

## ANNOTATION

**Issabek Zarina Ramazanovna** on the topic "Development of an automatic control system for the process of milling road surfaces with road milling machines" for the degree of Doctor of Philosophy (PhD) in the specialty 6D071200 – Mechanical engineering.

**General characteristics of the work.** In the dissertation work, the existing technological methods of milling the top layer of road surfaces and the known designs of the road cutters used are studied, their main disadvantages are revealed; for the first time it is proposed to consider a road milling machine as an object of automatic control and to create on the basis of them automatic control systems (ACS) for milling road surfaces, automatic systems for manufacturing the required shape and size of stoves at the site of destroyed joints between the canvases and repairing roads with cracks of temperature origin. The modernization of standard units of road milling machines is justified, original designs are developed, the calculation of the structures of elastic elements built into standard units, which are primary non-electrical converters of both measuring transducers and actuators of automatic milling control systems, is carried out. Experimental studies of prototypes of assemblies with elastic elements embedded in them were carried out on the developed stand. For the first time, the proposed solutions made it possible to increase the efficiency of road milling machines (RMM), including expanding their operational, technological, economic, and design and mechanical capabilities.

**The relevance of the work.** The technological process of mechanical action on the upper layers of the road surface with road cutters is the main and only one for repairing damaged sections of asphalt concrete road surfaces, as well as for preparing surfaces for laying new layers without heating the coating, but only by crushing the grains of asphalt concrete mixture and changing the granulometric composition of the surfaces being repaired.

To date, the operational and technical characteristics of the equipment used - road milling machines – are limited, and their design and technological resource of modernization is almost exhausted, while the equipment itself operates under conditions of significant loads and the action of a large number of external destabilizing factors. Additional difficulties are created by the multifactorial nature of the milling process, the nonlinearity of most of the characteristics of the relationship between the input and output variables of the milling process, the absence of analytical dependencies between them. In these conditions, a new approach is needed to improve and increase the efficiency of this class of road construction machines.

The analysis of the functioning of road milling machines, as well as patent and information research in this area, allowed us to identify a promising way to further improve the technology and equipment used in the form of the development of a cold milling process based on standard units of road milling machines. Scientific research in this direction is new, relevant, promising and the only true way to expand the operational, technological, economic, design and mechanical capabilities of road milling machines.

Thus, the dissertation work aimed at developing an automatic control system for the process of milling road surfaces with modernized road milling machines is relevant, and the scientific direction itself is fundamentally new and has no analogues.

**As a result of the dissertation research , the results were obtained:**

- The layout schemes of road milling machines (RMM) are considered, a variant of improving the main element of the RMM is proposed – a milling drum that provides cutting and delivery of chips from the ends of the drum to centrally located ejectors.
- The shapes of the worn surfaces of rotary tool inserts of milling drums in real operating conditions have been studied, a new wear element has been identified for the first time – the kinematic profile of the wear site on the cutting surface of the tool insert and a stationary device has been developed for finding and quantifying all wear elements of tool inserts (Pat.RK № 35400).
- For the first time, the RMM is considered as an object of automatic control, the main physical states, input, output and disturbing parameters and effects on the milling process are highlighted, which made it possible to develop an original automatic control system (ACS) of the milling process to maintain a given milling depth (Pat.RK № 35040) and SAR of asphalt concrete milling to ensure the correct geometric shape and dimensions of the struts at the site of the destroyed joints between the road surfaces of highways (Pat.RK № 34933).
- The main components of the RMM have been improved and modernized, ensuring the achievement of a new technical result:
  - a) road milling cutters (Pat.RK № 34246), which ensures the rapid creation of different depths of the vertical crack wall and the automatic formation of different shelf widths above it;
  - b) milling drum (Pat.RK № 35091), which provides the creation of a variously point, adaptively variable shock-concentrated force point impact on the treated surface, varying according to the location on the surface of the road surface;
  - c) a device for cutting cracks in road surfaces (Pat.RK № 35118), which made it possible to automatically cut slots of different widths with the maximum number of working strokes;
  - d) milling drum (Pat.RK № 35196), providing removal of the required milling depth of the defective pavement layer;
  - e) milling working body (Pat.RK № 34247) for removing marking marks from road surfaces.
- The design of the measuring wedge has been improved (Pat.RK № 34221) for measuring the evenness of asphalt concrete pavement rails.
- A method for selecting a controlled parameter of the state of the RMM equipment has been developed;
- The methodology was compiled and the elastic elements of the assembled measuring transducers of the milling process were calculated, the static and dynamic characteristics of the main functional elements and nodes of the milling process were evaluated.

