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INVESTIGATION OF THE WEAR PROCESS OF MIXER ELEMENTS USING INFORMATION TECHNOLOGY

Today, mechanical engineering is one of the dynamically developing sectors of the economy of Kazakhstan.

Any production process involving machines imposes requirements for reliability and durability to ensure stable and trouble-free operation of technological processes.

In this regard, ensuring the operational characteristics of machines for a long time is a key factor when choosing a manufacturer.

The quality of the materials used in the production of machines significantly affects the service life and operational characteristics of machines.

The wear of machine parts is one of the main causes of breakdowns and accidents.

The financial costs of car repair items are quite large.

To date, the wear control of the mixer elements, removable elements of the blades is carried out only visually and replacement occurs without a system, after complete abrasion or breakage.

Since these elements are not always available in the warehouse of the enterprise, downtime of equipment can take a considerable time.

Modeling of the wear process of mixer elements in the MATLAB program allowed us to develop a simulation model using the vibroacoustic control method. Analysis and processing of vibration signals is carried out using standard programs. The developed algorithm of the process of monitoring the wear of the mixer elements allows you to form a library of signals and noises, comparing them with the reference values of the signals, to determine the degree of wear of the mixer elements. The algorithm can be implemented on standard hardware and software devices.

Keywords: Mixer, wear, model, control, MATLAB, management.

Introduction

The organization of business processes in the real sector of the economy requires large investments, both in the main production and in maintenance, which include operation, repair, maintenance of technological equipment.

In this regard, the requirements for durability, proper operation, and the expediency of using machines are prioritized.

The fulfillment of these requirements is achieved by the introduction of methods and controls that have the ability to detect malfunctions of machines and equipment at the early stages of their development.

Modern advances in information technology, industry, allow us to conduct research on various processes, including those related to the wear of the surfaces of parts and machine elements.

There are quite a large number of methods for determining the wear of parts.

It's no secret that the condition and dimensions of the working surface of the parts depend on the maintenance of the working functionality of the machine, see Table 1.

Table 1 − Data on the failure of machines

№	Reason	Data on failures from open sources		
1	Wear	49	50	51
2	Corrosion	4	3	9
3	Fatigue	19	21	17
4	Plastic deformation	28	26	19
5	Other	0	7	3

In terms of value, repair costs exceed 7–9 times the cost of machines for the entire service life [1–4].

From [5] to restore worn parts, up to 50 % of the total repair costs are required. In this regard, timely monitoring of the wear of parts allows you to reduce the cost of restoration.

Depending on the degree of wear, the parts can be restored.

One of the methods for determining the wear of parts is vibration-acoustic methods.

The essence of this method is to receive vibration and acoustic signals from various elements of machines with subsequent analysis of the frequency spectrum [1–4].

Currently, vibration-acoustic methods are used to control and detect defects in various critical parts, structures, machining technology, etc. [5].

To date, the work related to the study of wear of mixer elements using vibration-acoustic methods has not been published.

In this regard, the relevance of the study lies, first of all, in the need to develop a methodology for monitoring the wear process of mixer elements.

Materials and methods of research

The object of research is a mixer, the subject of research is methods of controlling the wear process of mixer elements.

The purpose of the study is to develop an algorithm for the process of monitoring the wear of mixer elements, new control methods, and prediction of wear parameters.

Research objectives:

– simulation of the process of receiving a vibroacoustic signal from a mixer;

– development of an algorithm for the process of monitoring the wear of mixer elements;

– development of a functional control scheme for the wear process of mixer elements;

The research uses simulation modeling methods, vibration-acoustic method of measuring machine signals received using sensors, system analysis method.

The MATLAB program is used as a modeling tool.

Results and discussion

The working elements of the mixer fig. 1 positions 1 and 2 are subjected to increased wear during operation due to the influence of aggressive media, solid components.

