

ANNOTATION

Dissertation by **Elmira Begimkulova** on the topic:
"Development of functional components of a bitumen distributor for the automatic
distribution of components for the construction of highways"
for the degree of doctor of philosophy (PhD) in the specialty 8D07159 – Transport,
transport engineering, and technologies

General characteristics of the work. This dissertation proposes a new layout scheme for the bitumen-chip spreader (BCS) based on an analysis of existing designs and provides a comparative analysis of different layout schemes. It suggests equipping the BCS with new automatic control systems (ACS) for distributing components (binder and chips) onto the road surface both individually using specialized units and synchronously as part of single- and dual-loop ACS. New technical means and functional units of the ACS have been developed, and theoretical and experimental studies have been conducted on the ACS in the bitumen-chip distribution process. A classification scheme has been compiled, and new technical means for information-instrumental support of ACS functionality have been developed, along with certificates for measurement methodologies of the designed devices. The theoretical and experimental research results on the technical means and units of the BCS have confirmed their operability and feasibility for use in the ACS for the bitumen-chip distribution process.

Relevance of the research. Bitumen-chip spreaders are the main specialized road machines used for surface treatment of repaired road sections. The analysis of existing layout schemes and functional units of the BCS has led to the development of a promising new layout. The operational experience of BCS has revealed deficiencies in the existing designs of key functional units, such as binder and chip distribution units. Under these conditions, equipping BCS with ACS for the bitumen-chip distribution process is highly relevant.

The analysis of BCS structures and the study of open publications have shown a lack of non-standardized measuring instruments (NSI), including those for measuring chassis and body tilt angles of the BCS, as well as devices for measuring the relative movement or joint rotation of BCS units. Such information is crucial for the operational metrological support of ACS performance. The development and error analysis of NSI are therefore highly relevant.

An identified promising approach to increasing BCS efficiency through the integration of ACS for the bitumen-chip distribution process can be implemented using single- or dual-loop ACS. The latter not only enables the preliminary dimensional adjustment of the main functional units of the BCS but also ensures the automatic stabilization of the selected control parameter, such as the spatial position of the BCS chassis.

This dissertation is dedicated to addressing these important issues.

Research objective. The objective of this work is to enhance the efficiency of bitumen-chip spreaders by developing new technical means and functional units that

enable the integration of single- and dual-loop automatic control systems for the bitumen-chip distribution process, as well as to confirm the operability of the developed ACS through theoretical and experimental research.

Research tasks:

- Conduct an analysis of scientific studies in the field of bitumen-chip spreader (BCS) design development, including their layout schemes, and identify promising BCS layout configurations;
- Develop automatic control systems (ACS) for the distribution of individual components (binder and chips), as well as ACS for their synchronous distribution, including single- and dual-loop ACS for the bitumen-chip distribution process;
- Develop new technical means and functional units (blocks) for the BCS to operate within the ACS;
- Develop new technical means for the informational and metrological support of ACS functioning in the bitumen-chip distribution process and create a certified methodology for measuring with a non-standardized measuring instrument;
- Conduct theoretical and experimental studies on the ACS in the bitumen-chip distribution process, including separate loops of the dual-loop ACS;
- To confirm the operability of such systems and refine their functional and technical characteristics, develop specialized test stands and conduct experimental studies of the designed technical means and functional units equipped with automatic control systems for bitumen-chip spreaders.

The object of the research is a specialized construction and road machine – the bitumen-chip spreader equipped with an automatic control system.

The subject of the research is the technical means and functional units of bitumen-chip spreaders equipped with automatic control systems.

Scientific novelty:

- a new layout scheme for the bitumen-chip spreader with two bodies and a retractable conveyor (Patent RK No. 36509), along with the results of a comparative analysis of all BCS layout schemes;
- new automatic component distribution systems: binder distribution (Patents RK No. 35037, No. 35553) and chip distribution (Patents RK No. 35022, No. 35539), as well as automatic synchronous component distribution systems (Patents RK No. 35539, No. 36301, and Patent Application RK No. 36496);
- a new dual-loop automatic control system for the bitumen-chip distribution process (Patent RK No. 36600) and the results of its theoretical and experimental studies;
- new technical means and functional units for a bitumen-chip spreader equipped with an ACS for the bitumen-chip distribution process: a reflective screen (Patent RK No. 35534), a multi-section body (Patent RK No. 35501), a hydraulic cylinder with a movable rod section (Patent RK No. 36052), a tire pressure monitoring device (Patent RK No. 36056), and an ACS actuator for the bitumen-chip distribution process (Patent RK No. 36670);
- a classification scheme and new technical means for the informational and metrological support of the ACS for the bitumen-chip distribution process: a device

for measuring the relative position or joint rotation of objects (Patent RK No. 36036), a device for measuring the body tilt angle of the BCS (Patent RK No. 36497), and a device for measuring the chassis tilt angle of the BCS (Patent RK No. 35536);

- results of an error analysis for the body tilt angle measuring device and a certified methodology for measuring the body tilt angle of the BCS;
- results of theoretical and experimental studies on technical means and functional units of bitumen-chip spreaders equipped with automatic control systems for the automatic synchronous distribution of components for road repair.

