Optimize\textsuperscript{IT} Expert Optimizer

Industrial\textsuperscript{IT} Solutions for Mineral Processing Industries
What is Expert Optimizer?
Expert Optimizer is a hybrid intelligent system solution developed by ABB as part of its wide optimization suite. It is primarily designed for expert closed loop process control and optimization of industrial processes, but can also be used for decision support applications.

A hybrid intelligent system is not a substitute for a plant DCS or PLC system. It is rather a high level supervisor that supplies setpoints to the lower layer of control systems. Our hybrid intelligent system Expert Optimizer possesses human-like knowledge within specific domains. It adapts itself and learns in changing environments, thus making decisions and taking actions.

Why Expert Optimizer?
The main objective of Expert Optimizer is to achieve continuous process optimization so as to improve your plant’s overall performance. By coordinating the setpoints of the different parts of the process and immediately detecting deviations among the different parts of the mine operation, Expert Optimizer can be used as an overall plant process optimization decision support tool. It helps the plant management to reach profitability and sustainability goals.

Expert Optimizer is a graphical engineering and programming platform, which is used to control and optimize:

- comminution (crushing, grinding) process
- (alumina, fertilizer, titanium) kilns
- flotation circuits
- digestion process
- production scheduling, etc.

by using a combination of proven advanced control techniques. Expert Optimizer adds value to the operational performance: it brings the process closer to its operational limits.

Tangible Benefits

- Increased profits (5%–10%)
- Increased production (3%–10%)
- Energy savings (3%–7%)
- More stable product quality (10%–20%)
**Manual Setpoint**

**Benefits due to Optimization**

**Optimized Setpoint**

**Maximum Process Capacity**

**Optimize**

**Stabilize**

**Manual**

**Automatic using Expert Optimizer**

Diagram showing Expert Optimizer drawing the process setpoints... to the maximum process capacity.

«Problem solving in **partnership**»

**How does Expert Optimizer work?**

Often the process behaviour is well known to experts. In other words, the expert knows and understands the forces acting on the process. This knowledge allows the expert to build a detailed relationship, which is able to tie the process measurements to its control commands. In the same fashion, the core of any Expert Optimizer control strategy consists of variable gain, multi-variable fuzzy ruleblocks, neural networks and Model Predictive Control. Expert Optimizer has successfully applied this technique and achieved more than 4 million hours run time in closed loop control.

The Expert Optimizer Toolkit provides a comprehensive variety of advanced control techniques for appropriate strategy development. This, coupled to the graphical engineering environment, ensures fast development and implementation with long term maintenance of a system.

The Expert Optimizer Toolkit is used to build and display the control strategy required to achieve the process and business objectives. Typically the process engineer will break up the strategy into various solution components. These components are linked together to form a control strategy. Such solutions may be hierarchically arranged into logical workspaces.

As of today, Expert Optimizer is controlling more than 260 processes worldwide. It is saving more than $100 million for our customers, year after year.

**Basic idea:**

- **First**, stabilize the process.
- **Then** optimize.
- **Supervise.**
- **Repeat.**

**Expert Optimizer: unmatched performance**

- Tirelessly supervises desired process parameters
- Unchallenged reaction speed
- Consistently takes the best decision
- Executes many small changes as opposed to few large changes
- Immediately recognizes abnormal conditions and acts accordingly
The key objectives in the mill strategy are to produce consistent quality, at maximum throughput, and at optimal energy usage and minimal consumption of utilities.

Expert Optimizer brings you full time help to achieve your objectives.

The Expert Optimizer strategy to optimize the grinding process is to keep an adequate grain size distribution inside the milling circuit and to guarantee an optimal balance between the inflow of coarse material and the outflow of product.

These goals are achieved by a successful strategy comprising:

- Boolean operations
- Fuzzy logic
- Neural networks
- Model predictive control

Our strategy resembles the actions of an experienced operator that always acts fast, consistently and tirelessly.

While the optimization targets are customer dependent, the following benefits have been recorded at the more than 90 mills controlled by Expert optimizer.

**Increased output**

By continually monitoring the loading of the mill and balance of the material flows through the system, it is possible to identify situations when the feed to the mill and the output can be increased while the product quality remains in the specified bandwidth.

