SIMCA-online

Solution

What is control?

8 June 2020

The term **control** within process manufacturing has many meanings and interpretations. Control is used to describe the monitoring of a system's state with applications in Statistical Process Control (SPC) or Quality Control. It is also used to describe an engineering discipline, process control, for directing a process towards a desired state. Common names for process control include regulatory control, supervisory control, advanced control, model-based control, model predictive control or real-time optimization to name a few. This paper describes the objective of these various methods.

Are you in-control?

Assuring that a system remains in-control has a long history in manufacturing industries. Ever since the advent of data collection, procedures emerged to decide if the data suggests the process is running in a normal way (**in-control**) or has deviated into an out-of-control state. Shewhart and later Deming pioneered many of the basic principles that are still in use today.

Defining the **in-control** state of a system is usually based on characterizing normal common cause variation. For very simple systems with few parameters univariate control charts may be used to track a few key parameters. For systems with many variables, or where important information is contained within the correlation structure of the parameters, multivariate methods such as principal component analysis (PCA), partial least squares (PLS) or orthogonal PLS (OPLS) are used to summarize the overall state of the data collected.

SPC and quality control are passive methods that do not directly correct an out-of-control situation or prevent process deviations. SPC provides detection and diagnosis of process faults, however corrective action is a manual task.

Process monitoring in SIMCA/SIMCA-online

In **SIMCA** characterizing **in-control** is performed by fitting a multivariate model (PCA, PLS or OPLS) on a set of data where the process operated in a desirable way and produced good quality product.

Monitoring of new data is performed by projecting the data through the model. Control charts of multivariate summary parameters (scores, Hotelling's T2, DModX) and critical process parameters are used to determine if the system is in-control or out-of-control. Diagnosis of a process fault is provided using contribution charts, which highlight the variables responsible for a deviation.

In real-time, **SIMCA-online** is used to automatically collect data, perform multivariate calculations, and generate control charts. Diagnosis of deviations and alarms is provided through interactive drill down features.

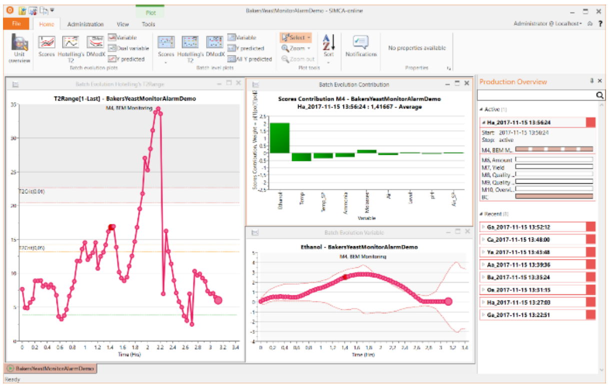

Figure 1, Batch control charts in SIMCA-online showing a deviation in a score evolution (left) contribution chart for the deviation (top right) and univariate control chart of a responsible variable (bottom right).

SIMCA-online Forecast

Predictive methods may be used to extend the power of monitoring to include forecasting a process' state into the future. Deviations may be detected and diagnosed before they occur, allowing proactive actions to be taken. **SIMCA-online** includes an optional feature, **Control Advisor** with a **Forecast** mode. Forecast provides predictions of future process trajectories of multivariate metrics and univariate process parameters.

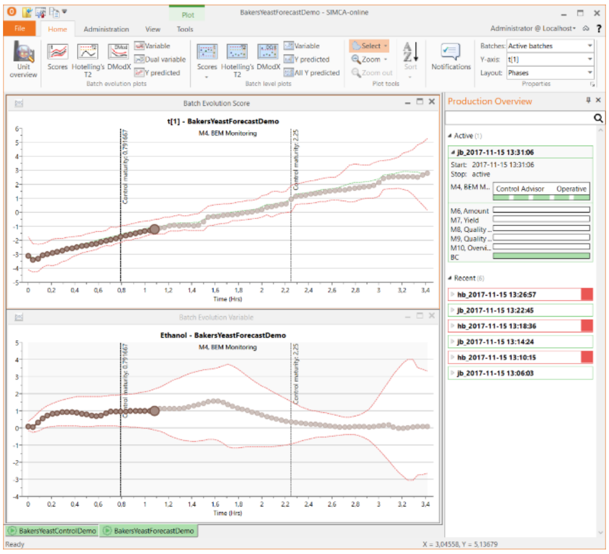

Figure 4, Batch control charts in with Control Advisor Advised future mode in SIMCA-online showing predicted operation up to the current time and both forecasted and advised trajectory to batch completion.

Process control

If a system deviates from its desired state, finding proper adjustments to return to in-control are necessary. Process control is the engineering discipline dealing with methods and algorithms associated with determining appropriate actions to maintain a system within a desired range. Process control methods are divided into two general hierarchical levels, regulatory and supervisory.

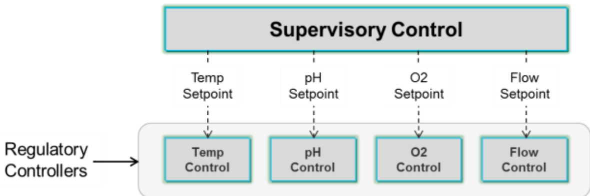

Figure 3, Hierarchy of supervisory and regulatory control layers.

Regulatory control

Regulatory control refers to the base level automation layer that is responsible for maintaining process variables at specified setpoints. Regulatory controllers include simple single-input-single-output (SISO) algorithms such as proportional-integral-derivative (PID). Stable regulatory control of a process is a prerequisite to performing high level control such as process optimization.

Supervisory control

The supervisory control layer is tasked with determining setpoints for the regulatory controllers to provide high level control of product quality or process optimization. Supervisory controllers are generally complex multi-input-multi-output (MIMO) structures that utilize models of the process to predict the influence of parameter adjustments on the future trajectory of the process.

SIMCA-online Advised future

SIMCA-online includes supervisory control as part of the **Control Advisor**. This mode is called **Advised future**. The Advised future contains predictions of future process trajectories for a given set of optimal process adjustments. These adjustments may be manually implemented by the operator or automatically written to the regulatory control layer. Control Advisor, and supervisory control in general, can be used to simultaneously accomplish many objectives including,

- detect and correct process deviations before they happen
- assure product quality within specifications
- maintain a process within the design space
- reduce cost and energy consumption

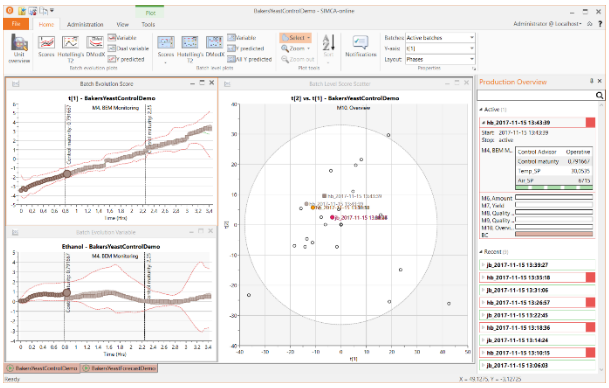

Figure 2, Batch control charts with Control Advisor Forecast mode showing predicted operation up to the current time and forecasted trajectory to batch completion.