UDC 62-503.5

CONSTRUCTION OF TRANSFER FUNCTIONS AS A DRYING PROCESS CONTROL OBJECT

Xusanov Suban Nurullayevich - Doctor of Philosophy (PhD) in Technical Sciences,
e-mail: xusanovsuban@gmail.com

Karshi engineering-economics institute, Karshi city, Uzbekistan

Abstract. *The purpose of modeling in the development of a model of a drying process control object is presented in the article. Approximation of the transition characteristic in the control channels, obtaining the transfer functions of the object on all the main channels of the influence transmission, the Simoyu method was used. Taking into account the fact that the main channels of the object under study have significant inertia and delay, as well as its dynamic properties, transfer functions with sufficient accuracy are proposed. The proposed mathematical model of the drying process allows for the synthesis of adaptive control laws for the considered process.*

Keywords: *drying process, control object parameters, function, Simoyu method, synthesis, adjuster.*

UO‘K 62-503.5

QURITISH JARAYONINI BOSHQARISH OBYEKTI SIFATIDA UZATISH FUNKSIYALARINI QURISH

Xusanov Suban Nurullayevich – texnika fanlari bo‘yicha falsafa doktori,
e-mail: xusanovsuban@gmail.com

Qarshi muhandislik-iqtisodiyot instituti, Qarshi sh., O‘zbekiston

Annotatsiya. *Maqolada quritish jarayonini boshqarish obyektining modelini ishlab chiqishda modellashtirishdan ko‘zlangan maqsadi keltirilgan. Boshqarish kanallarida o‘tish xarakteristiksini approksimatsiyalash ta’sirlarni uzatishning barcha asosiy kanallari bo‘yicha obyektning uzatish funksiyalarini olish Simoyu usuli foydallanilgan. Tadqiq qilinayotgan obyektning asosiy kanallari sezilarli inersiyali va kechikishli ekanligi hamda uning dinamik xossalarini inobatga olib, yetarli darajada aniqlik bilan uzatish funksiyalari taklif etilgan. Quritish jarayonining taklif etilgan matematik modeli ko‘rib chiqilayotgan jarayon uchun adaptiv boshqarish qonunlarini sintez qilish imkonini beradi.*

Kalit so‘zlar: *quritish jarayoni, boshqarish obyekt parametrlari, funksiya,Simoyu usuli, sintez, rostlagich.*

УДК 62-503.5

ПОСТРОЕНИЕ ПЕРЕДАЧНЫХ ФУНКЦИЙ КАК ОБЪЕКТА УПРАВЛЕНИЯ ПРОЦЕССОМ СУШКИ

Хусанов Субан Нуруллаевич - доктор философии по техническим наукам
e-mail: xusanovsuban@gmail.com

Каршинский инженерно-экономический институт, г. Карши, Узбекистан

Аннотация. *В статье представлены цели моделирования при разработке модели объекта управления процессом сушки. Для аппроксимации переходной характеристики в каналах управления, получения передаточных функций объекта по всем основным каналам передачи воздействия использован метод Симою. С учетом того, что основные каналы исследуемого объекта имеют значительную инерционность и запаздывание, а также его динамические свойства, предложены передаточные функции с достаточной точностью. Предложенная математическая модель процесса сушки позволяет синтезировать законы адаптивного управления рассматриваемым процессом.*

Ключевые слова: *процесс сушки, параметры объекта управления, функция, метод Симою, синтез, регулятор.*

Introduction

When developing a mathematical model of a control object, first of all, it is necessary to take into account the intended purpose of modeling. The purpose of modeling determines the requirements for the form, accuracy of the mathematical model, the adequacy of the obtained model to the object, and the range of necessary modes. For control purposes, the parameters of the object are used from dynamic mathematical models that reflect their changes depending on time.

Wet product drying is considered a complex stochastic process, characterized by a turbulent multi-factor, which are controllable (moisture of potassium fertilizer, temperature) and uncontrollable (consumption of material to be dried at the entrance of the drum dryer, initial moisture content, distribution composition of particles of the material to be dried). In the operation of the drum dryer in the installed mode, uncontrollable turbulence changes over time, and first of all, it depends on the composition of potash fertilizers and the gas flow on thermal changes. Also, the difficulty of synthesizing the mathematical expression of the object means that the performance description of the considered process is multi-mode. The multi-mode nature of the drum dryer operation, in turn, ensures the non-stationarity of its description. It depends on the efficiency limitations of the boundary areas of the object in question or the operation with a variable load (the amount of matter or energy passing through the object per unit of time) caused by the periodic consumption of different types of energy. In the above cases, the load affects the parameters of the object, and in some cases, the load itself can serve as an incoming (task) signal, which its changes also affect the changes in the object's characteristics.

