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Short Communication — OMICS International

Quality Integral Regulator

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Process control practitioners have made lots of contributions in the past half century to integrate Statistical Process Control (SPC) and Automatic/Engineering Process Control (APC/EPC). A Process Control and Quality Regulator will use a 'feedback integral regulator algorithm', that is developed and based upon the research knowledge and expertise presented in the monographs of Box and Jenkins [1-3], Astrom [1], technical publications in the Technometrics [4-10] journals, IEEE Transactions, Journal of the Royal Statistical Society, Journal of Quality Technology [6] and other citations [7,8,11-19] in process control literature.

The Quality Integral Regulator minimises (optimises) the variance (square of standard deviation), of the outgoing product quality (variable) through the (mathematical) predictive and learning (adaptive) process control algorithm. The regulator algorithm integrates 'Statistical Process Control' (SPC) and 'Automatic Process Control' (APC) methodologies at their interface and will use among other process control principles, one – step ahead forecasting feature of a ('time series') integral controller, 'Exponential Weighted Moving Average' (EWMA) Charting [6] (instead of the conventional Shewhart SPC charts [11]), correlation properties, and incorporates 'integral', 'dead time' (time delay) compensation terms and two process 'time constants' (dynamic parameters).

The EWMA charts have the unique property of detecting small changes in process variables, (which is not possible with 'Cumulative Sum' (CUSUM), and Shewhart Control Charts [11]). In monitoring a closed-loop process, when inflicted by 'white noise' (disturbances), and operating under a known regulator control algorithm, the information about underlying changes in the process are reflected in the sequences of control actions and process output. This is found from the values of input adjustments from simulation of the regulator algorithm. This information is used to detect process changes by means of EWMA forecasts. A feedback control action is initiated when the forecasts cross the control limits. As long as the forecast falls within the control limits (and hence is considered close to the target), no change is made in the process. Appropriate adjustment is made when a forecast crosses the control limits. The range of control error standard deviations is used to formulate 'process regulation schemes' (Figure 1).

The integral regulator element in the quality integral regulator calculates the input adjustment required to bring the control error standard deviation of the outgoing product quality control variable as close to the regulator set point (target). The integral regulator yields control data about the number of adjustment intervals, (sampling periods), required to bring the output product quality variable close to the desired target, (regulator set point). The integral and dead-time compensation terms in the integral regulator algorithm take action to minimise over correction of the control error.

The integral regulator functions to control product quality through process regulation schemes and uses combinations of the noise (disturbance) parameter and the process dynamic parameters that satisfy feedback control stability conditions. The process computer uses the integral regulator algorithm and performs the required computations that are necessary for the calculations. The process control practitioner has the option to choose the process regulation scheme depending on the desired control error standard deviation and adjust the process accordingly. The integral regulator algorithm can be implemented by means of parallel processing architecture [13].

The Figure 2 explains the working of the 'Digital Control Implementation of Quality Regulator. Briefly, the Process Control and Product Quality Integral Regulator helps in automatic process control of industrial processes such as oil refining, petrochemical industries, ores dressing, food processing and container packaging, 'calendering' in the paper manufacturing process etc. by means of input feedback control adjustments that yields the number of adjustment intervals, (sampling periods), during which the process has to be adjusted when inflicted by white noise ('process disturbances') using the time constants and inertial (dynamic) properties of the stable process through a second order filter.

It minimizes control error variance (square of standard deviation), of outgoing product quality bringing the product quality variable close to the Regulator control set point (target). The commercial opportunities for this kind of integral regulator application are possible in manufacturing operations where both statistical and automatic process control tools and techniques are used together at the same time concurrently to control processes in hybrid industries. For example, in electronic industries, the soldering, manufacturing process of electronic components and output product quality control are important for efficient process operation and manufacturing of marketable quality products etc.

A practical example of both parts and process manufacturing SPC–APC application is in the manufacture of Printed Circuit Boards (PCBs) for the electronic industry. The plain printed circuit blanks are to be processed for the hardness, metal thickness etc. through Engineering Process Control (EPC) and the PCBs after soldering the circuit boards are to be tested for operational functional effectiveness, connectivity/circuit continuity etc. by means of SPC control charts for quality.

It is envisaged that the use of the integral quality regulator in process control industries will help for example, by an one per cent reduction in output product variance and will yield huge savings, through efficient and effective and improved process control, power, energy and cost

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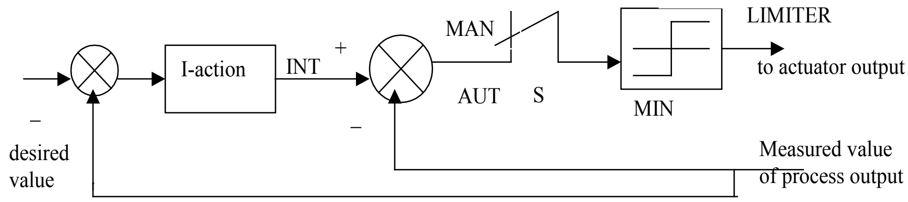

Figure 1: Practical realisation of integral regulator.

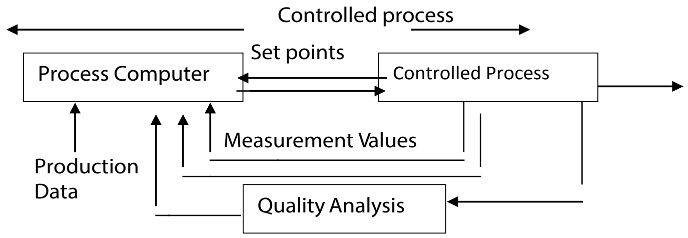

Figure 2: Digital Control Implementation of Quality Regulator.

savings, productivity increases, better marketable quality products, increase in revenue and profits, reduced manufacturing costs in terms of power, material use, rework etc. The integral regulator can be used in food and process industries to check the over-filling and under filling of processed food containers in order to minimise production costs for the manufacturer and also to comply with the local consumer protection laws so that the consumers are not at disadvantaged of under filled food containers and deprived of value for money. The process control practitioners currently use conventional Siemens, Alan Bradley and Programmable Logic Controllers (PLC) for process control. New method of process and quality control through the Quality Integral Regulator will yield immense benefits through the use of this novel and innovative application in process and quality control.

The exploitation and growth of the research and development of Advanced Process control technology has been exponentially phenomenal in the past decades. It is expected that a Quality Integral Regulator will definitely answer the challenging demands of modern computer remotely controlled complex dynamic processes that present with extreme and uncontrollable stochastic (random) nature in the presence of large dead times (time delays), as it may not be possible to understand well the technical capacity of the existing controllers to extend their process control capabilities up to certain level and extent only. It is expected that the use of the Quality Integral Regulator will provide practical solutions to such huge demands and meet the growing needs of the process control industry for better and efficient process and quality control.

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