ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский
технический университет им. К. И. Сатпаева

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
named after K. I. Satpayev

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

6 (438)

NOVEMBER – DECEMBER 2019

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://nauka-nanrk.kz /geology-technical.kz

Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 6, Number 438 (2019), 302 – 307 **https://doi.org/10.32014/2019.2518-170X.182**

A. Seitmuratov[1], A. Dauitbayeva[1], K. M. Berkimbaev[2], K. N. Turlugulova[1], E. Tulegenova[1]

[1]Korkyt Ata Kyzylorda State University, Kazakhstan,
[2]Khoja Akhmet Yassawi International Kazakh-Turkish University, Kentau, Kazakhstan.
E-mail: angisin_@mail.ru, aicos@mail.ru, kamalbek.berkimbaev@ayu.edu.kz.

CONSTRUCTED TWO-PARAMETER STRUCTURALLY STABLE MAPS

Abstract. In this paper we consider a linear stationary closed control system, which describes the equation of state with undefined parameters. This system will help to solve the problem of constructing a linear stationary observer system in the class of two-parameter structurally stable maps for objects with one input and one output, as well as the conditions of asymptotic robust stability of steady-state control systems corresponding to the critical points of Morse from the theory of catastrophes.

Key words: stationary, closed system, critical point, object matrix, stability.

Consider a linear stationary closed control system, describing the following equation of state with undefined parameters

$$\dot{x}(t) = Ax(t) + Bu(t) + f(t)\ \ y(t) = Cx(t) + V(t),\ x(t_0) = x_0,\ t \geq t_0\ . \qquad (1)$$

Here $x(t) \in R^n$ the state vector of the object, $u(t) \in R^m$, $y(t) \in R^l$ input and output vectors, A, B, C - respectively, the matrix of the object of control and observation. The object is subject to disturbances $f(t)$ and "noise (error) measurements" $\vartheta(t)$. It is believed that when the system is available to measure the processes $u(t), y(t),\ \ a\ x(t), f(t), \vartheta(t)$ - not available. The problem of obtaining an assessment of the state of the object is considered $x(t)$. A process $x(t)$ obtained with the help of some algorithm must in a certain (for example, in an asymptotic) sense approach the process $x(t)$ $(x(t) \to \hat{x}(t)\ \ on\ t \to \infty)$ regardless of the initial state of the object x_0.

Let the matrix of the control A object of dimension $n \times n$ and the matrix b and c - respectively control and output have the form.

$$A = \begin{Vmatrix} 0 & 1 & 0 & \dots & 0 \\ 0 & 0 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & 1 \\ -a_n & -a_{n-1} & -a_{n-2} & \dots & -a_1 \end{Vmatrix};\quad b = \begin{Vmatrix} 0 \\ 0 \\ \vdots \\ b_n \end{Vmatrix};\quad c = \begin{Vmatrix} c_1 & 0 & \dots & 0 \end{Vmatrix}$$

For stationary systems the observer is described by the equation

$$\dot{\hat{x}}(t) = A\hat{x}(t) + Bu(t) + L(y(t) - \hat{y}(t)),$$
$$\hat{y}(t) = C\hat{x}(t),\ \hat{x}(t_0) = \hat{x}_0,\ \ t \geq t_0\,. \qquad (2)$$

Here $\hat{x}(t) \in R^n$ - the state vector of the observer, which serves as an assessment of the state of the object; $\hat{y}(t) \in R^l$ - the output vector; L - the feedback operator on the residual between the outputs of the object and the observer.

The synthesis of the observer lies in the choice of the operator *L*. We will consider an observer whose dimension of the state vector is the same as that of the object (the so-called full-order observer, or Kalman observer).

