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ADVANCED CONTROL - GOALS AND OBJECTIVES. TECHNOLOGIES OF BUILT-IN ADVANCED CONTROL IN DELTAV APCS

Jurayev Aburayxon Xoliqulovich
Karshi Engineering Economics Institute, Karshi, Uzbekistan,
aburayxonjurayev75@gmail.com

Ibragimov Islomnur
Karshi Engineering Economics Institute, Karshi, Uzbekistan,
iislomnur@gmail.com

Mirzayev Shoxrux Normurodovich
Karshi Engineering Economics Institute, Karshi, Uzbekistan,
shmirzayev@gmail.com

ABSTRACT

The main effect of advanced plant-level control systems comes from the continuous optimization of plant operation. Through continuous adjustment of the process mode towards the given optimization targets and the control of limitations, the plant operation mode is as close to the best as possible, which gives a daily economic effect.

Keywords: automation, improved management, improvement of the quality of regulation, optimization, evaluation of the economic effect.

INTRODUCTION

Advanced Process Control (APC) is a set of modern technologies in the field of automation that allow you to get an economic effect from the introduction of modern digital control systems by maximizing the use of their technical capabilities with relatively small investments. Advanced Process Control Systems (HRMS) include a variety of technical solutions beyond standard control schemes that solve two related and interrelated tasks [1]: improving the quality of TP control in order to achieve the specified values of process parameters or comply with regulated restrictions, and optimizing TP. In the normal TP mode, the operational personnel manage in such a way as, on the one hand, to ensure safety and compliance with technological limitations, on the other hand, to achieve a given number of products with regulatory quality indicators. Operators monitor the TP parameters measured by instrumentation instruments (temperature, pressure, flow and phase level), set the settings of the control circuits (e.g. flow) and the parameter values adjusted manually (e.g. bypass valve position). As a rule, operators monitor the quality indicators of products according to laboratory control data, which are measured manually with an interval of several hours to a day and above. The successful solution of the tasks set is largely determined by the knowledge and experience of operators. Often, in order to avoid violations of the product specification or technological limitations, operators allow a significant margin for product quality relative to a given specification. This ensures the required quality and reduces the likelihood of defects, but is usually achieved by reducing product yield, increasing losses or increasing energy consumption. Operators are reluctant to reduce their quality stock and feel insecure when, at the direction of the dispatcher, they must simultaneously ensure the specified quality and yield of products, which requires a continuous search for the optimal process mode. The situation is complicated by the fact that as enterprises modernize, management requires an increase in the efficiency of operators, so that each operator monitors an increasing number of parameters; meanwhile, the change of generations in factories leads to the replacement of experienced operators with beginners who do not have sufficient qualifications to solve the tasks. Advanced control systems are designed to help operational personnel solve these problems by calculating the optimal process mode and performing the control actions necessary to maintain it. Relieving the operator of routine work, they allow him to focus on other tasks that cannot be performed without his participation. The main effect of advanced control systems at the enterprise level arises from the continuous optimization of plant operation. Thanks to the continuous adjustment of the technological regime in the direction of the set optimization goals and the control of restrictions, the operating mode of the plant approaches the best as much as possible, which gives a daily economic effect. Thus, when introducing SUTP at the primary oil refining unit, the system continuously calculates how much it is possible to increase the yield of light petroleum products and, if possible, increases their output, trying to approach the regulatory limitation of product quality, but not to violate it. Due to this, there is a measurable economic effect in the form of an additional volume of light petroleum products obtained from crude oil. The practical implementation of such systems allows us to tentatively assess the effectiveness of the implementation of advanced control systems at various TPThe potential economic effect of the introduction of SUSP at each installation is individual and depends both on the characteristics of the TP and on the organization of work and experience of operators. On average, according to various sources, the payback of THE SUSP varies from six months to one and a half years [2].

