Determining Critical Temperature Thresholds for Tensile Residual Stress Development in Grinding Operations / R. Strelchuk, O. Kupriyanov, P. Vasylianskyi, J. M. Machado // Innovations in Mechanical Engineering. Lecture Notes in Mechanical Engineering. / J. Machado, J. Trojanowska, E. Ottaviano (eds). – Springer, Cham, 2026.

Abstract. This study investigates the critical temperature thresholds governing the transition between compressive and tensile residual stress development in grinding operations. Through theoretical modeling and experimental validation, the dominant role of thermally-induced stresses in tensile residual stress generation is demonstrated. The influence of heat source geometry on stress outcomes is found to be minimal, with variations under 6%. Material properties, particularly temperature-dependent yield strength and heat treatment history, are identified as critical determinants of stress development. A systematic methodology for characterizing the onset temperatures at which tensile residual stresses form in ground components is presented. The model successfully predicts transitional temperature boundaries across different grinding conditions for various steel grades, with a transitional temperature range of 200-230°C established for hardened and tempered En9 steel. These findings provide a practical framework for residual stress control by transforming the problem into one of temperature management, achievable through optimized grinding parameters and effective coolant delivery strategies. The study integrates thermal modeling of the grinding process with constitutive relations for thermally-induced stress development, enabling prediction of both temperature distributions and resulting residual stress fields under specified grinding conditions. The analytical framework establishes a foundation for assuring component surface integrity through thermal management in grinding operations.

Keywords: Grinding temperature, Stress transition, Surface integrity.