ANNOTATION

dissertation on the topic "Development of parallel manipulators with two endeffectors", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D071200 - "Mechanical Engineering" **Naurushev Batyr Kabirovich**

Relevance of the Research:

Automation of loading and unloading operations in stamping production requires the use of efficient manipulation systems with high speed and accuracy. One of the promising areas of automation for such processes is the use of parallel manipulators, which offer advantages such as high rigidity, precise positioning, and compact design. However, existing designs are mainly focused on a single endeffector, which limits their functionality in multi-tool production operations. Parallel manipulators with two end-effectors can increase process productivity, reduce equipment costs, and minimize mechanical loads on actuators. In this regard, the development of parallel manipulators with two end-effectors is a highly relevant scientific and technical task.

Research Objective:

To develop and analyze new designs of planar parallel manipulators with two end-effectors for use in automated technological processes, including metal blank stamping.

Research Tasks:

Analyze current methods of designing parallel manipulators.

Develop a methodology for the structural and kinematic synthesis of planar manipulators with two end-effectors.

Perform kinematic and kinetostatic analysis of the developed mechanisms.

Develop mathematical models describing the motion and force interaction of manipulator components.

Conduct numerical modeling and fabricate 3D models of the developed designs.

Evaluate the practical applicability of the proposed solutions and develop recommendations for their implementation in industrial production..

Object of Research:

Planar parallel-structure robotic manipulators intended for automation of manufacturing processes.

Subject of Research:

Structural-kinematic and kinetostatic characteristics of parallel manipulators with two end-effectors.

Research Methods:

The research uses methods of structural and kinematic synthesis, theory of machines and mechanisms, kinetostatic analysis, mathematical modeling, and technologies of 3D computer design and simulation (CAD/CAE).

Scientific Provisions and Results Submitted for Defense:

A method for structural and kinematic synthesis of planar manipulators with two end-effectors.

Results of kinematic and kinetostatic analysis of parallel mechanisms of class III and V.

New designs of planar parallel manipulators with two end-effectors.

Design solutions of manipulators suitable for implementation in automated stamping systems.

Developed mathematical models describing kinematic and kinetostatic characteristics.

Experimental results confirming the operability of the proposed solutions in designing mechanisms for press automation..

Scientific novelty:

The scientific novelty of the research lies in the development of a new structural scheme of a parallel manipulator with two end-effectors, which expands the functional capabilities of traditional mechanisms by using synchronized control from a single actuator. Mathematical models have been developed to accurately analyze and optimize motion and force interaction.

Methods for the structural and kinematic synthesis of parallel mechanisms are proposed. A comprehensive kinetostatic analysis was conducted with consideration of real-world operating conditions. Developed mathematical models were validated through numerical simulations.

Practical Value and Implementation of the Results:

The developed manipulator designs can be used in mechanical engineering for automating loading, unloading, and technological operations. The proposed methodologies can be applied in engineering calculations and the development of new industrial robotic systems. The work is based on formalized mathematical models, proven methods of mechanism theory, and numerical simulation supported by experimental data. The proposed approaches have been validated through the creation of 3D models and prototypes. The developed models and methods can be applied in the design of industrial robots and adapted for specific manufacturing tasks. Some results were implemented as 3D models and engineering solutions for automating cam-screw and crucible presses.

Publications:

1. Baigunchekov, Z., Naurushev, B., Zhumasheva, Z., Mustafa, A., Kairov, R., Amanov, B. Structurally parametric synthesis and position analysis of a robomech class parallel manipulator with two end-effectors, Article. IAENG International Journal of Applied Mathematics, V 5, I 1-77, 1 January 2020, P 1-11, ISSN: 19929978, Scopus, Applied Mathematics – 49%.

2. Zh. Baigunchekov, S. Ibrayev, M. Izmambetov, Naurushev, B., T. Baigunchekov, A. Mustafa. Synthesis of cartesian manipulator of a class RoboMech, Conference Paper, Mechanisms and Machine Science, V 66, 2019, P 69-76., ISSN: 22110984, DOI: 10.1007/978-3-030-00365-4_9, Scopus, Mechanical Engineering – 25%.

3. Baigunchekov, Z., Kalimoldayev, M., Ibrayev, S., Naurushev, B., Izmambetov, M., Baigunchekov, T., Aisa, N. Parallel manipulator of a class RoboMech, Conference Paper, Lecture Notes in Electrical Engineering, Volume 408, 2017, Pages 547-557, ISSN: 18761100, DOI: 10.1007/978-981-10-2875-5_45, Scopus, Industrial and Manufacturing Engineering – 33%.

4. Наурушев Б.К., Дүйсенбек Ә.Н., Кинетостаческий анализ параллельного манипулятора с двумя рабочими органами, Механика и технология, - Тараз, Республика Казахстан, № 4 (66), 2019 г. – С. 21-28, ISSN 2308-9865, https://journals.dulaty.kz/images/archive/meh-teh/2020/meh-teh-2019-4.pdf.

