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

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

№1
2026

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

CENTRAL ASIAN ACADEMIC
RESEARCH CENTER

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES

1 (475)

JANUARY – FEBRUARY 2026

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, 2026

The scientific journal News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences has been indexed in the international abstract and citation database Scopus since 2016 and demonstrates stable bibliometric performance.

The journal is also included in the Emerging Sources Citation Index (ESCI) of the Web of Science platform (Clarivate Analytics, since 2018).

Indexing in ESCI confirms the journal's compliance with international standards of scientific peer review and editorial ethics and is considered by Clarivate Analytics as part of the evaluation process for potential inclusion in the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (AHCI).

Indexing in Scopus and Web of Science ensures high international visibility of publications, promotes citation growth, and reflects the editorial board's commitment to publishing relevant, original, and scientifically significant research in the fields of geology and technical sciences.

«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылымиметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

Научный журнал «News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences» с 2016 года индексируется в международной реферативной и наукометрической базе данных Scopus и демонстрирует стабильные библиометрические показатели.

Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

Индексирование в Scopus и Web of Science обеспечивает высокую международную востребованность публикаций, способствует росту цитируемости и подтверждает стремление редакционной коллегии публиковать актуальные, оригинальные и научно значимые исследования в области геологии и технических наук.

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: «Central Asian Academic Research Center» LLP (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Communications of the Republic of Kazakhstan Nº KZ50VPY00121155, issued on 05.06.2025
Thematic scope: *geology, hydrogeology, geography, mining and chemical technologies of oil, gas and metals*
Periodicity: 6 times a year.
http://www.geolog-technical.kz/index.php/en/

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)
Меншіктеуші: «Орталық Азия академиялық ғылыми орталығы» ЖШС (Алматы қ.).
Қазақстан Республикасының Ақпарат және коммуникациялар министрлігінің Ақпарат комитетінде 05.06.2025 ж. берілген № KZ50VPY00121155 мерзімдік басылым тіркеуіне қойылу туралы куәлік.
Тақырыптық бағыты: *геология, гидрогеология, география, тау-кен ісі, мұнай, газ және металдардың химиялық технологиялары*
Мерзімділігі: жылына 6 рет.
http://www.geolog-technical.kz/index.php/en/

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)
Собственник: ТОО «Центрально-Азиатский академический научный центр» (г. Алматы).
Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и коммуникаций и Республики Казахстан № KZ50VPY00121155, выданное 05.06.2025 г.
Тематическая направленность: *геология, гидрогеология, география, горное дело и химические технологии нефти, газа и металлов*
Периодичность: 6 раз в год.
http://www.geolog-technical.kz/index.php/en/

CONTENTS

Abdullaev A.U., Kamberov I.M.
Possibilities of mercury studies in seismic hazard assessment and earthquake forecasting........8

Agzamova I.A., Abdurakhmanov B.M., Normatova N.R., Ermatova Ya.S., Agzamova N.Sh.
Forecast assessment of disturbances and fracturing during development of solid mineral deposits........18

Arystanov M.B., Zhandiyar A.G., Kaipbayev Y.T., Sultanbekova A., Nikam B.R.
A geospatial approach to managing irrigation water resources of the big almaty canal.....32

Babii K., Kiriia R., Smirnov A., Kuttybayev A., Mishchenko T.
Justification of parameters of a steeply inclined tubular conveyor of cyclic-flow technology at a deep open pit in Kryvbas........55

Bryukhanova N.N., Gladkikh V.A., Idigova L.M., Lepekhina Yu.A., Kondratiev V.V.
Engineering control of blast-induced seismicity and environmental safety in underground ore mining under complex geodynamic conditions........74

Evsyukov D.Yu., Pchelintseva S.V., Vakhrusheva I.A., Ermolaeva O.S., Modina M.A.
Geophysical investigation of technogenically disturbed areas for environmental assessment in Southern Russia........90

Galiyev S.Zh., Axanaliyev N.E., Sarsenbayev Y.Ye.
Justification of technological parameters and energy consumption of quarry excavators taking into account the quality of rock preparation for excavation........109

Hryhoriev Y., Lutsenko S., Hryhoriev I., Kuttybayev A., Kuantayev N.
Adaptive modeling of mining schedule using genetic algorithm in a dynamic environment........120

Ismailov V.A., Aktamov B.U., Yodgorov Sh.I., Yadigarov E.M., Avazov Sh.B.
Assessment of the possible seismic risk of residential buildings in the Samarkand region based on a scenario earthquake........135

Ismayilov S.Z., Aliyev I.N., Karimov I.C.
Real-time monitoring and statistical analysis: optimizing sand detection in oil wells.....155

Kazakov A.N., Khakberdiyev M.R., Qurbonov H.A., Turgunov Sh.Sh., Obidov M.I.
Effect of rock mass discontinuities on underground mine stability (Uzbekistan)............170

Kukartsev V.V., Stupina A.A., Khudyakova E.V., Stepantsevich M.N., Matasova I.Yu.
Diagnostics of the structure of crystalline materials of rock formations by the method of thermally stimulated depolarization........182

Medetov Sh.M., Zaidemova Zh.K., Suyungariev G.E.
Oscillatory dynamics of rigging operations in the development of exploration wells......196

Mustapayeva S., Nikolaeva S., Kabanov P., Omarova G., Assambayeva A.
New ammonoid records and gamma-spectrometry in the stratotype of the Beleutian regional substage (Central Kazakhstan) 215

Nurpeissova M., Menayakov K., Aitkazinova Sh., Nukarbekova Zh., Bakyt N.K.
Environmental and industrial safety of subsurface development near a nuclear power plant..231

Obeidat M.A., Shmoncheva Y.Y., Jabbarova G.V.
Immiscible displacement of Herschel–Bulkley fluids in porous media: a modified Buckley–Leverett approach..247

Sakhmetova G.E., Uralov B.K., Brener A.M., Turymbetova G.D., Absamatova Z.
System analysis of scaling problems while designing biogas plants in the context of energy...274

Salikhov T.K., Issayeva Zh.B., Onal H., Akhmetzhanov Zh.B., Atasoy E.
Using GIS technologies and traditional ground-based methods to analyze the vegetation cover of ecosystems in the West Kazakhstan Region...286

Satybaldina D., Teshebayev N., Shmitov N., Kissikova N., Zakarina A.
Methods for improving oil production efficiency using pumping units...........................303

Shalabaeva G.S., Abdimutalip N.A., Koishiyeva G.Zh., Ozler M.A., Toychibekova G.B.
Study of hydrological and geostructural changes in the koskorgan reservoir due to climatic changes..318

Suiintayeva S.Ye., Bakhtybayev N.B., Imangazin M.K., Andagulov D.T., Atageldiyev K.T.
Experience in the use of self-propelled drilling rigs to increase the efficiency of drilling and blasting operations with sublevel mining systems..................................332

Tolesh A.B., Mamitova A.D., Karlykhanov O.K., Tazhieva T.Ch., Kalmakhanova M.S.
Flow regulation of the Syrdarya River at Shardara under energy releases.......................345

