ABSTRACT

Contemporary trends in machining processes focus on the use of cooling and lubrication methods that are environmentally friendly and safe for human health. Studies have shown that, in addition to the basic lubricating agents used in mineral oils, water-based emulsions, and synthetic fluids, the lubricating properties of cutting fluids can be improved by introducing appropriate additives. A review of the literature clearly indicates that cutting fluids enriched with nanomaterials effectively reduce friction and enable better control of the temperature of surfaces in contact.

In this dissertation, particular attention was paid to selecting appropriate types of nanoparticles and cooling–lubricating fluids (CCFs) to obtain a stable cutting fluid–nanoparticle system. This stage was crucial from a technological standpoint. The next stage involved operational tests, including the evaluation of the anti-wear performance of the developed tribological systems and the execution of pre-implementation tests.

The doctoral dissertation was divided into four main parts. The first part presents an introduction and a review of the state of the art regarding tribological phenomena and processes, with particular emphasis on those occurring during machining. The characteristics of the CCF system were also presented, along with a discussion of the properties of the nanomaterials. The second part outlines the aim, hypothesis, and scope of the research. The third part describes the research objects and methods, as well as the methodology used for obtaining the nanofluids. The fourth part presents the obtained research results and the conclusions drawn from their analysis. First, experimental tests performed using micro- and macro-scale tribological testers are presented; these tests allowed for the assessment of wear resistance and friction coefficients of the examined material pairs under sliding motion. The results of these tests formed the basis for the pre-implementation studies conducted during longitudinal turning using the CCF system. After the completion of the tribological tests and turning processes, the samples were analyzed using various microscopic techniques and profilometry.

The final chapter provides a summary of the conducted analyses and the concluding remarks based on the experimental findings. The results indicate that the coolant containing nanomaterials exhibited better properties than the classical coolant used for comparison. The CCF system containing nanoparticles—particularly Bi_2S_3 nanostructures—ensured stable operation of the tribological system and contributed to the reduction of both the friction

coefficient and wear of the tribological pair. This effect resulted from the formation of an anti-wear layer in which bismuth and sulfur interacted synergistically.

Owing to its effective lubrication and cooling, the CCF system enriched with nanoparticles performed its operational function properly. Therefore, it can be applied both on conventional machine tools and on numerically controlled machine tools (CNC – Computer Numerical Control), particularly during the machining of steel.