

МИНИСТЕРСТВО ВЫСШЕГО ОБРАЗОВАНИЯ,
НАУКИ И ИННОВАЦИЙ РЕСПУБЛИКИ УЗБЕКИСТАН
ТАШКЕНТСКИЙ ГОСУДАРСТВЕННЫЙ ТЕХНИЧЕСКИЙ
УНИВЕРСИТЕТ ИМЕНИ ИСЛАМА КАРИМОВА

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ
ОЛИЙ ТАЪЛИМ, ФАН ВА ИННОВАЦИЯЛАР ВАЗИРЛИГИ
ИСЛОМ КАРИМОВ НОМИДАГИ
ТОШКЕНТ ДАВЛАТ ТЕХНИКА УНИВЕРСИТЕТИ



II МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ
«Состояние и тенденции развития стандартизации и
технического регулирования в мире»

«Жаҳонда стандартлаштириш ва техник жихатдан
тартибга солиш ҳолати ва ривожланиш истиқболлари»
II ХАЛҚАРО АНЖУМАН

14
ОКТАБРА

ВСЕМИРНЫЙ ДЕНЬ
СТАНДАРТОВ



СБОРНИК НАУЧНЫХ ТРУДОВ

14 – 15 октября, 2024
Ташкент, Узбекистан

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ

Организаторы конференции:

- ❖ Ташкентский государственный технический университет;

Партнеры конференции:

- ❖ Министерство инновационного развития Республики Узбекистан;
- ❖ Министерство высшего и среднего специального образования Республики Узбекистан;
- ❖ Узбекское агентство по техническому регулированию;
- ❖ Национальный исследовательский ядерный университет (МИФИ), Москва, Россия;
- ❖ Московский государственный технический университет им. Н.Э. Баумана, Москва, Россия;
- ❖ Московский государственный технический университет гражданской авиации;
- ❖ Государственное учреждение «Узбекский национальный институт метрологии»;
- ❖ Государственное учреждение «Научно-исследовательский институт стандартизации, сертификации и технического регулирования» (Институт стандартов);
- ❖ Берлинский технический университет, Германия, Берлин;
- ❖ Белорусский национальный технический университет, Беларусь, Минск;
- ❖ Институт энергии и технологии, Норвегия, Шэллер.
- ❖ Ташкентский университет информационных технологий.

Председатель организационного комитета:

С.М.Турабджанов – д.т.н., академик, ректор Ташкентского государственного технического университета, Ташкент, Узбекистан

Сопредседатели:

А.Р. Жуманазаров – директор, Узбекское агентство по техническому регулированию, Ташкент, Узбекистан

Н.Р.Юсупбеков – д.т.н., академик АН РУз, профессор ТГТУ, Ташкент, Узбекистан

П.Р.Исматуллаев – д.т.н., профессор ТГТУ, Ташкент, Узбекистан

П.М.Матякубова – д.т.н., профессор, заведующая кафедрой Метрологии, технического регулирования, стандартизации и сертификации ТГТУ, Ташкент, Узбекистан

П.В.Борисюк – д.ф-м.н., доцент Московский инженерно-физический институт «МИФИ», Москва, Россия

П.Серенков – д.т.н., профессор Белорусский национальный технический университет, Минск, Белоруссия

Д.Островецков – т.д.н., профессор Берлинский технический университет, Берлин Германия

С. Каражанов – к.т.н., Институт энергии и технологии, Шэллер, Норвегия

Кафедра «Метрология, техническое регулирование, стандартизации и сертификации» Ташкентского государственного технического университета

Редакционная коллегия: акад. Турабджанов С.М., проф. Донаев С.Б., академик. Юсупбеков Н.Р., проф. Исматуллаев П.Р., проф. Матякубова П.М., проф. Рахманов А.Т., проф. Кодирова Ш.А., проф. Тургунбоев А., доц. Бобоев Г.Г., доц. Машарипов Ш.М., доцент Назарбоева Б.А., доцент Усманова Х.А., доцент Эргашев Ф.А., доцент Жабборов Х.Ш., доцент Кулуев Р.Р., доцент Бекмуротов Ч.А., доцент Махмуджонов М.М. доцент Шеина Н.Е. ст.пред. Фаттоев Ф.Ф.