Torekhanova M.T., Tleuzhanova G.B., Yeserkegenova B.Zh., Kadyrov Zh.N., Kadyrova B.B.
Innovative technical approaches to the development of automatic control systems for bitumen-chip spreading...362

Tynchenko V.S., Krasovskaya L.V., Ashmarina T.I., Kononenko R.V., Shtyrkhunova N.A.
Geomechanical justification of underground mining technologies for ore deposits in complex rock massifs from the standpoint of nature and resource conservation.............382

Zholtayev G.Zh., Rassadkin V.V., Umarbekova Z.T., Mashrapova M.A., Miniskul S.D.
Formation and development prospects of placer gold deposits in Southern Junggar.......396

NEWS OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC
OF KAZAKHSTAN, SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224–5278
Volume 1.
Number 475 (2026), 362–381

https://doi.org/10.32014/2026.2518-170X.609

UDC 625.8:658.562 (043.3)
IRSTI 30.15.35

©Torekhanova M.T.[1], Tleuzhanova G.B.[1], Yeserkegenova B.Zh.[1], Kadyrov Zh.N.[2*], Kadyrova B.B.[2], 2026.
[1]D. Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan;
[2]«Kadyrov and Partners» Patent Law Office LLP, Almaty, Kazakhstan.
E-mail: kadyrov.1954@mail.ru

INNOVATIVE TECHNICAL APPROACHES TO THE DEVELOPMENT OF AUTOMATIC CONTROL SYSTEMS FOR BITUMEN-CHIP SPREADING

Torekhanova Maral — PhD student, Senior lecturer, D.Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan,
Email: maraltt_1985@mail.ru, https://orcid.org/0009-0004-9993-4037;
Tleuzhanova Gulnur — PhD student, Senior lecturer, D.Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan,
Email: tleuzhan_gulnur@mail.ru, https://orcid.org/0009-0005-0032-8924;
Yeserkegenova Bekzat — PhD, Senior lecturer, D.Serikbayev East Kazakhstan Technical University, Ust-Kamenogorsk, Kazakhstan,
E-mail: glamour_25@mail.ru, https://orcid.org/0000-0002-3719-2582;
Kadyrov Zhannat — Doctor of Technical Sciences, Professor, Director of «Kadyrov & Partners» Patent Law Office LLP, Almaty, Kazakhstan,
E-mail: kadyrov.1954@mail.ru, https://orcid.org/0009-0003-5247-1752;
Kadyrova Bakhyt — Candidate of Pedagogical Sciences, Deputy Director of «Kadyrov & Partners» Patent Law Office LLP, Almaty, Kazakhstan,
E-mail: bakhyt.k2@mail.ru, https://orcid.org/0009-0000-2672-0282.

Abstract. *Relevance***.** The development of a new class of construction and road machinery–bitumen and chippings synchronous spreaders (BCSS)–has introduced new engineering challenges. As performance requirements and surface treatment technologies evolve, existing equipment increasingly fails to meet modern quality standards. Operational experience has revealed significant design limitations in key functional units of BCSS, particularly in bitumen and chippings distribution systems. *Objective.* To improve the efficiency of BCSS through control of the synchronous distribution process of binder and aggregate on road surfaces. *Methods.* The study analyzed BCSS operational conditions and assessed the utilization of its components. Mathematical modeling and experimental testing were used to evaluate the performance of critical system elements. *Results and Conclusions.* A novel dual-loop automatic control system for BCSS is proposed. It consists of a dimensional adjustment loop for the bitumen distributor and a chassis stabilization loop. A functional diagram was developed based on the transfer functions of each component. Stability criteria for both control loops were mathematically defined, and the elastic deformation sensor's ring element in the stabilization loop was analytically evaluated. Experimental results confirmed the feasibility and effectiveness of the proposed system, demonstrating strong performance of the prototype control elements. The findings support the potential of automatic control systems to enhance the precision and reliability of synchronous bitumen and chippings distribution.

Keywords. Bitumen-chip spreading, Automatic control system, Dimensional adjustment loop, chassis position stabilization, Measurement transducer, Actuator

For citations: *Torekhanova M.T., Tleuzhanova G.B., Yeserkegenova B.Zh., Kadyrov Zh.N., Kadyrova B.B. Innovative Technical Approaches to the Development of Automatic Control Systems for Bitumen-Chip Spreading. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. 2026. No.1. Pp. 362–381. DOI: https://doi.org/10.32014/2026.2518-170X.609*

©Төреханова М.Т.[1], Тлеужанова Г.Б.[1], Есеркегенова Б.Ж.[1], Кадыров Ж.Н.[2*], Кадырова Б.Б.[2], 2026.

[1]Д.Серікбаев атындағы Шығыс Қазақстан мемлекеттік техникалық университеті, Өскемен, Қазақстан;

[2]«Кадыров и Партнёры» патенттік сенім білдірілген өкілдер кеңсесі, Алматы, Қазақстан.

E-mail: kadyrov.1954@mail.ru

БИТУМ-ҚИЫРШЫҚ ТАС ТАРАТУДЫ АВТОМАТТЫ БАСҚАРУ ЖҮЙЕЛЕРІН ӘЗІРЛЕУДІҢ ЖАҢА ТЕХНИКАЛЫҚ ШЕШІМДЕРІ

Төреханова Марал — докторант, аға оқытушы, Д.Серікбаев атындағы Шығыс Қазақстан мемлекеттік техникалық университеті, Өскемен, Қазақстан,
E-mail: maraltt_1985@mail.ru, https://orcid.org/0009-0004-9993-4037;
Тлеужанова Гульнур — докторант, аға оқытушы, Д.Серікбаев атындағы Шығыс Қазақстан мемлекеттік техникалық университеті, Өскемен, Қазақстан,
E-mail: tleuzhan_gulnur@mail.ru, https://orcid.org/0009-0005-0032-8924;
Есеркегенова Бекзат — PhD, аға оқытушы, Д.Серікбаев атындағы Шығыс Қазақстан мемлекеттік техникалық университеті, Өскемен, Қазақстан,
E-mail: glamour_25@mail.ru, https://orcid.org/0000-0002-3719-2582;
Кадыров Жаннат — техника ғылымдарының докторы, профессор, «КПП «Кадыров и Партнёры» ЖШС директоры, Алматы, Қазақстан,
E-mail: kadyrov.1954@mail.ru, https://orcid.org/0009-0003-5247-1752;

Кадырова Бахыт — педагогика ғылымдарының кандидаты, ЖШС «КПП «Кадыров и Партнёры» директорының орынбасары, Алматы, Қазақстан,
E-mail: bakhyt.k2@mail.ru, https://orcid.org/0009-0000-2672-0282.

