KnowledgeScape has pioneered the use of Expert Systems in minerals processing plants throughout the world. Our SAG mill strategies automatically adjust feed rate, mill speed and water addition to reduce upsets, eliminate grind-outs, protect liners/lifters, and increase tonnage. We maintain desired operating conditions by constantly monitoring bearing pressure, mill power, recycle pebbles, mill density, charge toe and mill acoustics, and can increase throughput by 3-6%.
GrindingExpert™ is a turnkey grinding solution that combines our industry leading MillScanner™ acoustic Smart Sensor with our highly intelligent KSX Expert System software to significantly improve SAG/ball mill performance. MillScanner™ with AID™ (Accurate Impact Detection) is a cutting edge Smart Sensor that rotates with the shell of the mill to display a radial trend of mill sound and vibration energy and identifies charge toe and shoulder levels for unprecedented SAG mill control and reliability. The KSX software works through the plant’s DCS stabilizing control system to provide the decision making capability of an entire expert operating team. KSX harnesses our 30 years of minerals processing experience as a starting point, and then applies fuzzy logic, neural networks, and genetic algorithms to create a truly intelligent Expert System capable of predicting and optimizing set points autonomously.

The throughput and efficiency of a SAG mill depends on the volumetric load: An overloaded mill has reduced coarse ore breakage, as the cascading balls and rock cannot drop far enough, reducing kinetic energy for breakage. An underloaded mill will break coarse ore well, but at the expense of added grinding ball consumption and increased risk of liner damage. Also, if underloaded, significant throughput will be lost in the fine and mid-size fractions as the surface area for attrition is reduced. Traditional methods of using bearing pressure to optimize throughput can have issues with changes in temperature, mill direction, liner/lifter profiles, and ore density occur. With MillScanner™, charge toe, acoustics, and media angles are combined with our expert grinding strategies to quickly stabilize the circuit, regardless of disturbances, at an optimal throughput. Additional benefits include extending liner, lifter and steel life, and minimizing power and water consumption.

GrindingExpert™ isn’t just about SAG mills. Our GrindingExpert™ solutions include ball mill strategies that achieve the target grind size while maximizing throughput, or when the circuit is SAG mill limited, achieve the finest grind size possible, thus increasing mineral liberation and recovery. GrindingExpert™ has been shown to typically increase throughput by 3-6%.
Objectives
- Protect the mill
- Maintain smooth and stable operation
- Maximize tonnage

Manipulated Variables (Directly Changeable)
- Feed Rate
- Mill Speed
- Feed Water
- Dilution Water
  Maintain smooth and stable operation

Control Variables (Not Directly Changeable)
- Bearing Pressure
- Mill Power
- MillScanner™ (sound, impact detection, charge toe and shoulder levels)
- Mill Density
- Recycle Pebbles
- Screen Amps

Control Branch Rules
The expert system rules calculate a new set point for each manipulated variable every minute. Data is read from the DCS every 10 seconds, and calculations and filters are performed every 30 seconds. Each decision cycle the expert system calculates a change in the feed set point. This change is applied (added to or subtracted from the current set point).

Feed Rules
A negative set point change will be applied if any of the following conditions are true:
- Bearing pressure is high
- Speed has been reduced already, and mill power remains high
- Speed has been reduced already, and recycle remains high
- Speed has been reduced already, and screen amps remain high

A positive set point change will be applied if all of the following conditions are true:
- Bearing pressure is ok
- Mill power is ok
- Recycle is ok
- Screen amps is ok

Speed Rules
A negative set point change will be applied if any of the following conditions are true:
- Mill power is high
- Mill sound is very high
- Recycle tonnage is high
- Screen amps are high
- Mill feed is at its maximum, and bearing pressure remains low
- Mill feed is at its maximum and mill sound is high

A positive set point change will be applied if all of the following conditions are true:
- Mill power is ok
- Mill sound is ok
- Recycle tonnage is ok
- Screen amps are ok
- Bearing pressure is not very low

Water Rules
A negative set point change is applied if the mill density is low or if the mill density is within its range and any of the following conditions are true:
- Mill power is high
- Mill sound is high
- Recycle tonnage is high
- Screen amps are high
- Mill feed is at its maximum, and bearing pressure remains low

A positive set point change is applied if the mill density is high or if the mill density is within its range and all of the following conditions are true:
- Mill power is ok
- Mill sound is ok
- Recycle tonnage is ok
- Screen amps are ok
- Bearing pressure is not very low