To construct an observer consider the estimation errors

$$\varepsilon(t) = (x(t) - \hat{x}(t))$$

Subtracting from (1) equation (2), we obtain the equation for the error

$$\dot{\varepsilon}(t) = A\varepsilon(t) - LC\varepsilon(t) + f(t) - Lv(t), \tag{3}$$

$$\varepsilon(t_0) = \varepsilon_0 = x_0 - \hat{x}_0,\ t \geq t_0 .$$

As can be seen from this equation, the sources of error $\varepsilon(t)$ are the initial mismatch $\varepsilon_0 = x_0 - \hat{x}_0$, perturbation and interference measurements $\vartheta(t)$. The dynamics of the transient error $\varepsilon(t)$ is determined by the operator $\varsigma(t) = A - L(t)C$.

It is necessary to investigate the behavior of the process $\varepsilon(t)$.

The synthesis of the observer lies in the choice of the operator L. Select the operator L in the form:

$$L(t) = \varepsilon_1^3 - k_1\varepsilon_1^2 - k_2 ; \tag{4}$$

$$\begin{cases} \dot{\varepsilon}_1(t) = \varepsilon_2(t) \\ \dot{\varepsilon}_2(t) = \varepsilon_3(t) \\ \vdots \\ \dot{\varepsilon}_n(t) = -\dfrac{1}{4}c_1\varepsilon_1^4 - \dfrac{1}{2}c_1k_1\varepsilon_1^2 + c_1(k_2 - a_n)\varepsilon_1 - a_{n-1}\varepsilon_2 - \ldots - a_2\varepsilon_{n-1} - a_1\varepsilon_n \end{cases} \tag{5}$$

The stationary state of the system is determined by the solution of the equation

$$\begin{cases} \varepsilon_{1S}^1 = 0,\ \varepsilon_{2s} = 0, \ldots \varepsilon_{n-1,s} = 0,\ \varepsilon_{ns} = 0 \\ -\dfrac{1}{4}c_1\varepsilon_{1s}^4 - \dfrac{1}{2}c_1k_2\varepsilon_{1s}^2 + c_1(k_2 - a_n)\varepsilon_{1s} - a_{n-1}\varepsilon_{2s} - \ldots - a_2\varepsilon_{n-1,s} - a_1\varepsilon_{ns} = 0 \end{cases} \tag{6}$$

$$f(\varepsilon_{1s}, C_1, k_1, a_n, k_2) = -c_1\varepsilon_{1s}^4 + c_1k_1\varepsilon_{1s}^2 + c_1(k_2 - a_n)\varepsilon_{1s} = 0 \tag{7}$$

The critical, twice-degenerate and thrice-degenerate critical points of the assembly (7) are determined by equating the first, second and third derivatives (7) to zero, respectively. Condition (7) is satisfied at critical points

$$-4c_1\varepsilon_{1s}^3 + 2c_1k_1\varepsilon_{1s} + c_1(k_2 - a_n) = 0 \tag{8}$$

and

$$-12c_1\varepsilon_{1s}^2 + 2c_1k_1 = 0 \tag{9}$$

The points of the control parameter space that parameterize functions with twice degenerate critical points are determined from equations (9) and (8)

$$(k_1 = 6\varepsilon_{1s}^2 \Rightarrow a_n + k_2 = -8\varepsilon_{1s}^3 \tag{10}$$

If the position of a twice-degenerate critical point is denoted by ε_{1s}, then formula (10) gives the values of the control parameters k_1 and $a_n + k_2$, which describes a function with a twice-degenerate critical point ε_{1s}

Equation (10) defines a parametric representation of the relationship between k_1 and $a_n + k_2$. A more direct expression for the relation between k_1 and $a_n + k_2$ can be obtained by excluding ε_{1s} from (10):

$$\left(\frac{k_1}{6}\right)^{\frac{1}{2}} = \varepsilon_{is} = \left(-\frac{a_n + k_2}{8}\right)^{\frac{1}{3}} \text{ or } \left(\frac{k_1}{3}\right)^{\frac{1}{2}} = \varepsilon_{is} = \left(-\frac{a_n + k_2}{2}\right)^{\frac{1}{3}}, \left(\frac{k_1}{3}\right)^3 = -\left(\frac{a_n + k_2}{2}\right)^2$$

$$\left(\frac{k_1}{3}\right)^3 + \left(\frac{a_n + k_2}{2}\right)^2 = 0 \tag{11}$$