- A device has been developed for the automatic creation of a force that is adjustable in magnitude in the direction of loading the milling drum, dependencies have been found for calculating the coordinates of the vertex of the displacement vector of the center of mass of the milling drum;
- Empirically, the stand confirmed the possibility of creating on the basis of upgraded milling drum assemblies (in particular, on the basis of its bearing supports) the ASC of the milling process.
- The optimal functional and technical characteristics of the measuring transducers built into the standard RMM unit have been empirically confirmed, namely, high sensitivity to variation of the diagnosed parameter, reliability and invariance with respect to external destabilizing and loading factors.

The relevance and prospects of creating a milling process based on the RMM, ASC are confirmed by nine patents of the Republic of Kazakhstan for inventions.

**Purpose of the work** - improving the efficiency of road milling machines by considering them as an object of management and creating automatic milling process control systems on the basis of standard road milling machine units.

**Research objectives:**

- to substantiate the possibility of considering road milling machines as objects of automatic control;
- develop an automatic milling control system based on road milling machines with a milling drum, using parts of their upgraded standard components as a primary non-electric converter;
- to develop a system for automatic control of the milling process of destroyed joints between road surface strips of highways;
- upgrade the main components of road milling machines, namely, milling drums, a road milling cutter, a milling working body and a device for cutting slots;
- to develop technical means of metrological support for the operation of the ATS, namely, a measuring wedge for measuring the evenness of the coating and devices for measuring the wear of tool inserts;
- to calculate the elastic elements of the main functional units of the automatic control system of the milling process and equipment for the repair of road surfaces;
- to evaluate the static and dynamic characteristics of the standard upgraded units of road milling machines used in the automatic control system;
- to develop a stand and conduct experimental studies of prototypes – upgraded bearing supports of the milling drum.

**The object of the study** is a road milling machine and the systems of automatic control of the milling process implemented on the basis of it.

**The subject of the study** is the upgraded standard components of road milling machines with built-in elastic-deformable parts that implement the functions of a measuring converter of an automatic milling control system.

**The scientific novelty is:**

- a new approach in considering road milling machines as an object of automatic milling control;
- original automatic milling control systems based on standard units of road milling machines and technical solutions for upgraded machine parts and assemblies,

protected by nine patents of the Republic of Kazakhstan: 34040, 34221, 34246, 34247, 34933, 35091, 35118, 35196 i35400;

- results of calculations of elastic elements of the main functional units of the automatic control system of the milling process;

- the results of experimental studies on the original stand of prototypes of upgraded bearing supports of the milling drum, confirming the operability of the developed ASC milling process.

**The practical significance of the research is:**

- in the possibility of using prototypes of upgraded milling drum bearing supports in automatic milling control systems implemented on the basis of them;

- in newly created original designs of standard units of road milling machines;

- in the original technical means of operational control of the qualitative parameters of the asphalt concrete coating being constructed and operated, in particular, the measuring wedge for measuring the evenness of the coating rail;

The following scientific provisions are submitted for protection:

- the composition and implementation of two automatic control systems (ASC) of the milling process, as well as technical solutions for upgraded machine parts and assemblies, including:

- a) ASC of the milling process regulation process (Pat. RK № 34040);

- b) ASC of the milling process of destroyed joints (Pat. RK № 34933);

- c) a road milling cutter for cracking (Pat. RK № 34246);

- d) a milling working body of a road machine (Pat. № RK 34247);

- e) milling drums (Pat. RK № 35091 and № 35196);

- f) a device for cutting cracks (Pat. RK № 35118);

- g) measuring wedge (Pat. RK № 34221) and devices for measuring the wear of tool inserts (Pat. RK № 35400);

- method of calculation of elastic elements of the main functional units of the automatic control system of the milling process and equipment for the repair of road surfaces;

- the design of the stand and the results of experimental studies of experimental samples of bearing supports of the milling drum obtained on it.

**Approbation of the work.** The results of the research were reported and discussed at the V International Scientific and Practical Conference "Improving the reliability and safety of transport facilities and communications, November 27-28, 2019 (Russian Federation, Saratov).

**Publications.** On the topic of the dissertation research published 12 scientific papers, including two articles in the journal indexed in the Scopus database, received 9 patents of the Republic of Kazakhstan for inventions and one article in the proceedings of the V International Scientific and Practical Conference.

**Implementation of research results.** Prototypes of upgraded bearing supports of the milling drum were tested at the site of Akmolapribor LLP (Astana) and introduced into the prototype of the automatic control system of the asphalt concrete milling process in 2022 in Astana.

**The structure and scope of the dissertation.** The dissertation work consists of definitions, designations and abbreviations, an introduction, 5 sections and a conclusion, a list of sources used, standards and regulatory documents, as well as three appendices. The work is presented on 157 pages of typewritten text, includes 64 figures, 10 tables, a list of used sources, standards and regulatory documents from 86 titles, 3 appendices.