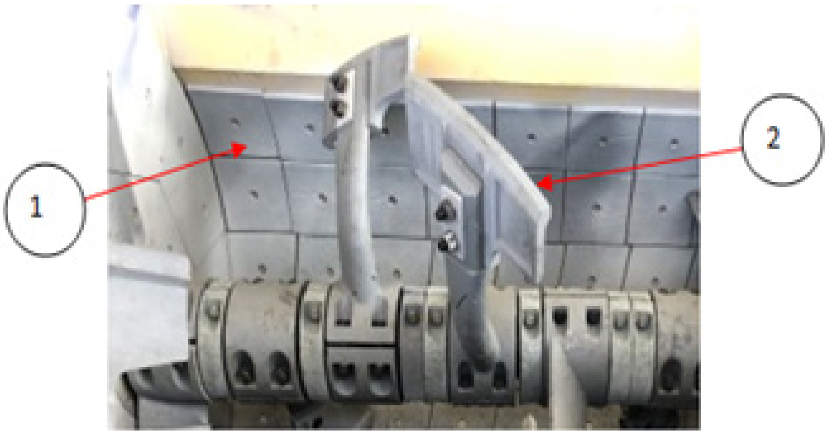

Figure 1 − Working elements of the mixer

The working surfaces of the mixer (position 1) are made of high-strength steel 30HGSNA, 40HGSN3VA, 30X5MSFA, 09G2S, attached to the walls with screws.

The working surfaces of the mixer blades (position 2) are made of CHH9N5 cast iron.

According to the passport data, the hardness of the material of the working elements of the mixer should ensure reliable operation for a certain time (the period is not specified).

Depending on the hardness of the material, the degree of wear varies Table 2 [1–5].

Table 3 − Effect of material hardness on wear resistance

Material used	Hardness H B	Wear resistance %
09Г2С	220	26
ЧХ9Н5	194	18

At the same time, it should be borne in mind that the type of thermal impact, the structure of the material, affect the resistance to wear in an abrasive environment. In any case, the strength of the elements of the mixer material should be stronger than the material of the abrasive medium.

The mixer studied in the article fig. 2, commissioned in 2018, over the past period, the working elements (items 1-2) have undergone significant wear in aggressive working environments, in this regard, the interest is how much the thickness of the working surface of the mixer elements has changed.

Figure 2 − Mixer elements

As mentioned above, the aggressiveness of the medium has a significant effect on the rate of wear and corrosion [6–9]. Figure 3 shows the dependence of the wear of the mixer elements on the aggressive environment of the operating time.

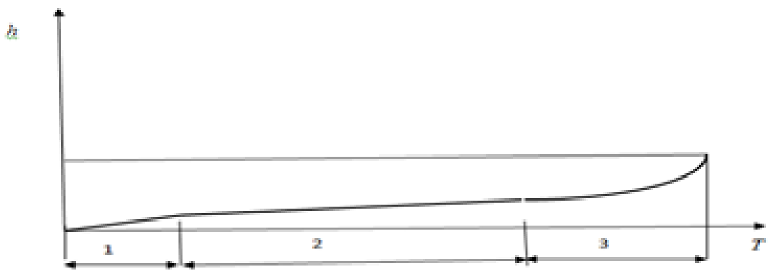

Figure 3 − Dependence of the rate of wear and corrosion on the aggressiveness of the medium

As can be seen from Fig. 3, 1 is the run–in zone, 2 is the normal wear zone, 3 is the critical wear zone.

To date, one of the devices capable of receiving vibration signals is an accelerometer, the accuracy of which depends on both the noise level and the sensitivity of the sensor itself. Using the matlab tool, we will build a model of the process of receiving an accelerometer signal from a mixer. Figure 4 shows a block diagram of a sensor for detecting a signal from a source.

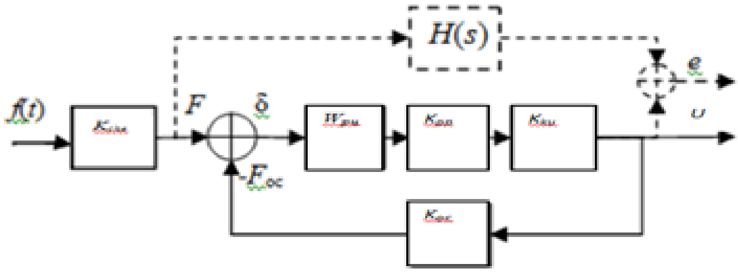

Figure 4 − Block diagram of the sensor

where

f(t) is the incoming signal;

K_{che} – transmission coefficient of the sensing element;

W_{pu} – transfer function of the mobile node;

K_{pp} – transmission coefficient of a capacitive displacement converter;

W_{ku} – the transfer function of the correction device;

K_{oc} – is the transmission coefficient of the feedback link;

U – is the output voltage.