Hence, given (11), equation (7) has the solution:

$$\varepsilon_{1s}^2 = \sqrt[3]{a_n + \frac{k_2}{2}}, \quad \varepsilon_{is} = 0, \quad i = 2, \ldots, n \tag{12}$$

$$\varepsilon_{1s}^{3,4} = -\sqrt[3]{a_n + \frac{k_2}{2}}, \quad \varepsilon_{is} = 0, \qquad i = 2, \ldots, n \tag{13}$$

The full time derivative of the Lyapunov $V(\varepsilon)$ vector functions taking into account the equations of state (3) is defined as the scalar product of the gradient of the Lyapunov function on the velocity vector i.e.

$$\frac{dV(\varepsilon)}{dt} = -\sum_{\mathrm{i}=1}^{\mathrm{n}} \left(\sum_{j=1}^{n} \frac{\partial V_i(\varepsilon)}{\partial \varepsilon} \right) \frac{d\varepsilon_i}{dt} =$$

$$= -\sum_{i=1}^{n} \left[-\frac{1}{4} c_1 \varepsilon_1^4 + \frac{1}{2} c_1 k_1 \varepsilon_1^2 - c_1 (k_2 - a_n) \varepsilon_1 - a_{n-1} \varepsilon_2 - a_{n-3} \varepsilon_3 - \ldots - a_2 \varepsilon_{n-1} + \ldots a_1 \varepsilon_n \right]^2 \tag{14}$$

It follows from equation (14) that the full time derivative of the Lyapunov function will always be a sign-negative function, i.e. a sufficient stability condition will always be satisfied for any stationary state.

We investigate the stability of the stationary state (13). Equation of state (4) in deviations relative to the stationary state (13). To do this, calculate:

$$\left(\frac{\partial F_1}{\partial \varepsilon_2}\right)_{\varepsilon_s} = \varepsilon_2, \left(\frac{\partial F_2}{\partial \varepsilon_3}\right)_{\varepsilon_s} = \varepsilon_3, \left(\frac{\partial F_{n-1}}{\partial \varepsilon_n}\right)_{\varepsilon_s} = \varepsilon_n$$

$$\left(\frac{\partial F_n}{\partial \varepsilon_2}\right)_{\varepsilon_s} = a_{n-1,} \left(\frac{\partial F_n}{\partial \varepsilon_3}\right)_{\varepsilon_s} = a_{n-2}, \left(\frac{\partial F_n}{\partial \varepsilon_1}\right)_{\varepsilon_s} = a_{n-3}, \ldots, \left(\frac{\partial F_n}{\partial \varepsilon_1}\right)_{\varepsilon_s^4} = 2(a_n + c_1 k_2) +$$

$$+ 3(a_n + c_1 k_2) + (a_n + c_1 k_2) + (a_n + c_1 k_2) = 6(a_n + c_1 k_2),$$

$$\left(\frac{\partial^2 F_1}{\partial \varepsilon_1^2}\right)_{\varepsilon_s^{3,4}} = \left[-3c_1 \varepsilon_1^2 + 2c_1 k_1 \right]_{\varepsilon_s^{3,4}} = -5c_1 \sqrt[3]{\left(\frac{a_n + c_1 k_2}{2c_1}\right)^2}$$

$$\left(\frac{\partial^3 F_1}{\partial \varepsilon_1^3}\right)_{\varepsilon_s} = -6c_1 \varepsilon_1 \Big|_{\varepsilon_s^3} = -6c_1 \sqrt[3]{\frac{a_n + c_1 k_2}{2c_1}}$$

$$\frac{\partial^3 F_1}{\partial \varepsilon_i \partial \varepsilon_j \partial \varepsilon_k} = 0, i \neq j \neq k, \; i = 2, \ldots, n, \; j = 1, \ldots, n, \; k = 1, \ldots, n$$

$$\left(\frac{\partial^4 F_n}{\partial \varepsilon_1^4}\right) = -6c_{i,} \, i = 1,2,\ldots, n$$