Ответственный редактор: асс. Муминов Х.Д.

17. Bennett C.H. Generalized privacy amplification / C.H. Bennett, G. Brassard, C. Crepeau, U.M. Maurer // IEEE Trans. Inform. Theory. – V. 41, issue 6. – P. 1915–1923 (1995).
18. Vasiliu Y.V. Optimization of an incoherent attack on the quantum protocol of distribution of keys with transmission of cues / E.V. Vasiliu, L.M. Vasiliu // Proceedings of the Odessa Polytechnic University.. - Issue. 1(27). – P. 136–141. – (2007).
19. Vasiliu E.V. Comparative analysis of security and efficiency of quantum key distribution protocols with qudits / E.V. Vasiliu, R.S. Mamedov // Proceedings of International Conference on IT Promotion in Asia. – 139 p. (2009)
20. Cerberis // [Электронный ресурс] <http://www.idquantique.com/products/cerberis.htm>
21. QKS. Toshiba Research Europe Ltd., Cambridge Research Laboratory // [Электронный ресурс] <http://www.toshiba-europe.com/research/crl/qig/quantumkeyserver.html>.

TRANSFORMATION CHARACTERISTICS OF MEASUREMENT SYSTEMS USING A DATA TABLE WITH AN ALGORITHMIC CORRECTION METHOD

Vagif Abbasov¹, Mahabbat Khudaverdiyeva² and Kamran Aliyev³

^{1,2,3} Azerbaijan State Oil and Industry University, Azadlig street, Baku AZ1010, Azerbaijan

***Abstract.** Reducing the errors of measurement channels of measuring systems requires the use of a priori information, mathematical models and transformation characteristics about the measurement object, the measured quantity and the measurement channel. The conversion characteristics of measurement channels can be stored in memory in analytical, tabular and graphical form as part of a specific knowledge base of intelligent information measuring systems. There are known correction methods based on dividing the conversion characteristics of measurement channels of measuring systems, specified in analytical form, into discrete pieces and introducing pre-stored corrections into the measurement result inside each discrete piece. The issues of automatic correction of the nonlinear transformation characteristic, specified in the form of a table of input-output data of the measuring channel of measuring systems, have not been sufficiently developed. Technological, constructive, schematic, structural and structural-algorithmic methods do not meet the requirements for methods of automatic correction of nonlinear characteristics without the use of high-precision standard measuring instruments and without disconnecting the measured value from the input, and even more so without interfering with the principles of construction and structure of sensors of non-electrical quantities. The purpose of the article is to study the proposed and developed algorithmic correction method based on the processing of measurement information, which can be applied to a wide class of transformation characteristics specified in the form of tables of input-output data, without special requirements for the degree of their nonlinearity.*

***Keywords:** the measurement system, measurement channel, transformation function, transformation characteristic, correction, correction factor, multiplicative method*

1 Introduction

1.1 Statement of the problem

The automatic correction of the transformation characteristic of the measurement channels of measurement systems is considered one of the main functions performed in order to reduce

measurement errors. The implementation of this function requires the use of apriori information about the measurement object, the measured quantity, and the measurement channel, mathematical models, transformation function and characteristics. Correction methods based on dividing the transformation characteristic of the measurement channels in the analytical form into segments, and inserting predetermined and stored corrections into the measurement result within each segment have been proposed and published [1,2,3]. At this time, the number of segments that provide the required accuracy, the values of their boundaries, and appropriate corrections is also determined by analytical expressions. The issues of automatic correction of the non-linear transformation characteristic given in the form of the input-output data table of measurement channels of measurement systems have not been sufficiently studied.