5. Наурушев Б.К., Дүйсенбек Ә.Н., Структурно-параметрический синтез плоского параллельного манипулятора с двумя рабочими органами, Механика и технология, - Тараз, Республика Казахстан, № 4 (66), 2019 г. – С. 29-41 ISSN 2308-9865, <u>https://journals.dulaty.kz/images/archive/meh-teh/2020/meh-teh-2019-4.pdf</u>.

6. Naurushev B., Nugman E., Baigunchekov Zh., The Possibilities of Using a Planar Parallel Manipulator with two End-Effectors for Moving Workpieces, Университет еңбектері-Труды университета, - Караганда, Республика Казахстан, № 1, 2025г. – С. 59-63 ISSN 2710-3382, <u>https://tu.kstu.kz/issue/issue/download/105</u>, DOI: 10.52209/1609-1825_2025_1_59

7. Baigunchekov, Z., Naurushev B., Zhumasheva, Z., Mustafa, A., Kairov, R., Amanov, B. Parallel Manipulator of a Class RoboMech with Two End-Effectors, Conference Paper, Lecture Notes in Engineering and Computer Science, Volume 2240, 2019, Pages 449-454, ISSN: 20780958.

8. Baigunchekov Zh., Ibrayev S., Izmambetov M., Naurushev B., Baigunchekov T., Synthesis of the Intellectual Parallel Manipulator with Two Degrees of Freedom, DEStech Transactions on Engineering and Technology Research, 2017, volume 162, p. 361-365. DOI 10.12783/dtetr/amsm2017/14871.

9. Askarov, E., Zhauyt, A., Naurushev B., Abilkaiyr, Z., Zhankeldi, A., New type cam-screw mechanical press, Engineering for Rural Development, Volume 16, 2017, Pages 36-41, 16th International Scientific Conference Engineering for Rural Development; Jelgava; Latvia; 24 May 2017 до 26 May 2017; Код 131321, ISSN: 16913043.

10. Kosbolov, S., Tulegenova, K., Naurushev B., Bekenov, E., Zhauyt, A., Kinematic synthesis of initial kinematic chains, Engineering for Rural Development, Pages 155-169, 15th International Scientific Conference on Engineering for Rural Development; Jelgava; Latvia; 25 May 2016 до 27 May 2016; Код 122094, ISSN: 16913043.

11. Baigunchekov Z., Ibrayev S., Naurushev B., Izmambetov M., Zhumasheva Z., Baigunchekov T., Mustafa A., Sagyntay M., Synthesis of Reconfigurable Positioning Parallel Manipulator of a Class RoboMech, 2018 International Conference on Reconfigurable Mechanisms and Robots, ReMAR 2018 – Proceedings, 28 August 2018, Номер статьи 8449852

12. Baigunchekov Z., Ibrayev S., Izmambetov M., Naurushev B., Zhumasheva Z., Baigunchekov T., Mustafa A., Sagyntay M. Synthesis of Reconfigurable Positioning Parallel Manipulator of a Class RoboMech, 2018 International Conference on Reconfigurable Mechanisms and Robots, ReMAR 2018 – Proceedings, 28 August 2018, Номер статьи 8449852. 13. Baigunchekov Zh., Ibrayev S., Naurushev B., Izmambetov M., Baigunchekov T., Synthesis of Intellectual Parallel Manipulator with Two Degrees of Freedom, 2017 2nd International Conference on Applied Mathematics, Simulation and Modelling, August 6-7, Phuket, Thailand, 2017, pp. 361-365., ISSN 1951-6851.

14. Baigunchekov Z., Ibrayev S., Izmambetov M., Naurushev B., Baigunchekov T., Mustafa A. Synthesis of Cartesian manipulator of a class RoboMech, 4th IFToMM Symposium on Mechanisms design for Robotics, September 11-13, 2018, Udine, Italy.

15. Наурушев Б.К., Измамбетов М.Б., Байгунчеков Ж.Ж., Дүйсенбек Ә.Н. Исполнительный механизм робота с двумя схватами, Патент на полезную модель №4389. НИИС РК. Бюллетень №44 – 01.11.2019.

A total of 15 publications have been made on the topic of the research, including 3 articles indexed in the Scopus database with CiteScore percentiles of 49%, 33%, and 25%; 3 articles published in journals recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan; 7 articles presented at international scientific-practical conferences; and 1 utility model patent registered by the National Institute of Intellectual Property of Kazakhstan.

Structure and Volume of the Dissertation:

The dissertation consists of an introduction, five chapters, a conclusion, a list of references, and appendices. The total volume is 123 pages, including 28 figures and 14 tables, and 73 sources were used.