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

4 (436)

JULY – AUGUST 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 4, Number 436 (2019), 79 – 85 **https://doi.org/10.32014/2019.2518-170X.100**

UDC 004.6:681.121.8:006.91:622.034.822

S. S. Zhussupbekov[1], L. K. Ibrayeva[1], S.G. Khan[1], P. Komada[2]

[1]Almaty university of Power Engineering and Telecommunications, Almaty, Kazakhstan,
[2]Lublin polytechnic university, Lublin, Poland.
E-mail: zhussupbekovs@mail.ru, ibrayeva_lk@mail.ru, khan.sv2011@gmail.com, p.komada@pollib.pl

THE EXPERIENCE OF APPLICATION OF MEASUREMENT UNCERTAINTY EVALUATION METHODS IN CALIBRATION

Abstract. The article reviewed and analysed two methods for estimating the uncertainty of the relative error of an electromagnetic flow meter (GUM and Monte-Carlo) during its calibration at the developed laboratory equipment of a mobile geotechnological information and metrological complex (GIMC). Less commonly, the Monte-Carlo method has shown high confidence in estimating measurement uncertainty and can be considered as a practical alternative to the GUM method for estimating uncertainty.

Keywords: GUM and Monte-Carlo uncertainty estimation methods, calibration of an electromagnetic flow-meter, geotechnological information-metrological complex.

Problem statement. In underground leaching of uranium, a large number of technical flowmeters are applied to consider the flow of working solutions into the feed wells (in average, the number of flow-meters in a single mine varies from several hundreds to thousands).

To control the technical condition of the flowmeters it is necessary to carry out their periodic calib-ration. The existing calibration procedure requires the dismantling of the flowmeters from work positions. All this significantly affects the workflow and leads to an increase in production costs.

The authors conduct the research work on a state grant on the "Development and testing of a mobile Geotechnological Information-Metrological Complex (GIMC) to increase the efficiency of uranium mining" theme.

The purpose of the work is to develop GIMC for calibration of flowmeters, which allows to increase the economic efficiency of uranium mining processes using the underground well leaching method with application of modern methods for evaluation the measurement uncertainty. The concept of uncertainty is widely introduced in various areas of human activity in Kazakhstan [1].

The relevance of scientific research work is to develop a new calibration methodology for flowmeters with the evaluation of the uncertainty of their measurement and the creation of the mobile GIMC for the calibration of flowmeters without removing them from the operating site. And also, in the development of a program for calculating the uncertainty of measurement of technical flowmeters, based on the International "Guide to the Expression of Uncertainty in Measurement" (GUM-1993) [2], and its appli-cation in the metrological practice of the Republic of Kazakhstan. The Guide (GUM-1993) are an extre-mely important document. It unifies the methods for calculating the measurement uncertainty and there-fore allows to compare the measurement results regardless of who made the measurements and where.

After this document was published, it is actively applied in the calibration measuring instruments [3], and was repeatedly audited, which provides the metrological community the opportunity to correct this document [4, 5].

"Guide to the Expression of Uncertainty in Measurement" (GUM-1993) considers two approaches to quantifying measurement uncertainty evaluation: GUM method and Monte-Carlo simulation method. Both of these methods are applied by the authors in the task of evaluation the uncertainty of measuring a Coriolis flowmeter applied as an etalon (standard) in GIMC [6].

In GUM method the main stages in evaluation of uncertainty include the formulation of the measurement task and the calculations. At the stage of formulation of the measurement task the following tasks are conducted: determination of the output (measured) value; identification of input values on which the output value depends; drawing up a measurement model. The calculation stage consists of calculating the mean of the output value, this mean is taken as the value of the estimated output value; standard deviation of the output value taken as standard uncertainty; coverage interval containing the output value with a given probability of coverage.

The algorithm for evaluation the uncertainty using this method is given in [1].