1.2 Analysis of existing studies and publications

There are technological, constructive, schematic, structural, structural-algorithmic, and algorithmic methods for automatic correction of the transformation characteristics of the measurement channels of measurement systems [1-12]. Technological, constructive, schematic, structural, and structural-algorithmic methods do not meet the requirements for automatic correction methods of the non-linear characteristics of the measurement system (without using high-precision sampling tools and without separating the measured quantity from the input, and especially without interfering with the construction principles and structure of sensors of non-electrical quantities [4-6]). Algorithmic methods based only on the processing of measurement information received from MS and do not involve the inclusion of additional functional blocks or elements in its structure can meet the above requirements [1-3,5,6].

1.3 The purpose of the article

The purpose of the paper is to propose and study an algorithmic correction method based on the processing of measurement information, which can be applied to a wide range of transformation characteristic classes given in the form of input-output data tables without the need for special requirements in the degree of nonlinearity.

2 Multiplicative Method

The transformation characteristic $Z = f(X)$ is divided into segments along the Z ordinate axis. M_I , which is the correction factor for each section segment, is determined. By multiplying the digital output measurement results, which is the direct result of the measured quantity's interaction with the input stage of the measurement system (MS), the nonlinear transformation characteristic $Z = f(X)$ is approximated to the linear characteristic $Z^* = X$ in the segment interval. In Fig. 1, the multiplicatively corrected i -th part of the non-linear transformation characteristic $Z = f(X)$ of the MS is expressed by the function $f(X)_{KI} = f(X) \cdot M_I$, where X - the values of the measured quantity to the input of the MS; Z - digital measurement results obtained at the output in the MS;

E_{MI} – A segment of the corrected non-linear transformation at the boundaries of the interval of $[Z_{I-1}, Z_I]$ showing the maximum deviation values from the linear characteristic (linearization error); M_I – Multiplicative correction coefficient for the non-linear transformation characteristics in the interval of $[Z_{I-1}, Z_I]$.

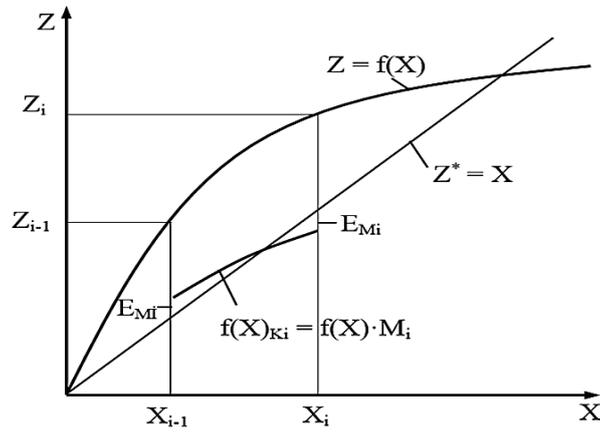


Fig. 5. Multiplicative correction of an i-th line segment in non-linear transformation characteristics

The remaining segments of the non-linear transformation characteristic of the MS are also corrected according to the presented rule. The non-linear transformation characteristic of the MS compared to the linear characteristic depends on the value of the correction coefficient. The measuring channels of the MS are given in an analytical form, and the value of the correction coefficient (M_i) is determined from the following condition [1]:

$$f(X_{I-1}) \cdot M_i - X_{I-1} = X_I - f(X_I) \cdot M_i = E_{MI} \quad (1)$$

or

$$Z_{I-1} \cdot M_i - X_{I-1} = X_I - Z_I \cdot M_i = E_{MI} \quad (2)$$

If condition (1) is met, the positive and negative values of the maximum deviations of the corrected parts of the nonlinear transformation characteristic from the linear characteristic at the boundaries of the section parts are ensured to be equal, and the following expression is obtained for the calculation of the correction coefficient:

$$M_i = (X_I + X_{I-1}) / (Z_I + Z_{I-1}) \quad (3)$$

In these expressions:

Z_{I-1} and X_{I-1} – lower limit values corresponding to the output and input quantities of the i-th segment of the transformation characteristic;

Z_I and X_I are the upper limit values corresponding to the output and input quantities of the i-th segment of the transformation characteristic.