Аннотация. *Өзектілігі.* Жаңа сыныптағы құрылыс-жол машиналары – байланыстырушы және қиыршық тасты синхронды тарататын битум-қиыршық тасты таратқыштардың (БҚТ) пайда болуымен қатар жаңа міндеттер де туындады. Жол жамылғысының беткі өңделу сапасына қойылатын талаптардың артуына және беткі өңдеудің технологиялық түрлері мен әдістерінің кеңеюіне байланысты қолданыстағы жабдықтардың бұл талаптарды орындай алмауы айқын болды. БҚТ-ны пайдалану тәжірибесі олардың құрамындағы байланыстырушы және қиыршық тасты тарату агрегаттары сияқты негізгі функционалдық тораптарының құрылымында кемшіліктер бар екенін көрсетті. *Мақсаты.* Жол жамылғысына байланыстырушы мен қиыршық тасты синхронды тарату процесін басқару арқылы битум-қиыршық тасты таратқыштардың жұмысының тиімділігін арттыру жолдарын зерттеу. *Әдістері.* Зерттеу барысында БҚТ-ның жұмыс жағдайлары мен олардың тораптары мен механизмдерін толық пайдалану деңгейі талданды, сондай-ақ жабдық тораптарының жұмысын сипаттайтын математикалық есептеулер мен эксперименттік зерттеулер жүргізілді. *Нәтижелері мен қорытындылары.* Мақалада алғаш рет байланыстырушы мен қиыршық тасты тарату процесін екі контурлы автоматты басқару жүйесі сипатталып отыр: бірі – байланыстырушы таратқыш агрегатты өлшемдік баптау контуры, екіншісі – БҚТ шассисінің күйін тұрақтандыру контуры. Әрбір буынның беріліс функциясы негізінде битум-қиыршық тасты тарату процесін екі контурлы автоматты басқару жүйесінің функционалдық сұлбасы құрастырылды, контур жұмысының орнықтылығын анықтайтын математикалық тәуелділіктер ұсынылды, шассидің күйін тұрақтандыру контурының серпімді деформация датчигінің сақиналы элементіне есептеу жүргізілді. Жүргізілген эксперименттік зерттеулер синхронды тарату жүйелеріндегі автоматты басқару контурларының функционалдық элементтерінің тәжірибелік үлгілерінің жұмысқа қабілеттілігін және жақсы техникалық сипаттамаларын растады.

Түйін сөздер: битум-қиыршық тас таратқыш, автоматты басқару жүйесі, өлшемдік баптау контуры, шасси орнын тұрақтандырушы, өлшем түрлендіргіші, атқарушы механизм

©Тореханова М.Т.[1], Тлеужанова Г.Б.[1], Есеркегенова Б.Ж.[1], Кадыров Ж.Н.[2*], Кадырова Б.Б.[2], 2026.
[1]Восточно-Казахстанский государственный технический университет им.Д.Серикбаева, Усть-Каменогорск, Казахстан;
[2]Контора патентного поверенного «Кадыров и партнёры», Алматы, Казахстан.
E-mail: kadyrov.1954@mail.ru

НОВЫЕ ТЕХНИЧЕСКИЕ РЕШЕНИЯ ПО РАЗРАБОТКЕ АВТОМАТИЧЕСКИХ СИСТЕМ УПРАВЛЕНИЯ БИТУМОЩЕБНЕРАСПРЕДЕЛЕНИЕМ

Тореханова Марал — докторант, старший преподаватель, Восточно-Казахстанский государственный технический университет им.Д.Серикбаева, Усть-Каменогорск, Казахстан,
Email: maraltt_1985@mail.ru, https://orcid.org/0009-0004-9993-4037;
Тлеужанова Гульнур — докторант, старший преподаватель, Восточно-Казахстанский государственный технический университет им.Д.Серикбаева, Усть-Каменогорск, Казахстан,
Email: tleuzhan_gulnur@mail.ru, https://orcid.org/0009-0005-0032-8924;
Есеркегенова Бекзат — PhD, старший преподаватель, Восточно-Казахстанский государственный технический университет им.Д.Серикбаева, Усть-Каменогорск, Казахстан,
E-mail: glamour_25@mail.ru, https://orcid.org/0000-0002-3719-2582;
Кадыров Жаннат — доктор технических наук, профессор, Директор ТОО «КПП «Кадыров и Партнёры», Алматы, Казахстан,
E-mail: kadyrov.1954@mail.ru, https://orcid.org/0009-0003-5247-1752;
Кадырова Бахыт — кандидат педагогических наук, зам.Директора ТОО «КПП «Кадыров и Партнёры», г.Алматы, Казахстан,
E-mail: bakhyt.k2@mail.ru, https://orcid.org/0009-0000-2672-0282.

Аннотация. *Актуальность.* С появлением нового класса строительно-дорожных машин — битумощебнераспределителей (БЩР) с синхронным распределением вяжущего и щебня — возникли новые научно-технические задачи. В условиях повышения требований к качеству устройства поверхностной обработки покрытий и расширения технологических видов и методов поверхностной обработки стало очевидно, что существующее оборудование уже не обеспечивает выполнение этих требований. Опыт эксплуатации БЩР показал несовершенство конструкций основных функциональных узлов машин, в частности агрегатов распределения вяжущего и щебня. *Цель.* Исследование путей повышения эффективности работы битумощебнераспределителей за счёт управления процессом синхронного распределения вяжущего и щебня на дорожное покрытие. *Методы.* В исследовании выполнен анализ условий работы БЩР и оценка полноты использования его узлов и механизмов; проведены математические расчёты и экспериментальные исследования функционирования узлов оборудования. *Результаты и выводы.* В статье впервые представлена двухконтурная система автоматического управления процессом битумощебнераспределения, включающая контур размерной настройки агрегата распределения вяжущего и контур стабилизации положения шасси битумощебнераспределителя. На основе передаточных функций звеньев составлена функциональная схема двухконтурной системы, представлены математические зависимости для оценки устойчивости работы контуров, а также выполнен расчёт кольцевого элемента датчика упругих деформаций, используемого в контуре стабилизации положения шасси. Экспериментальные исследования подтвердили работоспособность и высокие технические характеристики опытных образцов функциональных элементов контуров автоматического управления системой синхронного распределения компонентов.

Ключевые слова: Битумощебнераспределение, система автоматического управления, контур размерной настройки, стабилизация положения шасси, измерительный преобразователь, исполнительный механизм

Introduction. The emerging trend in the development of automatic control systems for various technological processes (Shishkin, 2019; Esnouf, 2017; Janisch et al., 2019; Hicks et al., 2019) highlights the growing relevance of research focused on designing technical components for key functional units of automatic control systems (ACS) and constructing single-loop and multi-loop ACS architectures based on them.

The authors have accumulated experience in designing single-loop automatic control systems for the bitumen-chip spreading process (Yeserkegenova et al., 2021; Yeserkegenova et al., 2022). Due to the complexity of the bitumen-chip spreading process itself, it is necessary to incorporate multiple control loops, each representing a closed-loop control system. In the context of bitumen-chip spreaders (BCS), such control loops include the dimensional adjustment loop (DAL) for the binder distribution unit along the road surface, and the chassis stabilization loop (CSL) for the BCS. The former (DAL) ensures a triple overlap of binder spray patterns in automatic mode, while the latter (CSL) maintains the required chassis position (parallel to the road surface) regardless of the body tilt or the level of aggregate in its compartments.

The dual-loop ACS architecture for the bitumen-chip spreading process, proposed here for the first time, significantly extends the functional capabilities of BCS machines and improves the quality of surface treatment.

