ABSTRACT

The doctoral dissertation concerns the analysis and modelling of the plunge-grinding process of cylindrical surfaces in aerospace components made of EI961 steel after gas nitriding and AMS6308 steel after carburizing. The main objective of the work was to determine the relationships between the grinding conditions—which include the grinding wheel characteristics, dressing method, and cutting parameters—and the condition of the technological surface layer, understood as the micro-geometrical structure of the surface, 2D and 3D roughness parameters, grinding force profiles, and microstructural morphology.

In the first part of the dissertation, a review of the current state of knowledge was conducted, and key production challenges occurring in the industrial environment were identified. These included, among others, instability of grinding parameters, variations in the formation of the surface layer, difficulties in ensuring process repeatability, and the risk of micro-defects such as white layer formation or microcracking. A detailed research plan was developed, encompassing measurements of the grinding force components (F_t and F_n), assessment of grinding wheel wear, 2D and 3D surface topography measurements, microscopic analysis of microstructures, and detection of grinding burns. An important aspect was the evaluation of the influence of grinding wheel type—traditional fused alumina wheels and modern microcrystalline alumina tools—on the formation of the wheel active surface and on process stability. The results revealed distinct differences in the dynamics of cutting forces and wear behaviour between the analysed tools. The conducted analyses enabled the development of mathematical models describing the relationships between the grinding process parameters and the resulting condition of the surface layer. It was confirmed that properly selected machining parameters, combined with appropriate wheel conditioning, allow the avoidance of white layer formation and uncontrolled microstructural alterations. The dissertation provides both cognitive value—by expanding the knowledge base on the mechanics of grinding thermochemical-hardened materials—and utilitarian value through implementations in the aerospace industry. The findings form a foundation for further research on grinding process modelling, optimisation, and the design of manufacturing processes aimed at minimising the formation of micro-defects in the surface layer.