One of the main characteristics of continuous and discrete control systems in potash drying systems is that there is a delay in the control channels. This feature, delay, has the greatest impact on system performance when compared to the time discretization step. To account for the delay, it is possible to include a mechanism that pretransmits signals about the state of the control object to the structure of the synthesizer.

The specific characteristics of volatile materials as an object of control consist of internal connections between parameters and non-stationary states associated with physical and chemical changes in the process.

Generally, the efficiency of the drying process is measured by the amount of material to be dried, which can be done by the operator. Therefore, from the point of view of management, giving the material, and therefore the performance of the dryer, which is tightly connected with it, is not given to the internal adjustment; all other processes should be designed for the external performance of the dryer. From this, the efficiency of the dryer, the speed of the drying agent transferred to the drum when drying potash fertilizer is determined by internal agitation.

Likewise, the moisture content of the material entering the drying unit cannot be controlled in the operating mode, so it is considered a disturbance from the point of view of controlling the drying process.

Based on the analysis, it can be concluded that the drying process of sylvinite in the production of potassium fertilizer is a complex stochastic process characterized by multifactoriality, controlled and uncontrolled effects, and the presence of disturbances. Due to the complexity and diversity of the process occurring in the drying drum, as well as the large number of elements that make up it, the methods of building mathematical models based on the physico-chemical laws of the technological process being studied are less effective. This is explained by the complexity of the phenomena observed in the researched process and the fact that they are not sufficiently studied, as well as the obtained results are not well reviewed.

Formulation of the problem

The selection of the structure of the mathematical model, the determination of the main control variables affecting the quality parameters of the process was carried out at the initial stage of the study of the normal operation of the drum dryer. The following variables were considered as the main parameters describing the drying process, and the following main variables were taken as the main quantities describing the process under consideration:

management parameters $U=(u_1,u_2)$, here u_1– drying result in the entrance of the drums appointing the heat carrier temperature, u_2 – drying drums

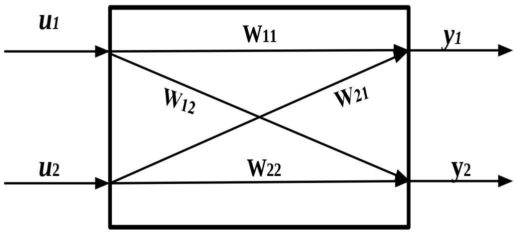
the result will be spent on transport of heat in appointing access;

out parameters Y=(y_1,y_2), where y_1 – drying drums

appointing the humidity of potassium fertilizer result in dried out, y_2 – drying drums out of the heat carrier temperature in appointing result;

not to control the effects of uncontrollable rebellion $W=(w_1,w_2)$here, w_1 – at the entrance of the drums, which spent drying and the dried material w_2 – in access to primary dried potassium fertilizer, which is the humidity.

The object management 2×2-dimensional, if its reciprocal link the scheme of the channel will be in the following form (1-picture).



1-picture. 2×2 - dimensional object of the scheme

Considering the size of the dynamic equations and the expression for the drying process which potash fertilizers on the basis of formal matrisa in the form of the above function can be expressed as:

$W_{11}(p)$, $W_{12}(p)$, $W_{21}(p)$, $W_{22}(p)$ - respectively, the effects of the transmission of all channels on: “the entrance of the heat carrier and result in the drying drums appointing appointing the humidity of potassium fertilizer result in dried out”, “in appointing result of the drying agent into drum and result in the drying agent temperature", “the drums will result in the entrance of the drying agent consumption appointing appointing production of the finished product and result in wet” and “your drums into result result in in appointing appointing the temperature of the drying agent drying agent consumption and production” between link.

Solving the problem

A statistical method we will use in determining transfer functions.

$$R_{yu}(\tau)=\int_0^{\infty} R_{uu}(\tau-t)\,k(t)dt\,. \tag{1.1}$$

Correlatsion the functions and the experiment results on the basis of approximate the formula using is:

$$R_{uu}(\mu)=\frac{1}{N-\mu}\sum_{\upsilon=1}^{N-\mu} U_{\upsilon}\cdot U_{\upsilon+\mu}\,,$$

here: N– expansions for discrete eigenvalues out increase of ordinata number; μ – correlatsion expansions for discrete eigenvalues of the function argument.