By substituting expression (2) in (1), the following expressions are obtained for the calculation of the upper limit values of the sections:

$$Z_I = Z_{I-1} \cdot (X_I - E_{MI}) / (X_{I-1} + E_{MI}) \quad (4)$$

Equation (4) can be solved by using the substitution of $Z_I = f(X_I)$ into a one-variable equation and applying non-linear equation solving methods or iteration methods.

X_{I-1} and E_{MI} , involved in equation (3), are known because the start and end of the operational range of each MS as well as $E_{M_{BB}}$ (maximum allowable error) are known in advance.

After some mathematical transformations, from the expression (4) by the method of multiplicative correction, the following expression for E_{MI} is obtained for calculating the maximum value of the linearization error in the range of $[Z_{I-1}, Z_I]$.

$$E_{MI} = 0.5 \cdot [(Z_I - Z_{I-1}) \cdot M_i - (X_I - X_{I-1})] \quad (5)$$

3 Algorithmic Correction Method using a DATA table

When applying the linearization method using the input-output data table of the MS, the process of dividing the transformation characteristic into segments is performed by sequentially selecting a pair of input-output quantities from the table. For this purpose, the first pair ($X_{1A} = X_1$, $Z_{1A} = Z_1$) from a series of input-output quantities (N_1) is accepted as the lower limit value of each section.

The upper limit value (X_{1Y} , Z_{1Y}) of the first segment is determined by sequential selection from the series of subsequent data pairs in the table based on the proposed algorithm.

Thus, when applying the multiplicative linearization method, the second pair of input- output quantities (X_2 , Z_2) and the linearization error are calculated for this part:

$$E_{M1} = 0.5 \cdot [(Z_2 - Z_1) \cdot M_1 - (X_2 - X_1)] \quad (6)$$

Here:

$M_1 = (X_2 + X_1) / (Z_2 + Z_1)$ is the multiplicative correction coefficient of the temporary, first part of the partition.

Then the condition $E_{M1} < E_{M_{BB}}$ is checked. $E_{M_{BB}}$ – is the maximum allowable value of the linearization error, given in the condition of the problem.

If the condition $E_{M1} < E_{M_{BB}}$ is satisfied, the third pair of data from the table (X_3 , Z_3) is selected as the upper limit value of the first part, and by calculating M_2 and E_{M2} , $E_{M2} < E_{M_{B.B}}$ is checked.

The process of selecting the pair of upper limit values of the first segment from the table in this manner is continued until $E_{MI} > E_{M_{BB}}$ is taken, and the upper limit value of the first part X_{1Y} is the data pair before the last taken:

$$M_{11} = (X_{1A} + X_{1Y}) / (Z_{1A} + Z_{1Y}) \text{ and } E_{M11} = 0.5 \cdot [(Z_{1Y} - Z_{1A}) \cdot M_{11} - (X_{1Y} - X_{1A})] \quad (7)$$

is calculated. Naturally, in this case, condition $E_{M11} < E_{M_{B.B}}$ will be satisfied.

The upper limit value of the first part is considered as the lower limit value of the second part ($X_{2A} = X_{1Y}$, $Z_{2A} = Z_{1Y}$), and the upper limit values of the second part (X_{2Y} and Z_{2Y}) are determined by searching for the same rule.

In this case:

$$M_{22} = (X_{2A} + X_{2Y}) / (Z_{2A} + Z_{2Y})$$

and

$$E_{M22} = 0.5 \cdot [(Z_{2Y} - Z_{2A}) \cdot M_{22} - (X_{2Y} - X_{2A})] \quad (8)$$

Here:

M_{22} – the multiplicative correction factor of the 2nd section;

X_{2A} and Z_{2A} – a pair of lower boundary values of the 2nd section;

X_{2Y} and Z_{2Y} are a pair of upper boundary values of the 2nd section fragment.

Thus, the transformation characteristic given in the tabular form of the MS is divided into parts satisfying the previously given condition and its parameters are determined.

