Control loops: pleasure or plague?

A plant floor view within the process industry

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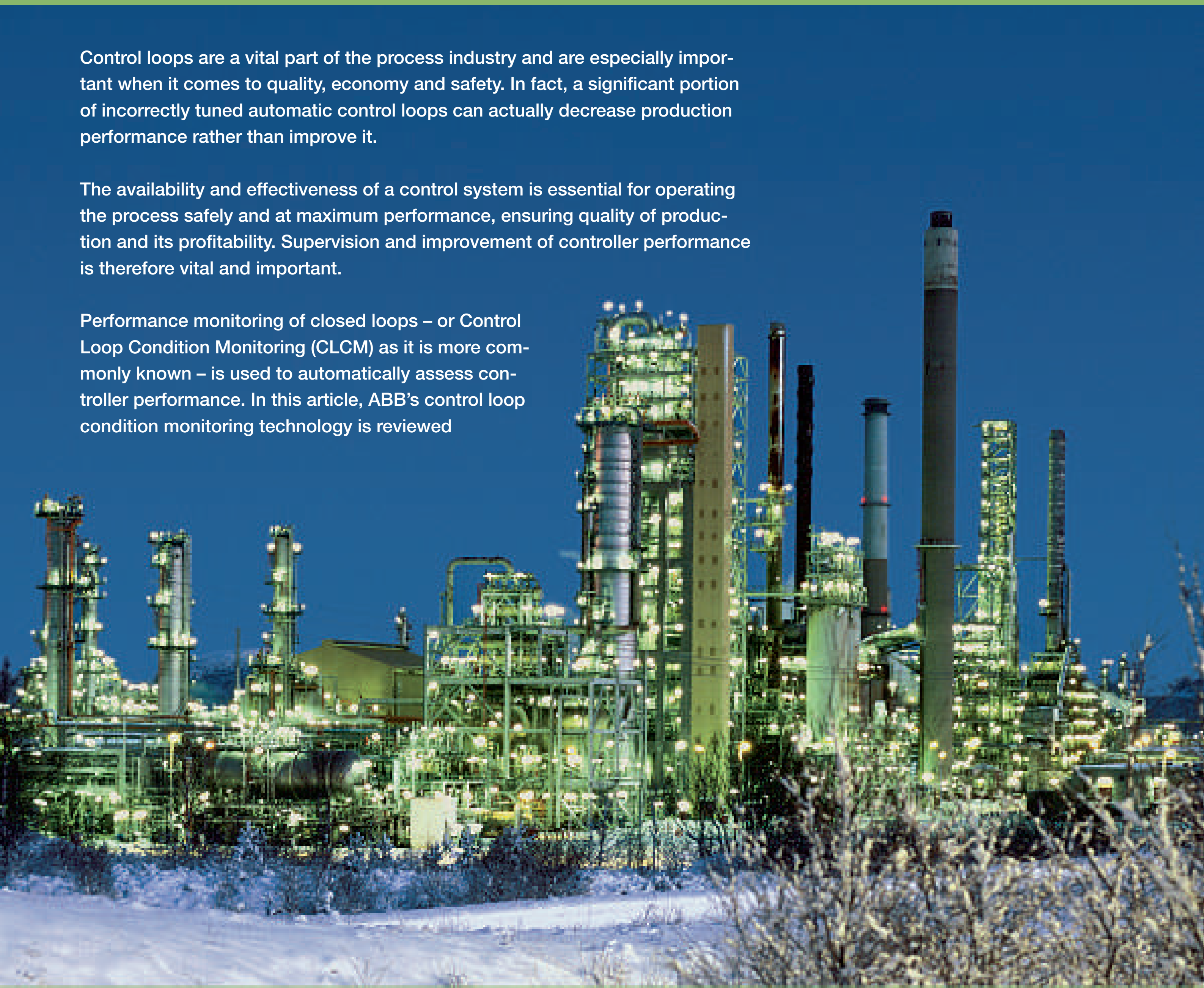
Control loops are a vital part of the process industry and are especially important when it comes to quality, economy and safety. In fact, a significant portion of incorrectly tuned automatic control loops can actually decrease production performance rather than improve it.

The availability and effectiveness of a control system is essential for operating the process safely and at maximum performance, ensuring quality of production and its profitability. Supervision and improvement of controller performance is therefore vital and important.

