International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Calculation and Development of the Device for Determining the Beginning, End and Extremum of Peak at the Output of the Adsorption Unit

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Abstract. ***It is known that the solution of such fundamental problems as the direct conversion of thermal and solar energy into electrical energy, the creation of superconducting materials, thermally stable materials and the development of the nanotechnology industry is directly dependent on the solution to the problem of obtaining highly pure substances. In practice, purification systems such as distillation columns, centrifuge-based devices, surface tension-based devices and adsorption-based devices are used to purify substances from impurities. The development of technology currently predisposes to the use of adsorption separation of the method in the analysis of multicomponent mixtures in many industries and the national economy and is gradually taking the place of traditional chemical and physico-chemical methods. The production of highly pure substances with a percentage of microimpurities less than 10^{-6}% is possible only when using an adsorption unit with a large number of columns used. In industrial production, the number of columns in this installation is from 5000 to 10000 pieces. In this case, the signals coming from the adsorption unit in the form of a peak described by the Gauss function characterize the percentage of the test substance and to automate this process, the necessary condition is the use of devices for processing this signal. The efficiency of adsorption methods is significantly increased due to the automation of data processing at the output of the adsorption installation, which develops mainly in three directions: the use of universal general purpose personal computers for processing, the use of specialized computing devices. In general, the automation process involves pairing the adsorption unit with a personal computer, and to achieve this, it is necessary to use such devices for processing signals at the output of the adsorption unit as amplifiers, analog-to-digital converters, and a device for determining the beginning and end of the peak. This article is devoted to the calculation and development of a device for determining the beginning and end of a peak at the output of an adsorption tube. The developed device can be used in the production of high-purity silicon. Having available silicon of high degree of purification there is a possibility of production of such electronic devices as-the diode, the transistor, chips and other various semiconductor devices which essentially differ on the qualitative indicators. Along with this, the use of materials with a high degree of purification gives ample opportunities to improve the quality of manufacturing solar cells and LEDs of increased power.***

Key words: highly pure substances, adsorption unit, adsorption process, beginning and end of a peak.

Revised Manuscript Received on December 30, 2019.
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I. INTRODUCTION

In various industries, often for the determination or purification of multicomponent substances from impurities, adsorption units with a gas or liquid carrier are used, with the help of which the quality of the products is monitored and regulated. In accordance with the task, an adsorption analysis method is selected, the essence of which is the separation of multicomponent mixtures, which has recently become increasingly important in the medical and biological fields of research. Increasing the sensitivity and reliability of adsorption equipment opens up completely new prospects for using adsorption analysis methods to solve biomedical problems, changing the possibilities of studying the composition of samples of biological origin, not only in terms of biological origin, accuracy and ease of investigation, but also the purity of separation of multicomponent mixtures. In addition, the use of adsorption methods in combination with such methods as asspectrometry, nuclear magnetic resonance, infrared spectroscopy, etc. allows for unique biochemical studies. In this case, the signals coming from the adsorption unit in the form of a peak described by the Gauss function characterize the percentage of the test substance with high accuracy and to automate this process, the necessary condition is the use of devices for processing this signal. The efficiency of adsorption methods is significantly increased due to the automation of data processing at the output of the adsorption installation, which develops mainly in three directions: the use of universal general purpose personal computers for processing, the use of specialized computing devices.

Coupling the adsorption unit with a general-purpose universal personal computer leads to the creation of systems that are too expensive and not sufficiently reliable; moreover, it is difficult to correct the studies carried out due to the time gap between the registration of the output signal and obtaining the processing results.

Specialized computing devices are cheap to manufacture and operate, but their applying is limited to using the same simple processing algorithms, which is caused by a rigidly defined structure. The application of a personal computer, combining the advantages of specialized computing devices with the flexibility of modern personal computers, makes decentralization of computing possible. Since the small size, weight and power consumption, programmable logic and low cost of a personal computer allow you to bring the machine directly to the source of information and the control object, which leads to significant cost savings on communication lines, increasing the flexibility and adaptability of the processing system.

The problem of automation of adsorption analysis affects two aspects: automatic processing of output signals and automatic control of its nodes and modes. Moreover, the primary processing of adsorption information is the most significant stage in the automation of data processing of adsorption analysis, on which all subsequent stages are based and on the results of which metrological and reliable characteristics of the final analysis results depend. The primary processing of the output information is to determine the informative parameters of the output signal.

