High Clay Ores-A Mineral Processing Nightmare Part 2

Introduction

Clay minerals can cause nightmares with Mineral Processing because of the inherent difficulties of processing high clay ores. These clay minerals typically form in near surface geological environments due to weathering, particularly above the natural water table, sedimentation and diagenesis and are common in hydrothermally altered rocks. Clay minerals associated with alteration is referred to as Argillic alteration. The extremely small particle size, usually <2 microns (sometimes coarser or finer) and with the very high surface area these clay minerals are highly reactive and respond to changes in the processing environment. This article continues as Part 2 of an article that appeared in the July August, 2011 edition of AJM and discusses some of the solutions to processing high clay ores.

The Problems With High Clay Ores

Mineral Processing has to deal with the suspension of clays causing inefficiency with beneficiation and dewatering and disposal. The problems are physicochemical and impact on all facets of Mineral Processing. This has significant undesirable economic and environmental impacts. The mineral industry's understanding of the issues and solutions of clay-related processing issues remains poor and in many cases the processing problems associated with clays are simply avoided by not processing the ores.

As operators we approach the problem of processing high clay ores by finding chemical and engineering solutions but a better fundamental understanding particularly of rheology is required to solve these problems in the longer term.

Identification

Clays are ultrafine-grained (normally considered to be less than 2 micrometres in size on standard particle size classifications and so require special analytical techniques. Standards include x-ray diffraction, electron diffraction methods, various spectroscopic methods such as Mössbauer spectroscopy, infrared spectroscopy, and SEM-EDS or automated mineralogy solutions. These methods can be augment polarized light microscopy, a traditional technique establishing fundamental occurrences or petrologic relationships

X Ray Diffraction (XRD) has historically been used to identify clay minerals but other techniques such as infrared spectroscopy and electron microscopy, scanning electron microscopy (SEM) and Qemscan can be applied. XRF or X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science and archaeology. In combination with XRD XRF can be used to identify the clay minerals present.

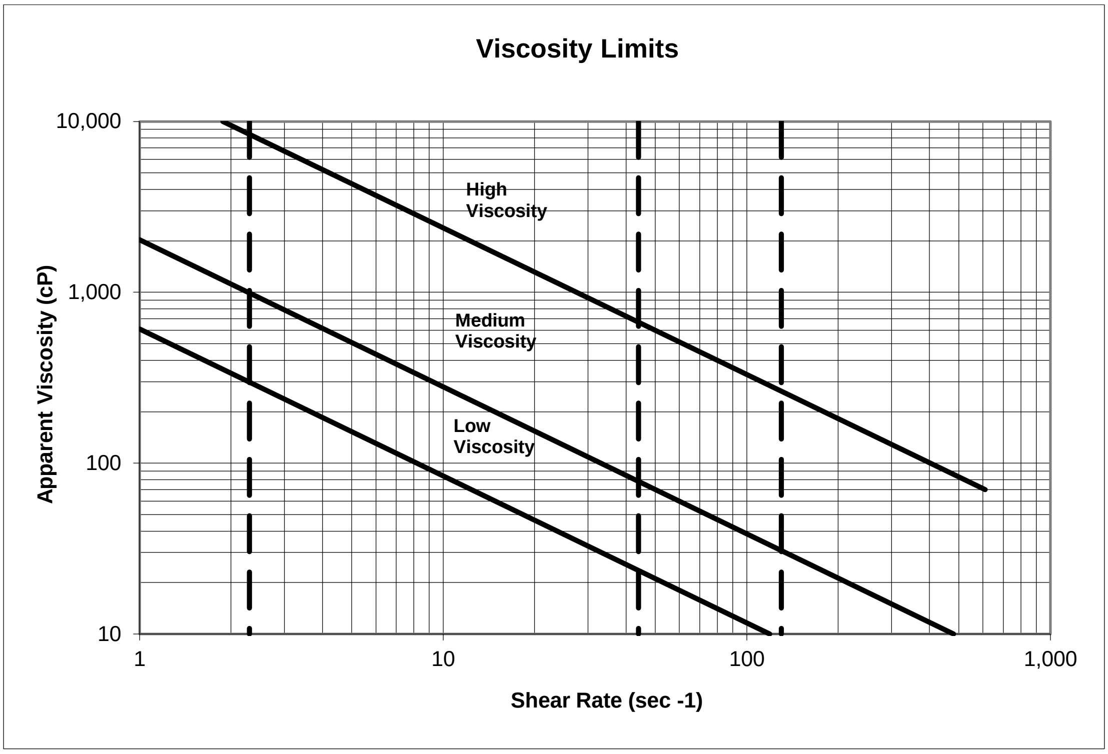
QEMSCAN is the name for an integrated Automated Mineralogy solution providing quantitative analysis of minerals, rocks and man-made materials. QEMSCAN is an abbreviation standing for Quantitative Evaluation of Minerals by SCANning electron microscopy and a registered trademark owned by FEI Company since 2009. The integrated system comprises a Scanning Electron