Performance monitoring of closed loops – or Control Loop Condition Monitoring (CLCM) as it is more commonly known – is used to automatically assess controller performance. In this article, ABB's control loop condition monitoring technology is reviewed



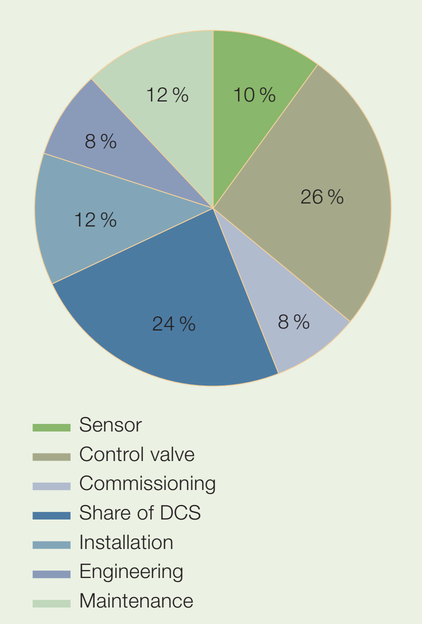
Control loops are an intrinsic part of any automation system. Estimations, as shown in 1, indicate that each control loop is a $25,000 asset. According to a recent editorial from the Hydrocarbon Processing Journal [1], "Without properly tuned control loops to minimize variability, and updated process models used by the advanced controls to reflect real constraints and business objectives, substantial benefits are lost". In other words, as the title of the editorial says, "Include control loops in asset management".

Control Loop Condition Monitoring (CLCM) is as natural as the condition monitoring of valves and transmitters. Because basic control loops have the same principle of operation no matter what the control application, CLCM is able to use general principles across many different industries and applications.

Automated CLCM is highly attractive in most plants because there are simply too many control loops to be maintained by one service engineer on a regular basis, ie, at least every six months. Another reason why many industries are interested in CLCM is its inherent non-invasiveness.

CLCM works like a doctor's stethoscope: it obtains a diagnosis by passively listening to the process. Typically, no more information than standard DCS tags – setpoint (SP), process variable (PV), controller output (CO) etc.) – is required. In a typical production plant in the process industry, for example, there may be up to several thousand control loops. Rather than assessing each and every loop, it makes more sense to identify the worst performing loops. 2 shows a typical and important loop performance ranking result, including typical data for each category.

1 Cost distribution of a control loop.



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The need for CLCM?

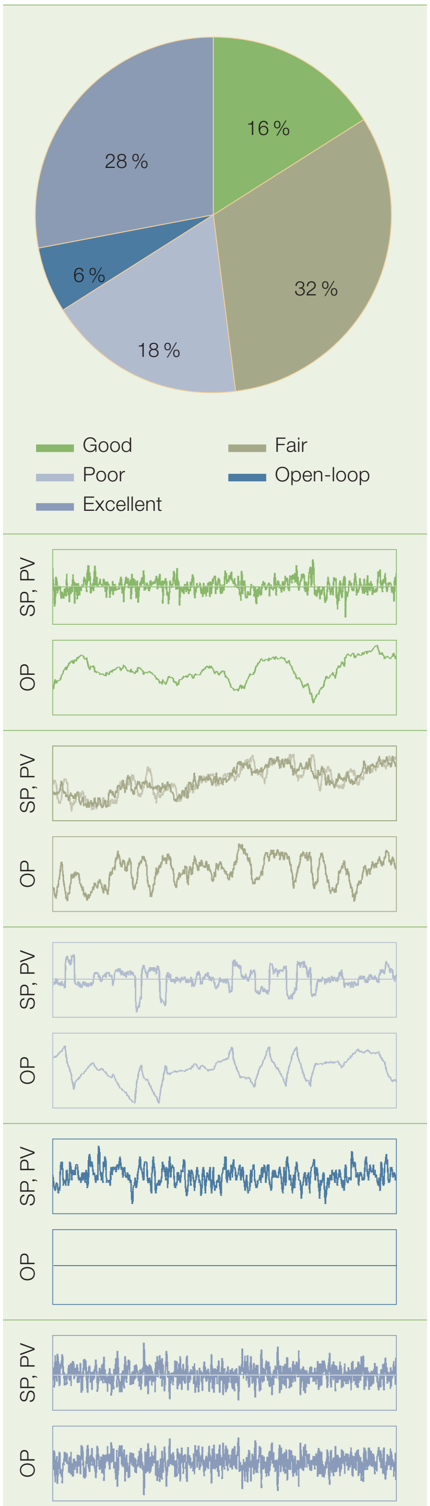
Assessment of control loop behavior is as old as controller design. In the design phase, the designer usually creates a controller that satisfies some given performance specifications. Unfortunately, these performance specifications often cannot be evaluated using measurement data obtained from normal plant operation.

