SUCCESS STORY

IC-MPPE
Integrated Computational Materials Process and Product Engineering.

Programme: non-COMET

Programme Line: FFG, Take Off

Project: AeroDOM (nk216), 10/2021-09/2025, industrial research/ multi-firm

Forged aircraft components. Image: MCL AI-generated (chatgpt)

OPTIMIZED AIRCRAFT PARTS THROUGH RESIDUAL STRESS MODELING

MODELING RESIDUAL STRESSES IN TI-6AL-4V AIRCRAFT COMPONENTS HELPS IMPROVE UNDERSTANDING OF THE PRODUCTION PROCESS, REDUCE SCRAP, AND THEREBY ENHANCE BOTH COST-EFFICIENCY AND SUSTAINABILITY.

Ti-6Al-4V is an ideal material for aircraft components due to its excellent strength-to-weight ratio. It is used for a wide range of parts, especially structural components operating at temperatures below 300 °C.

The most common manufacturing process for critical aircraft components generally consists of forging, heat treatment, and milling. During heat treatment, stresses introduced during forging are relieved, while the mechanical properties of the component are adjusted. In this process, the part is held at high temperature and then quenched to room temperature using different cooling methods.

During quenching, residual stresses can develop within the component. These stresses may cause the part to distort during subsequent milling operations. It is therefore essential to understand the residual stress state within the component so that distortion during machining can be minimized as much as possible. In this way, scrap parts can be reduced or even avoided entirely.

Impacts and Effects

Residual stresses arise during cooling as a result of non-uniform temperature distribution combined with

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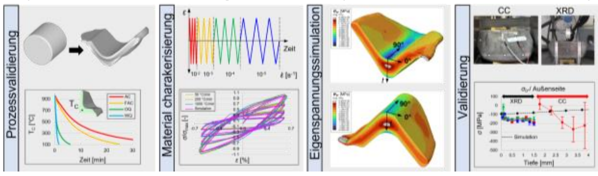
plastic material behavior. It is therefore important to represent both aspects accurately in a model.

To determine the temperature distribution, a test component was forged that represents a section of an aircraft part and was then subjected to the relevant cooling conditions. Temperatures were measured at various positions on the component during the process. Based on these measurement data, the cooling behavior can be reproduced in a simulation model.

To simulate residual stresses, the material behavior over a wide temperature range must be investigated. This material characterization forms the foundation for the mathematical description of the material. Using computer-aided simulation methods, the residual stress field within a component can then be calculated.

The calculated residual stress fields were validated using modern measurement techniques as well as internally developed methods. Additional milling experiments confirmed these results through analysis of component distortion. The data obtained are used to optimize milling processes for distortion reduction and are also incorporated directly into component design, since intentionally introduced compressive residual stresses can increase service life.

This improves the economic efficiency and sustainability of the aircraft semi-finished products manufactured by voestalpine BÖHLER Aerospace. In view of a projected market growth for aerospace materials to USD 62.3 billion by 2030, this deep understanding of component behavior secures a decisive competitive position in a dynamic market expected to grow by 8.4% annually.



Methodology for residual stress simulation and validation, Copyright MCL

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