The random processes for implementing observed to note the time T and get information from time interval G'i Δt seethehouse in the expression orqBy is determined:

$$\frac{S_{R(\tau)}}{R(\tau)} = 2\left[\tilde{N} + 0{,}01\left(\frac{\alpha \cdot \Delta t}{2}\right)\right]$$

$\tau = 0$ in point $\frac{S_{R(\tau)}}{R(\tau)} = 0{,}2$; here: $\frac{S_{R(\tau)}}{R(\tau)}$ – correlatsion the function at any point in the assessment of the average relative squared error; α – the time unit is performed increase of nollar average number related , which is a value; $C - \alpha T$ function.

Random process of stasionar correlatsion the functions and various the time range for the mathematical developments are expected to compare the way with was checked (random processes out increase stasionar random process to close the properties having enough long-term segment to select the possibility it gives). Qitto rita, the processi's ergodikligi is the correlatsion functions with is confirmed.

(1.1) We used frequency method for solving equation. (1.1) to convert the equatsion into frlequency zone brings follaving expression:

$$S_{yu}(\omega) = S_{uu}(\omega) \cdot W(j\omega) \tag{1.2}$$

the object amplituda-phase characteristics compared to:

$$W(j\omega) = \frac{1}{2\pi}\int_0^{\infty} k(t)\, e^{-j\omega t} dt \tag{1.3}$$

and random process in the spectrum density:

$$S_{yu}(\omega) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} R_{yu}(\tau)\, e^{-j\omega t} d\tau; \;\; S_{uu}(\omega) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} R_{uu}(\tau)\, e^{-j\omega t} d\tau \,.$$

(1.2) from the expression comes so, the actual frequency characteristic$R(\omega)$, amplituda-phase characteristic (1.3) to fit comes in and the following expressionby calculated can be:

$$P(\omega) = \frac{\operatorname{Re} S_{yu}(\omega)}{S_{uu}(\omega)} \cdot \qquad R_{yu}(\mu) = \frac{1}{N-\mu}\sum_{\upsilon=1}^{N-\mu} Y_{\upsilon} \cdot U_{\upsilon+\mu},$$

The spectrum of clonal density $S_{uu}(\omega)$ function in correlatsion $R_{uu}(\tau)$ Fure to replacement of through the looking. Mutual in the spectrum of the densityreal part , while the following expression with calculated:

$$\operatorname{Re} S_{yu}(\omega) = \frac{1}{\pi}\int_0^{\infty} \frac{R_{yu}(+\tau) + R_{uy}(-\tau)}{2} \cos \omega\tau \, d\tau \,. \tag{1.4}$$

(1.4) at the integrated graphics in the way - trapezoidal characteristic method with carried out.

Table-1

Transfer functions according to main channels of transmission effects

Channel assignment	**Appearance of transmission function**	**Channel assignment**	**Appearance of transmission function**
u_1-y_1	$W(p) = \frac{0{,}22}{12{,}18p^2 + 7{,}12p + 1} e^{-3{,}6p}$	u_2-y_1	$W(p) = \frac{0{,}16}{11{,}33p^2 + 7{,}2p + 1} e^{-4{,}1p}$
u_1-y_2	$W(p) = \frac{0{,}4(1 + 0{,}67p)}{6{,}84p^2 + 5{,}5p + 1} e^{-2{,}1p}$	u_2-y_2	$W(p) = \frac{0{,}14(1 + 0{,}82p)}{8{,}82p^2 + 6{,}3p + 1} e^{-2{,}8p}$
u_1-y_2	$W(p) = \frac{0{,}4(1 + 0{,}67p)}{6{,}84p^2 + 5{,}5p + 1} e^{-2{,}1p}$	u_2-y_2	$W(p) = \frac{0{,}14(1 + 0{,}82p)}{8{,}82p^2 + 6{,}3p + 1} e^{-2{,}8p}$

Transition characteristics of controlling channel are calculated wish trapezuim method. Shaped and method of transition xarakteristik approksimasiyalash the effects of transmission on all the main channels on the object of the transfer functions get the opportunity to gave (1.1-in the table).Transition characteristics of controlling channel are calculated wish trapezium method.

So, the main channels of researched object were inerfcial and delayed by considering dynamic properties. Transfer function of the research is expressed as following.

$$W_1(p)=\frac{K}{Hp^2+Gp+1}e^{-p\tau};\;\; W_2(p)=K\,\frac{Dp+1}{Ep^2+Fp+1}e^{-p\tau}.$$

Conclusion

Thus, the mathematical model of the drying process of potassium fertilizer developed between quantitative variables associated establish the main entrance and exit, consider the process with management to forecast the condition of the law and available or selected for the new process allows to synthesize adaptive control laws.

References

[1] Shagin A.V., Demkin V.I., Kononov V.Yu. Kabanova A.B.: Osnovi avtomatizatsii texnologicheskix protsessov [Fundamentals of process automation]. Handbook, Yurayt (2017).