**Consistent quality**

The continual monitoring of the mill loading and adjustment of the feed, separator, cyclones and/or water sump pumps results in reduced variations in product size production. The control strategy is designed to respond to disturbances in the process but still achieve quality consistency, eliminating both over and undersize product.

**Stable material flow**

By continuously introducing small changes in the process inputs, as opposed to fewer but larger ones, more smooth and stable material flow is achieved. The result is better product quality, less plant downtime, and longer equipment life.

Additionally, lower specific power consumption and reduced consumption of grinding media is achieved.
Flotation Banks and Circuits Optimization

Mining plant engineers know that the control of flotation cells banks is a complex task due to high nonlinear interaction between process parameters and variables. Any action on a part of the system generates disturbances that propagate both upstream and downstream, often with amplified effect.

The process is characterized by
- large stream volumes
- time delays/lags
- material properties uncertainties
- high sensitivity of the process to having adequate conditions

Most control strategies in common use are based on plant data. However, due to time delays and the occasional fouling of measurement devices, this information is often not appropriate for tight control.

In Expert Optimizer modern mathematical techniques, acting in concert, compensate not only for variations in mineralogy and flotability, but also for disturbances caused by the grinding circuits like feed rate, pulp density and particle size distribution.

Expert Optimizer strategies manipulate
- reagent feeding
- flotation cell levels
- flotation cell air flows
- wash water

In order to
- produce the best grade-recoveries curve
- reduce concentrate quality variability
- stabilize material flows
- minimize reagents usage

Expert Optimizer strategy successfully compensates for uncertainty in the ore mineralogy and flotability.

Benefits
- Predictive control strategy based on material balances
- Increased recovery
- Lower usage of reagents
- Consistent concentrate quality
- Elimination of shift-to-shift variations
- Enhancement of site-specific knowledge
Kiln and Calciner Optimization

«For business and environmental sustainability»

**Tireless performance**

The potential benefits that you can expect to achieve by installing Expert Optimizer to control your kiln or calciner can be assessed on the basis that performance will improve from that of an average person to that of a very fast and precisely acting ideal operator, who performs at their best for 24 hours a day, every day. The quantifiable process benefits that can be forecast are:

- increased output
- lower fuel consumption
- longer refractory life
- consistent quality

Other important benefits, which are sometimes difficult to quantify, will also be obtained:

- control strategy focused on business objectives
- control of emissions to meet environmental legislation
- lower plant maintenance costs through improved run times
- consistent control of the process, eliminating shift-to-shift variations
- enhancement of kiln-specific knowledge
- empowerment of operators allowing greater productivity

**Environmentally sound sustainable business**

How does Expert Optimizer achieve this? Because the combustion in rotary kilns is controlled more efficiently, the energy requirements of the process are reduced. This reduction in energy consumption reduces the quantity of greenhouse gasses emitted into the atmosphere. In addition the kiln process runs at a lower temperature, which reduces the amount of NOx formed in the flame.

The effectiveness of Expert Optimizer as a tool to reduce nitric oxide emissions has been recognized by a British government environmental award.

**Benefits**

- Efficient control reduces energy requirements
- Lower burning temperature reduces amount of NOx formed in the flame
- Expert Optimizer is recognized by environmental authorities as a control strategy for NOx reduction
The challenge of consistency

The removal of unwanted substances (oxygen, CO2, fluorine, etc) via calcination or reduction is often done in kiln or fluidized bed calciners. This is for instance the case for our alumina, lime, fertilizers and direct reduction iron customers. The need to optimize and economically achieve consistency in end product quality and production capacity, represents a major challenge in these industries.

The process problems are basically the same as in related industries as to variable and complex feed chemistry, rings and balls in kiln, refractory life, long feed residence time, all of which are well known to ABB via our experience in hundreds of kiln processes.

ABB’s Expert Optimizer employs the best of control philosophies including fuzzy logic, neural networks and model predictive control to tackle these issues.

ABB has preconfigured strategies for these systems. Process and plant specific actions are easily introduced using Expert Optimizer graphical toolkit.