Automatic control systems have also been developed for other road surface treatment processes, such as asphalt pavement milling (Tabylov, 2007, Shishkin, 2019, Zhu et al., 2024), and for component processing on CNC lathes (Kadyrov, 1991; Balovnev, 1981).

The aim and central idea of this research are to develop new technical solutions and functional units that can be integrated into existing BCS equipment to implement single- and dual-loop control systems for bitumen-chip spreading, and to validate their performance through theoretical and experimental investigations.

To achieve this goal, the authors conducted an in-depth review of existing research on automatic control systems for bitumen-chip spreading, designed novel technical components and modules, and built several single-loop systems as well as a dual-loop ACS. Theoretical modeling and experimental testing confirmed their functionality and clarified their technical and functional characteristics.

Design and Operating Principle of the Dual-Loop Automatic Control System for the Bitumen-Chip Spreading Process. A control loop is defined herein as a closed-loop automatic system comprising a measurement transducer (MT) (Cypkin, 1977; Kadyrov, 1991; Balovnev, 2006) for registering a selected parameter of the bitumen-chip spreading process – either binder or aggregate distribution – and an actuator (AC) that compensates for deviations between the measured and the reference values of the regulated parameter. The control loop operates in accordance with a predefined control algorithm.

The dual-loop automatic control system for the bitumen-chip spreading process (Figure 1), (Kadyrov et al., 2024) includes the following main components mounted sequentially on the chassis (1): a multi-section hopper (2), a drive unit (3) for angular adjustment of the hopper relative to the cantilever-mounted non-rotatable support (4), a binder tank (5) containing binder material (6), and a binder distributor (7) mounted in the form of a transverse spray bar (8) with a row of nozzles (9) oriented perpendicular to the chassis.

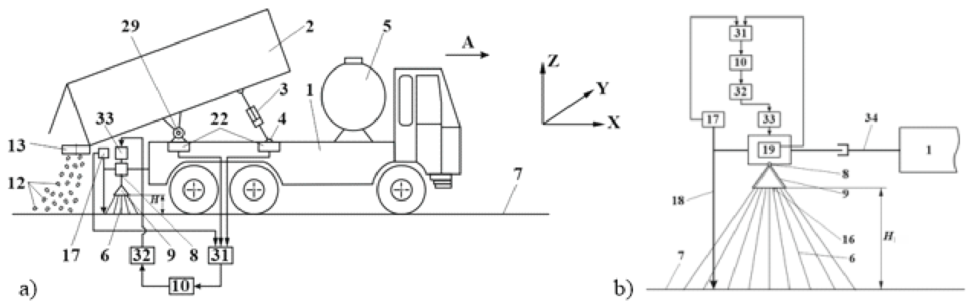

Figure 1 – Bitumen-chip spreader equipped with a dual-loop control system

The system also includes a microprocessor control unit (10), a GPS navigator (11), a distance sensor to measure the gap between the nozzles and the road surface, and a mixing device (13) for aggregate. The outputs of all sensors are connected to the microprocessor unit, which in turn controls the drive (3) for angular adjustment of the hopper, the drive (14) for opening and emptying the hopper sections, and the drive (15) for rotating the mixing blades of the aggregate mixer.

According to the proposed technical solution, the distance sensor between the nozzle tips and the road surface is implemented as a composite unit consisting of an interacting contact sensor (17) with a retractable rod (18) and a linear displacement sensor (19) to measure vertical movements of the spray bar with nozzles. The linear displacement sensor is implemented using a linear inductosyn. Measurement begins when the retractable rod contacts the road surface, triggering the contact sensor.

The BCS chassis is constructed in two halves separated by a three-sided open horizontal slot (20): an upper half (21) with embedded strain gauges (22), and a lower half (23) housing a controllable linear actuator (24) located between the two chassis sections (Figure 2a).

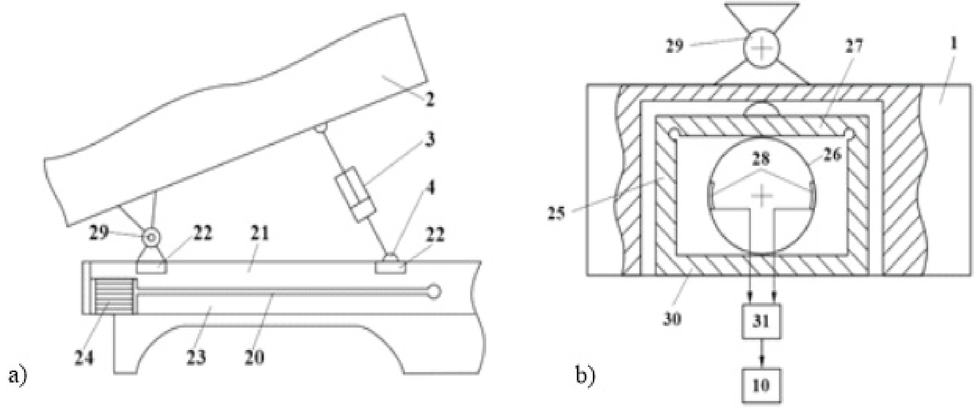

Figure 2 – BCS chassis with integrated strain gauges and linear actuator

Each strain gauge sensor, as shown in Figure 2b, is formed by a thin-walled ring element (26) housed in a rectangular open-frame casing. The ring interacts locally with transverse crossbars – bottom and top – of the casing. Primary electrical transducers (28), such as foil strain gauges, are placed at locations of maximum elastic deformation on the ring element.

The linear actuator is implemented, for instance, using a set of flat piezoelectric elements.

The strain gauges are located on the upper chassis half, opposite the fixed support (29) and the support of the hopper tilt drive. The linear actuator is located in the cantilevered part of the lower chassis half.

All measuring transducers, including the additionally integrated touch sensor, the linear displacement sensor for vertical movement of the nozzle comb, strain sensors, and strain gauges, are connected to the input of the microprocessor-based control unit via an amplification and conversion module. The output of the control unit is, in turn, connected to a set of piezoelectric elements of the linear actuator through another amplification and conversion module.

The touch sensors and the linear displacement sensors for vertical movement of the nozzle comb, together with the controlled actuator, form the first control loop of the system – the Dimensional Adjustment Loop (DAL) of the binder distribution unit, which ensures automatic triple overlap of binder spray patterns.

The strain sensors and the linear actuator form the second control loop – the Chassis Stabilization Loop (CSL) – which ensures the BCS chassis remains parallel to the road surface, regardless of hopper tilt or aggregate fill level.

The dual-loop control system operates as follows:

Aggregate of various fractions is loaded into the hopper sections, and binder –

such as bitumen or bitumen emulsion – is poured into the tank, which includes an automatic heating device. The DAL is first adjusted: initial parameters (such as the required distance H between nozzle tips and the road surface) are entered into the control unit. Upon command, the actuator (33) lowers the entire binder distribution assembly vertically until the retractable rod contacts the road surface, activating sensor. The actuator then lifts the assembly by the specified height H (Figure 1), thereby setting the required nozzle-to-surface distance.

