УДК 681.5

EDN WZSRVE

https://www.doi.org/10.47813/rosnio-II.2023.8.225-231

Разработка автоматизированной системы управления процессом сероочистки сырьевого газа

М.С. Панин, Н.И. Кечкина*, Т.Н. Павлычева, Н.О. Кулигина

Нижегородский государственный технический университет им. Р.Е. Алексеева, Нижний Новгород, Россия

*E-mail: nataliyakechkina@yandex.ru

Аннотация. Автоматизация технологического процесса — это совокупность методов и средств, предназначенных для внедрения системы или комплексов, которые позволяют управлять самим технологическим процессом без непосредственного участия человека или оставляют за человеком право принимать наиболее ответственные решения. Повышение качества управления, осуществляемого системой управления технологическими процессами, обеспечивается за счет системного подхода к решению этой проблемы и использования технико-экономических критериев управления. В статье представлен анализ технологического процесса десульфурации сырого газа как объекта управления с целью выбора оптимальной системы управления.

Ключевые слова: автоматизация, система управления, удаление серы из газа, эффективность, качество продукции, технологический процесс, сера.

Development of an automated control system for the process of source gas sulfur removal

M.S. Panin, N.I. Kechkina*, T.N. Pavlycheva, N.O. Kuligina

Nizhny Novgorod State Technical University R.E. Alekseeva, Nizhny Novgorod

*E-mail: nataliyakechkina@yandex.ru

Abstract. Automation of a technological process is a set of methods and means designed to implement a system or systems that allow the management of the technological process itself without the direct participation of a person, or leaving the right of a person to make the most responsible decisions. Improving the quality of management, carried out by the process control system, is ensured through a systematic approach to solving this problem and the use of technical and economic management criteria. The article presents an analysis of the technological process of desulphurization of raw gas as a control object in order to select the optimal control system.

Keywords: automation, control system, gas sulfur removal, effectiveness, product quality, technological process, sulfur.

1. Introduction

Automation of a technological process is a set of methods and means designed to implement a system or systems that allow the management of the technological process itself without the direct participation of a person, or leaving the right of a person to make the most responsible decisions [1].

Improving the quality of management, carried out by the process control system, is ensured through a systematic approach to solving this problem and the use of technical and economic management criteria. The process control system performs centralized and integrated processing of primary information at the pace of the technological process and uses its results to control this process. At the same time, the system converts this information into a form suitable for use at higher levels of management in solving operational-production and organizational-economic problems. Thus, carrying out effective management of the relevant technological object, the process control system is also a source of objective, reliable and timely primary information for the control systems of higher levels at an industrial enterprise [2].

The analysis of the technological process as a control object is carried out to determine its effectiveness, identify problematic issues and opportunities for improving productivity and product quality. The analysis allows you to identify bottlenecks in the process, determine the causes of problems and develop measures to eliminate them. Also, the analysis of the technological process allows you to determine the optimal process parameters that provide maximum productivity and product quality with minimal resources.

2. Description of the technological process

The feed gas enters the first feed gas preheater E0006 where it is heated to 200 °C.

After passing the first preheater, the feed gas is sent for further heating to the second feed gas preheater E0004, where it is heated to a temperature of 380°C.

The heated feed gas enters the R0001 hydrogenation reactor, where hydrogenation of sulfur compounds and saturation of unsaturated hydrocarbons proceed on a cobalt-molybdenum catalyst.

The hydrotreated feed gas from the R0001 reactor enters the final purification stage in series-connected R0002A/B hydrogen sulfide absorption reactors, in which hydrogen sulfide and sulfur compounds are absorbed on a zinc catalyst.

The piping of the R0002A/B reactors provides for the sequential passage of feed gas from the R0002A lead reactor to the R0002B follower.

The sulfur content in the feed gas at the output of the lead reactor in normal operation should not exceed 0.02 wt. ppm. A short-term increase of up to 0.05 wt. ppm for the period needed to prepare the lead reactor for catalyst replacement. At this stage, it is necessary to increase the control of the sulfur content in the feed gas after the R0002B reactor, which should not exceed 0.02 wt. ppm, which provides protection for catalysts in pre-reformers and reformers.

The R0002A lead reactor is switched off for the catalyst refueling operation, the unit continues to operate with one R0002B adsorber.

To carry out preparatory work for the replacement of the catalyst, the R0002A/B reactors are equipped with stationary steam and nitrogen supply circuits for purging and pressure testing.

The main controlled and adjustable technological parameters of the process are: feed gas temperature after the E0006 heater, temperature after the E0004 heater, pressure drop across the R0001 and R0002A/B reactors, pressure at the outlet of the R0002A/B reactors, temperature in the catalyst beds of the R0001 reactor, feed gas temperature reactor outlet R0001, reactor outlet feed gas temperature R0002A, reactor inlet feed gas temperature R0002B, reactor outlet feed gas temperature R0002B.

3. Analysis of the technological process as a control object

The object of control is the process of desulfurization of raw gas. This process is continuous.