The many years experience of the practical application of theoretical and practical knowledge get the job done. Our projects result in large benefits in terms of production rate, fuel consumption and process stability. Additionally, there is major potential in increasing process understanding: our customers enjoy process transparency, better training of operators and enhancement of the knowledge of plant process engineers.

Fast payback

The expected benefits show that a payback period of under one year should be easily achieved with Expert Optimizer installed in the process.

Depending on the application expected benefits include:

- Energy consumption reduction
- Reduction in steam costs
- Increased output for high value feed products
- Reduced premature brick fouling and build-up of clinker
- Reduced frequency and costs for shooting kilns
- Operate closer to edge to save fuel and maintain quality
- Reduce over-burning

**Benefits**

<table>
<thead>
<tr>
<th>Process</th>
<th>Feed increase</th>
<th>Fuel decrease</th>
<th>Quality std dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alumina case 1</td>
<td>11%</td>
<td>8%</td>
<td>Reduced</td>
</tr>
<tr>
<td>Alumina case 2</td>
<td>4.5%</td>
<td>7.3%</td>
<td>Reduced</td>
</tr>
<tr>
<td>Lime</td>
<td>na</td>
<td>4%</td>
<td>-20%</td>
</tr>
</tbody>
</table>
Optimal Plant Flows and Energy Management

Be the chess grandmaster of your plant

Expert Optimizer offers a new solution for advanced control and optimization at mineral plants. The basic idea is to combine Model Predictive Control with the online mass and energy balances to exploit the available degrees of freedom (buffer tanks, silos, energy reservoirs) in order to tackle process bottlenecks and efficiency losses. Due to the predictive character of the proposed control scheme, superior levels of stability and process consistency are achieved. This leads to higher production rates, less consumption of raw materials and reagents, more stable downstream operations, and more consistent quality.

Example: control of ore charge and reagents

In digestion control the system would know the chemical composition of the main streams and levels of tanks (layout on the chess board). From this knowledge and a mathematical model of the installation, Expert Optimizer is able to predict the effect of ore charge changes on the chemical reactions taking place in the digester sections and thus on the reagent to raw material ratios after the digester, and further downstream. These predictions put the system in the position to choose the best ore charging rate and reagent ratios according to the process targets. The plant model is adapted online using the measured differences between the model predictions and the true process parameters. Typical examples of this situation are alumina and titanium dioxide plants.

Example: control of heat exchanger networks

In this case a model containing the basic energy balances is created in Expert Optimizer. This is used for predicting temperatures and selecting the optimal (steam) flows in order to meet the specifications. Further, due to online monitoring of the heat transfer coefficients, advice can be given on the optimal point in time for cleaning of the heat exchangers. Typical examples of this situation are alumina plants.

Combat process bottlenecks

With the help of explicit material and energy balances and the accurate estimation of the associated time delays via modeling of plant piping and equipment, Model Predictive Control puts us in the position to predict the effect on the process of given control decision and disturbances. It becomes possible to take due actions at the due times with the sake of better fulfillment of the targets.

Dependent on the application, the following benefits should be expected:

- Lower consumption of raw materials
- Less waste heat
- Less condensate contamination
- Better temperature control
- Better process conditions downstream
- Lower thermal stress
- Continuous monitoring of process efficiency

«Checkmate process bottlenecks»
Overall Economic Process Optimization

«The quest for overall economic performance»

Expert Optimizer – your answer to overall economic performance
Continuous operating performance and high profit is one of the major concerns in the mining industry. Plant management systems are expected to reinforce and enable conformance to these requirements.

Implementation of advanced intelligent systems like Expert Optimizer as a decision support tool in the mine can reduce costs, optimize investment and create a shorter payback by processing the information available and suggesting decisions.

Production efficiency is reached via integration of process, production, market and quality information into one decision support tool.