Microscope (SEM) with a large specimen chamber, up to four light-element energy dispersive X-ray spectrometers (EDS), and a proprietary software suite controlling the automated data acquisition, as well as providing interactive data analysis and report functionality.

Assay by size and even Laser Refraction sizing will highlight the amount of clay present in the ground ore.

Metallurgical Testwork

Don't dry samples because this will change the properties of the clays (reduces viscosity). It is best to keep some samples un dried and test the rheological properties of the ore.



Unit Operation	Reference Shear Rate sec^-1	Low Viscosity	Medium Viscosity	High Viscosity
Agitators	2.3	<300	<1000	<8000
Pumps	45	<25	<80	<700
Cyclones	130	<10	<30	<260

Figure 1. A Benchmarking Guide To Viscosity

Flocculant screening tests are required to establish settling rates and ultimate underflow density. It is difficult to obtain clear overflows from high clay ores. Thickener areas are higher as a result

Vacuum and pressure filtration tests are required to adequately size the filters required. Clays are extremely difficult and slow to filter.

Crushing & Screening Solutions

Bypass facilities so that simply passing through the jaw crusher and into a passive stockpile so it can be fed to a ball mill using a front end loader is one solution. Secondary crushing and screening may not be possible particularly if the ore is wet and sticky. Cone crushers bridge and screens become blinded. Putting clay ores into bins or stockpile with reclaim tunnels can be a disaster. They simply don't work. Feeding direct into SAG mills is a much better option if this suits the process.

Blending of high clay ores with competent is one option although not always possible if the ores have different metallurgical characteristics.

Milling & Classification

At the Kurara gold project the ore was so viscous it would not flow out of the mill even with lower densities. Also cyclone efficiency is negatively affected resulting in a less sharp separation. Clays affect the grinding efficiency necessitating operating the mill with a lower density to flush the clay out of the mill In addition DSM screens and trash screens are not as efficient because of the clays. The use of viscosity modifiers or caustic soda rather than lime will mitigate these effects.

Heap Leaching Solutions

High clay ores require agglomeration with cement in an agglomeration drum and time to cure before stacking. If agglomeration is not used the percolation will be very low and effective recovery from the heap very low. The addition rate required is critical and can affect the economics of the process.

Gold CIP Solutions

For CIP gold plants the issues are manageable although high clay ores can be problematic and require viscosity modifiers adding to the process cost. It can also necessitate using caustic instead of lime due to the lower viscosity issues. Clay ores can result in preg robbing and here CIL is preferred. Freevis and TSPP are several viscosity modifiers currently used to great effect. The tanks overflowing because of insufficient fall on the tanks and high viscosities is another issue in CIP plants with high clay ores. At some early Goldfields CIP projects caustic soda had to be used for pH control because lime exacerbated the thixotropic nature of these pulps. This added to the processing cost but unless caustic was used the thick pulps could not be pumped or transported though the leach tanks.