The model presented in Fig. 4 is constructed according to the method [10–12] using the transfer function formula (1):

$$W(s)=Kche\frac{KppT1(Js)}{1+KjcT1(jS)}=\frac{Kchen(1)}{KocJ(KocKppT1)S+1} \quad (1)$$

The transfer function includes the feedback coefficients K_{oc}, the sensing element K_{che}, K_{pp} – the transmission coefficient, T- time constant, J-the moment of inertia.

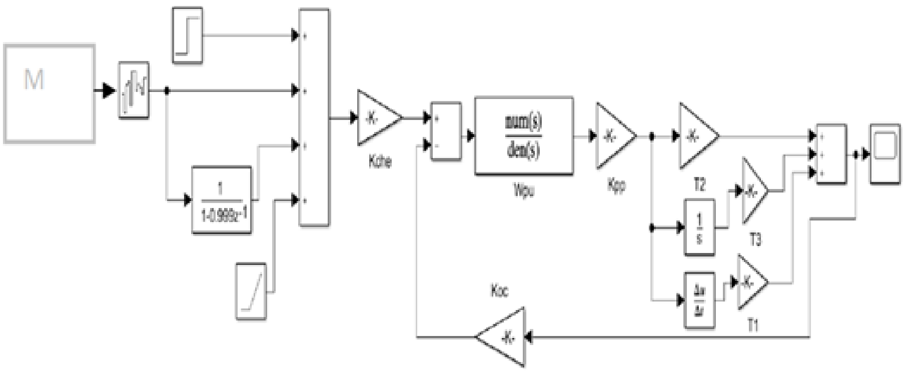

Figure 4 − Simulation model of the process of receiving a signal from a mixer

Based on the simulation results, the theoretical possibility of obtaining dynamic signals from the sensor is obtained.

Table 3 shows the parameters of the accelerometer for modeling.

Table 3 − Accelerometer data for simulation

Parameter	m_1, m_2, m_3, kg	Weight, kg	J, kg/m^2	G, H·m	T_1,T_2,T_3
Data	4,024× 10^{-5} 5,678 ×10^{-5}	5,70 ×10^{-5}	1,41× 10^{-10}	2,76 ×10^{-6}	0,0024 168,7
Parameter	K_{ku}	K_{pp}	K_{che}	K_{oc}	T_{pp},sec
Data	1×10^7	3×10^{-5}	1,1×10^{-8}	2,541× 10^{-8}	2,36 ×10^{-5}

When removing signals from the source, there are difficulties associated with the purity of the identification of the signal, which is affected by extraneous noise.

Fig. 5 shows the results of modeling using the simulation model Fig.5 of various signal sources 1–noise from the fan, 2–noise from the generator.

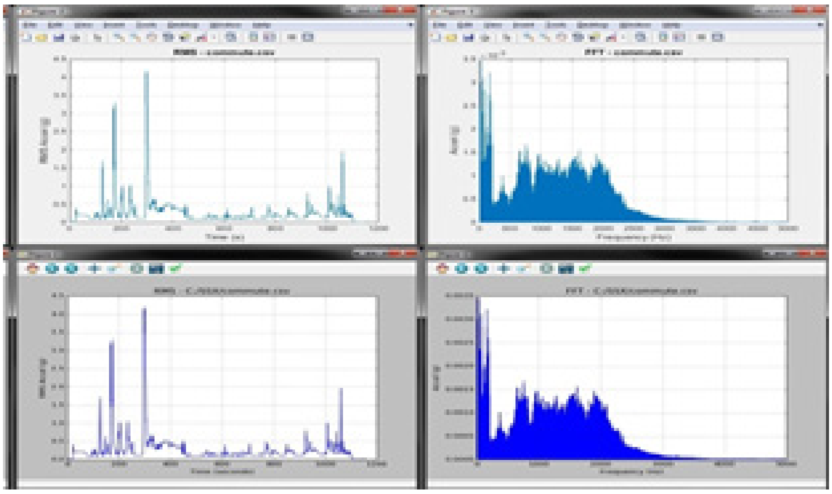

Figure 5 − Results of modeling signals from various sources

As can be seen from Fig. 5, the frequency spectra from external signals are quite visual, the height of the amplitudes are clearly traced, the components are separated from each other.