Expert Optimizer as the plant management support tool
Expert Optimizer is ideally suited to provide these functionalities:
• immediate detection and remedial action to changes to process boundary conditions
• consistent overall economic process optimization (process setpoints and coordination thereof, energy management, production planning, energy supply contract optimization etc.) of the plant as a whole

• enforcement of environmental sustainability issues, where these issues have appropriate weight in the enterprise’s operations since it becomes possible to track and enforce the fulfillment of the company’s environmental goals

Application example
As an example, the flotation bank operation can be coordinated with the ore grinding process, and this, in turn, with the availability and properties of the material, market conditions and the contract with the energy suppliers. Real-time true optimization is the result, which leads to:
• precise material balancing
• throughput as dictated by the market
• lower energy consumption
• better and more stable quality
• lower maintenance costs

The modelling technology used in Expert Optimizer allows the use of plant mathematical models that include batch and continuous processes, making possible the perfect coordination of these two worlds.

Benefits
• Increased process stability
• Higher production
• Lower consumption of raw materials and reagents
• Reduced energy consumption
• More consistent quality
• KPI targets fulfilled
Strategy for Success

Win trough Combination

Arithmetic Functions
Fuzzy Logic
Rule Based Control
Neural Networks
MPC & MLD

Expert Optimizer Toolkit

Expert Optimizer introduces a new era in expert systems for optimization of mining operations. Rather than ‘just’ optimizing the process, Expert Optimizer gives the global picture by providing complete thin client based monitoring, diagnostics and guidance. This empowers not only operators, but also process engineers and plant managers. In order to reach these goals, Expert Optimizer includes a tailor made toolkit using:

- Web based graphical user interfaces
- Extremely user friendly development environment
- Familiar Windows look and feel
- Real-time numerical and graphical data
- Real-time explanation – messaging software
- Drag and drop configuration
- Fuzzy logic
- Boolean logic
- Neural networks
- Model predictive control (MPC)
- Mixed logical dynamical systems (MLD)
- Preconfigured control strategies

Process optimization goals are achieved through technologies that enable the knowledge of the best expert to be applied accurately, tirelessly and consistently at all times. The forecasts of quantifiable potential benefits are often exceeded as a result of the additional process expertise from ABB application engineers and because of the interaction between these engineers and the client’s specialists. These benefits will include:

- increased production
- consistent product quality
- reduced operating costs
- reduced key variable standard deviation
- operational consistency

The objective of Expert Optimizer is to achieve continuous process optimization, improving the plant’s overall performance. By combining the powerful control techniques available in the Toolkit, an engineer is able to use his experience and expertise to develop solutions for optimizing each process element from mills to the flotation circuits and beyond.
In the Expert Optimizer Toolkit a number of proven control techniques for the development of the application are offered. In a control strategy, use is made of all of these control techniques to develop a robust control and optimization solution.

- The fuzzy logic inference system incorporates human knowledge to make and implement effective decisions during the process.
- Neural networks are used to learn relationships between key process variables and adapt themselves to cope with changing process conditions. The ability of these objects to learn relationships is extremely useful when it is not possible to continuously measure a process variable that is important to the control and optimization of the process. In kiln control an obvious example is predicting the clinker phases. In other applications, for instance flotation or digestion, the system will predict the concentrations of chemical components.

- Model predictive control allows incorporation of predictive elements into the strategy by exploiting concrete knowledge about the process chemistry, mass flows and its thermodynamics.

Expert Optimizer graphical tools allow the construction of process models and application of techniques like Model Predictive Control (MPC) with models in the Mixed Logical Dynamical (MLD) systems framework. This allows exploitation of process knowledge to the maximum, increasing performance and reducing long term maintenance costs.

The integration of all these complementary control techniques, coupled with ABB’s extensive process experience and expertise, allows the engineering of powerful robust solutions. Well engineered solutions provide constant financial benefits to our customers for extended periods of time.
**ABB OptimizeIT Expert Optimizer**

Expert Optimizer is your productized solution from ABB. Be up and running quickly with this customizable solution. Get fast ROI with world wide support from ABB’s local experts. Only Expert Optimizer brings you the perfect blend between, off the shelf and inclusion of your specific needs, enabling you to roll out the benefits across all your plants, quickly, time and time again.

More than 500 systems installed worldwide are using ABB knowledge-based solutions for information management and process optimization. A world leader in process specific Collaborative Production Management – ABB, always at the forefront of developing cutting-edge technology.