Equations of state (4) in deviations relative to the stationary state (13) is written:

$$\begin{cases} \dot{\varepsilon}_1(t) = \varepsilon_2(t) \\ \dot{\varepsilon}_2(t) = \varepsilon_3(t) \\ \dots \\ \dot{\varepsilon}_n(t) = -c_1\varepsilon_1^4(t) + 4c_1\sqrt[3]{\dfrac{a_n + c_1k_2}{2c_1}}\varepsilon_n^3(t) - 9c_1\sqrt[3]{\left(\dfrac{a_n + c_1k_2}{2c_1}\right)^2}\varepsilon_n^2(t) + 6(a_n + c_nk_2)\varepsilon_n(t) - a_{n-1}\varepsilon_2 \\ -a_{n-3}\varepsilon_3 -, \dots, -a_1\varepsilon_n \end{cases} \quad (15)$$

The full time derivative of the Lyapunov vector functions $\nabla V_i(\varepsilon)$, taking into account the equations of state (15), will be equal to:

$$\frac{dV(\varepsilon)}{dt} = -\frac{1}{2}\varepsilon_2^2 - \frac{1}{2}\varepsilon_3^2 - \dots - \frac{1}{2}\varepsilon_n^2 - \left[\begin{array}{l} c_1\varepsilon_1^4 + 4c_1\sqrt[3]{\dfrac{a_n + c_1k_2}{2c_1}}\varepsilon^3 - 9c_1\sqrt[3]{\left(\dfrac{a_n + c_1k_2}{2c_1}\right)^2}\varepsilon_1^2 + 6(a_n + c_nk_2)\varepsilon_1 + \\ + a_{n-1}\varepsilon_2 - a_{n-3}\varepsilon_3 -, \dots, -a_1\varepsilon_n \end{array}\right]^2 \quad (16)$$

A sufficient stability condition will always be satisfied. We find the gradient components of the Lyapunov vector functions $\nabla V_i(\varepsilon)$ by the components of the velocity vector, i.e. by the equation of state.

$$\frac{\partial V_1}{\partial \varepsilon_1} = 0, \frac{\partial V_1}{\partial \varepsilon_2} = \varepsilon_2, \dots, \frac{\partial V_n}{\partial \varepsilon_n} = 0$$

$$\frac{\partial V_2}{\partial \varepsilon_1} = 0, \frac{\partial V_2}{\partial \varepsilon_2} = 0, \frac{\partial V_2}{\partial \varepsilon_3} = \varepsilon_3, ..., \frac{\partial V_2}{\partial \varepsilon_n} = 0$$

$$\dots$$

$$\frac{\partial V_n}{\partial \varepsilon_2} = a_{n-2}\varepsilon_2, \frac{\partial V_n}{\partial \varepsilon_2} = a_{n-3}\varepsilon_3, \dots,$$

$$\frac{\partial V_n}{\partial \varepsilon_1} = c_n\varepsilon_n^4 - 4c_1\sqrt{\frac{a_n + c_1k_2}{2c_1}}\varepsilon_1^3 + 9c_1\sqrt[3]{\left(\frac{a_n + c_nk_2}{2c_1}\right)^2}\varepsilon_1^2 - 6(a_n + c_1k_2)\varepsilon_1, \dots, \frac{\partial V_n}{\partial \varepsilon_n} = -a_1\varepsilon_n$$

The potential function has the form:

$$V(\varepsilon) = \frac{1}{5}c_1\varepsilon_1^5 - c_1\sqrt[3]{\frac{a_n + c_1k_2}{2c_1}}\varepsilon_1^4 + 3c_1\sqrt[3]{\left(\frac{a_n + c_1k_2}{2c_1}\right)^2}\varepsilon_1^2 - 3(a_n + c_1k_2)\varepsilon_1^2 - \frac{1}{2}\varepsilon_2^2 - \frac{1}{2}\varepsilon_3^2 \dots - \frac{1}{2}a\varepsilon_n^2 - \frac{1}{2}a_1\varepsilon_n^2 \quad (17)$$