The obtained mathematical expressions can be written in a generalized way for any partition fragment (K) as follows:

$$M_{KK} = (X_{KA} + X_{KY}) / (Z_{KA} + Z_{KY})$$

and

$$E_{M_{KK}} = 0.5 \cdot [(Z_{KY} - Z_{KA}) \cdot M_{KK} - (X_{KY} - X_{KA})] \quad (9)$$

The scheme of the division algorithm into segments for multiplicative correction of the transformation characteristic given in the tabular form of the MS is shown in fig. 2 is shown.

In the block diagram of the algorithm:

block 1 starts;

block 2 – input the number, and values of the data pair given in the form of a table containing input and output quantities, the given value of the linearization error: $n, X(n), Z(n), E_{BB}$;

block 3 – the number of the initial pair of input-output values taken from the table as the lower limit of the first segment $I = 1$ and J – the serial number of the partition segments.

block 4– assignment of the current input- output value in the table to the lower limit value of the segment: $XA(I) = X(I); ZA(I) = Z(I)$;

block 5 – increment the number of the current input-output value pair for the purpose of finding the upper limit value of the current section: $II = I+1$;

block 6 – calculation of the multiplicative correction coefficient of the current partition: $M(II)=(XA(I)+ X(II))/((ZA(I)+ Z(II))$;

block 7 – calculation of the linearization error for the current segment: $E(II)=0.5 \cdot [(Z(II)-Z(A(II)) \cdot M(II)-(X(II) - XA(I))]$;

block 8 – comparing the linearization error obtained from the calculation for the current section segment with the given value that can be omitted: $E(II) < E_{BB}$? If this condition is not met, return to block 5;

block 9 – if the condition $E(II) < E_{BB}$ is met, the assignment of $X(II)$ to the upper limit value of the current section: $XY(II) = X(II), ZY(II) = Z(II)$; block 10 – printing of the pair of the current value of the EI and the upper boundary values of the current section: $II, XY(I); ZY(I)$;

block 11 – the number of the pair of input- output values taken from the table as the lower limit value of the next segment by increasing the current value of the UI corresponding to the upper limit value of the current section by 1 unit $= J+1$; block 12 – acceptance of the pair of upper boundary values of the current partition as the lower boundary value of the next fragment: $XA(I) = XY(I), ZA(I) = ZY(I)$;

block 13 – checking that all pairs of values given in the form of a table are used: $I < n$?

block 14 – if not all of the given pair of values have been used, then return to block 4. Otherwise, the cycle ends.

The mathematical model of the multiplicative correction process of the transformation characteristic given in the tabular form of the MS is as follows:

$$Z_{KI} = L_I(Z) \cdot Z \cdot M_I \quad (10)$$

Here:

$L_I(Z)$ is a logical function.

The digital measurement result Z obtained at the output of the OP $[Z_{I-1}, Z_I]$ falls into the interval $L_I(Z) = 1$, otherwise

$L_I(Z) = 0$ takes value.

The functional-structural model of the multiplicative correction process is shown in Fig. 3 is shown.

Here:

$I_0(Z)$ – transmission of the measurement result for carrying out comparison and calculation operations;

$I_1(S; Z_I); I = 1, S$ – storage of the boundary values of the partition fragments of the nonlinear characteristic;

$I_2(Z_i)$, $I_5(M_i)$, $I_7(Z_{ki})$ – transmission of boundary values of partition segments for comparison with the output quantity of MS; transferring the numerical value of the multiplicative correction coefficient and the corrected measurement result to the corresponding modules;