In helping to resolve this issue, Harris [2] developed a simple and very appealing performance measure that evaluated any control loop under normal operating conditions. It compared current controller performance to the theoretically best achievable one, based on normal operating data. During the last ten years, considerable research has been carried out to enable the further development of a holistic and non-invasive methodology that can automatically assess controller performance. An overview of ongoing research is presented in [3].

Much of the current research and development efforts focus on methods of locating the root cause of bad controller behavior, deciding whether it is internal or external, and how performance can be optimized.

The most obvious and serious control loop problem is regular or continuing oscillations. Such behavior may occur because of: bad controller settings; external problems; valve friction; equipment failure; or process-related reasons. Irregular deviations from tar-

2 Loop ranking overview for a typical plant in the process industry.



gets are even more difficult to analyse. Luckily nowadays, oscillations and poor performance can be automatically detected - with a little help for example from what is known as the Harris Index [2]. However, the main challenge of diagnosing bad performance remains.

CLCM typically focuses on large numbers of basic control loops that are vital in achieving the targeted product quality and plant performance. However, in situations where highly advanced control loops are used, more advanced supervision functionality is needed. Advanced control (eg, model-predictive controllers) relies heavily on the assumption that the underlying basic control loops perform satisfactorily. CLCM ensures this requirement.

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CLCM in industry

The chemical, petro-chemical and pulp and paper industries were the first to apply CLCM methods and have, over the years, built up considerable experience. More recently, there have been successful applications in power plants. The increasing number of academic research groups and the increasing interest from different automation system vendors is another indication of the usefulness of CLCM.

This interest is also an effect of the more general trends affecting asset management. These trends have been recently published by the ARC group [4]:

- Deliver recommendations, not only pure information.
- Extend the usage of current assets (no trend to replace current equipment).
- Provide tight integration with the IT environment.
- Avoid high commissioning and implementation costs and efforts.
- Reduce plant staff and increase competitiveness by creating a new maintenance paradigm.

Modern CLCM tools strive to support these trends. In fact ARC recommends the combination of control loop condition monitoring with a controller tuning tool.

ABB has adopted this idea and integrated both functionalities into what it calls the Optimize^{IT} Loop Performance Manager (LPM) tool [5].

What's on offer from ABB

ABB offers CLCM functionality on different levels throughout the automation system to fit different industry needs and different automation architectures 3.

Optimize^{IT} Loop Performance Manager (LPM)

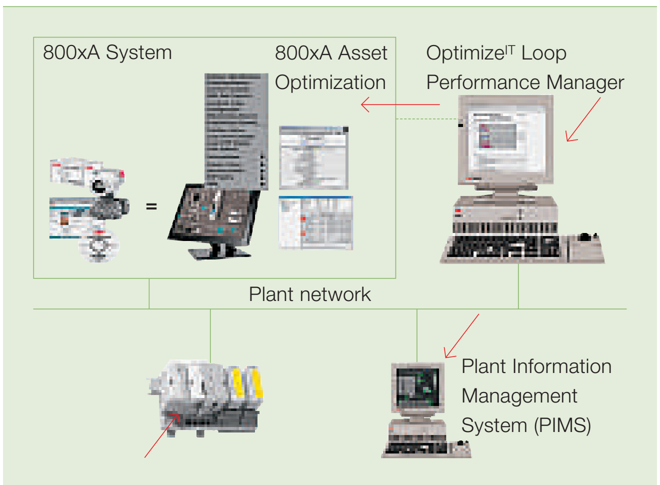
ABB's Optimize^{IT} Loop Performance Manager (LPM) Ver. 2.1 is a general and powerful tool for controller performance condition monitoring. It combines both control loop assessment and controller tuning functionality, and runs with any automation architecture via OPC data connectivity 4.

LPM's control loop auditing not only indicates the best and worst performing loops in a plant section, but it also gives detailed analyses on how to remove identified problems. These problems include discrepancies in the final control element, external disturbances, and controller tuning. So if re-tuning the controller, for example, can solve the problem, then the tuning functionality can conveniently achieve this task using state-of-the-art tuning methods that are easy to use at the same time.

