Success Story
COMET

MPPE
Materials, Processing and Product Engineering
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K2-Centres
COMET subproject, duration and type of project:
Residual stresses in aviation components, 02/2013 – 03/2016, multi-firm

Parts for future aircrafts

Air traffic is rapidly increasing worldwide. This has far-reaching consequences for the environment and the people in urban regions. To address this problem future turbine engines must be quieter, cleaner and more efficient. MCL is working with the Böhler Schmiedetechnik and MTU Aero Engines on the development of mathematical models to determine the local material properties of forged turbine components. The aim of the research is to simulate the loads and strength in a turbine disk and thus to provide the constructing engineer with a powerful tool for the design optimization of aircraft turbines.

Modern process technology for quieter, …

According to a forecast of a European aircraft manufacturer 40,000 airplanes will be in the air up in 2035. That would be twice as many as today. With the current state of technology in the aircraft industry, this would mean that twice the amount of air pollution would be emitted and climate change would be further accelerated. With a worldwide increase in passenger traffic the noise impact on city regions and the global consumption of raw materials will further increase. To counteract this development engine manufacturers have to decrease noise, weight and fuel consumption. Furthermore, the service intervals should be extended. In order to develop the powerful, environmentally friendly and quiet engines of tomorrow a steady development is needed.
The Materials Center Leoben developed for MTU Aero Engines and the BÖHLER Schmiedetechnik GmbH & Co KG a numerical model for the simulation of residual stresses in turbine disks. Turbine disks are highly stressed parts of a jet engine, in which the turbine blades are mounted. With the aid of the combustion gas the turbine rotation is produced and consequently the thrust. The systematic development of highly loaded turbine components is unthinkable without computer models. In order to improve the properties by the manufacturing process powerful computer models are required to predict the local material structure, material strength and residual stresses.

… cleaner and more efficient turbines

The strength is the resistance of a material against plastic deformation. It is not a fixed value and can be adjusted by a heat treatment process. For optimum strength, the material needs to be understood on many metaphysical levels. Thermal, mechanical and chemical processes flow into one another. After forging, the still hot component is quenched with a variety of liquids or gases. Much like for a hot glass that shatters when it is filled with cold water, the cooling leads

bmwfw Federal Ministry of Science, Research and Economy
bmvit Austrian Ministry for Transport, Innovation and Technology

to stresses in the material. These so-called residual stresses have an influence on the lifetime of all engines, because they overlap with the stresses during rotation of the turbine disk, and reduce the service lifetime and efficiency.

Fig. 1: Silent and efficient - the geared turbofan is the aero engine technology of the future (Source: MTU Aero Engines)

Impact and effects

The Materials Center Leoben describes complex processes and influences on the material properties during the heat treatment mathematically and develops new computer models. The property distributions in the component are known at the end of a simulation chain and are a powerful tool for the constructing engineers to design aircraft turbines. It is thus possible to save material upon construction and at the same time meet the high safety standards with respect to life and load capacity in the aircraft industry.

Fig. 2: Heat treatment measurements after forging with thermocouples in a turbine disk (Source: Böhler Schmiedetechnik)

Contact and information
MPPE / A6.17 "Residual stresses in aviation components"

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