According to Morse's Lemma, the potential function (17) can be carried out by replacing the variables to a quadratic form with a Hess matrix of diagonal form.

$$V_{i,j} = \left\| \left(\frac{\partial^2 V(\varepsilon)}{\partial \varepsilon_i \partial \varepsilon_j} \right)_{\varepsilon_{is}^2} \right\| = \begin{Vmatrix} \lambda_1 & 0 & 0 & \dots & 0 \\ 0 & \lambda_2 & 0 & \dots & 0 \\ 0 & 0 & \lambda_3 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & \lambda_n \end{Vmatrix},$$

where

$$\begin{cases} \lambda_1 = -3(a_n - c_1 k_2) \\ \lambda_2 = -(a_{n-1} + 1) \\ \lambda_3 = -(a_{n-2} + 1) \\ \dots \\ \lambda_n = -(a_1 + 1) \end{cases}$$

The conditions of positive definiteness of the Lyapunov function or the stability conditions of the Hess matrix will be expressed by a system of inequalities:

$$\begin{cases} -3(a_n - c_1 k_2) > 0 \\ -(a_{n-1} + 1) > 0 \\ -(a_{n-2} + 1) > 0 \\ \dots \\ -(a_1 + 1) > 0 \end{cases} \quad (18)$$

Thus, the observing device constructed in the class of two-parameter structurally stable mappings will be stable within an unlimited range of changes in the undefined parameters of the control object $\varepsilon_i (i = 1,2,...,n)$. The stationary state of the observing device (6) exists and is stable when the undefined parameters of the object in the region (2) change, and the stationary states (12) and (13) appear when the state (6) loses stability. These stationary states do not exist simultaneously and among stationary states (12) and (13) is stable. It should be noted that the stationary state (13) in the region (18) does not exist.

А. Сейтмұратов, А. Даутбаева, К. М. Беркимбаев, Н. Турлугулова, Э. Төлегенова

Қорқыт Ата атындағы Қызылорда мемлееттік университеті, Қазақстан,
Қожа Ахмет Ясауи атындағы Халықаралық қазақ-түрік университеті, Кентау, Қазақстан

ҚОС ПАРАМЕТРЛІК ҚҰРЫЛЫМДЫ-ТҰРАҚТЫ КЕСКІНДЕРДІ ТҰРҒЫЗУ

Аннотация. Берілген жұмыста анықталмаған параметрлері бар күй теңдеуін сипаттайтын сызықтық стационарлы тұйықталған басқару жүйесі қарастырылады. Бұл жүйе бір кіру және бір шығу жолы бар объектілер үшін екі параметрлік құрылымдық-тұрақты бейнелеулер класында бақылаушының желілік стационарлық жүйесін құру кезінде тапсырманы шешуге көмектеседі, сондай-ақ апаттар теориясынан Морстің сыни нүктелеріне сәйкес келетін Басқару жүйелерінің қалыптасқан жай-күйінің асимптотикалық робастикалық тұрақтылығының шарттары алынды.

Түйін сөздер: стационарлық, тұйық жүйе, сыни нүкте, объект матрицасы, тұрақтылық.

А. Сейтмуратов, А. Даутбаева, К. М. Беркимбаев, Н. Турлугулова, Э. Тулегенова

Кызылординский государственный университет имени Коркыт Ата, Казахстан,
Международный казахско-турецкий университет им. Ходжа Ахмеда Ясави, Кентау, Казахстан

ПОСТРОЕНИЕ ДВУХПАРАМЕТРИЧЕСКИХ СТРУКТУРНО-УСТОЙЧИВЫХ ОТОБРАЖЕНИЙ

Аннотация. Рассматривается линейная стационарная замкнутая система управления, которая описывает уравнение состояния с неопределенными параметрами. Эта система поможет решать задачу при построении линейной стационарной системы наблюдателя в классе двухпараметрических структурно-устойчивых отображений для объектов с одним входом и одним выходом, а также получать условия асимптоти-

ческой робастной устойчивости установившихся состояний систем управления, соответствующие критическим точкам Морса из теории катастроф.