After configuring the DAL, the binder is fed from the tank to the nozzles. As the BCS moves in direction A, the binder is evenly distributed across the road surface. The aggregate is applied 1–1.5 seconds after binder spraying, thus implementing synchronous component distribution.

The hopper is tilted using drive (3), and upon activation of drives (14) and (15), the aggregate is mixed and evenly spread over the binder layer, completing the surface dressing cycle.

When the hopper tilts, the strain gauge located opposite the fixed support detects the motion and sends a signal to the control unit, which commands the actuator (24) to restore the horizontal chassis position relative to the road surface. The actuator uses piezoceramic plates with a diameter of at least 16 mm and a thickness of 2 mm, assembled into sets of 48–60 plates. The linear dimension of the actuator varies under applied voltage via the inverse piezoelectric effect.

As the BCS moves along steep or curved roads and the hopper sections gradually empty, the system performs periodic adjustments to both the binder distribution assembly and chassis position—fully automatically.

This dual-loop system has proven to be highly effective, enhancing the functional performance of the BCS and significantly improving the quality of road surface treatment.

Theoretical and Experimental Investigation of the Dual-Loop Automatic Control System for Bitumen-Chip Spreading.

In the investigation of the control loops within the system, performance indicators such as accuracy and stability were determined by analyzing the dynamic properties of the constituent components (Khattak and Bhuyan, 2024; Makarov D. et al., 2016, Cypkin, 1977). After identifying the transfer functions of each system element, functional diagrams were developed for both the dimensional adjustment loop (Figure 3a) and the chassis stabilization loop of the bitumen-chip spreader (Figure 3b).

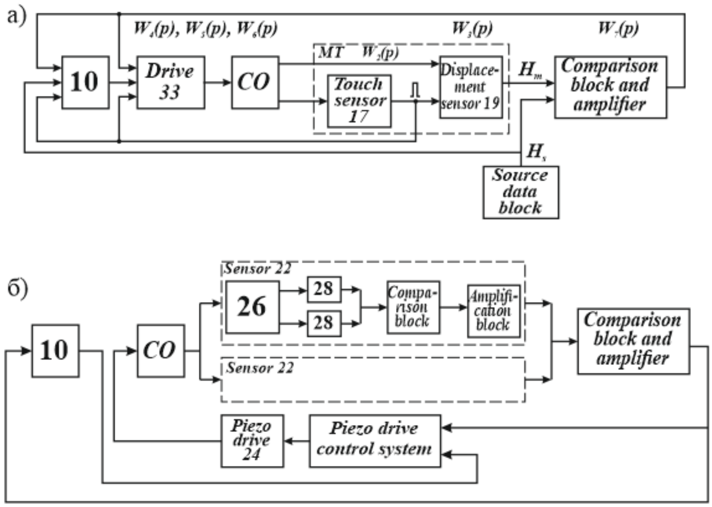

Figure 3 – Functional diagram of the dimensional adjustment loop and the chassis stabilization loop

The following notations are used in the diagram:

The numbers correspond to the positions shown in Figures 1–2;

CO – controlled object;

MT – measurement transducer;

H_m and H_s – the measured and set values of the distance from the nozzle tips to the road surface.

The block diagram of the dimensional adjustment loop (DAL) is presented in Figure 4.

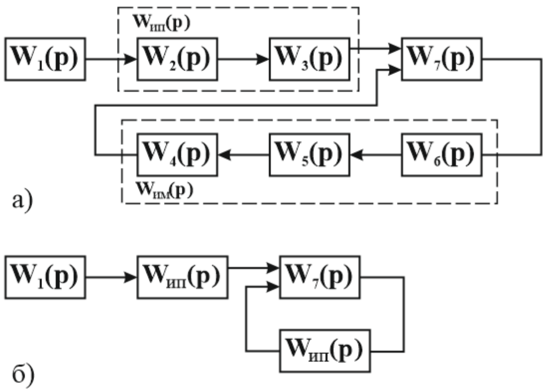

Figure 4 – Block diagram of the dimensional adjustment loop

The delay element (1) accounts for the physical positioning of the contact sensor (17) and the displacement sensor (19) relative to each other and the road surface, as illustrated in Figure 1b.

The transfer function of element 1 is defined by the expression:

$$W_1(P) = e^{-\tau_1 \cdot p},$$

where τ_1 is the pure delay time in seconds.

Given the small value of τ_1, we can approximate $W_1(p) = 1$.

The measurement transducer (MT) of this loop consists of the contact sensor (17) and the linear displacement sensor (19) that measures vertical movement of the spray bar with nozzles (a linear inductosyn). Both can be modeled as non-inertial elements with gain coefficients k_{ts} and k_{ds}, respectively:

$$W_2(p) = k_{TS}$$
$$W_3(p) = k_{DS}$$

The transfer function of the constant pitch motor (DPM) used in the actuator is expressed (Janisch, 2019) as:

$$W_4(P) = \frac{k_{DPM}}{1 + T_M \cdot p}$$

The operation of the direct current motor in the actuator is controlled by pulse-width modulation (PWM) of the control signal using a pulse-width converter (PWC). The PWM controller is modeled as a combination of a non-inertial element (Kadyrov, 1991) and a pure delay:

$$W_6(p) = k_{PWM} \cdot e^{-\tau_{PWM} \cdot p},$$

k_{PWM} – gain coefficient of the pulse-width modulation converter

τ_{PWM} – pure time delay of the control signal in the pulse-width modulation converter

Empirical results showed that τ_{PWM} is small, hence the PWM unit is considered non-inertial:

$$W_6(p) = k_{\text{PWC}}$$

The open-loop transfer function is given by:

$$W_C(p) = W_S(p) \cdot W_F(p),$$

where $W_S(p)$ and $W_F(p)$ are the transfer functions of the single-loop system and the feedback, respectively.

The closed-loop transfer function is:

$$W_C(p) = \frac{W_S(p)}{1 + W_S(p) \cdot W_F(p)},$$

By substituting actual values into this expression, the real parts of the complex roots of the characteristic equation were found to be negative, indicating that the system (DAL) is stable (Balovnev, 1981).

A separate theoretical calculation was conducted for the ring element of the strain gauge in the chassis stabilization loop (CSL). The analysis focused on determining the elastic deformation along the length of the primary electrical transducer (PET), i.e., a foil strain gauge (28), under applied loading (Kadyrov, 1991).

Assuming a symmetric thin-walled ring geometry with initial parameters: R=25,00 мм, a=10,0 мм, h=1,0 мм, φ=360°, and an applied force P=5,0 н, canonical equations were used to derive bending moments across any ring section as a function of angle φ:

$$M = P \cdot R_C \cdot (0{,}5 \cdot \sin\varphi - 0{,}318),$$

where R_C – radius of the center of gravity of the section

To determine the radial deflections (displacements) of an arbitrary point on the elastic element, a differential equation was formulated:

$$\frac{d^2\omega}{dy^2} + \omega = -\frac{M \cdot R_C^2}{EJ}$$

The solution to this equation for calculating radial deflections (displacements) takes the following form:

$$\omega = -\frac{P \cdot R_C^2}{E \cdot J}(0{,}467 \cdot \cos\varphi + 0{,}25 \cdot \sin\varphi - 0{,}25 \cdot \varphi \cdot \cos\varphi - 0{,}318)$$

Let us determine the strain (elongation or shortening) of the fiber passing through the centroid of the cross-section of the ring-shaped elastic element.