Fuzzy Logic
In the above rules, references are made to values like ok, high, very high etc. These values are called fuzzy variables, and are defined within the expert system by shapes called fuzzy sets. The fuzzy sets allow the expert system to gauge how high something is. The calculated response (set point change) varies in magnitude based on the truth value (how high) of the control variable. So the high-er the control variable is, the larger the corresponding change. The fuzzy value for each control variable is calculated based on the distance from the actual value to the limit, and the rate of change, or slope of the trend for that variable. That is to say, if a control variable is still below its limit, but is moving rapidly towards it, it may be determined to be high. Likewise, a control variable may be above its limit, but moving rapidly down, thus may be determined to be ok.

The expert system calculates the fuzzy values for each of the control variables, then calculates the set point change for each of the manipulated variables that will best meet the objectives of protecting the mill, controlling smoothly and maximizing tonnage.
Many GrindingExpert™ solutions will include our MillScanner™ Smart Sensor. Using a highly innovative solution that is fixed in rotation with the shell of the mill, MillScanner™ accurately and continuously monitors a mill’s contents to provide invaluable information regarding charge toe and media angles, liner/steel impact detection, and volumetric loading in realtime. MillScanner™ provides information to KSX via OPC communication, and displays radial trends graphically to the control room operator. Combined with traditional process variables such as bearing pressure, mill power, and recycle pebbles, the data provided by MillScanner™ allows the KSX Expert System to make the best possible decisions, in the least amount of time, for all conditions.

The information that MillScanner™ provides to KSX ensures that the software is able to effectively optimize mill set points and increase efficiency better than any other system. Control strategies can now factor in volumetric loading, charge toe angles, and steel-to-liner impacts in the decision tree along with bearing pressure, recycle pebbles, and mill power.

Compromising accuracy when selecting an acoustic sensor for your girding circuit will only compromise the integrity of the control system for future improvements. Control does not have to be what it was 30 years ago, and with KnowledgeScape leading the way in automated process optimization, higher throughput and increased reliability are now possible. Utilizing a MillScanner™ results in better grinding, clear vision of the mill contents at all times, reduced steel and power usage, longer liner life, and significantly increased profits.
The KSX Expert System is the foundation of all of our projects and it truly is the “brain” of the operation. Instead of relying entirely on traditional PID control and crisp logic, KSX utilizes genetic algorithms, adaptive models, and fuzzy logic to learn, predict, and react to changes in realtime.

KSX’s predictive controller has the ability to forecast process responses for multiple set point changes, while simultaneously accounting for multiple objectives, and ultimately select the approach yields the best possible outcome. KSX’s powerful routines easily handle input disturbances, like a change in raw material properties, and can take the necessary corrective actions before the process is ever pushed off target by autonomously readjusting set points to optimize throughput.

KSX also monitors itself, runs in a server environment with no need for a person to start and stop it, and it can detect and respond to communication failures and software crashes. A graphical user interface can be used for full transparency, and KSX when used in a GrindingExpert™ solution is proven to increase throughput by 3-6%.

Because KSX is always on, always monitoring, and always predicting and exploring optimal configurations, you will spend more time in the ideal set point range for your circuit with the GrindingExpert™ solution in place.

Our ability to distill our 30 years of grinding experience into cognitive software, and couple that powerful software with Smart Sensors like MillScanner™ and PlantVision™, ensures the very best results with the least amount of downtime on your circuit during implementation.

By reducing downtime and upsets, and finding the highest sustainable tonnage for your mill, you will increase the average tonnage by 3-6%.
The Best Companies Use KnowledgeScape

Over three decades, we have established ourselves as a trusted partner, and demonstrated the ability to provide a superior product at the best price. Because of this, our strategies are used in the biggest and best concentrators in the world. Please call us for a full client list and references at any time.

Our Clients

KnowledgeScape is very aggressive in our pricing, and we guarantee to not only beat any competitor on price, but in value. Our customer service and technical support is second-to-none, and we guarantee the best possible solutions for your minerals processing plant.

Because the scope of a typical project can vary greatly, we also offer a wide range of solutions at varying price points. The great thing about working with KnowledgeScape is that our years of experience will result in the quickest implementation possible and the provide best possible results. This means less downtime to our customers, and larger increases in your profits. Feel free to contact us at anytime and we can provide a timely and highly competitive quote for your minerals processing project.

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