When using this model to study vibration signals from various objects, it is necessary to identify the parameters of the frequency spectrum and noise, software and hardware, as well as reference data on the classification of noise from various sources, as well as the development of libraries of vibration signals and noise of the studied objects. [13–14].

Figure 6 shows the algorithm of the process of monitoring the wear of the mixer elements.

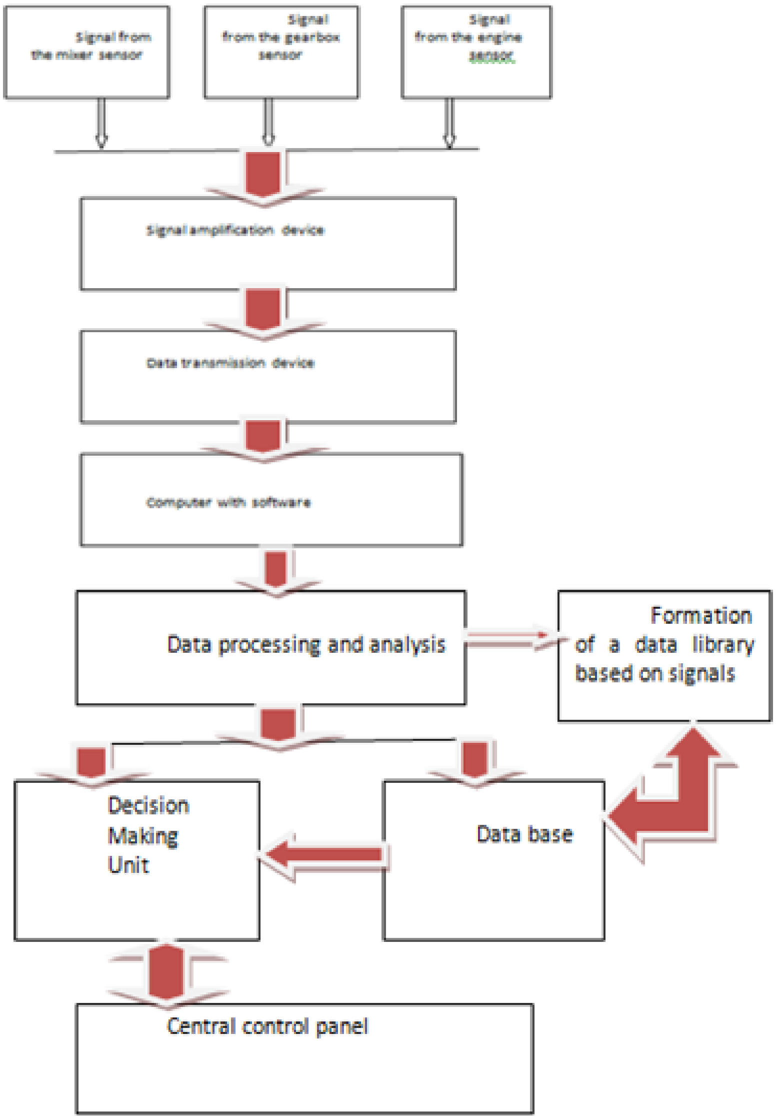

Figure 6 – Algorithm of the process of monitoring the wear of mixer elements

The algorithm works as follows: vibrations and noise transmitted by a mixer, gearbox, motor, recorded by sensors, are transmitted to a signal amplifier, then transmitted via communication channels to a computer and software is used to analyze, process the received data, and identify signals, identified signals are sent to the library and stored in a database. After identification of signals, comparison with reference samples of signals from the library takes place and management decisions are made. All data on monitoring the wear process of the mixer elements are sent to the central control panel. Figure 7 shows the algorithm for processing the signal from the source.