For Merrill Crowe gold plants clays can be a nightmare. The problems with thickening, washing, achieving clear solutions and the ability to filter the ore can prove extremely difficult. Flocculant screening and filter aids may mitigate the impact to some extent.

Mineral Sands Solutions

The mineral sands industry uses hydrosizers up front to remove clays from the mineral sands feed. Clays negatively impact on the separation process using spirals.

Iron Ore Solutions

The original Windimurra beneficiation plant had a cyclone deslime at 10 microns to remove the clay from the ground ore. The removal off the clays improved the magnetic separation of the ore.

Dense Media Separation

Dense media separation (DMS) plants fail to achieve a separation if clay is present in the ore. This usually requires a scrubber up front to remove the clays and pump them to a tailings dam. The DMS plant at Mt Tom Price suffered from these issues when first commissioned.

Manganese Solutions

The standard manganese beneficiation plant includes a scrubber up front to remove clays. This is because the downstream DMS plant cannot handle the clay in the feed. The main problem being maintain bath density.

Flotation Solutions

For flotation where clays are present the consumption of reagents is higher and selectivity is adversely affected. At Mt Keith the flotation feed is deslimedv using small polyurethane cyclones for exactly this reason. Improved flotation recovery is achieved as a result.

Thickening Solutions

Thickening of clays is difficult due to the fine particles(<2 microns) which are highly charged surfaces. This requires flocculant screening and optimisation of the pH to achieve acceptable settling rates. The overflows can be dirty which may cause problems with downstream processing. In addition the presence of clays affects the ultimate underflow density and the choice of underflow pumps (positive displacement not centrifugal pumps).

Filtering Solutions

Pressure filters will always provide higher performance than vacuum filters. The nature of the clay and the volume percentage in the feed impacts adversely on filtration rates, clarity of filtrate, spillage and maintenance issues. Filter aids will increase filtration rates including, high pH, Coagulants, Guar and combinations of which all result in lower water recovery and .have to be tested in the laboratory. The presence of clays causes excess spillage with clays sticking to cloths requiring washing and excess maintenance issues.

Tailings Solutions

High clay ores require larger tailings dam footprints and have lower water recovery and are geotechnically less stable. The tailings don't beach and drying of a thin layer with a high insitu density is slow and difficult. The economic and potential environmental issues are serious when treating high clay ores.

Materials Handling

For high clay ores Tunra type testing to determine rill angles, angles of repose and materials handling characteristics is a must. Only apron feeders are effective feeders with high clay ores. The use of stockpiles is not possible because of rat holing and the difficulties getting the ore to flow in a stockpile or bin is extreme. Conveying is also difficult requiring the use of belt washing stations plus increased tracking issues.

Pumping Solutions

Oversize pumps are another option to allow for the difficulties encountered when pumping highly viscous clay ores. Viscosity measurements are critical to plot yield stress against shear rate and benchmark this against other problematic ores.

Pump selection is also an issue because highly viscous clay ores can de rate the calculated pump capacity by up to 50%. For pumps under thickeners centrifugal pumps may be totally unsuitable and either peristaltic or mono pumps will be required.

Conclusions

Understanding the Geology, Mineralogy and correctly selecting representative samples of the ore to be processed is critical in getting the Mineral, Processing right. Clays have the potential if not recognised to destroy project economics. Testing at an early stage of representative ore samples is critical.

The presence of clays in hard rock comes as a surprise if not fully understood. Similarly waste dilution from country rock containing clay can adversely affect the process. There are some solutions which assist in processing ores but don’t negate all of the difficulties.

The presence of clays has a major influence on the process selection and equipment used in the final flowsheet. The industry has paid a heavy price on a number of projects where the clay was not recognised or the process plant was based on a hard rock design which later proved to be totally unsuitable. Trying to mitigate the impact of clay on the process if the percentage of clay in the feed cannot be controlled is a Mineral Processing nightmare.

References

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