The deformation of the considered fiber is given by:

$$\Delta L = L - l,\ L = \int_{l_1}^{l_2} \sqrt{1 + (\omega')^2}\,dl,$$

where l and L are the lengths of the fiber before and after the application of the load, respectively, and l_1 and l_2 are the limits of integration defined by the area of foil strain gauge application.

After transformations, we obtain:

$$L = \int_{l_1}^{l_2} \sqrt{1 + \left(\frac{PR_C^3}{EJ}\right)^2 \cdot \left[-0{,}467 \cdot l + 0{,}255\frac{l^2}{R}\right]^2}\, dl$$

This formula allows for calculating the deformation value ΔL of the considered fiber based on the initial parameters.

For example, using a foil strain gauge with a base length of 20.0 mm affixed to the inner surface of a ring with identical parameters, we obtain the deformation of the analyzed fiber as:

$$\Delta L = 4{,}0915067 \cdot 10^{-6} \cdot P^2 + 2{,}5232546 \cdot 10^{-11} \cdot P^4$$

Thus, the deformation of the inner surface of the ring-shaped elastic element beneath the foil strain gauge is ε = –0.5073499 μm. In other words, when a force of 1.0N is applied to the ring-shaped elastic element, the surface beneath the foil strain gauge shortens by 0.5073499 μm.

As part of this study, experimental investigations were conducted on the elements of automatic control systems used in the bitumen-chip spreading process.

Experimental tests were conducted to evaluate the metrological characteristics of the strain gauge (Figure 2b) under different loading conditions. The test bench layout is shown in Figure 5.

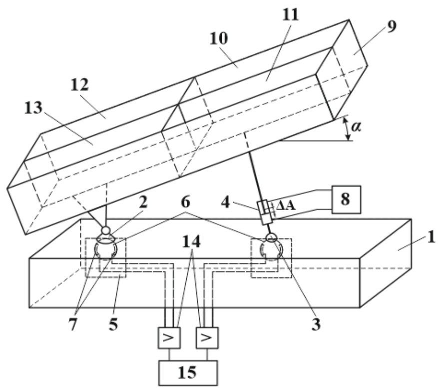

Figure 5 – Experimental test bench layout

On a flat platform, supports (2) and (3) for the hydraulic cylinder (4) were fixed. Opposite these supports, strain gauges (5) with ring elements (6) and foil strain gauges (7) were mounted. Control of the hydraulic system was implemented via control block (8). The cylinder stroke altered the hopper tilt angle α, affecting four sections (10–13) of the hopper. The ring elements were made from 65G spring steel.

Experimental variables included:

1. Geometric parameters of PMT;
2. Aggregate weight in hopper sections (10–13);
3. Hopper tilt angle α;
4. Stroke amplitude ΔA of hydraulic cylinder.

Aggregate was simultaneously loaded into sections 12 and 13 as α varied between 15° and 30°.

Comparative elastic deformation values for two rings are shown in Figure 6.

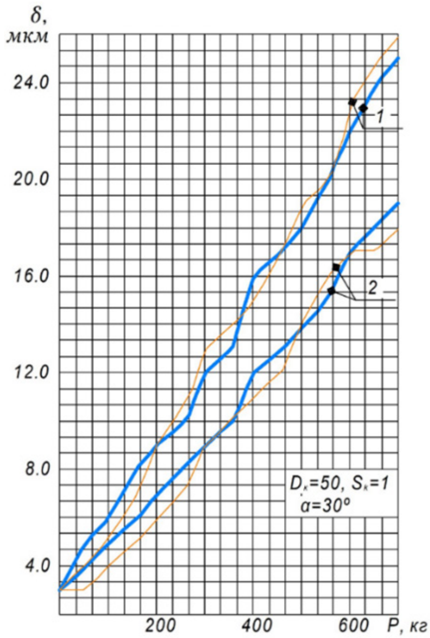

Figure 6 – Comparative elastic deformation values for rings 1 and 2, D_R=50 mm, S_R=1 mm

To obtain the static characteristic of the strain-sensitive ring element (PET), a reference force was incrementally applied to it (Khattak and Bhuyan, 2024, Kadyrov, 1991). The corresponding output values (proportional to the elastic deformations of the ring) were read using a digital voltmeter. The measurement result was taken as the arithmetic mean of five consecutive readings obtained under identical applied reference force conditions. A straight line was fitted to the resulting data points (Figure 7) using the least squares approximation method.

The proposed measurement method is justified by the fact that the measurement errors follow a normal distribution and are independent of the measured value. The random error is primarily caused by additive noise, due to the narrow measurement range.

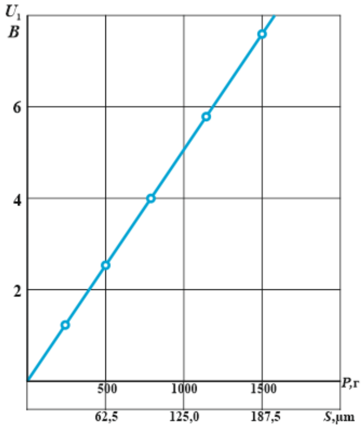

Figure 7 – Static characteristic of the PMT (ring)

These studies enabled determination of the technical and metrological characteristics of the custom-designed measuring tool.

Table 1 – Technical specifications of the strain gauge

№	Parameter	Value
1	Measurement method	Contact
2	Conversion principle	Electrical (foil strain gauge)
3	Measuring force, N	1 … 4
4	Measurement range, N	5 … 10000
5	Response time, ms	1 … 30
6	Sensitivity, mV/N	0,1 … 0,5
7	Max intrinsic error, N	1-3 … 15-20
8	Supply voltage, V	±12
9	PMT dimensions, mm	50,0 … 60,0
10	PET dimensions, mm	Foil or semiconductor
11	Weight, kg	0,25 … 0,3
12	Operating conditions	
а)	Ambient temp, °C	20±5
б)	Temp variation, °C/h	≤ 2
в)	Humidity, %	60±20

Further static and dynamic tests were conducted on the actuator plate of the system using controlled loads on both sides of the deformable plate (Figure 8a, 8b).