ARCHITECTURAL SOLUTION

Advanced control includes many technical solutions, but most often this term is applied to the technology of multiparameter control with a predictive model (Model Predictive Control, MPC). Currently, mpc technology based on linear process models with a linear or quadratic optimization criterion is generally accepted in the industry. Emerson has developed and implements advanced control technology on the software and hardware basis of the modern DeltaV process control system. Emerson's SUSP consists of functional advanced control modules that are performed in the software and hardware of the DeltaV automated process control system and carry out direct automatic control and optimization of TP and applications of the engineering and operator interface designed for configuration and operator control (Fig. 1). Advanced control algorithms are implemented inside DeltaV functional modules in the library block diagram language. Functional modules of advanced control as part of the HMS include the following modules:

• multi-parameter regulators with a predictive model and a built-in optimizer;
• virtual analyzers of quality indicators;
• communication, calculation of key performance indicators (KPIs) of the system, advanced regulatory control algorithms, etc.

Multi-parameter regulators

The most important functional unit of advanced control is the multi-parameter controller unit with a predictive model, which exists in two versions: the MPCPRO controller unit (for operation in the DeltaV controller ver. 8 and above) and the MPC-PLUS controller-coordinator unit (for work on the DeltaV workstation ver. 12 and above). The MPC-PRO/MPC-PLUS function block contains a mathematical model of the process in the form of a matrix of responses of the input parameters of the regulator (controlled variables CV, variable constraints LV) to step changes in output parameters (adjustable variables MV) and perturbations (DV), which are presented in the form of a finite response model in time (Finite Impulse Response, FIR) or gear functions of links of the 1st and 2nd order with a delay. The maximum dimension of the matrix is up to 80 input parameters and 40 output parameters, but in practice the number of outputs usually does not exceed 10... 15 units. Based on the model, the MPC-PRO/MPC-PLUS functional unit calculates a forecast of the behavior of the process on the forecasting horizon and calculates such a control effect that will ensure the achievement of control and optimization goals. The real-time optimizer is built into the MPC-PRO/MPC-PLUS function block and works in conjunction with a multi-parameter controller. The optimizer calculates the stationary point of the optimum, and the multiparameter regulator calculates the control plan to reach the specified optimum point on the forecasting horizon. Optimization goals are determined by a given optimality criterion, which takes the form of a weighted sum of factors and can take into account both technological and economic indicators. The block takes into account the specified constraints and seeks to find an optimum point that satisfies all constraints; if this is not possible at the same time, the restrictions that have the lowest priority are violated. The speed of reaching the optimum point is determined by the coefficients of adjustment of the regulator (Penalty on Move and Penalty on Error), the values of which, as in the case of PID controllers, are a compromise between the requirements of robustness, control speed and compensation of perturbations. The block compensates for the measured perturbations according to the model, and the unmeasured perturbations - due to feedback. Control actions are calculated continuously with the scanning frequency of the module, which varies from 1 time per second for fast small regulators to 1 time in a few minutes for multiparameter regulators of inertial devices with a forecasting horizon of several hours. The MPC-PRO unit is used for forecasting and optimal control of small and medium-sized technological devices. Function modules containing this unit are typically executed in a DeltaV controller. The MPC-PLUS unit is primarily designed for large and non-linear tasks and is performed on a DeltaV Application Workstation with extensive computing capabilities. When constructing a SUSS installation, the modules of multiparameter regulators can be combined with each other in a cascade of multiparameter regulators, take into account the limitations common to all modules or due to the actions of parallel modules. This allows you to build a multi-level LMS that can solve problems ranging from controlling a separate apparatus to coordinating the mode of the entire installation with the possibility of further integration with higher-level systems.

CONCLUSION

Advanced control systems are a promising direction for the development of automation, which allows to obtain an economic effect by optimizing the TP. Emerson offers APCS based on technologies built into the DeltaV automated process control system and ensures the full implementation of the project from preliminary survey and design to post-project confirmation of the economic effect. Today, many CIS enterprises are either already implementing programs for the implementation of THE SUSP, or are considering the possibility of their implementation at their technological facilities.

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