Control Loop Performance Monitoring
– An Overview

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Abstract
An overview of Control Loop Performance Monitoring (CLPM) which combines different control performance measures and valuation techniques is presented in this paper. Using automatic production processes, CLPM necessitates assessing hundreds of loops at a time instead of loop-by-loop analysis. This cannot be done by way of working out or physical tools. Due to extensive applications of automatic control systems, the effects of controller performance on automatic production processes are becoming progressively substantial. Control loops used in production is increasing constantly and there are difficulties in keeping them functioning at an acceptable level. During the last 27 years, CLPM is an active area of research which was useful to sense the malfunctioning of loops and to identify the root cause diagnosis. As a final point, their forthcoming necessities and trends are likewise discussed.

Keywords: CLPM, Performance measures, Valuation techniques, root cause diagnosis.

I. INTRODUCTION
Plant personnel would not attain optimistic outcomes and give up some control loops utterly, when process control systems did not accomplish their actions. To raise the productivity and efficiency it must be ensured that the control system is used effectively and efficiently. The article of M. Bauer et al. studied the achievement of Control Performance Monitoring (CPM) in the last three decades. They have emphasized on management and assessment of CPM to control the industrial processes mainly in the companies like chemical, oil and gas, pulp and paper. Many research questions were grouped into an online survey and these questions were circulated to various production plant control engineers. They have engrossed on
single control loops and predominantly on PID loops as a survey which involves relatively large number of applicants [1]. Q. Jiang et al. [2] suggested the theme of centralized monitoring which encompasses all the measured variables in a single model. They proposed that the presence of variables which lacks beneficial information causes performance degradation and put forward a performance-driven scheme based on distributed monitoring that combines Bayesian diagnosis and Kernel Principal Component Analysis (KPCA) system for nonlinear processes which is operated on a large-scale. This distributed monitoring is applied on the Tennessee Eastman benchmark and a simulated continuous stirred tank reactor process.

ABB’s perception [3] on Loop Performance Monitoring (LPM) with various novel features and future research guidelines are emphasized. Loop Performance Monitoring is scrutinized from an industrial perspective and put forth the novelties of LPM which have instigated ABB’s solution. Their association with performance measurement areas in production which includes maintenance, asset management and efficiency studies are drawn. Using control loop performance measures N. Vatanski et al. projected a stratagem to assess the economics of control performance [4]. It is proposed that the outline presented is suitable in presenting control quality in a common language understood by management, operators and engineers. Jacques F. Smuts et al. Suggested Control Loop Performance Monitoring (CLPM) software products automatically and unremittingly monitors the control loop performance. The software possibly pinpoints several traits of poor control and produces a list of problem loops with diagnoses [5].

Xinqing Gao et al. synthesized ample facts in the context of big data, with forthcoming ideas and favorable methods are sketched to possibly elucidate problems in industrial applications. Strategic causes of poor controller performance with the approaches of control loop diagnosis and practical barriers of CPA in practical processes are scrutinized [6]. M. Jelali (2006) reviewed the status of Control Performance Assessment (CPA) in industrial applications. A methodical technique for continuous CPM and optimization was proposed which combines diverse control performance metrics and assessment techniques [7]. Derrick J. Kozub et. al. deliberated the controller performance monitoring and diagnosis was favorable to certify cost-effective execution of control in practice [8]. Also they conversed on the state of monitoring with reverence to single input single output control in which specific consideration was given to the monitoring problem of optimizing multivariable controllers.

S. Joe Qin presented an overview of the status of CPM using minimum variance principles. Trade-off between performance and robustness issues, extensions to PID-achievable performance assessment and trade-off between performance associated with deterministic and stochastic points were deliberated [9]. Future research directions are pointed with regard to plant-wide performance valuation, adequacy valuation of prevailing control stratagems, root-cause diagnosis and multivariable valuation. Subsequently, controller maintenance is perilous to permit routine actions of industrial practices. The workflow of controller maintenance commonly encompasses the succeeding strides: Monitor functioning controller performance and
identify performance degradation, analyze possible root causes of control system blips, to resolve allied complications by taking precise actions. An overview of the mainstream of CLPM is provided and various prevailing issues are also scrutinized and deliberated.

II. CLPM AGENDA

Several authors noted that CLPM is effective only when it is entrenched in the company’s prevailing operation and workflows. Jelali [7] intends an agenda for executing CLPM techniques and lists the key corrective actions. The controller does a noble job in certain cases but then the operator does not have faith on the procedure, due to which they may turn the controller into manual. Conversely, it is dreadful to train all involved staffs on deducing the CLPM outcomes of individual techniques. As an alternative, Agenda of CLPM provides assistance towards the nature of root cause of a loop which has been poorly performed.

III. CLPM VALUATION

Monitoring the performance of controllers is intensely entrenched in the repetitive operation of the plant. Plant staff ensures the cost-effective, persistent and safe operation of the plant. Control loops are frequently evaluated principally by control engineers tailed by process engineers. Maintenance persons and operators are not as frequently involved in the conversation of control loops. Other persons involved in CLPM include Key Performance Indicator managers, chemical engineers and system experts. Several times 70% of loop assessment is done only by control engineers involved in CLPM. The outcomes are circulated to all parties, who are involved in CLPM valuation in an easy to understand design. CLPM valuation is typically directed on a weekly basis habitually in combination with a summit. Others carryout the valuation of CLPM less frequently, though others do day-to-day monitoring or evaluate the performance unremittingly and report problems as they arise.