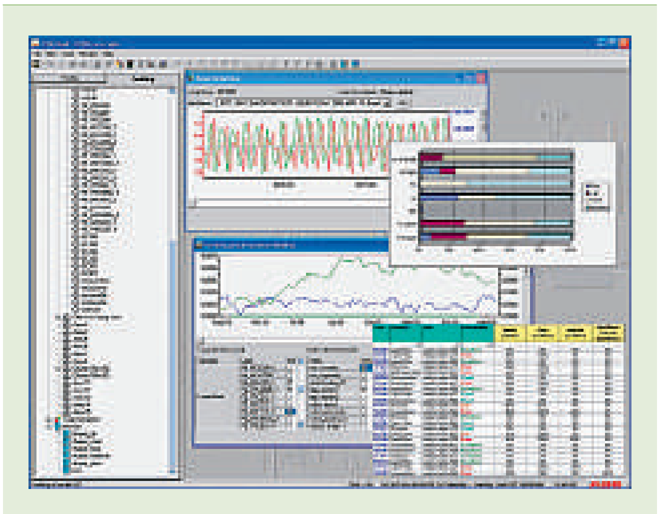
Controller hardware: Control^{IT} AC800M

On the field device level, some basic functionality exists for control loop condition monitoring. For example, oscillations due to valve stick-slip behavior are unfortunately very common. The good news is that these oscillations can now be automatically detected by ABB's AC800M controller.

3 Automation architecture indicating controller condition monitoring functionality (red arrows).



4 ABB Loop Performance Manager (LPM): loop auditing window.



Not only this but by using CLCM functionality, the AC800M controller can overcome the sticking valve movement by adding pulses to the manipulated variable so the valve moves to the desired position [6]. 5 shows a typical measurement signal (PV) in a control loop exhibiting stick-slip and the corresponding AC800M functionality.

The controller can detect sticking valves and apply a stiction compensator algorithm to guarantee best possible controller action until the next valve maintenance. Within the AC800M PID controller block, the detection of sluggish control loop behavior is also possible.

CLCM is able to detect loop performance deficiencies and can contribute to substantial gains once the appropriate maintenance actions have been taken.

System 800xA: Asset Optimization and control loop asset monitoring

ABB's 800xA control system includes an integrated version of the LPM. Therefore, for quick and efficient controller optimization, the detection and diagnosis of control loop performance is fed into the asset optimization data handling of the 800xA system [7]. Messaging, connection to the computerized maintenance management system (CMMS), and access to historical data and other real-time plant information helps the user trace problems and initiate corrective actions.

System 800xA: Information Management

The System 800xA Information Management database [8] issues standard reports, thus enabling the user to perform simple signal processing operations on historical data. Because of this, CLCM methods can be employed to determine simple key performance indicators (KPI). In other words, past controller performance can be evaluated and compared with current performance. In addition, LPM gives users the possibility of adding their own performance indices to the standard evaluation.

Industrial applications

Without any doubt, industries experience various control-loop related problems. These problems vary depending on the industry in question.

A simple example is to compare the high-precision position controller in a disc drive with a surge tank level controller in a paper mill. Obviously, both controllers share the same task but their respective benchmarks should be set on two different scales.

Consequently, some of the control performance monitoring methodology would fit the first application, some of it the other. Since control performance monitoring traditionally originates from the process industry, most established methods focus on the problems that are typically encountered in this industry.

Diagnosis of controllers in the (petro-)chemical and pulp & paper industry

6 shows a subset of data before and after a performance improvement initiative in a pulp mill. CLCM methods detected oscillatory control loops, and experiments verified the diagnoses. The subsequent improvements are obvious from the data collected later.

Diagnosis of controllers in power plants

CLCM-related problems in power plants are very similar to those in other industries. Some aspects, however, do differ, such as the total number of control loops is somewhat lower than in the chemical industry. This allows greater sophistication when it comes to the configuration and tuning of each of the loops. Cascades, feed forward and more advanced control logics are also more common and CLCM needs to take such configurations into account.