The idea of Monte-Carlo method is as follows: each time the measurement function is calculated, the generated random values of input variables are substituted into it, varying around their nominal value within the uncertainty interval in accordance with the distribution law.

To apply Monte-Carlo method, it is necessary to select the number *m* of model estimation that you need to produce, and the level of confidence *p*. It is best to choose the value of *m* a large enough compared to *1/(1-p),* (for example, exceeding it 10^6 times). The algorithm of Monte-Carlo method is given in [7].

The research. In this article the authors explore the application of these methods to evaluate the measurement uncertainty of a working electromagnetic flowmeter (EMF).

The evaluation of the measurement uncertainty by GUM method is conducted on the basis of the standard of the Republic of Kazakhstan "Method of calibration of electromagnetic flowmeters" [8]. This standard regulates the evaluation of the uncertainty of the relative error of an EMF and offers the measurement model of the following type:

$$\delta = \frac{Q_r - Q_p}{Q_p} \times 100, \quad (1)$$

where Q_r is the result of flow measurement by an EMF; Q_p is the result of flow measurement with a calibration equipment (CE) (a standard Coriolis flowmeter in our work).

The calculation of the measurement uncertainty evaluations includes the evaluations of the uncertainty for type *A* and type *B*.

The calculation of type *A* uncertainty includes the statistical processing of the measurement results of the EMF and the CE: the calculation of the mean, variance and standard deviation.

The standard uncertainty of the EMF relative error on type *A* is found by the formula:

$$u_A(\delta) = \frac{\sigma(\delta)}{\sqrt{3}}, \quad \text{where} \quad \sigma(\delta) = \frac{\sigma(\Delta)}{\sqrt{n} \cdot Q_p}; \quad (2)$$

where $\sigma(\Delta)$ is the standard deviation of the EMF absolute error; *n* is the number of measurements.

The type *B* uncertainty calculation includes:

1) the uncertainty of the readings of the electromagnetic flowmeter Q_r, due to the discreteness of the readings of the EMF d_r assuming the rectangular probability distribution:

$$u_{B1}(Q_r) = \frac{d_r}{2\sqrt{3}}, \quad (3)$$

2) the uncertainty of the CE readings is indicated in the document on it. In case of specifying in the document on CE only its errors Δp, assuming a rectangular probability distribution:

$$u_{B2}(Q_p) = \frac{\Delta p}{\sqrt{3}}, \quad (4)$$

where Δp is the CE error;

3) the uncertainty of CE indications due to the discreteness of its testimony, in the assumption of a rectangular probability distribution:

$$u_{B3}(Q_p) = \frac{d_p}{2\sqrt{3}}. \quad (5)$$

The total uncertainty of type *B* of EMF relative error is calculated by the formula:

$$u_B(\delta_Q) = \sqrt{C_{Qr}^2 u_{B1}^2(Q_r) + C_{Q_p}^2 (u_{B2}^2(Q_P) + u_{B3}^2(Q_P))}\,, \tag{6}$$

where C_{Qr} is the sensitivity coefficient of the EMF:

$$C_{Qr} = \frac{100\%}{Qp}; \tag{7}$$

where C_{Qp} is the sensitivity coefficient of the CE:

$$C_{Qp} = -\frac{Q_r 100\%}{Q_p^2}. \tag{8}$$

To calculate the total standard uncertainty of the EMF relative error, the formula is applied:

$$u_c(\delta_Q) = \sqrt{u_a^2(\delta_Q) + u_{B\Sigma}(\delta_Q)}\,. \tag{9}$$

The calculation of the expanded uncertainty of the EMF relative error is fulfilled applying the formula:

$$U_c(\delta_Q) = k \cdot u_c(\delta_Q). \tag{10}$$

Based on the above formulas the algorithms and programs have been developed for calculating the relative error of the EMF by two methods. The programs are implemented in the LabView graphical software.