[2] Sxirtladze, A. G.: Avtomatizatsiya texnologicheskix protsessov i proizvodstv [Automation of technological processes and production]. Abris, Moskva (2012), 565p.

[3] Igamberdiyev, X.Z., Sevinov, J.U., Zaripov, O.O.: Regulyarniye metodi i algoritmi sinteza adaptivnix system upravleniya s nastraivayemimi modelyami [Regular methods and algorithms for the synthesis of adaptive control systems with customizable models], Tashkent: TSTU (2014) 160p.

[4] Mallayev, A.R., Xusanov, S.N.: Estimation of Parameters of Settings of Regulators Based on Active Adaptation Algorithm. International Journal of Advanced Research in Science, Engineering and Technology 6(8), 10376-10380 (2019).

[5] Mallayev, A.R., Xusanov, S.N., Sevinov, J.U.: Algorithms for the synthesis of stabilizing state controllers for discrete objects based on linear matrix inequalities. International Journal of Advanced Research in Science, Engineering and Technology 8(3), 16979-16986 (2021).

[6] Kolesnikov, A.A.: Modern Applied Control Theory: Synergetic Approach in Control Theory, Taganrog, Tomsk (2000).

[7] Yusupbekov, N.R., Igamberdiev, H.Z., Sevinov, J.U.: Formalization of Identification Procedures of Control Objects as a Process in the Closed Dynamic System and Synthesis of Adaptive Regulators. Journal of Advanced Research in Dynamical and Control Systems. 12(06). 77-88 (2020). doi:10.5373/JARDCS/V12SP6/SP20201009.

[8] Mallaev, A.R., Xusanov, S.N., Sevinov, J.U.: Algorithms of Nonparametric Synthesis of Discrete One-Dimensional Controllers, International Journal of Advanced Science and Technology, 29(5 Special Issue), 1045-1050 (2020).

[9] Sevinov, J.U., Mallaev, A.R., Xusanov, S.N.: Algorithms for the Synthesis of Optimal Linear-Quadratic Stationary Controllers. In: Aliev R.A., Yusupbekov N.R., Kacprzyk J., Pedrycz W., Sadikoglu F.M. (eds) 11th World Conference “Intelligent System for Industrial Automation” (WCIS-2020). WCIS 2020. Advances in Intelligent Systems and Computing, vol 1323. Springer, Cham. https://doi.org/10.1007/978-3-030-68004-6_9.

[10] Mallayev, A.R., Xusanov, S.N.: Algorithms for synthesis of discrete controllers in nonlinear control systems with delay. Chemical Technology, Control and Management: 2021(2), 80-86 (2021). doi: https://doi.org/10.51346/tstu-02.21.1-77-0012.

[11] Egupov, N.D., Pupkov, K.A.: Metodi klassicheskoy i sovremennoy teorii avtomaticheskogo upravleniya [Methods of classical and modern theory of automatic control]. Handbook (5 chapter), MGTU im.N.E.Baumana (2004).

[12] Igamberdiyev, H., Sevinov, J., Khusanov, S.: Controllers Synthesis Algorithms in the Construction of Discrete Control Systems for Technological Objects. (2023) Lecture Notes in Networks and Systems, 762 LNNS, pp. 426-439.
[13] Aleksandrov, A.G.: Optimalniye i adaptivniye sistemi, Nauka, Moscow (2003) 278p.
[14] Voskoboynikov Yu.E. Ustoychiviye metodi i algoritmi parametricheskoy идентификации. – Novosibirsk: NGASU (Sibstrin), 2006. –180 s.
[15] Kabanixin S.I. Obratniye i nekorrektniye zadachi. Uchebnik dlya studentov visshix учебных zavedeniy. – Novosibirsk: Sibirskoye nauchnoye izdatelstvo, 2009. –457 s.
[16] Malin A.S., Muxin V.I. Issledovaniye sistem upravleniya. Izd-vo: GU VSHE, 2005. –400 s.
[17] Kuzmenko, N.V. Avtomatizatsiya texnologicheskix protsessov i proizvodstv : uchebnoye posobiye : v 2 ch. / N. V. Kuzmenko. – Angarsk, 2005. Ch. 1. –78 s.
[18] Richard C Dorf,. Robert H Bishor. Modern Control Sustems, Twelfth yeition, 2010. –890 r.
[19] Karabutov N.N.Adaptivnaya identifikatsiya sistem: informatsionniy sintez. 2006.-384 s.
[20] Sikunov A.M. Adaptivnoye upravleniye s kompensatsiyey vliyaniya zapazdivaniya v upravlyayushem vozdeystvii // Izvestiya akademii nauk. Teoriya i sistemi upravleniya, №4, 2000. -S.78-81.