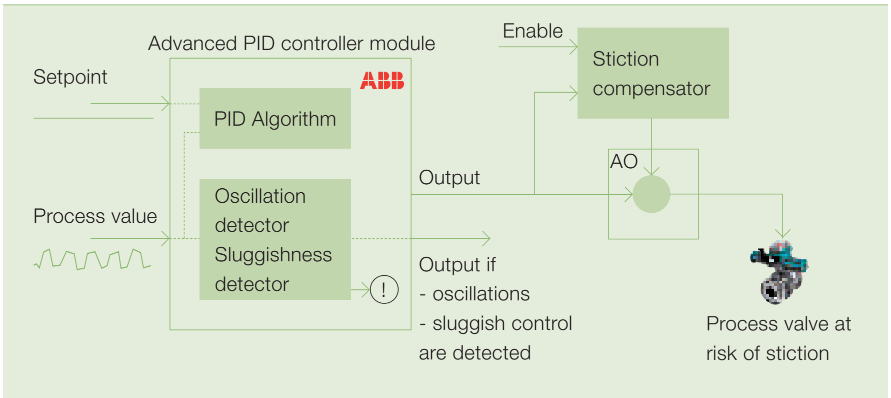
The benefits gained by removing control performance bottlenecks and performance degradations due to bad control are substantial.

One important point is the ability to classify CLCM results by the current load situation in the power plant. Controller behavior is typically a function of the load (eg, high, low, start-up, load change) or of other properties like raw material type etc. Modern CLCM methods do consider such conditions.

Diagnosis of control-relevant disturbances in cold rolling mills

In the rolling mill industry, a few highly sophisticated control loops are needed for tension and thickness control. However, the application of standard CLCM methods in the rolling mill industry is perhaps not as straightforward as in the chemical industry, as recent applications of these methods have produced results that are difficult to interpret.

5 Oscillation detection and stiction compensation function overview in the 800M controller. The process value exhibits typical stiction behavior.



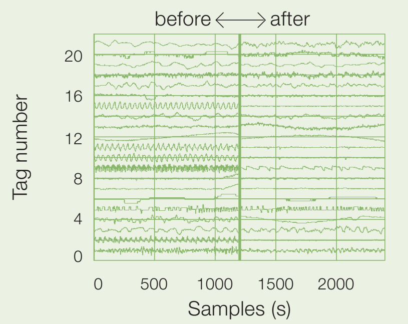
On the other hand, where CLCM functionality has been specially designed for rolling mill applications, the results have been very encouraging. To be more specific, CLCM functionality has been successfully designed to diagnose and remove periodic disturbances which are predominant in rolling mills [9], and a typical automated diagnosis screenshot is shown in 7.

Beyond single-loop controller condition monitoring

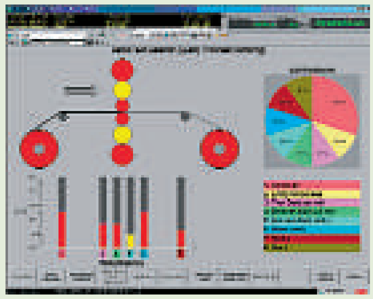
CLCM is able to detect loop performance deficiencies and can contribute to substantial gains once the appropriate maintenance actions have been taken. However, there are cases where the plant is not properly optimized even though the controllers are performing well. In such cases, it is highly probable that the current controller structure is not sufficient. A systematic and fast way of assessing the controller landscape and the prevailing automation infrastructure is by using a benchmarking service provided by ABB [10].

ABB's CLCM has caught the attention of various industries, and many are starting to apply such techniques.

From a development point of view, ABB has recently taken the step to view controller performance from a plant-wide view rather than from single controllers. Together with the Imperial College London/University College London's Center for Process Systems Engineering, the company has set out to productize functionality for the monitoring and root-cause analysis of plant-wide performance problems [11]. CLCM fits perfectly into this framework in that it can perform the detailed analysis before and after a likely root-cause has been identified. Therefore, plant-wide analysis techniques will become an integral part of single-loop controller performance analysis tools [4].



6 Improvement of controller performance after application of CLCM with subsequent maintenance.



7 ABB Operate[IT] screen for the diagnosis of periodic disturbances.

Conclusions

CLCM is inherently a passive and automatic technique which has caught the attention of many industries. The benefits gained by removing control performance bottlenecks and performance degradations due to bad control are substantial. So much so that more and more industries and companies are starting to apply such techniques. ABB's research and product variety has enabled a flexible application of CLCM across many different industries. These applications have been adapted so that the existing hardware at a customer site is used. CLCM can be applied to any process architecture regardless of whether ABB's 800xA System or a third-party DCS is installed.

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Additional reading

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