Thesis (Bachelor or Master): Material Models for Predicting Lifetimes of Cast Superalloys via a Micromechanical Simulation Approach

Micromechanical modelling of materials (e.g. crystal plasticity finite element method) has been increasingly used in recent years. The material models used in these methods are able to capture field quantities such as stresses or strains on the microscopic scale. However, due to the high experimental effort, these models are usually validated only at the macroscale, which leads to questionable validity for some applications (e.g. fatigue modelling). Another challenge in this field is the high computational cost of some of these models which prevents their widespread adoption in the industrial context, despite the ever increasing computational resources. An in-depth study of different material models taking all the aforementioned factors into account is therefore highly relevant.

Tasks:

- Work on a project focused on lifetime modeling of cast nickel-based superalloys for aero engine blades and vanes
- Review the state of the art research to identify suitable material models for the engineering problem at hand
- Implement the most promising models as a user material ("UMAT") in a finite element solver such as Abaqus or CalculiX
- Assess the accuracy of the material models using experimental results allowing for validation on the microscopic level
- Develop a quantitative error measure to compare different material models
- Deduce a recommendation for the optimal material model, taking into account various factors such as the conformity of the model with validation experiments and computational cost

Requirements:

- Studying a STEM subject with a strong computational background (e.g. computational engineering, mechanical engineering, materials science, physics or similar)
- Experience of the finite element method
- Coding experience in a high-level programming language (e.g. Python, Fortran)
- Ideally experience of implementing user material models and some materials science fundamentals
- Possibility of an internship to familiarize yourself with the used tools is given
- Good English and/ or German language skills
- Highly motivated, able to work independently on complex technical challenges
- Strong problem-solving mindset

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