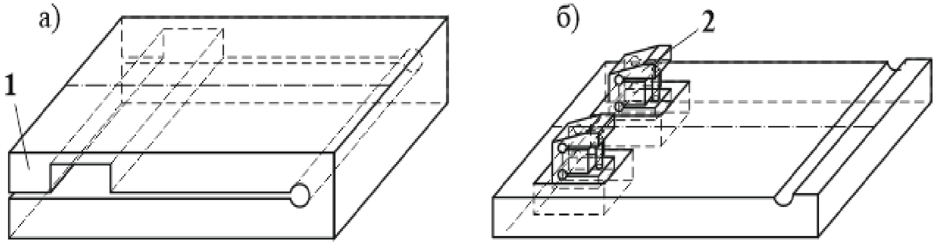

Figure 8 – Modular actuators for controlled displacement within the lower chassis section

Experiments were repeated seven times for reliability. The relationship between elastic deformation Δλ and load variation ΔP was assumed linear:

$$\Delta\lambda = k \cdot \Delta P$$

Using the method of least squares, the parameters (*k*) of the linear dependence were determined for various experimental configurations. The approximated values of $\lambda = f(P)$ are presented in Figure 13. Based on the obtained dependencies of $\lambda = f(P)$, a graph was constructed (Figure 9) showing the relationship between the elastic deformation of the plate and its structural parameters that influence the functional and technical characteristics of the actuator. One such parameter is the bridge width *B*.

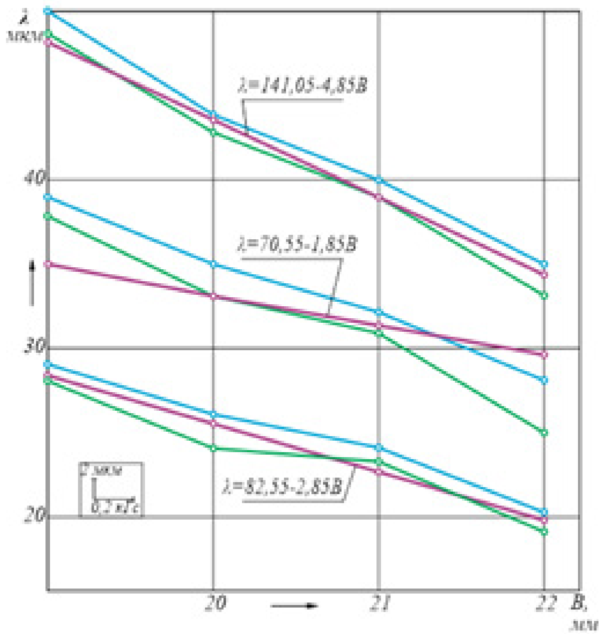

Figure 9 – Deformation of the actuator plate vs. bridge width *B*

The conducted static tests of the actuator plate revealed the following:

1. The plate exhibits stable elastic characteristics under both loading and unloading conditions.
2. The identified A_1 dependencies for various loading schemes allow for the formulation of a control algorithm for the actuator to compensate for the error signal in the automatic control system (ACS) of the bitumen-chip spreading process.
3. Based on the obtained dependencies, it is also possible to solve the inverse problem-namely, by setting a target value for the fine-tuning displacement as specified in the technical requirements, the technical characteristics of the designed actuator can be determined, including its overall dimensions and the force required for adjustment.
4. By setting a specific bridge width B (chosen, for example, according to manufacturing constraints), the magnitude of possible elastic deformations of the actuator plate can be estimated.

The test bench for dynamic testing of the actuator plate was built on the basis of the static test bench and also consists of a loading unit and a measurement unit. For generating dynamic loads, the loading unit includes an electric motor mounted on a stand, with an eccentric sleeve (with 1 mm eccentricity) fixed to the output shaft. The load generated by the loading unit follows the law:

$$P = P_0 \cdot \sin \omega t$$

where P_0 – load generated by the eccentric sleeve,

$\omega = 2\pi \cdot f_C$ – angular frequency,

f_C – natural frequency of the sleeve oscillation.

Harmonic loading was created at values f_C = 22.5 Hz and ω = 131.3 Hz.

The measurement unit employed DN-3-type piezoelectric vibration sensors, which were mounted using threaded studs on the outer surface of the actuator plate.

Figure 10 presents the amplitude-phase frequency characteristic (APFC) obtained for this experiment at loading values of P = 300 kgf and bridge widths B = 22 mm and 19 mm, constructed based on the following formulas:

$$W_{\mathbf{EDE}} = A_{\mathbf{EDE}} \cdot e^{iJ_{\mathbf{EDE}}},$$

$$A_{\mathbf{EDE}} = \frac{k_{\mathbf{EDE}}}{\sqrt{T_2^2 \cdot \omega^2 + (1 - T_1^2 \cdot \omega^2)^2}}$$

$$\varphi_{\mathbf{EDE}} = arctg \frac{T_2 \cdot \omega}{1 - T_1^2 \cdot \omega^2}$$

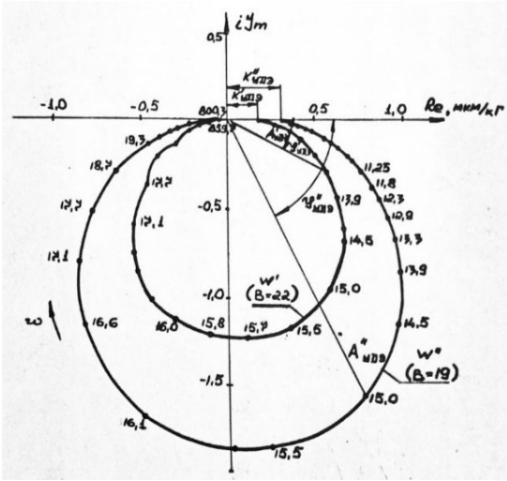

Figure 10 – Amplitude-Phase Frequency Characteristic (APFC) under impulse loading at P = 300 kgf, B = 22 and 19 mm

To evaluate the degree of system stability based on the rate of decay in transient processes (Kadyrov, 1991, Kadyrov et al., 2024), logarithmic decrements (λ) were calculated:

$$\lambda = \ln \frac{A_n}{A_{n+1}}$$

$$\lambda = \frac{\Delta A}{A_n}$$

where A_n and A_{n+1} – amplitudes of two successive oscillations;

ΔA – difference between these amplitudes.

The obtained results are summarized in Table 2:

Table 2 – Logarithmic Decrement Values of Damping

Sensor number	A_n	A_{n+1}	A_n	λ
DN-1	16	7	9	0,563
DN -2	19	11	8	0,421
DN -3	13	6	7	0,538

Based on the obtained APFC, the following conclusions can be drawn:

1. The actuator plate, as the object under investigation, represents a stable system according to the Nyquist stability criterion.

2. The segment of the real axis on the APFC (at ω = 0), which serves as the static characteristic of the system, is sufficiently small, indicating the high rigidity of the bitumen-chip spreader (BCS). In the experimental study, ω was varied from 0 to 30 kHz, fully simulating the operating frequency range of the BCS.

3. The calculated values of the logarithmic decrement λ_i confirm the system's good stability (i.e., the actuator plate), as well as the presence of a stability margin, based on the distance of the APFC curve from the point –1.0 on the real axis of the complex plane.

Conclusions. This paper has presented a detailed analysis of the design and operating principles of a dual-loop automatic control system (ACS) for the bitumen-chip spreading process, comprising a dimensional adjustment loop (DAL) for the binder distribution unit and a chassis stabilization loop (CSL) for the bitumen-chip spreader (BCS). By determining the transfer functions of each system component, both structural and functional diagrams of the control loops were developed. Mathematical relationships describing the behavior of all elements within the system were derived, demonstrating the stability of the dimensional adjustment loop.