The main informative parameters of the output signal, which is a sequence of peaks of various amplitudes and durations, separated by a zero value of the baseline, are the areas of these peaks bounded by the function curve and the baseline, and such are the times when their maxima appear. The values of the peak areas judge the quantitative content of the individual components in the analyzed mixture, the moments of the appearance of the maxima are the initial information for a qualitative analysis. Automation of the primary processing of adsorption information is complicated by its features: a wide dynamic range of the signal from the output of the adsorption installation, baseline drift, the presence of various kinds of noise and interference. Thus, at the stage of primary processing of the analysis data, it is necessary to make an automatic selection of the measurement range of the processed signal, determine the law of change of the baseline, detect the useful signal, separate it from interference and measure its determining parameters.

The results of the stage of the primary processing of information at the output of the adsorption unit are the initial data for the stage of final processing carried out by a personal computer. The use of computer technology for the primary processing of information inevitably leads to the need to convert the input analog information to digital form and to avoid signal loss, the amplification of the signal under study should be used. Along with this, in order to accurately determine each test substance, it is necessary to precisely determine the time at which the peak appears, for the qualitative implementation of this goal it is necessary to use a device for determining the beginning and end of the peak.

II. RESULTS AND DISCUSSION

To carry out a deep purification of substances from impurities using an adsorption unit on an industrial scale, it is necessary to use a large number of adsorption columns and, accordingly, the same number of amplifiers, analog-to-digital converters, and devices for determining the beginning and end of a peak are required for processing output signals from them. When using a personal computer, the number of required analog-to-digital converters and amplifiers is the same. A personal computer can replace the operation of devices for determining the beginning, end and extremum of a peak. Considering that, the determination of the informative parameters of the peak should be performed in real time to ensure the operability of the cleaning system, several hundred personal computers should be used. Therefore, it is economically advantageous to use digital devices for determining the informative parameters of the output peak.

The objective of the device for determining the beginning, end and extremum of the peak is to increase the efficiency of the adsorption unit and simplify the determination of the appearance of the peak described by the Gauss function used in the system for producing highly pure substances with impurities of less than 10^{-6}% [1].

The developed device used an analog-to-digital converter of the tracking type [2], while the developed device for determining the informative parameters of the studied function is much simpler and cheaper than using an analog-to-digital converter for bitwise coding [3].

The main advantage of this device for determining the beginning, end and extremum of the peak is the use of the output signals “+1” and “-1” of the reversible counter included in the analog-to-digital converter of the tracking type. Due to this fact, the schemes of devices for determining the beginning, end, and extremum of a peak are much simpler, which makes it possible to turn on a trap at the output of this adsorption column in time, characterized in that it is extremely simple and contains only nine digital elements. Considering that the system for producing highly pure substances contains up to 10,000 adsorption columns, the constructed system has a large economic component.

The beginning, end and extremum of the peak is determined with an error of 0.2% for the threshold voltage value U_t. Based on the moment of determining the beginning and end of the peak, the selection device at the output of the adsorption column is turned on and off. In the industrial production of highly pure substances in one cleaning system, the number of adsorption columns reaches up to 10,000 pieces. Therefore, even a slight simplification of the device for determining the beginning, end and extremum of a peak leads to very significant savings in material resources used in the construction of a system for obtaining highly pure substances.

III. CALCULATION AND DEVELOPMENT OF THE DEVICE FOR DETERMINING THE BEGINNING, END AND EXTREMUM OF PEAK AT THE OUTPUT OF THE ADSORPTION UNIT

A block diagram of a device for determining the beginning and end of a peak at the output of an adsorption unit is shown in Fig. 1, which shows a device for determining the beginning, end, and extremum of a peak described by a Gaussian function. In the initial state, the triggers M6 and M8 are in the reset state. The information inputs of DR-shift registers M1 and M2 are connected to the counting inputs of a reversible counter, which is part of an analog-to-digital converter of a tracking type [4]. The counting input *C* of the shift registers is connected to the clock generator f_t of an analog-to-digital converter of a tracking type. The device contains two shift registers (M1, M2), three logical elements «3AND» (M3, M4, M5), three inverters (M9-1, M9-2, M9-3), one logical element «2AND» (M7) and two *D* flip-flops (M6, M8).