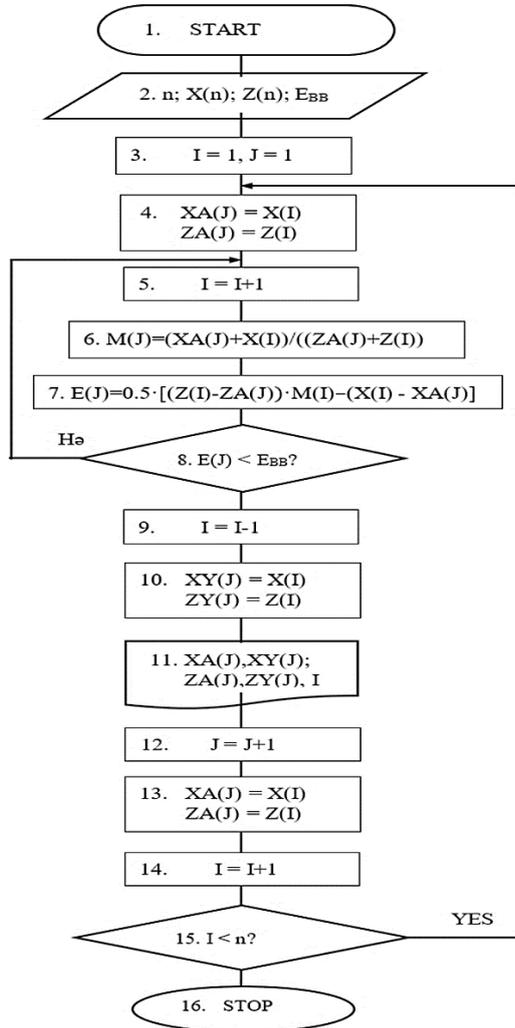


Fig. 6. Transformation characteristics

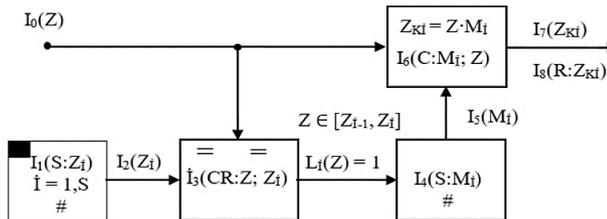


Fig. 7. Functional-Structural model of a multiplicative correction

$I_3 (CR: Z; Z_i)$ – comparing the output quantity of the MS with the Z_i boundary values of the partitions;

$I_4 (S: M_i)$; $I = 1, N$ – storage of the numerical values of the multiplicative coefficients for the sections of the nonlinear characteristic;

$I_6 (C: M_i; Z)$ – performing the multiplication operation between the multiplicative M_i coefficients and the measurement result Z ;

Z_{ki} – the corrected value of the measurement result;

$I_8 (R: Z_{KI})$ – a digital indication of the corrected value of the measurement result in the MS.

5 Conclusions

In the article, the proposed algorithmic correction method, which is based on the processing of digital measurement results, solves the problems of automatic correction without placing special restrictions on the degree of nonlinearity, and of deviation from the linear characteristic of the nonlinear transformation characteristic given in the form of the input-output data table of the measuring channels in the measurement system.

At the same time, with the application of the multiplicative correction method, an important issue such as the distribution of computing resources among the functional blocks of the information measurement and control systems is solved.

References

1. Abbasov V.: Algorithmic methods of linearization characteristics of measuring systems transformation. In: Proceedings of the National Aviation University, pp. 62-66. National Aviation University Publishing House, Kyiv (2018).
2. Abbasov V.: Multiplicative method for linearization characteristics of measuring systems transformation. Black sea scientific journal of academic research 42(5), 40–45 (2018).
3. Abbasov V.: Additivnyy sposob linearizatsii kharakteristiki preobrazovaniya izmeritel'nykh sistem. In: 1st International Conference: Modern Information, Measurement and Control Systems: Problems and Perspectives (MIMCS'2019), pp. 27. ASOIU Publishing House, Baku (2019).
4. Aliyev, T., Seidel, L.: Avtomaticheskaya korrektsiya pogreshnostey tsifrovyykh izmeritel'nykh priborov. 1st edn. Energiya, Baku (1975).
5. Radevich, R., Pavlov-Kagadeev, M., Milivoevich, N.: Analogovaya linearizatsiya rabochey kharakteristiki Pt100. Serbskiy Zhurnal Elektrotekhniki 12(3), 345–357 (2015).
6. Tuz, Y.: Strukturnyye metody povysheniya tochnosti izmeritel'nykh ustroystv. Kyiv: Vishcha shkola. Kyiv (1976).
7. Knuth, D.: The Art of Computer Programming, Vol. 1: Fundamental Algorithms. 3rd edn . Addison Wesley Longman Publishing Co. Inc. USA (1997).
8. Shturnel, Y., Kamenskii, M.: Approksimatsiya funktsiy i tsifrovaya linearizatsiya v sensorykh sistemakh.. In: At & p plus2 2006 senzorové systémy a spracovanie signálov, pp. 13-17. HMH s.r.o. Tavarikova osada 39 841 02 Bratislava 42 IČO: 31356273, Bratislava (2006).