IV. CLPM EXECUTION

A list of obtainable CLPM elucidations with their vital features is found in Jelali [7]. From an industrial perspective, two diverse means of providing the product of CLPM are either as a service or as a product. When CLPM is a product, the software solution is used by the end user and not by the CLPM supplier. CLPM as a service means that consistent reports are calculated by service provider and is directed to the end user. The core dissimilarity is that CLPM as a service is to be more standardized and automatic since it has to be interpreted by non-expert users. The report focuses mainly on the loops which are critical with underlying causes and proposes corrective actions. This means that the methods are clear with definite results and there is a petite room for confab and elucidation.
V. CLPM USING PERFORMANCE INDICATORS

CLPM outcome is expressed as Key Performance Indicator (KPI). KPIs are measurable, understandable and are scrutinized so that they have been evaluated periodically. The operator where not constantly trained to deduce the outcomes properly. If the performance index was scaled between 0% and 100% the operator was unclear whether 60% indicated to be a satisfactorily good outcome or whether the loop required consideration. An alteration in mind-set happened when it was clear that performance indices should be expressed in relation to process and not in relation to control. All the stated results of CLPM have a diagnostic competency so that staffs who are not the experts of CLPM also can understand the outcomes. The metrics which are essential for assessing the performance of the control loop includes the Fraction of time controller in manual mode, Oscillation of loops, Measurement noise, Controller receptiveness to set point changes and disturbances, Number of process alarms produced by the control loop and its related process, Tuning constant modifications done on the controller etc.,

VI. CLPM DIAGNOSIS – AN INDUSTRIAL OUTLOOK

Derrick J. Kozub has made a significant progress with univariate control; further challenging research opportunities still continue to report the practical issues concerned with industrial multivariable control [8]. CLPM and diagnosis is advantageous to ensure cost-effective execution of control in practice. Specific consideration is given to the problem for industrial multivariable controllers monitoring.

The preceding decade has perceived a growing importance in the process industries in the arena of CLPM. An extensive quantity of techniques, software packages and applications was established and described in the literature. An emerging acceptance of the CLPM technology in various industries is owing to the awareness that software is documented to be a principal strength which has to be preserved, scrutinized, and reviewed consistently. The CLPM arena has currently developed to the fact where numerous profitable algorithms and vendor amenities are accessible for control performance assessing or monitoring. Jelali [7] gives a summary of these progresses, with strategies, endorsements and tendencies from the industrial point of vision.

VII. CLPM - A DATA DRIVEN APPROACH

A Data Driven approach illustrates how basic process understanding and process data are used to suitably address, highlight and elucidate the peak challenging problems which has substantial influence on maintenance and control engineers in routine operation. The suggested methodology [10] associates the bottom-up scheme of single loop performance valuation with an inventive top-down process for plant-wide disturbance analysis. The mixture of these two procedures has the capability to maximize plant asset consumption without necessitating key investments which is accomplished through the use of a precise, multi-technology software platform.
VIII. DIAGNOSIS OF OSCILLATIONS IN CONTROL LOOPS

Among several control loops in industrial process plant, relatively few loops exhibit oscillatory behavior. Root causes of these oscillatory loops are due to incorrect control structure, poor controller tuning, valve stiction and external disturbances. This paper [11] affords an approach for oscillation diagnoses using statistical analysis of process measurements. The suggested technique uses the signals that are constantly available and it does not use the position of the valve which has been effectively validated on simulation and industrial data.

Detection and Diagnosis of oscillations in process measurements uses the power spectra measurements [12] as they are insensitive to phase lags which are produced by time delays and process dynamics. Principal Component Analysis when applied to power spectra is in turn used for detection of groups of oscillatory process measurements.

The manuscript [13] defines two techniques for automatic monitoring of CLPM. One is for detection of oscillations in control loops, and the other is for detecting sluggish control loops. It focuses mainly on various executions that are likely and accessible in industrial applications.

IX. OPEN RESEARCH ISSUES

More than 27 years of dynamic research in CLPM, it is of prodigious importance to inquire whether there are any significant research queries left open. The key outcome is that the applicants ask for improved assistance on corrective actions to be taken. Appropriate corrective action is a criterion for economic returns of the investment in CLPM. The next vital research relates to the prioritizing control loops. In our assessment, the key areas for future research include; several indices to monitor the control loops performance have to be developed and the assimilation of diverse features involving plant performance has to be established.

One of the current research activities in the area of CLPM brings the focus in assessing control loop performance from a statistical point of view. The work in CLPM affords an opportunity for the process control community to pay more consideration to the stochastic nature of plant disturbances. There are various theoretical issues and practical problems which are to be addressed before performance monitoring can have a substantial influence on industrial practice. Other areas such as automatic process control, data-driven detection of stiction behavior in valves are comprehensively researched. To address the future significant research questions, it is endorsed that academic organizations team up with the process industry, which is with end users. This guarantees that the related problems are elucidated; the outcomes are likely to be inferred and used.
X CONCLUSION

This paper presented the overview of Control Loop Performance Monitoring (CLPM) which combines different control loop performance metrics and assessment techniques in the process industries. Control loop performance metrics are established for maintenance purposes. It has become evident that there is substantial familiarity of CLPM existing in various process industries. The area of monitoring and assessing control performance has been significant in the past and will continue to be vital in the future. The maximum paybacks for using CLPM are attained when evaluating more than hundreds of control loops. After 27 years of rigorous research there are still pertinent research questions to be elucidated in the area of CLPM. Detection and Diagnosis of root-causes is still problematic but, detection of malfunction in the loops is done with a noble level of confidence in various circumstances at present. The control performance in the process industry has enhanced through the later 27 years or in other words concluding this, it would have depreciated without CLPM.

REFERENCES