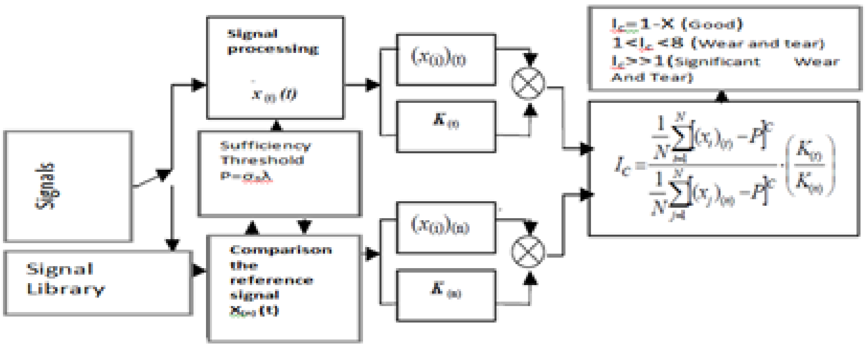

Figure 7 – Signal processing algorithm

As can be seen from Fig. 7, the incoming signal processed by the program is constantly compared with the reference signal (from the library), until the moment when it exceeds the sufficiency threshold. Only 3 conditions are good, the beginning of wear, critical wear.

Figure 8 shows the functional control scheme of the wear process of the mixer elements.

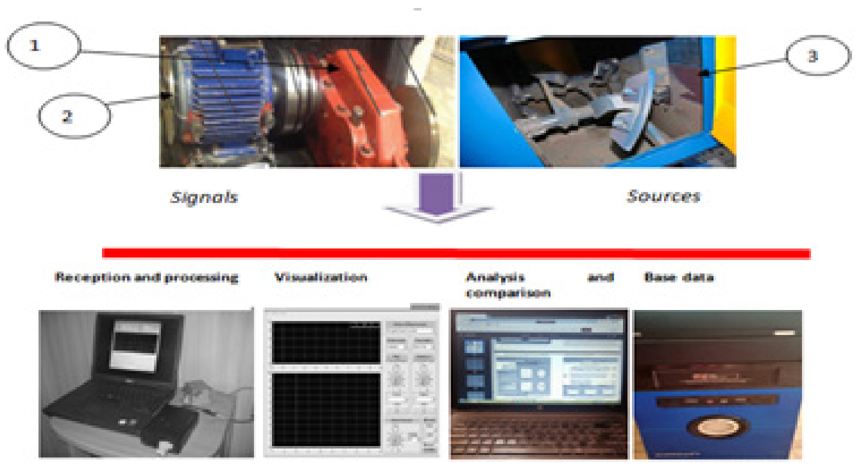

Figure 8 − Functional control diagram of the wear process of the mixer elements

Sensors can be installed directly on vibration and noise sources. Vibration signals and noise from sources 1 (gearbox), 2 (motor), 3 (mixer) are transmitted to the ADXL210 Argus soft device, where signals are registered and processed. There are a large number of programs for processing vibration signals and noise. In our study, a development [15] operating at a frequency of 8...14 kHz can be used to analyze vibroacoustic signals.

To work with the program, you need a computer with Linux OS, a mini-ITX motherboard (size 170x170 mm).

The ADXL210 Argus soft supports Intel Pentium M and Celeron M processors with a system bus frequency of 400/533 MHz.), a 10/100 Ethernet network controller. DDR SDRAM OP is 1 GB, connection of 2 devices with Serial ATA serial interface (bandwidth up to 150 MB/s). The proposed hardware is implemented on standard solutions, which is not a little important.

Due to the fact that there is no data on vibration signals and noises from the mixer elements to date, it is necessary to identify them for various operating modes and time intervals, in order to form a library of vibration signals and noises, as well as the formation of dependencies to determine the wear of the mixer elements.

Conclusion

The algorithm presented in the article for monitoring the wear of mixer elements allows processing vibration signals and noises in the range of 8–14 kHz, comparing signals and noises with reference data, forming an object identification library, monitoring the wear of mixer elements.

The hardware part of the proposed automated control system can be made from a standard set of peripheral and computing devices.

To date, there are no works related to the study of the wear of the mixer elements. In particular, the works of I. Artobolevsky, E. Hayrapetov, B. Abramov, V. Dorofeev, B. Pavlov, F. Balitsky, M. Genkin and others are devoted to the detection of defects in machines and mechanisms using vibroacoustic methods.

In this regard, the presented methodology for monitoring the wear process of mixer elements will be useful to anyone who deals with issues of non-destructive wear control using information technology.