To determine the metrological characteristics of the deformation sensor used in the CSL, a theoretical analysis was performed for the ring-shaped elastic element, focusing on the deformation of its inner surface under mechanical stress. This analysis served as the foundation for evaluating the performance of the custom strain gauge incorporated into the control loop.

Both theoretical and experimental studies of the control loops yielded acceptable technical characteristics for their use within the automatic control system. The research identified the most effective method for enhancing BCS efficiency–namely, implementing control over the synchronous distribution of binder and aggregate onto the road surface.

The successful implementation of such control systems requires the integration of additional measurement transducers (MT) to monitor the distribution process and actuators (AC) to compensate for deviations between target and actual parameters. When equipped with feedback mechanisms, these systems can range from basic single-loop configurations to more advanced dual-loop systems with expanded functionality.

The implementation of such systems demands proper informational and metrological support, as well as comprehensive theoretical and experimental validation of the control loops.

All developments have been protected by patents of the Republic of Kazakhstan. The results confirm the effectiveness and feasibility of implementing a dual-loop ACS to improve the quality of road surface treatment.

List of Abbreviations

BCS	Bitumen-Chip Spreader
ACS	Automatic Control System
DAL	Dimensional Adjustment Loop
CSL	Chassis Stabilization Loop
MT	Measurement Transducer

AC	Actuator
PET	Primary Electrical Transducer
PMT	Primary Mechanical Transducer
PWM	Pulse-Width Modulation
PWC	Pulse-Width Converter
DC Motor	Direct Current Motor
EDE	Elastic Deformable Element
APFC	Amplitude-phase frequency characteristic

References

Balovnev V.I. (2006) Mnogocelevye dorozhno-stroitel'nye i tehnologicheskie mashiny. Uchebnoe posobie dlja vuzov. [Multipurpose road construction and technological machines. Textbook for university students] – Omsk – OAO «Omskij dom pechati». – 320 p. (in Russian)

Balovnev V.I. (1981) Modelirovanie processov vzaimodejstvija so sredoj rabochih organov dorozhno-stroitel'nyh mashin: Uchebnoe posobie dlja studentov vuzov [Modeling of processes of interaction with the environment of working bodies of road construction machines: Textbook for students of higher education institutions]. – M.: Vyssh.shkola. – 335 p. (in Russian)

Cypkin Ja.Z. (1977) Osnovy teorii avtomaticheskih sistem [Fundamentals of the theory of automatic systems] – M.: Nauka. – 560 p (in Russian)

Esnouf, J. (2017) Towards Safer Sprayed Sealing Operations – Forward moving aggregate spreading //Safer Roads Conference Committee. – 12 p. URL: https://saferroadsconference.com/wp-content/uploads/2017/06/Towards-Safer-Sprayed-Sealing-Operations-Full-Paper.pdf (in English)

Hicks R.G, Cheng D.X., Lane L. (2019) Manual for chip seals / Mineta Transportation Institute Report. – San José. – 84 p. URL: https://transweb.sjsu.edu/sites/default/files/1845A-Chip-Seal-Manual.pdf (in English)

Kadyrov Zh.N. (1991) Diagnostika i adaptacija stanochnogo oborudovanija gibkih proizvodstvennyh sistem [Diagnostics and adaptation of machine tools for flexible manufacturing systems] – L.: Politehnika. – 144 p. (in Russian)

Kadyrov Zh., Begimkulova E., Yeserkegenova B. (2024). Dvuhkonturnaja sistema avtomaticheskogo upravlenija processom bitumoshhebneraspredelenija [Dual-Loop Automatic Control System for the Bitumen-Chip Spreading Process]. Patent of the Republic of Kazakhstan, N36600. (in Russian)

Khattak M. J., Bhuyan M. R. (2024) Performance Evaluation of Chip Seal Treatment on Flexible Pavements. International Journal of Pavement Research and Technology, 17. – P.1340–1352. doi: https://doi.org/10.1007/S42947-023-00305-Y (in English)

Makarov D., Miller S., Dorée A. (2016). Developing a real-time process control system for asphalt paving and compaction. Paper presented at CROW Infradagen 2016, Arnhem, Netherlands. – 11 p. https://ris.utwente.nl/ws/portalfiles/portal/122496291/makarov2016developing.pdf (in English)

Nedorezov I.A., Kabashev R.A. (2013) Mashiny stroitel'nogo proizvodstva i ih rabochie sredy vzaimodejstvija. Uchebnoe posobie. [Machines of construction production and their working environments of interaction. Study guide] – Moskow-Almaty: Izd. «Bastau». – 444 p. (in Russian)

Shishkin E.A. (2019) Rabochij process i formirovanie komplektov dorozhnyh mashin dlja uplotnenija asfal'tobetonnyh smesej [Work process and formation of sets of road machines for compaction of asphalt concrete mixtures] Dissertacija ... kandidata tehnicheskih nauk: 05.05.04 – Khabarovsk. – 209 p. (in Russian)

Tabylov A.U. (2007) Obosnovanie parametrov rabochego organa shhebneraspredelitelja dlja ustrojstva shumovoj kraevoj polosy avtomobil'nyh dorog [Justification of the parameters of the working element of the crushed stone distributor for the construction of a noise-reducing edge strip of highways]. Avtoref.diss. … kand.tehn.nauk, special'nost' 05.05.04. – Almaty. – 24 p. (in Russian)

Yeserkegenova B., Kadyrov Z., Kim A. (2021) Automatic Control System of Bitumen and

Aggregate Distribution with Synchronous Component Distribution, International Review of Mechanical Engineering (IREME), 15 (10). – Pp. 511-519. doi: https://doi.org/10.15866/ireme.v15i10.20971 (in English)

Yeserkegenova B., Kadyrov Z., Kim A., Begimkulova, E. (2022) Improvement of the Design of the Unit for Automatic Graded Spreader, International Review of Mechanical Engineering (IREME), 16 (6). – Pp. 319-328. doi: https://doi.org/10.15866/ireme.v16i6.21647 (in English)

Zhu Y., Yuan Y., Wang K., Liu Y., Xu L. (2024) Research on the performance of hot recycled asphalt mixture based on recycled asphalt pavement dispersion uniformity. Transportation Research Record: Journal of the Transportation Research Board, OnlineFirst. doi: https://doi.org/10.1155/2022/4017071 (in English)

Publication Ethics and Publication Malpractice in the journals of the Central Asian Academic Research Center LLP

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 journals of the Central Asian Academic Research Center LLP 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 Central Asian Academic Research Center LLP 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 Central Asian Academic Research Center LLP.

The Editorial Board of the Central Asian Academic Research Center LLP will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:
www:nauka-nanrk.kz
http://www.geolog-technical.kz/index.php/en/
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Ответственный редактор *А. Ботанқызы*
Редакторы: *Д.С. Аленов, Т. Апендиев*
Верстка на компьютере: *Г.Д. Жадырановой*

Подписано в печать 06.02.2026.
Формат 70x90$^{1}/_{16}$. 20,5 п.л.
Заказ 1.

«Central Asian Academic Research Center» LLP
Алматы, Шевченко к-сі, 28