Problems of Automation and Management Principles
Information Flow in Manufacturing

E N Grigoryuk\textsuperscript{a} and V V Bulkin\textsuperscript{b}

Murom Institute of Vladimir state University, Orlovskaya, str., 23, Murom, 602264, Russia

E-mail: \textsuperscript{a}kat-grigoryuk@yandex.ru; \textsuperscript{b}vvbulkin@mail.ru

Abstract. Automated control systems of technological processes are complex systems that are characterized by the presence of elements of the overall focus, the systemic nature of the implemented algorithms for the exchange and processing of information, as well as a large number of functional subsystems. The article gives examples of automatic control systems and automated control systems of technological processes held parallel between them by identifying strengths and weaknesses. Other proposed non-standard control system of technological process.

1. Introduction
For several decades much attention is paid to study the creation and implementation of automatic control systems (ACS) and automated control systems of technological processes (ACSTP), which is one of the ways to improve production management and increase its effectiveness. High level of automation of technological objects allows increasing the quality and quantity ratio. ACSTP is intended primarily for development and implementation of control actions on the technological object of management. The goal is comparing the performance of ACS and ACSTP, analysis of management principles, as well as structuring and formalization of these principles. The non-standard control system of TP is offered.

2. The standard system of automatic control
A major part of control theory is the theory of automatic regulation. There is a standard system of automatic regulation (SAR) consisting of the control object, sensor and controller. Standard block diagram SAR shown in figure 1. For SAR affected by external factors (the disturbance $f(t)$) tending to bring it out of balance. Perturbations are: switching, harmonic, stepped, stochastic, white noise [1, 2].

The goal of SAR is to maintain a constant parameter or change it for a given algorithm, with adjustable size is slightly different from the original values.

Using some well-known approaches to the analysis of systems or devices auto-compensation of the interference influence [3], should pay attention to two principles of control – control perturbation (CP) and the control deviation (CD) [4].
The essence of the principle based regulation by the disturbance or compensation) based on the allocation of the total number of perturbations \( f(t) \), the chief responds to SAR. Compensation to the control parameter \( y(t) \) of the fundamental disturbance, and the regulatory impact \( u(t) \) is formed in the SAR, based on the measurement results of the main disturbing factor acting on the object [5]. Block diagram SAR Poncele presented in figure 2.

**Figure 1.** Standard block diagram SAR

**Figure 2.** Block diagram SAR Poncele

\[
\varepsilon(t) = x(t) - y(t) \quad \text{– misalignment}
\]

Advantages:
- possible full invariance to certain disturbances;
- the stability of the system in the absence of feedback.

Disadvantages:
- a large number of perturbations requires a corresponding number of compensation channels;
- when changing the parameters of the controlled object causes errors in management;
- ability to apply only in clearly designated the characteristics of the object.

The essence of the principle of regulation according to the deviation, based on any deviation of the controlled parameter \( y(t) \) from its initial value \( x(t) \), leads to the formation of the regulatory impact \( u(t) \) irrespective of the nature and number of disturbances. Block diagram SAR Polzunov–Uatt depicted in figure 3.

Consider the controlled parameter \( y(t) \) is the comparison with the set point \( x(t) \) defined on the misalignment \( \varepsilon(t) = x(t) - y(t) \) and the controller produce control action \( u(t) \) to generate the control action requires the existence of an error) [5].
Figure 3. Block diagram SAR Polzunov–Uatt
FB – feedback

Advantages:
- negative feedback reduces the error regardless of factors it caused;
- less sensitive to variation of parameters of elements of the system, compared to control external influences (disturbances).

Disadvantages:
- there is a problem of sustainability;
- in simple single-loop systems it is impossible to achieve absolute invariance.

3. Combined control
The combined principle (closed–open loop principle) is a symbiosis of the principle Poncele and the principle of Polzunov–Uatt, combining their advantages and disadvantages. A block diagram of a combined SAR is shown in figure 4.

Figure 4. Block diagram of a combined SAR

Advantages:
- the presence of negative feedback makes the system less sensitive to changes in the parameters;
- add any channels (sensitive to job or resentment) does not affect the stability of the feedback loop.

Disadvantages:
- hindered the practical implementation of channels sensitive to job or indignation because they contain differentiating units;
- the crossing does not allow for all objects.

The impact load $f(t)$ is provided by the instantaneous formation of the regulatory impact $u(t)$, given change of load (circuit I) and the difference (circuit II), for correction of errors arising due to inaccurate throttling under load [6].

4. Comparison of industrial automation systems
ACSTP are qualitatively different from SAR.

SAR is intended to stabilize the modes, processes and units. SAR, as a rule, is a closed management system, operating without personnel. The main purpose of the job optimally, ensuring the stabilization of the technological parameter or the desired physical quantity, wherein the reference value is always known and can be variable or constant, but of a known law [7, 8].