GUM method calculation. The initial data are the readings of the EMF and the Coriolis flowmeter (as CE) received on the laboratory equipment of the GIMC. The experiment means the measurement of the flow value of $0.95Q_{max}$, dm^3/h (Q_{max} is the maximum value of the measurement range of the calibrated EMF) by the calibrated flowmeter – Q_r and by the Coriolis flowmeter - Q_p; the number of measurements is 11.

To determine the type *B* uncertainty according to the formulas (3-5), the values of the relative error and discreteness of the EMF readings and the CE are specified.

As a result of the calculation a measurement uncertainty budget has been compiled, into which the uncertainty components of the EMF relative error calculated by the above formulas (3–10) are entered. The program interface with the results of calculating the budget uncertainty of the EMF relative error is shown in figure 1.

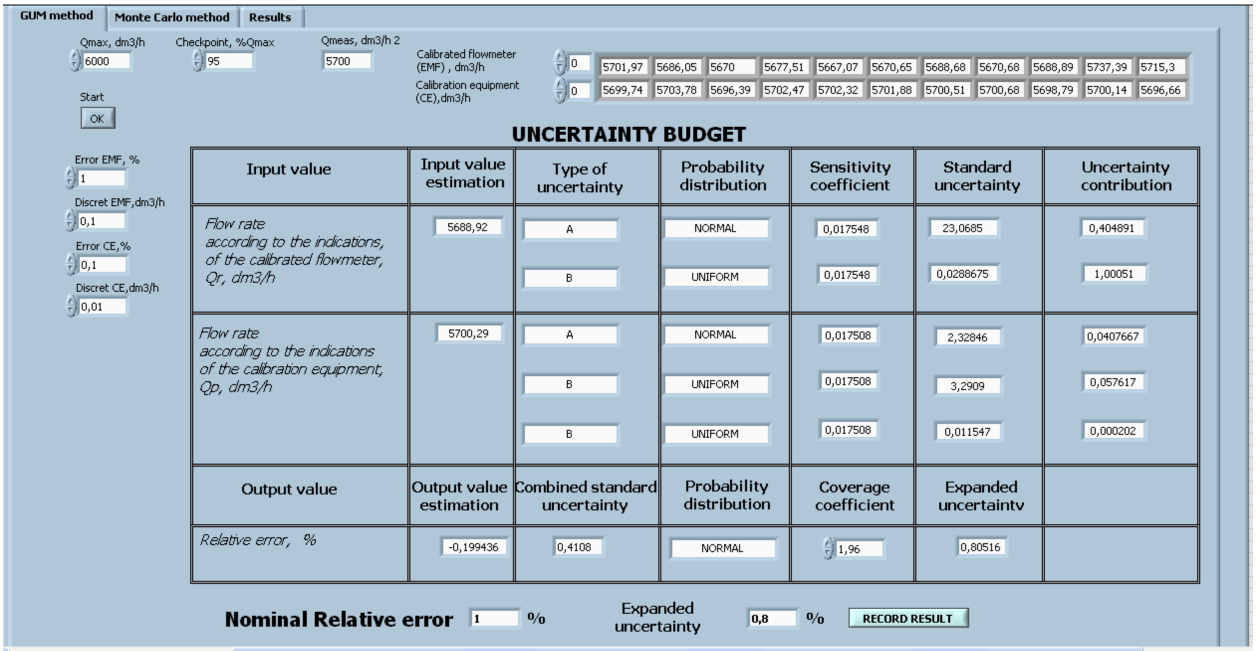

Figure 1 – The uncertainty budget of the EMF relative error

Monte-Carlo method calculation. The next stage of the research work was to apply Monte-Carlo method to evaluation the uncertainty of the EMF relative error. The modelling of the process of evaluation the uncertainty of the EMF relative error was performed as follows:

a) two arrays of random numbers, obeying the uniform distribution laws, of volume m=10^6 for input variables are generated:

- Q_r – the flow measurement results by the electromagnetic flowmeter;
- Q_p – the flow measurement results by the calibration equipment (Coriolis flowmeter);

b) an array of output value– the EMF relative error δ was generated;

c) estimates of the parameters of the obtained distribution are calculated:

- mean value: $M(\delta) = \frac{\sum_{1}^{11} \delta_i}{11}$; where δ_i is calculated by the formula (1);
- total standard uncertainty: $u_c(\delta) = \sqrt{\frac{\sum_{1}^{11} (\delta_i - M(\delta))^2}{10}}$;
- expanded uncertainty: $U(\delta) = \frac{1}{2}[\delta_{975000} - \delta_{25000}]$;
- coverage coefficient: $k = U(\delta)/u_c(\delta)$;

d) obtained measurement result: $\delta \pm U(\delta)$ %; $p=0.95$.

The program interface with the calculation results of the EMF relative error uncertainty by Monte-Carlo method is shown in figure 2.

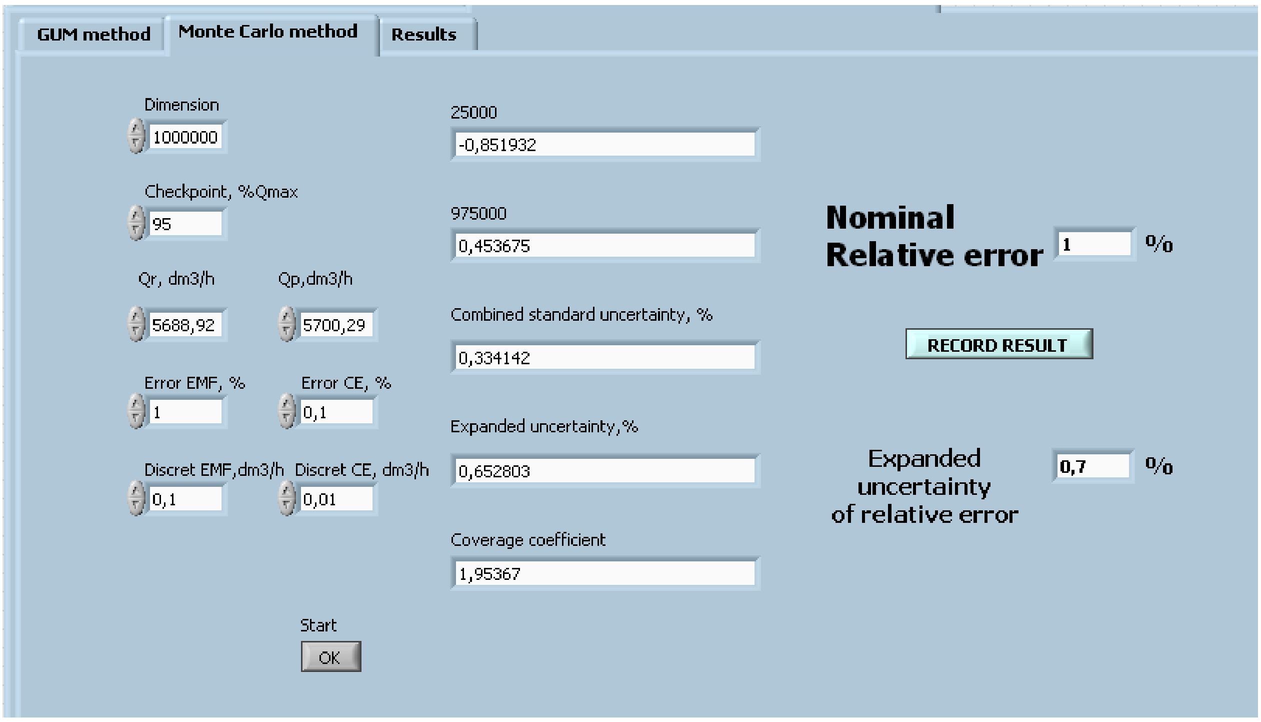

Figure 2 – The calculation results of the EMF relative error uncertainty by Monte-Carlo method

The analysis of the received results. Ten experiments were carried out for four nominal values of the measured flow (calibration points). The processing of the obtained experimental data was carried out by both methods - GUM and Monte-Carlo. The uncertainty values of the EMF relative error $U(\delta)$ for nominal value of 95% Q_{max} are given in table 1.

