Gerhard Schubert

Founder and Chief Executive of Gerhard Schubert GmbH: “I’m good at making things simple. It basically boils down to this: How can I make packaging machines cheaper? What is it that costs money?”

Advanced Process Control

How to Make Milling More Energy Efficient
The grinding stage in a cement plant is extremely energy-intensive, consuming almost half the plant’s total electric power requirement. An expert system designed especially for cement production uses real-time plant data to make precise statements about the plant’s quality parameters, and can be integrated into the existing control system with no additional hardware requirements.

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Experts in Cement Milling

Advanced process control boosts energy efficiency and product quality at a cement plant

The mill control can be optimized based on predicted quality parameters, which in turn reduce energy consumption and improve the cost-effectiveness and availability of the plant and the quality of the product.

At the Süddeckisches Portland-Zementwerk in Rohrdorf/Germany, raw materials extracted from nearby quarries are stored in a blending bed hall and then ground into “raw meal” in a raw mill. In the rotary kiln the raw meal is then burned to create Portland cement clinker, the basic material for all types of cement. The next step is to grind the clinker in a ball mill equipped with steel balls of varying sizes. Depending on the type of cement, other materials such as granulated blast furnace slag can be added at the grinding stage.

The Rohrdorf plant has four ball mills with a total grinding capacity of around 270 t/h.

The grinding medium moves in different ways depending on the rotational speed of the mill. Low speeds create a cascade motion in which the balls merely roll around. As the speed increases, the balls are lifted and fall onto the milled material (“cataracting” motion). Above the so-called critical speed, the balls are held against the drum wall by centrifugal force, so scarcely any grinding takes place. The optimum operating speed is above the point at which cataracting begins, and below the critical speed.
Requirements For Optimized Control

To optimize the energy consumption of the mill, Siemens has developed a new mill control system. The first pilot project involved one of the four ball mills at the Rohrdorf plant. Dating from 1965, this mill consists of two chambers: the first chamber is filled with large steel balls, and the second with smaller balls. The ball mill has a length of 11.6 m and a diameter of 3.8 m, and it has a rotational speed of 15.4 rpm. The drive power is 2,400 kW, and the grinding capacity is 60 t/h.

One of the most important quality-relevant parameters in cement grinding is the fineness of the product. Samples are taken every hour, analyzed in the lab, and the resulting particle size analysis used to correct the process. Acoustic sensors, meanwhile, record the filling level of the mill.

The idea behind the new control system was that it should record and adjust the quality parameters automatically. A further requirement was to replace the existing optimization system and to integrate the new system into the existing control system without any significant overhead. This demanded software that uses a knowledge-based approach and current plant data—an expert system—to predict the plant’s quality parameters and control them automatically, thus relieving the plant operator of these tasks.

Another aim was to achieve maximum throughput with the desired level of grinding fineness.

Architecture and Implementation

The result is a system known as Sicement IT MCO (Mill Control Optimization) from Siemens, based on components from the advanced process control (APC) library of the Simatic PCS 7 control system. Using APC, even complex relationships between process parameters and plant variables can be described mathematically and used to control the plant automatically and flexibly. In this case, a neural “soft sensor” records the process input variables and predicts the fineness of the cement leaving the ball mill. To reduce process deviations and to stabilize the grinding process, a model-based predictive controller (MPC) is used; this contains a complete model of the process dynamics with all interconnections. Together, the neural soft sensor and the MPC system provide accurate and responsive control of the complex grinding process.

The MCO system was implemented in three phases. First, the plant was analyzed to identify the existing input and output variables and examine the quality of the existing control solutions. In the second phase, plant tests were carried out to determine the step responses and collect production data. Once the data had been analyzed, the models for the neural soft sensor and the MPC system were developed. The third phase included the
Instrumentation/Process Automation

software engineering needed to integrate Sicement IT MCO into the existing Siemens PCS 7 control system.

The Sicement IT MCO system was commissioned without shutting down the ball mill. Initially the new controller ran in the background, shadowing the existing system. Once the new system had shown that it could handle all the required functions, the old system was switched off. The system was then refined to produce optimum results for each of the eight recipe types defined in the specification.

Functional Principles of the Mill Control Systems

The new mill control systems works in three steps. First, the neural soft sensor records a total of nine process input variables and uses these to predict the cement fineness. These input variables are:

- separator speed;
- quantity of fresh material;
- swirl flap position;
- four variables representing the fill level of the mill: circulating elevator flow, mill drive performance, acoustic sensor chamber 1, acoustic sensor chamber 2;
- mill temperature; and
- recipe type.

The fineness prediction from the neural soft sensor is compared with the values measured by the lab. The compared value for “fineness” (quality) and the measured fraction of “rejects” (oversize material) form the control parameters for the MPC. The values are optimized by changing the feed quantity and the separator speed. This is done via predictive calculation of the relevant control procedures based on a complete process model to bring the control parameters as near as possible to the desired setpoints. External setpoint settings are thus calculated for the lower-level individual controllers to optimize the future behavior of the plant over a specific time period.

Conclusion: Payback in Three Months

By determining the setpoints of the individual controllers more accurately than before, the MCO system ensures optimum throughput, energy consumption, and product quality, and maintains stable production conditions that can be adapted to the current mill situation at any time. A further advantage is that the time lag between a change to the system inputs and the corresponding response at the system output is significantly reduced. The result is a more uniform grinding process which optimizes the throughput of the mill while retaining product quality. It also makes the plant operator’s work easier. Energy consumption per tonne of cement has fallen, and the service life of the plant’s mechanical components has increased. Compared to operation without an expert system, the use of Sicement IT MCO achieved a performance boost of 5–8 percent, and the investment paid off within just three months.

In contrast to the old control system that was based solely on the Blaine value (a measure of the degree of fineness) as the input variable, Sicement IT MCO takes its inputs from parameters that are set much further upstream. As well as avoiding time lags, this also makes it much easier to collect and compare input data, and so paves the way for further optimization in the future based on an improved understanding of the grinding process. In contrast to other new systems, Sicement IT MCO can also be fully integrated into the plant and the existing PCS 7 control system, so there are no additional servicing and maintenance costs for the plant operator.

Following the success of the project to optimize control of the first ball mill, Siemens has now started work on the second mill, and the two other mills will follow in due course.