used to determine steel media and liner wear in crushers, rod mills, and ball mills.
- The JK Drop-Weight Test determines specific energy vs. breakage product size distribution. We use JK Drop-Weight test breakage parameters and the JK SimMet software package to simulate comminution circuits for optimization purposes (e.g. ball size, grate open area, etc.) or to integrate into a CEET®-based design.
- The MacPherson Autogenous Grindability Test determines the MacPherson Autogenous Work Index. This can be used in conjunction with the Bond Rod and Ball Mill Work Indices to determine power requirements and to suggest circuit configurations for AG/SAG circuits. We have evaluated more than 750 ore samples from more than 300 deposits using the MacPherson 18" mill test. This test is used in the design of power-efficient grinding circuits. One advantage of this test is the generation of a seasoned charge. This has particular value when considering autogenous circuits where the larger lumps must be present in the mill to provide grinding media.

Additional Equipment Available for Grind Testing

- Polysius Labwal High Pressure Grinding Rolls
- High Pressure Gravity Roll variability test unit for drill core

PILOT TESTING

Due to the size, complexity, or desire for absolute minimum start-up time or maximum efficiencies, there is no other substitute for pilot testing. Having said that, the best pilot programs are supported by thorough, bench-scale orebody characterisation and circuit simulation.

SGS' comminution pilot-plant capabilities are headlined by the 1.68 m diameter, fully instrumented Nordberg autogenous mill, followed by a wide variety of rod and ball mills. Circuit configurations, including AG, SAG, ABC or SABC, are evaluated easily. The circuit employs an integrated Distributive Control System (DCS) for monitoring plant conditions. Feed rate, mill speed, power, mill load, particle size distribution and other data are updated, trended, and recorded automatically for later retrieval. This full-instrumented pilot plant allows the circuit to be brought to steady-state rapidly and avoids wasted sample and pilot plant time. We have completed more than 150 pilot plant programs using this equipment.

TYPICAL PROGRAMS

A typical test program involves investigating the ore response to fully autogenous grinding as well as to SAG mill primary grinding. In the SAG mill testwork when the steel is added the SAG product classification size and ore feed size distribution is varied. If necessary, pebble crushing or mill speed can also be investigated. All tests are evaluated on the basis of feed rate, power consumption and product size analysis. Unless single-stage autogenous grinding must be considered, we recommend that the secondary ball or pebble mill circuit be operated in all tests to provide overall power data and to allow adjustment of the secondary mill conditions to be adjusted to obtain the desired fineness of grind.

OREBODY CHARACTERISATION, AND GEOMETALLURGY

CHARACTERIZATION

Regardless of the project stage, the first step in ore characterization is to measure the properties of the ore that will affect the performance of the grinding circuit. The degree of characterization increases as a project advances from concept to feasibility to understand the variability of the comminution parameters and represent it in the data set to be used for subsequent simulations. Characterization is of particular importance for production forecasting where shorter term forecasts are done on relatively small amounts of ore (compared to the overall size of the deposit).

GEOMETALLURGY

When the highest level of design confidence is needed, or when embarking on a high level production forecasting program, geometallurgical modelling is required. Geometallurgical modeling is the practice of creating rigorous metallurgical models of the orebody using geology and geostatistics. Geometallurgy weights each sample in your database using deposit specific parameters to generate a spatial model of the metallurgical data. This approach uses the same block structure as the resource model, and can assign an uncertainty to a circuit design or forecast. While geometallurgical modelling is not necessary to design a circuit, we highly recommend it at the bankable feasibility stage.

ON – SITE PROGRAMS

GRINDING CIRCUIT AUDITS

SGS routinely provides audit and optimization programs for existing grinding circuits to ensure maximum efficiency in your plant. Working directly with your plant staff to understand the practical aspects of your operation, we perform on-site testing and evaluation, including a review of your mine plan and historical data analysis.

SGS has over 300 grinding circuit benchmark surveys in our database to date. These on-site campaigns typically consist of 10 or more surveys of a

grinding circuit while milling the different ore types or the deposit. The deliverables from such work are:

- Fully calibrated computer models (CEET® and JK SimMet) for off-line investigation of optimization options or production forecasting purposes
- Specific recommendations on how to improve the operation of the grinding circuit based on observations and data collected during the benchmark campaign
- Comparison of the efficiency of primary and secondary mill operation to similar plants in our database

CONTACT INFORMATION

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