Table 1 – Experimental data obtained by GUM and Monte-Carlo methods for nominal value of 95% Q_{max}

	Method GUM									
flow Q	5684,24	5695,98	5711,02	5700,13	5691,16	5691,16	5709,97	5696,67	5693,15	5693,95
δmax_permissible %	1	1	1	1	1	1	1	1	1	1
uncertainty U(δ) %	0,832	0,805	0,744	0,964	0,619	0,63	0,726	0,781	0,837	0,666
coverage coefficient_k	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96
	Method Monte-Carlo									
flow Q	5700,02	5700	5699,98	5699,98	5699,98	5699,98	5700,01	5700	5699,99	5699,99
δmax_permissible %	1	1	1	1	1	1	1	1	1	1
uncertainty U(δ) %	0,653	0,653	0,655	0,655	0,654	0,652	0,654	0,655	0,654	0,655
coverage coefficient_k	1,954	1,954	1,954	1,952	1,953	1,952	1,953	1,953	1,952	1,952

According to the table, the graphs of the dependence of the relative error uncertainty on the number of the experiment (x-axis is the number of the experiment) obtained by both methods were plotted (figure 3).

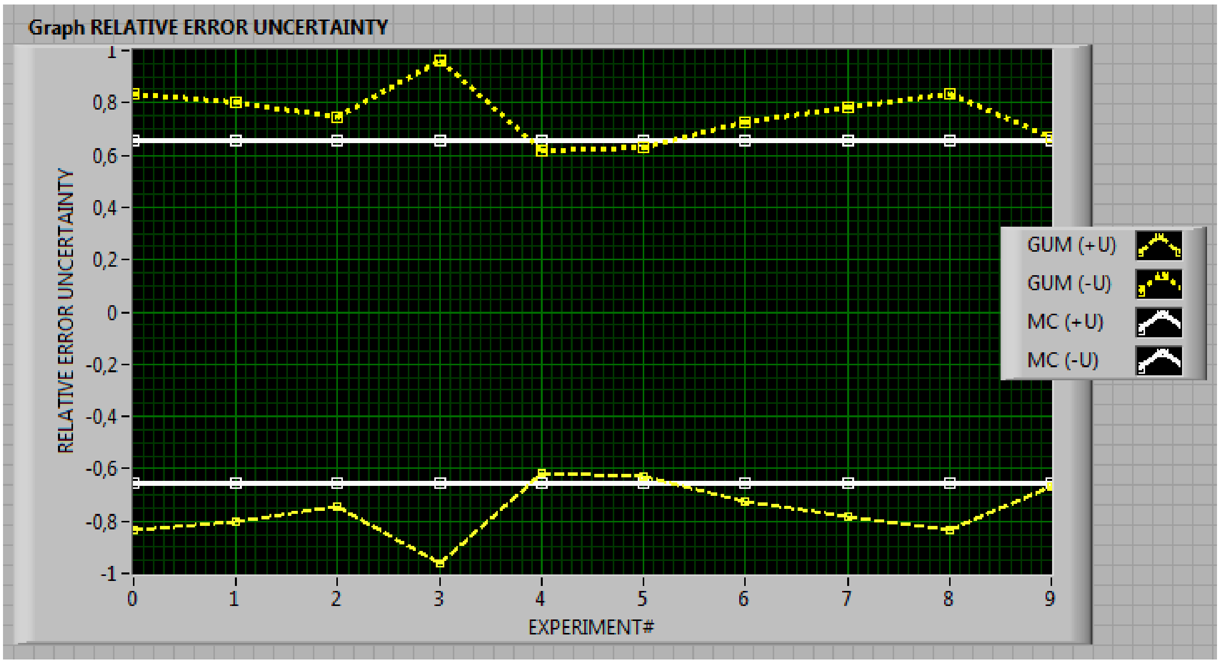

Figure 3 – The graphs of the dependence of the relative error uncertainty on the number of the experiment