In contrast to SAR, the structure of the process control system involves the participation of the operator in making management decisions, including the structure of the outline of the formation of operator control actions because a main goal of process control system is the implementation of the optimal operation mode [9]. Industrial automation system is depicted in figure 5.

Criteria of optimality of technological regimes are the technical and economic performance (efficiency, specific consumption of raw materials, energy, fuel, etc.), obtained in the process of computational procedures and typically cannot be changed.
5. Control system of complex technological process
The proposed control system (figure 6) is based on the structural study of the technological process [10]. At the entrance to the system of material and energy resources provided auxiliary production. Based on the theory of auto-compensation of interfering influences, the description of requirements represented as:

\[ P = U_0(t) \cdot e^{j[\omega t + \varphi_0(t)]}, \]  

where \( U_0(t) \) – is a quantitative characteristic of the reference stream; \( \omega \) – qualitative characteristic; \( \varphi_0(t) \) – is the phase (temporary deviation) of the reference flux; \( t \) – is time; \( j \) – is an imaginary unit.

Components of physical operations \( Q (Q = \{A,E,C\}) \), where \( A \) and \( C \) – respectively the inlet and outlet streams; \( E \) – conversion operation \( A \) in \( C \) expressed in terms of the ratio.

\[ A = U_1(t) \cdot e^{j[\omega t + \varphi_1(t)]} \]  

(2)

and

\[ C = U_2(t) \cdot e^{j[\omega t + \varphi_2(t)]}, \]  

(3)

where \( U_1(t) \) and \( U_2(t) \) – qualitative characteristics, respectively, the input and output streams; \( \varphi_1(t) \) and \( \varphi_2(t) \) – phase (temporary deviations) of the input and output streams.

The main (Central) process is a production process (conversion process), \( E \) is expressed via the ratio of the quantitative-qualitative conversion \( K(p,u,e) \)
\[ E = K(p, u, \varepsilon), \]  

(4)

where \( \varepsilon \) – external destabilizing factors (the factors of deceleration, changes of plans under the pressure of external circumstances, etc.) \( p = \frac{d}{dt} \) – Laplace operator, which allows to take into account the inertia of the system; \( u \) – control action.

Then (3), subject to (4) can be represented in the form

\[ C = U_1(t) \cdot e^{i(\omega t + \varphi_1(t))} = E \cdot U_1(t) \cdot e^{i(\omega t + \varphi_1(t))}. \]  

(5)

Of the comparison in the control system represents the reference comparison with the actual course of the process. The output is the product to meet quality standards.

6. Summary

High level of automation of technological objects allows increasing the quality and quantity ratio. The principles of process management are based on understanding and analysis of input and output information flows and reflect a common management approach. The introduction presents the control system of complex technological process will allow to increase productivity, improve product quality, to create conditions for saving of material and labor resources, and optimization of production costs. Based on this analysis, it is possible to build more complex multi-level system, exciting in his description of all the strata process.

References

[1] Volchkevich L. Automation of production processes (Russia: Publ: mechanical engineering) p 380
[2] Besekersky V. 2007. The theory of automatic control systems (Russia, Moscow: Profession) p 752
[3] Kurilov I., Romashov V., and Popov, P. 1984 The system of compensation in phase and amplitude in the measuring devices. Automation geomagnetic studies (Russia, Moscow: Science) pp 145-155.

[4] Kurilov I., Grigoryuk E., Kalinichenko M., Kirillov I., Lashin A., and Bulkin. 2013 Principles for the management of information flows in industrial processes Methods and devices of transmitting and processing information (Russia), 15 pp 60-65

[5] Miroshnik I. 2005 Automatic control Theory. The linear system (Russia: St. Petersburg Publ: Peter) pp 336

[6] Bulkin V. and Grigoryuk E. 2014 The control System of complex technological process of the industrial enterprise Collection of scientific papers of the XVIII International scientific and practical conference "System analysis in design and management (Russia: St. Petersburg, Russia) pp 147-149

[7] Edited Egupov N. Methods of classical and modern automatic control theory. 2000 vol. 2: controller Synthesis and optimization theory, automatic control systems (Russia, Moscow Publ: MGTU im. N. Uh. Bauman) p 736

[8] Konovalov, B. and Lebedev, Y. 2010 Theory of automatic control (Russia, Tomsk TUSUR) p 162

[9] Potapova T. 1999 Structural analysis of a control system of a continuous closed production equipment and control systems (Russia), 12 pp 16-24

[10] Grigoryuk E. and Bulkin V. Principles of management manufacturing process of the primer-igniter on the basis of simulation Proceedings of 2015 International Conference on Mechanical Engineering, Automation and Control Systems, MEACS 2015. DOI: 10.1109/MEACS.2015.7414859.