ISSUES OF ENSURİNG THE EFFİCİENCY OF GEAR GRİNDİNG BY THE COPYİNG METHOD

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Abstract: This paper presents a systematic analysis of the gear grinding process of shaped tooth profiles using the copying method. A concept for improving process efficiency is developed, and based on this concept, directions for efficiency enhancement are identified. Methods and tools for managing the efficiency of gear grinding by the copying method through both direct and indirect approaches are proposed.
Keywords: system, hierarchy, gear grinding, copying, analysis, improvement.

Introduction. Improving the efficiency of mechanical processing ensures both the enhancement of the operational performance of manufactured parts and products, and the reduction of production cost through increased technological flexibility, thereby improving competitiveness [1]. In this regard, a number of technological solutions have been developed for the gear grinding of shaped flat surfaces, particularly involute and other profiled surfaces, using the copying method, yielding positive results. However, the conducted studies have largely been of a local nature, and a generalized comprehensive approach has not been established. Therefore, it is necessary to develop a systematic approach to improving the efficiency of mechanical processing, taking into account the preceding and related technological processes. From this perspective, the development of a generalized concept aimed at improving the efficiency of mechanical processing based on the example of gear grinding by the copying method is considered relevant.

Problem Statement: Any technological operation, including gear grinding by copying and rolling methods, represents a complex system consisting of primary and auxiliary elements, as well as related constructive and technological factors and their interactions. This system includes the material of the gear, methods of blank formation, the gear cutting process, associated surface machining operations, and factors related to heat treatment, including constructive, technological, kinematic, and dynamic aspects. Gear grinding by the copying method functions as a higher-level system, while the processes associated with and preceding it form subsystems. Each output parameter of the grinding process is the result of transformations occurring within these subsystems. Therefore, to improve the quality and productivity of gear grinding, a systematic approach that considers all subsystems must be applied.

Solution Approach: To perform a system analysis of the gear grinding process using the copying method, the system was decomposed by considering all its interactions, including those related to preceding operations such as heat treatment and machining of rotational surfaces. Established methodologies of system analysis were employed for this purpose [2]. In this process, the principles of system integrity and emergence were maintained. Additionally, by considering features such as

constructiveness, orientation of components, interconnections, technological characteristics, and goal orientation, a hierarchical structure of the system was developed. When constructing the hierarchical scheme, typical generalized technologies for gear manufacturing and all operations directly or indirectly related to gear grinding by the copying method were considered as subsystems. In other words, certain gears may not include features such as keyways or splined surfaces; in such cases, the corresponding subsystem should be excluded from the hierarchical structure. In general, the initial factors affecting the efficiency of gear grinding by the copying method are systematized into six groups, differing in their nature and mechanisms of influence: material and heat treatment; blank formation and machining allowance; basing and positioning; pre-honing gear quality; technological passes and main time; auxiliary passes and auxiliary time.

Discussion: Based on the analysis of the hierarchical structure of the gear honing system using the copying method and the investigation of opportunities for improving its efficiency, it has been established that efficiency can be enhanced in three ways: direct, indirect, and combined methods. As a result of the conducted research and system analysis of the process, the following directions for improving the efficiency of gear grinding by the copying method have been identified:

- indirectly, by ensuring minimum and maximum machining allowances in accordance with both theoretical and experimental values accepted in mechanical engineering;
- directly, by reducing the number of passes through decreasing the actual cutting depth in gear grinding using the method developed at AzTU [3, 4];
- directly, by adopting an effective scheme of basing and positioning through controlling the condition of gear teeth and shaped surfaces within the honing zone.

Conclusion. A generalized concept for improving the efficiency of gear grinding based on a systematic approach has been developed. Methods and directions for enhancing efficiency through direct, indirect, and combined approaches have been presented.

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