The graphs received by Monte-Carlo method (solid lines) show a constant value of the uncertainty scatter of the relative error within ±0,65%. The graphs received by GUM method (dotted lines) show variable value of scatter of uncertainty of the relative error within ±0.9%. In this case, the limit of permissible relative error of EMF is equal ± 1%.

The received graphs let make the conclusions:

1. There are minor differences in the results of calculations by both methods.

2. GUM uncertainty values exceed Monte-Carlo values but do not exceed the permissible respective error of ± 1%. That is Monte-Carlo method provides high accuracy in evaluation of the measurement uncertainty.

The results of applying the methods of GUM and Monte-Carlo for the four test points during the calibration of the electromagnetic flowmeter are shown in table 2 (the estimations of the relative error δ, the expanded uncertainty U, the repeatability (convergence) limit u_r, the coverage interval CI).

From a comparative analysis of the data in Table 2 follow the conclusions:

1. Differences between estimates of the measured value (of the relative error) are not available; the differences of the expanded uncertainties are to 18.8%; the differences of the repeatability are to 16.9%.

Table 2 – Comparative table of the calculated values for the four test points by GUM and Monte-Carlo methods

Value of the verified point	The estimated parameter	By GUM	By Monte-Carlo	Difference, %
25% of Q_{max}	δ, % U u_r CI	0.007 0.758 0.379 [-0.751; 0.765]	0.007 0.658 0.337 [-0.651; 0.665]	0 13 11 13
50% of Q_{max}	δ U u_r CI	-0.003 0.790 0.395 [-0.793; 0.787]	-0.003 0.651 0.333 [-0.654; 0.648]	0 17.5 15.6 17.5
75% of Q_{max}	δ U u_r CI	0. 01 0.755 0.377 [-0.745; 0.765]	0.01 0.655 0.335 [-0.645; 0.665]	0 13.2 11.2 13.2
95% of Q_{max}	δ U u_r CI	0.005 0.805 0.402 [-0.8; 0.81]	0.005 0.653 0.334 [-0.653; 0.658]	0 18.8 16.9 18.6

2. For all four verified points according to GUM method, the coverage intervals were wider (maximum by 18.6%) and shifted to the right (to the area of large values). However, at all test points the coverage intervals in both methods do not exceed ± 1%.

3. Monte-Carlo method gives more accurate values of estimated parameters, which is most likely due to the large number of generated values (is equal to106).

4. Monte-Carlo calculation takes more time (due to sorting and processing of large arrays). But it can be performed by less qualified personnel (no deep knowledge of mathematics is required).

5. Monte-Carlo method can be considered as a practical alternative to GUM uncertainty evaluation method.

С. С. Жусупбеков[1], Л. К. Ибраева[1], С. Г. Хан[1], П. Комада[2]

[1]Алматы энергетика және байланыс университеті, Алматы, Қазақстан,
[2]Люблин политехникалық университеті, Люблин, Польша

ӨЛШЕУ АНЫҚТАЛМАҒАНДЫҒЫН БАҒАЛАУ ӘДІСТЕРІН КАЛИБРЛЕУ ӨТКІЗГЕНДЕ ҚОЛДАНУ ТӘЖІРИБЕСІ

Аннотация. Мақалада әзірленген геотехнологиялық ақпараттық және метрологиялық кешенінің зертханалық жабдықтарында электрмагниттік шығынөлшеуіштерге калибрлеу өткізгенде олардың салыстырмалы қателігінің анықталмағандығын бағалаудың екі әдісіне (Монте-Карло және GUM) шолу өткізіледі және анализденді. Монте-Карло әдісінің өлшеу анықталмағандығын бағалауының жоғары жинақталуы бар және бұл әдіс өлшеу анықталмағандығын бағалаудың GUM әдісінің альтернативасы болып табылады.