Practical significance of the research:

- the possibility of improving the efficiency of bitumen-chip spreaders by equipping them with single- and dual-loop automatic control systems (ACS) for the bitumen-chip distribution process;
- the use of the developed technical means and functional units of the BCS as part of the ACS;
- the application of technical means for the informational and metrological support of ACS operation;
- the operability of the studied technical means and ACS units, as well as the acceptability of the achieved technical characteristics.

Scientific provisions submitted for defense:

- a new layout scheme for the BCS;
- new automatic component distribution systems;
- new automatic synchronous component distribution systems;
- a dual-loop ACS for the bitumen-chip distribution process;
- new technical means and functional units for the ACS in the bitumen-chip distribution process;
- a classification system and new technical means for the informational and metrological support of the ACS in the bitumen-chip distribution process, including a certified methodology for measurement performance (MVI certificate);
- results of theoretical and experimental studies on the ACS for the bitumen-chip distribution process.

Results of the dissertation research:

- analysis and a new layout of the bitumen-chip spreader (Patent RK No. 36509);
- new automatic component distribution systems: binder distribution (Patent RK No. 35037, Patent RK No. 35553) and chip distribution (Patent RK No. 35022, Patent RK No. 35539);
- new automatic synchronous component distribution systems (Patent RK No. 35539, Patent RK No. 36301, and Patent RK No. 36496);
- a dual-loop automatic control system (ACS) for the bitumen-chip distribution process (Patent RK No. 36600), along with the results of its theoretical and experimental studies;

- technical means and functional units for a bitumen-chip spreader equipped with an ACS for the bitumen-chip distribution process:
 - a) reflective screen (Patent RK No. 35534);
 - b) multi-section body (Patent RK No. 35501);
 - c) hydraulic cylinder with a movable rod section (Patent RK No. 36052);
 - d) tire pressure monitoring device (Patent RK No. 36056);
 - e) ACS actuator for the bitumen-chip distribution process (Patent RK No. 36670).
- a classification scheme and new technical means for the informational and metrological support of the ACS in the bitumen-chip distribution process:
 - a) Device for measuring the relative position or joint rotation of objects (Patent RK No. 36036);
 - b) Device for measuring the body tilt angle of the BCS (Patent RK No. 36497);
 - c) Device for measuring the chassis tilt angle of the BCS (Patent RK No. 35536).
- results of the error analysis and a certified methodology for measuring the body tilt angle of the BCS;
- results of theoretical and experimental studies on technical means and functional units of bitumen-chip spreaders equipped with ACS;
- the operability and acceptable characteristics of the developed technical means and functional units of the BCS have been confirmed.

The topic corresponds to the directions of scientific development or government programs. The topic of the dissertation corresponds to the following priority areas of science development and government programs:

- The State Program for the development of Education and Science of the Republic of Kazakhstan for 2020 - 2025, systematization and use of information on topical issues of science and education;
- The State program of industrial and innovative development of the Republic of Kazakhstan for 2020 - 2025;
- The program "Energy and Mechanical Engineering", approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan.

Thesis approval. The research results were presented at the eighth international scientific and practical conference "Highways and transport Equipment: problems and prospects for development", dedicated to the 80th anniversary of R.A. Kabashev and the 20th anniversary of KazADI, held on december 19, 2019 at the Kazakh Automobile and Road Institute; at the XLIV international scientific and practical conference "Innovative technologies in transport education, science, practice" on april 17, 2020 at the Kazakh Academy of Transport and Communications; at the First International Scientific and Practical Conference "Innovative technologies in transport: education, science, practice", which was held on april 22, 2021 at the Academy of Logistics and Transport.

Publications. A total of 29 scientific papers have been published based on the dissertation research, including: 5 articles in scientific journals recommended by the

Committee for Control in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (MES RK); 2 article in a Scopus-indexed journal; 3 papers in the proceedings of international conferences; 19 patents of the Republic of Kazakhstan for inventions.

The doctoral student's contribution to the preparation of publications: drawing up plans for articles, selecting materials for review, writing a review and introduction, writing separate sections, discussing research results and conclusions, and publishing.

Implementation of research results. Prototype technical devices and functional units of the bitumen-chip spreader have been accepted for use at the testing site of LLP "Akmolapribor" (Astana) for further research, refinement for small-batch production, and integration into the automatic control system (ACS) for the bitumen-chip distribution process.

Structure and volume of the dissertation. The dissertation consists of definitions, designations, and abbreviations, an introduction, five chapters, a conclusion, a list of references, and appendices.

The work is presented on 151 pages of typed text, including 79 figures, 11 tables, a list of 61 references, and 3 appendices.