Rzeszów University of Technology
The Faculty of Mechanical Engineering and Aeronautics
Rzeszów, 2024

# Doctoral dissertation abstract

**Title:** Analysis of the influence of tool coating type and forming strategy on the surface quality and formability of titanium sheets in the incremental forming process

Author: mgr inż. Marcin Szpunar
Supervisor: prof. dr hab. inż. Tomasz Trzepieciński
Co-supervisor: dr inż. Robert Ostrowski

**Keywords:** analysis of variance, titanium sheets, single-point incremental sheet forming, finite element method, lubrication, Ti-6Al-4V, friction, surface topography

**Abstract:**

The main objective of this doctoral dissertation was to analyze the incremental sheet forming process of commercially pure titanium (CP-Ti Gr 2) and titanium alloy (Ti-6Al-4V), focusing on the relationship between process parameters, surface quality, and formability of the material during the forming of conical frustums with constant and variable wall angles at elevated temperatures. A specialized device was developed to enable the heating of Ti-6Al-4V sheet metals during the forming process.

Experimental tests were conducted to evaluate the influence of tool materials (WC, $Al_2O_3$ + SiC(w)) coated with different coatings (AlCrN, TiSiXN, and ZrN) on the incremental forming process. To establish the relationship between forming process parameters, forming force components, and surface quality of the drawpieces, statistical methods such as variance analysis, response surface methodology, and the restricted maximum likelihood method were used. A central composite design and a split-plot I-optimal design were employed to plan the experiments. The experimental research was complemented by thermomechanical numerical simulations (finite element method) of the incremental forming process for CP-Ti Gr 2 and Ti-6Al-4V sheets.

The use of hybrid heating techniques combining liquid under adaptive pressure with friction stir heating along with the selection of an appropriate forming strategy, tool material, and process parameters, enabled the successful forming of Ti-6Al-4V titanium alloy drawpieces. The studies identified key process parameters influencing the formability of CP-Ti Gr 2 and Ti-6Al-4V sheets in single-point incremental forming. The results demonstrated that the selection of parameters such as tool rotational speed, feed rate, forming strategy, step size, and oil pressure has a significant effect on the coefficient of friction, forming force components, and sheet metal formability.