УЛУЧШЕНИЕ ИЗМЕРЕНИЯ ВЯЗКОСТИ РАСТВОРИМЫХ И ЖИДКИХ ПРОДУКТОВ

Эргашева Камола Насриддиновна

доктрант кафедры автоматизации производственных процессов Ташкентского государственного университета Республика Узбекистан, г.Ташкент

Аннотация: В статье изложено современное состояние и проблемы коррекции и автоматического контроля состава растворимых жидких продуктов.

Ключевые слова: композиция, коррекция, автоматическое управление, вязкость, вращение, вибрация, интеллектуальный.

Усманова Х.А., Тургунбаев А., Гадов М. Метрология и проблемы влагометрии твердых и сыпучих материалов.....	256
Axmedov M.Ya., Bekmurotov Ch.A., Omanov O'.X. Oziq-ovqat mahsulotlarini ishlab chiqarish korxonalarida texnologik jarayonlarning metrologik tahlili.....	260
Махмудов Р.Я. Энергия истеъмолини назорат қилиш: кўп таърифли ҳисоблагичларнинг афзалликлари.....	264
Rakhmatullaev S.A. The significance of measuring the indicator of hydrogen ion activity (ph) in products in industrial sectors.....	268

ИНТЕЛЛЕКТУАЛЬНАЯ МЕТРОЛОГИЯ. МИРОВОЙ ОПЫТ В ВОПРОСАХ МЕТРОЛОГИИ И ВЫСОКОТОЧНЫХ ИЗМЕРЕНИЙ

Bekirova L., Bunyatova E. Intelligent Complex Monitoring System using Unmanned Aerial Vehicles.....	273
Aghazada F.R., Bekirova L.R. AI based Approaches for Real-Time Air Quality Monitoring in Urban Enviroments.....	279
Bekirova L., Huseynov S. Intelligent control system for product quality.....	288
Матякубова П.М., Муминов Х.Д. Анализ современных методов контроля уровня.....	296
Машарипов Ш.М. Научные основы оценивания неопределённости измерений физико-химических величин.....	300
Panjiyev U., Mo'minov N.SH. O'zbekiston Respublikasida putur yetkazmaydigan nazorat tizimini va uni rivojlantirish.....	304
Ismailov I.M., Agamaliyeva J.A. The Computer Models Appling at Flight Information Processing.....	309
Mammadov R., Mammadov U., Khidirov A., Suleymanova S. Increasing the Accuracy of the Estimation of the Capacity of a Drill Rig by Using New Information Technologies.....	315
Mansurov T.M., Yusifbayli N.A., Kerimova M.I., Mammadov R.S. The Analysis of the Security and Information Capacity of Protocols with Single and Multidimensional Quantum Systems.....	322
Abbasov V., Khudaverdiyeva M., Aliyev K. Transformation Characteristics of Measurement Systems using a DATA table with an Algorithmic Correction Method.....	330
Эргашева К.Н. Улучшение измерения вязкости растворимых и жидких продуктов.....	336
Хайруллаев М.Н., Бойматов Н.Т., Ҳақимов О.Ш. Метрология қонунчилигида назарда тутилган усулларни халқаро стандартлар талабларига мувофиқлаштириш.....	340
Nazarbayeva B.A., Sheina N.Y. Yumshoq metrologiya tushunchasi va mohiyati.....	350