The signal at the output of the adsorption column has an analog shape. In its turn leads to the establishment of an analog-to-digital converter at its output. According to its characteristics, the analog-to-digital converter of the tracking type is most acceptable. Since, the frequency of the output signal at the output of the adsorption column is several tens of Hz [5].

In addition, the cost of the analog-to-digital converter of the tracking type is relatively low and the operation of the device for determining the informative parameters of the output signal will be simplified [6].

When a peak arrives at the input of the analog-to-digital converter, signals corresponding to the value “1” will be displayed at the +1 input. At the time when the value “1” will be set three times in a row at the input “+1” of the reversing counter of an analog-to-digital converter of a tracking type three times in a row, an information signal equal to one will be installed at the output of the «3AND» circuit of the M3 chip. The leading edge of this signal translates the M6 trigger into a single state, and this leading edge is taken as the beginning of the peak. It should be noted that at this point in time the input signal of the analog-to-digital converter exceeds the threshold value *Ut*. The inverse output of the M6 trigger at this moment puts the M8 trigger in standby mode. Immediately after passing the extremum of the peak at the input "-1" of the reversible counter of the analog-to-digital converter of the tracking type, pulses corresponding to unity begin to appear. At the point in time when the value “1” is set three times in a row, the value “1” will appear at the output of the M5 chips, a signal corresponding to the peak extremum will appear.

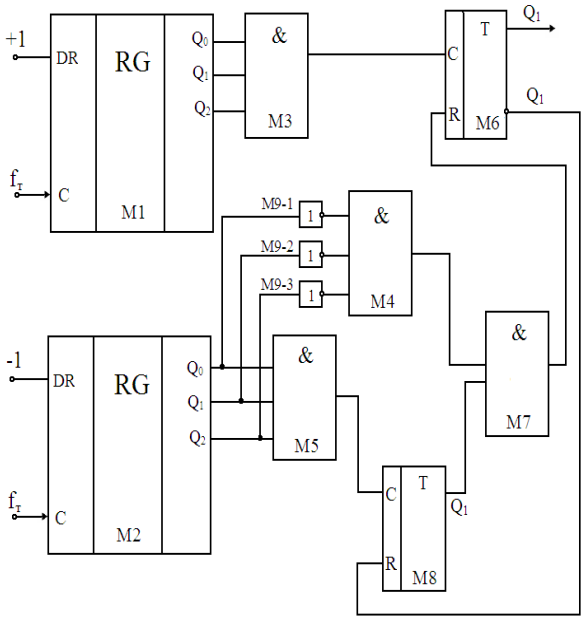

Fig. 1. Scheme of the device for determining the beginning, end and extremum of the peak described by the Gauss function.

The leading edge of this signal will translate the M8 trigger into a single state. The leading edge of the signal at the output Q1 of this trigger can be considered the extremum of the studied peak. After that, the M7 chip will be ready to determine the end of the peak. At the point in time when the value “0” appears three times in a row at the input “-1”, passing through the inverters M9 at the output of the microcircuit M4 they set the signal corresponding to the end of the peak. The leading edge of this signal will reset the M6 trigger. The trailing edge of the signal at the output Q1 of the M6 chip will correspond to the end of the studied peak.

IV. CONCLUSION

This work presents the calculation and development of a device for determining the beginning, end and extremum of a peak at the output of an adsorption installation, which is used to process signals in the form of a Gaussian function at the output of an adsorption installation. To obtain a highly pure substance, it is initially necessary to determine the percentage of components in the test material. In this case, devices serving to process the output signal with informative parameters are important elements of the system. The device contains two shift registers connected to the counting inputs of the reversing counter and to the clock generator f_t, to which the output signal is supplied from the adsorption unit, then the comparison of the output signal values with the help of logic elements is carried out, determining the value of the supplied signal. When a given signal corresponds to a given threshold, the triggers fix this state until the next specified threshold is reached. Developed the device for its settings, defines three States of the output informative signal such as the beginning, extremum, and end, and upon receipt of the signal, the device determines its precise condition, and detects the specified condition, which is an important indicator for the system development of cleaning agents, as having advance information about the appearance of the output the useful signal appears for a timely processing of the desired substance. And along with this, the use of the proposed device increases the accuracy, speed in signal processing, and at the same time taking into account that the determination of informative peak parameters should be performed in real time to ensure the operability of the cleaning system, several hundred personal computers should be used, instead of which it is possible to use the developed device, which in turn represents a great economic benefit.

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