Devices involved in the process:

1. Heater E0006
2. Heater E0004
3. Reactor R0001
4. Reactor R0002A
5. Reactor R0002B

The controlled parameters include the temperature of the feed gas at the outlet of the heater E0004 (figure 1) and the pressure at the outlet of the reactor R0002B (figure 2).

Description of the coordinates of the heater E0004 and the reactor R0002B, showing figures 3 and 5.

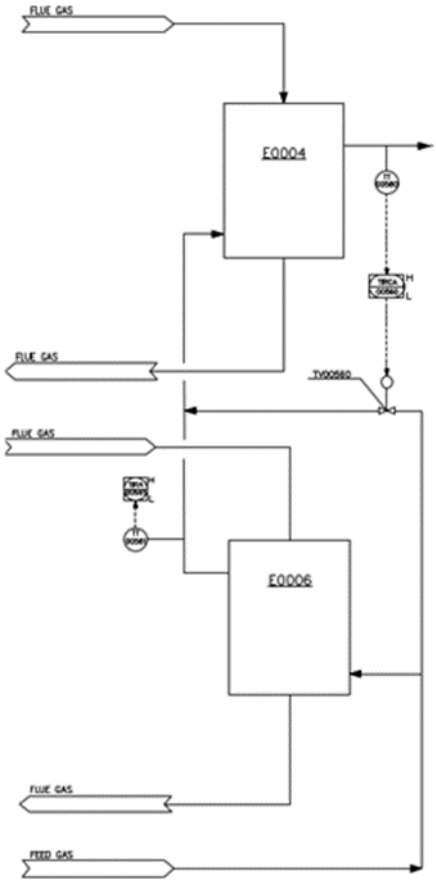

Figure 1. Fragment of the scheme with raw gas heating.

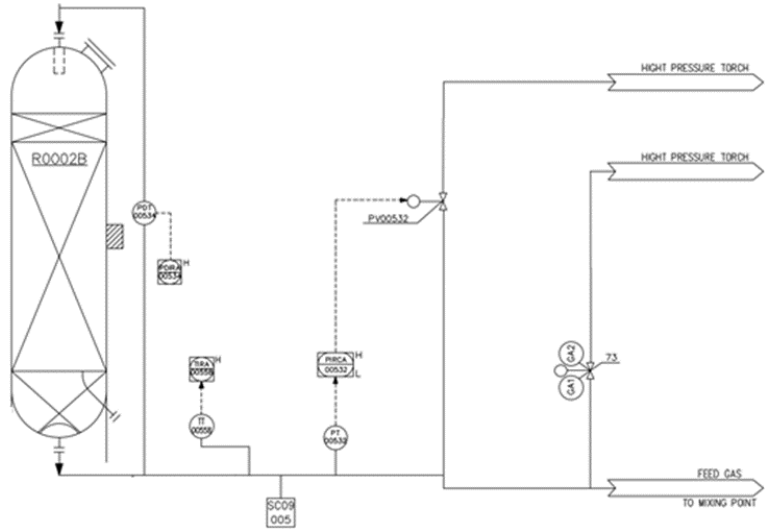

Figure 2. Fragment of the pressure control scheme at the outlet of the reactor R0002B.

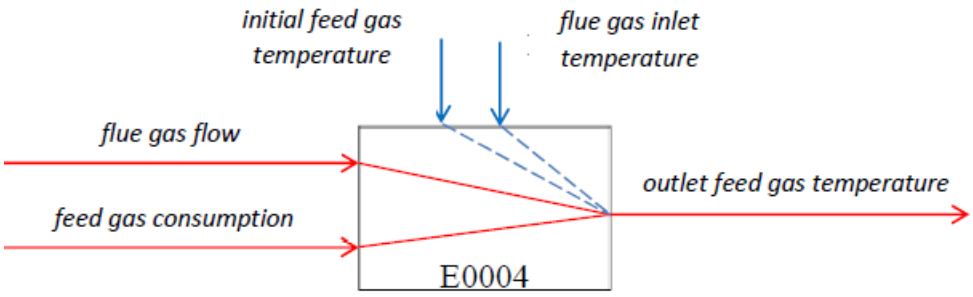

Figure 3. Description of the coordinates of the heater E0004 [5].

The priority control action, to maintain the temperature at a given level, is the flow of raw gas through the control valve pos. TV00560 installed on the E0006 preheater bypass line. Possible controlled disturbances in the process may be the initial flue gas and feed gas temperatures at the preheater inlet. The structural diagram of the control loop is shown in Figure 4. When controlling the temperature, control accuracy and higher speed are required, which determines the use of the PID control law [3, 4].

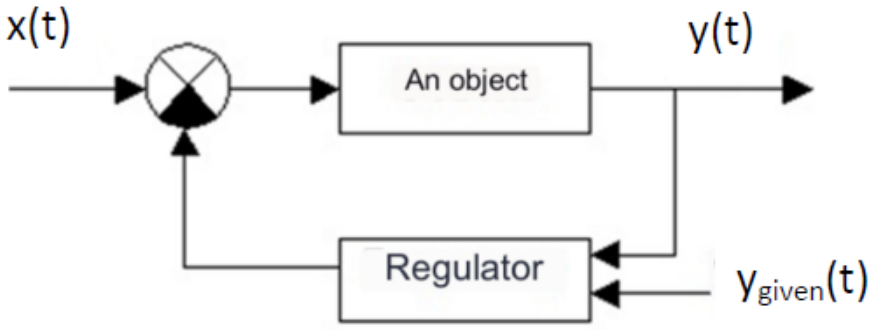

Figure 4. Structural diagram of the control loop [6, 7].