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АҚПАРАТТЫҚ ТЕХНОЛОГИЯЛАРДЫ ПАЙДАЛАНА ОТЫРЫП МИКСЕР ЭЛЕМЕНТТЕРІНІҢ ТОЗУ ПРОЦЕСІН ЗЕРТТЕУ

Бүгінгі таңда машина жасау Қазақстан экономикасының қарқынды дамып келе жатқан салаларының бірі болып табылады.

Машиналар қатысатын кез-келген өндірістік процесс технологиялық процестердің тұрақты және апатсыз жұмыс істеуін қамтамасыз ету үшін сенімділік пен беріктікке қойылатын талаптарды қояды.

Осыған байланысты машиналардың пайдалану сипаттамаларын ұзақ уақыт қамтамасыз ету өндірушіні таңдаудағы негізгі фактор болып табылады.

Машиналарды өндіруде қолданылатын материалдардың сапасы машиналардың қызмет ету мерзіміне және пайдалану сипаттамаларына айтарлықтай әсер етеді.

Машина бөлшектерінің тозуы сыну мен апаттардың негізгі себептерінің бірі болып табылады.

Машиналарды жөндеу баптарына қаржылық шығындар өте үлкен.

Бүгінгі күні бетон араластырғыштың, алынбалы қалақ элементтерінің қорғаныс элементтерінің тозуын бақылау тек көзбен ғана жүзеге асырылады және ауыстыру жүйелі түрде, толық тозғаннан немесе сынғаннан кейін жүзеге асырылады.

Өйткені, бұл элементтер әрдайым кәсіпорынның қоймасында, қарапайым жабдықта бола бермейді, бұл айтарлықтай уақытты алуы мүмкін.

MATLAB бағдарламасында араластырғыш элементтерінің тозу процесін модельдеу matlab бағдарламасында діріл-акустикалық әдісті қолдана отырып, модельдеу моделін жасауға мүмкіндік берді. Діріл сигналдарын талдау және өңдеу Стандартты бағдарламалар арқылы жүзеге асырылады. Миксер элементтерінің тозуын бақылау процесінің әзірленген алгоритмі сигналдар мен шулардың кітапханасын қалыптастыруға, оларды сигналдардың анықтамалық мәндерімен салыстыруға, миксер элементтерінің тозу дәрежесін анықтауға мүмкіндік береді. Алгоритм стандартты бағдарламалық және аппараттық құрылғыларда жүзеге асырылуы мүмкін.

Кілтті сөздер: миксер, тозу, модель, бақылау, MATLAB, басқару.

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ИССЛЕДОВАНИЕ ПРОЦЕССА ИЗНОСА ЭЛЕМЕНТОВ МИКСЕРА С ИСПОЛЬЗОВАНИЕМ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ

На сегодняшний день машиностроение является одной из динамично развивающихся отраслей экономики Казахстана.

Любой производственный процесс, в котором участвуют машины, предъявляет требования по надежности и долговечности, для обеспечения стабильного и безаварийного функционирования технологических процессов.

В этой связи обеспечение эксплуатационных характеристик машин продолжительное время, является ключевым фактором при выборе производителя.

Качество материалов используемых при производстве машин, значительно влияет на срок службы и эксплуатационные характеристики машин.

Износ деталей машин, является одной из главных причин поломки и аварий.

Финансовые затраты на статьи ремонта машин достаточно велики.

На сегодняшний день, контроль износа элементов, съемных элементов лопаток миксера, осуществляется только визуально и замена происходит без системно, после полного истирания или поломки.

Так как, эти элементы не всегда имеются в наличие на складе предприятия, простой оборудования, может занять значительное время.

Моделирование процесса износа элементов миксера в программе MATLAB, позволила разработать имитационную модель с использованием виброакустического метода контроля. Анализ и обработка вибросигналов осуществляется с помощью стандартных программ. Разработанный алгоритм процесса контроля износа элементов миксера, позволяет формировать библиотеку сигналов и шумов, сравнивая их с эталонными значениями сигналов, определять степень износа элементов миксера. Алгоритм, может быть реализован на стандартных программно-аппаратных устройствах.

Ключевые слова: Миксер, износ, модель, контроль, MATLAB, управление.

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