Ключевые слова: стационарная, замкнутая система, критическая точка, матрица объекта, устойчивость.

Information about authors:

Seitmuratov Angisin, Doktor of Physical and Matematical Sciences, Professoz Korkyt Ata Kyzylorda State University, Kazakstan; angisin_@mail.ru; https://orcid.org/0000-0002-9622-9584

Dauitbayeva Aigul Ospanovna, Candidate of Technical Sciences, senior lecturer, Korkyt Ata Kyzylorda State University, Kazakstan; aicos@mail.ru; https://orcid.org/0000-0003-2487-0687

Berkimbayev Kamalbek, Doctor of Pedagogical Sciences, Full Professor, Professor The International Kazakh-Turkish University named after Hoja Akhmet Yassawi, Kentau, Kazakhstan; kamalbek.berkimbaev@ayu.edu.kz; https://orcid.org/0000-0002-5191-8140

Turlugulova Nurzhanar Absamatovna, Master of science, senior lecturer, Korkyt Ata Kyzylorda State University, Kazakstan; jannur-08.73@mail.ru; https://orcid.org/0000-0003-1380-5150

Tulegenova Elmira Nurlanovna, Candidate of Economic Sciences, senior lecturer, Korkyt Ata Kyzylorda State University, Kazakstan; etulegenova@mail.ru; https://orcid.org/0000-0003-4501-7343

REFERENCES

[1] Dautbaeva A. O. Methods of robust stability research // Proceedings of the International Symposium "Information and communication technologies in industry, education and science".- Karaganda, 2010.- Pp. 131-133.

[2] Dautbaeva A. O., Construction of the observing device in the class of one-parameter structurally stable mappings in the field of canonical transformation variables. proceedings of the Republican scientific-practical conference "Uninterrupted professional knowledge: problems and future".-Kyzylorda state University named after. The Korkyt ATA.-2010.- Pp. 76-79.

[3] Dautbaeva A. O. Elements of the theory of catastrophes and qualitative theory of dynamical systems / / Materials of the Republican scientific-practical conference "Uninterrupted professional knowledge: problems and future".-Kyzylorda state University named after. The Korkyt ATA.-2010.- Pp. 74-76.

[4] Dautbaeva A. O. observer Construction for objects with one input and one output in the class of structurally stable mappings. Vestnik Karsu. After E. A. Buketov.- Karaganda, 2010.- No. 3 (59).- Pp. 31-34.

[5] Basenji M. A., O. A. Dautbayeva Controllability and observability of linear systems // Vestnik of KSU. The Korkyt Ata. Kyzylorda, 2009.- No. 2 (28).- Pp. 107-111.

[6] Beisenbi M. A. Robustly stable nonlinear systems of the first and second order. Proceedings Of the Institute of Informatics and control problems.- Almaty, 1996. Pp. 94-101.

[7] Dautbaeva A. O. Construction of the observing device providing operability for objects with m input and l in the class of two-parameter structurally stable mappings / / Vestnik KazNTU, - Almaty, 2010.- No. 3 (79).- Pp. 182-188.

[8] Seitmuratov A., Taimuratova L., Zhussipbek B., Seitkhanova A., Kainbaeva L. Conditions of extreme stress state// News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. 2019. Volume 5, Number 437 (2019), 202 – 206 https://doi.org/10.32014/2019.2518-170X.143

[9] Seitmuratov A., Tileubay S., Toxanova S., Ibragimova N., Doszhanov B., Aitimov M.Zh. The problem of the oscillation of the elastic layer bounded by rigid bouhdaries//News of NAS RK. Series of physico-mathematical.2018 5(321): 42 – 48 (in Eng). ISSN 2518-1726 (Online), ISSN 1991-346X (Print). https://doi.org/10.32014/2018.2518-1726.6.

Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://www.geolog-technical.kz/index.php/en/

Верстка *Д. Н. Калкабековой*

Подписано в печать 15.11.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
19,7 п.л. Тираж 300. Заказ 6.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18