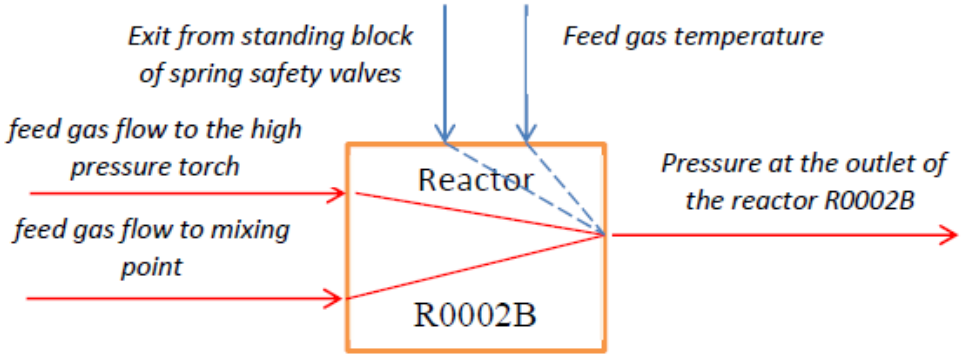

Figure 5. Description of the coordinates of the reactor R0002B [10].

The priority control action, to maintain the pressure at the outlet of the R0002B reactor, is the flow of raw gas through the control valve pos. PV00532 installed on the vent line for excess feed gas to the high pressure flare header. Possible disturbing influences in the process can be the temperature of the raw gas, as well as the exit from the standing block of the control room. In this case, regulation accuracy and low speed are required, which determines the use of the PI regulation law. In the event of an accident, if the control valve pos. PV00532 does not open, then the reset can be carried out through the valve poz.73.

4. Conclusion

As a result of the process analysis, a process control strategy was developed [8, 9]. For each circuit, the type of regulation was chosen, which will allow achieving the goals and objectives with maximum efficiency.

References

1. Of automation tasks and their solutions // Studopedia [electronic resource]. – URL: https://studopedia.ru/8_104321_zadachi-avtomatizatsii-i-ih-reshenie.html (date of last access 14.04.2023)
2. Industry-wide guidance materials on the creation and use of automated process control systems in industries (ORMM-3 process control systems) // RussianGost [electronic resource]. – URL: https://www.russiangost.com/p-161640-ormm-3-asutp.aspx (date of last access 14.04.2023)
3. Labutin A.N. Technological processes and production as objects of management: textbook / A.N. Labutin, G.V. Volkova. – Ivanovo, 2010 – P. 33-35
4. Pavlov Yu.L. System analysis of chemical-technological processes as control objects and methods of adjustment of regulators: textbook / Yu.L. Pavlov, N.N. Ziyatdinov, D.A. Ryzhov. – Kazan: KNITU, 2013. – 88 p. – URL: https://e.lanbook.com/book/73414 (date of last access 04.28.2023).
5. Svitek A.S. Development of an algorithm for identifying parameters of object models on the example of a temperature control system / A.S. Svitek // Engineering Bulletin of the Don. – 2021. – №8.
6. Vtyurin V.A. Automated process control systems. Software and hardware complexes: a textbook / V.A. Vtyurin. – Saint Petersburg: SPbGLTU, 2007. – 232 p. – URL: https://e.lanbook.com/book/60870 (date of last access 04.28.2023).

7. Fedorov Yu.N. Handbook of an automated control system engineer: Design and development: handbook / Yu.N. Fedorov. – Vologda: Infra-Engineering, 2022. – 928 p. – ISBN 978-5-9729-1034-2. – Text: electronic // Lan: electronic library system. – URL: https://e.lanbook.com/book/281246 (date of reference: 04.05.2023).
8. Fedotov A.V. Computer control in production systems: a textbook for universities / A.V. Fedotov, V.G. Khomchenko. – 2nd ed., ster. – Saint Petersburg: Lan, 2021. – 620 p. – ISBN 978-5-8114-8065-4. – Text: electronic // Lan: electronic library system. – URL: https://e.lanbook.com/book/171424 (accessed: 05/04/2023).
9. Zhigalov B.S. About the current state of automated systems / B.S. Zhigalov, A.G. Kondrashov // Modern tool systems, information technologies and innovations: Collection of scientific papers of the XVII International Scientific and Practical Conference, Kursk, March 17-18, 2022 / Editorial Board: Razumov M.S. (ed.). – Kursk: South-Western State University.
10. Zebzeyev A.G., Automated process control systems. Development and re-engineering / A.G. Zebzeyev, A.M. Malyshenko // Chief Mechanical Engineer. – 2019. – 4.