Түйін сөздер: анықталмағандықты бағалаудың GUM және Монте-Карло әдістері, электрмагниттік шығынөлшеуішті калибрлеу, геотехнологиялық ақпараттық және метрологиялық кешен.

С. С. Жусупбеков[1], Л. К. Ибраева[1], С. Г. Хан[1], П. Комада[2]

[1]Алматинскиц университет энергетики и телекоммуникаций, Алматы, Казахстан,
[2]Люблинский политехнический университет, Люблин, Польша

ОПЫТ ПРИМЕНЕНИЯ МЕТОДОВ ОЦЕНИВАНИЯ НЕОПРЕДЕЛЕННОСТИ ИЗМЕРЕНИЙ ПРИ КАЛИБРОВКЕ

Аннотация. В статье выполнен обзор и анализ двух методов (Монте-Карло и GUM) оценивания неопределенности относительной погрешности электромагнитного расходомера при калибровке на разработанном лабораторном оборудовании мобильного геотехнологического информационно-метрологического комплекса. Метод Монте-Карло показывает высокую сходимость в оценке неопределенности измерения и может рассматриваться как альтернатива методу GUM оценки неопределенности.

Ключевые слова: методы оценивания неопределенности GUM и Монте-Карло, калибровка электромагнитного расходомера, геотехнологический информационно-метрологический комплекс.

Information about authors:

Zhussupbekov S. S., PhD, Professor of Almaty гniversity of Power Engineering and Telecommunications; zhussupbekovs@mail.ru; https://orcid.org/0000-0003-3220-713X

Ibrayeva L. K., PhD, Professor of Almaty university of Power Engineering and Telecommunications; ibrayeva_lk@mail.ru; https://orcid.org/0000-0002-8342-6685

Khan S. G., PhD, Professor of Almaty university of Power Engineering and Telecommunications; khan.sv2011@gmail.com; https://orcid.org/0000-0002-7918-6690

Komada P., PhD, assistant Professor, Deputy Director for General Affairs of Institute of Electronics and Information Technology of the Lublin university of technology; p.komada@pollib.pl; https://orcid.org/0000-0002-9032-9285

REFERENCES

[1] Piriverdiyev I.A., Sarbopeyeva M.D., Asadova G.Sh. Analysis of modeling and decision-making processes for drilling wells under uncertainty // News of the National academy of sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. 2019. Vol. 1(433). P. 23-31. https://doi.org/10.32014/2019.2518-170X.2

[2] Guide to the Expression of Uncertainty in Measurement / First Edition. ISO (GUM: 1993). Switzerland, 1993.

[3] Expression of measurement uncertainty during calibrations. EAL-R2. Rev. 1. April 1997. DKD-3 (German Calibration Service).

[4] Bich W., Cox M.G., Harris P.M. Evolution of the "Guide to the Expression of Uncertainty in Measurement" // Metrologia. 2006. 43. P. 161-166.

[5] Rabinovich S.G. Towards a new edition of the "Guide to the Expression of Uncertainty in Measurement" // Accreditation and Quality Assurance. 2007. 12(11). P. 603-608.

[6] Khan S.G., Tashibayeva A.E., Bukayeva G. Development of program for estimating of Corolis flowmeters' measurement uncertainty // Vestnik AUPET (ISSN 1999-9801). Almaty, 2018. 1(40). P. 34-39.

[7] JCGM 101:2008. Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement". Propagation of distributions using a Monte-Carlo method.

[8] SD RK 2.328-2015. Electromagnetic flowmeters. Method of calibration: Committee for Technical Regulation and Metrology of the Republic of Kazakhstan. Astana, 2015.

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 22.07.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,7 п.л. Тираж 300. Заказ 4.

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