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Ryagin S.[1], Onyshchenko R.[2], Chernenko D.[3]
[1] PhD, Assistant professor, NU "Zaporizhzhia Polytechnic"
[2] PhD student, NU "Zaporizhzhia Polytechnic"
[3] student of the group M-614, NU "Zaporizhzhia Polytechnic"

COMPARISON OF APPROACHES TO THE OPTIMIZATION OF SPRING ELEMENTS IN MACHINES

Springs are widely used in mechanical engineering as elements for storing and transmitting mechanical energy and for load compensation in mechanical systems. Since such components usually operate under cyclic loading and high stress levels, the rational selection of their geometric parameters significantly affects the reliability, durability, and dimensions of engineering structures.

Traditional spring design relies mainly on standard design solutions and empirical relationships, which do not always provide an optimal combination of mass, stiffness, and strength characteristics. Therefore, the application of optimization methods is an important task in the design of spring elements.

Various optimization approaches are used in engineering practice. Parametric optimization is based on varying geometric parameters while preserving the structural topology and is widely applied due to its relatively low computational cost. Shape optimization focuses on improving stress distribution by modifying the geometry of elements. Topology optimization determines the rational distribution of material within a given design space and is mainly applied at the conceptual design stage. In addition, heuristic global search methods, including genetic and evolutionary algorithms, can be used for complex optimization problems.

The analysis shows that the design of spring elements generally represents a multi-criteria optimization problem, since several performance indicators must be considered simultaneously, including mass, overall dimensions, stiffness, and stress state.

Therefore, the authors propose the application of multi-criteria parametric optimization for the design of spring elements. The proposed approach includes several stages: development of a parametric model and selection of design variables; definition of objective functions and constraints; analysis of the stress–strain state using analytical or numerical methods; and determination of rational parameter values providing a compromise between multiple performance criteria.

The proposed method allows simultaneous consideration of structural and operational requirements and can be applied to the optimal design of various spring systems in mechanical engineering.