ABSTRACT

Dissertation Title: **Modeling and Numerical Simulation of the Gas Quenching Process of Pyrowear 53 Steel Gears.**

Deformation control of precision machine parts, such as aerospace gears, is one of the most important aspects of their quality control. The requirements of the aerospace industry, imposed both by aerospace regulatory bodies and by internal quality standards for the development and implementation of new technologies, impose the need to check and confirm the conformity of the characteristics of manufactured parts with the technical documentation. The efficiency of these activities is significantly increased by the use of computer simulation of technological operations, which is considered a pillar of automation of manufacturing processes.

The aim of the research (conducted within the framework of the "Implementation PhD" program) was to develop and validate a numerical model of the high pressure gas quenching (HPGQ) process for gears made of Pyrowear 53 steel, with a view to its application in the aerospace industry by Pratt & Whitney Rzeszów. It was assumed that the numerical model would provide an effective simulation tool capable of predicting the effect of changes in the heat treatment process parameters on the dimensional characteristics of the products. It is expected that it will allow to compare the results of the application of the innovative gas quenching method with the currently used oil quenching method and to optimize it in terms of minimizing the deformation of the processed parts. The expected result of the research conducted was also to contribute to increasing the manufacturing readiness level (MRL) of the new technologies on an industrial scale, which is an important step towards their certification and approval.

The dissertation develops a model of the process consisting of sub-models of material properties, diffusion or heat transfer, among others. The six chapters include: a study of the literature on the topic, covering the theoretical and technological issues in the field of heat treatment of structural steel, and the application of numerical analytical methods and computer simulations of these processes; an analysis of the state of the problem, on the basis of which the purpose and scope of own research was determined; the assumptions and methodology of own research and analysis; a discussion of the results achieved; a summary and conclusions resulting from the research conducted.

As a result of the research, it was established, among other things, that computer simulation makes it possible to optimize the quecheing technology of carburized gears already at the stage of the process design. The developed numerical model makes it possible to analyze the impact of changes in individual process parameters on the quality characteristics of machined machine parts. This applies to both quenching in quenching oil and quenching in gas. It is possible to predict changes in mechanical or dimensional properties of workpieces as a result of changes in coolant, temperature or process time. This supports the implementation of process changes and minimizes the need for time-consuming and costly experimental procedures.

Keywords: aircraft transmissions, gears, carburizing, LPC, quenching, HPGQ, modeling, computer simulation, DEFORM.