Problems and Prospects in Research on the Dynamics of Mechanical Systems with Servo-Constraints

Evgeniya Mikishanina

Chuvash State University, Cheboksary, Russia

The development of robotics is stimulating the interest of scientists in the field of mechanical system control. This report discusses the prospects and challenges associated with the study and control of mecanical systems with servo-constraints. These are the problem of steering a mechanical system into a motion regime that complies with servo-constraints, the problem of stability of servo-controlled motion and others.

In the scientific literature, there are several approaches to constructing equations of motion and determining control actions for systems with servo-constraints. This study uses an approach based on the generalized D'Alembert – Lagrange principle and program control [1–3].

Special attention is also devote to the stability of motion using the example of a system consisting of two spheres, where one sphere rolls over the surface of the other sphere (Fig. 1). To study the stability problem when one sphere moving along a circular path on the surface of the another one, a method based on equations in variations is used. When one sphere is held on the surface of the another one in an upper or lower position, the stability problem reduces to studying the stability of equilibrium positions.

Linearization of equations of motion in the neighborhood of the equilibrium positions does not answer the question of whether equilibrium positions are stable because all eigenvalues of the matrix of the linearized system have a zero real part. Therefore, a different approach is required. The existence of a complete set of first integrals and a measure makes the system of motion

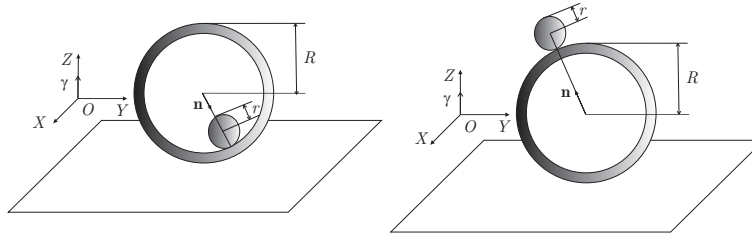

Figure 1. Systems of two spherical bodies.

equations integrable by the Euler – Jacobi theorem. To study the stability of equilibrium positions, we proceed to the study of the potential energy of the reduced system.

References

[1] Mikishanina E. A., Two ways to control a pendulum-type spherical robot on a moving platform in a pursuit problem, *Mechanics of Solids*, 2024, vol. 59, no. 1, pp. 127–141.

[2] Mikishanina, E. A., Control of a spherical robot with a nonholonomic omniwheel hinge inside, *Russ. J. Nonlin. Dyn.*, 2024, vol. 20, no. 1, pp. 179–193.

[3] Mikishanina E. A., Control of a System of Two Rigid Spherical Bodies Rolling over Each Other in a Gravity Field, *Nonlin. Dyn.*, 2025, vol. 113, pp. 20911–20922.