Internship position : Fine characterization of damage evolution in aluminium thick plate thanks to the coupling of ex situ tomography high temperature tensile tests and finite element modelling.

Scientific background Light alloys, such as aluminium 2050, play a very important role in the aeronautic industry, in particular because of their high mechanical properties and characteristic low density. During the processing of thick plates, hot rolling is applied in order to reduce the thickness and close pores that are formed during casting. Pore evolution depends on the mechanical field (stress/strain) and on the morphology of the pores. While models accurately predict the evolution for simple shaped pores, the situation is much less accurate for geometrically complex pores. Furthermore, new process windows may induce extreme conditions where pore behaviour is not well known and nucleation and growth may occur and models have not been yet validated due to the lack of experimental data. Acutally Constellium handle some materials laws including a damage model which reproduce the macroscopic response of the sample, but the relations between the mechanical damage parameter and the porosity state has to be studied more deeply.

X-ray micro computed tomography (micro-CT) is a unique tool able to probe in 3D non destructively the microstructural heterogeneities of a sample with a micrometric resolution. Hence, provided the sample geometry is compatible with the micro-CT acquisition, a 3D description the pores population can be provided, enabling local porosity estimation and pores morphology and size quantification. Previous pore evolution experimental setups are usually performed in situ on very small samples to enable the device to fit inside the instruments. These small tests are not able to ensure a proper decoupling between local pore evolution and mechanical fields. Interrupted high temperature tensile test conducted on standard coupons size would enable intermediate characterization by micro-CT while being representative of the behaviour of the material in real parts.

Thus a dual experimental/numerical tensile test would shed light on the relationship between the mechanical damage parameter and the porosity state.

Main Objectives Conduct a dual experiment/numerical tensile test combining 3D micro-CT images in the course of the tests and a digital twin finite element simulation :

- to quantify the porosity field in 3D and its evolution along a tensile test
- to quantify the strain field thanks to digital volume correlation [Stamati et al. 2020; Lhuissier et al. 2021]
- to quantify the damage parameter field thanks to finite element simulations and Hosford-Coulomb damage model [Mohr and Marcadet 2015]
- to link pore volume evolution to the damage parameter

Preliminary design of the sample shape and size and of the acquisition conditions will also be required.

Key Highlights

- The proposing group has proven expertise on in-situ and ex-situ tomography acquisition and analysis
- Exposure to performing X-ray tomography experiments and for the subsequent image reconstructions
- Exposure to performing finite element simulations
- Close collaboration with Constellium

Requirements - Skills/ Qualifications

- Background in material science or a closely related discipline
- Interested in experimental research activities, including numerical data processing and numerical modelling
- Solid basic knowledge in programming languages like Python or comparable
- Sound knowledge of image processing and segmentation methodologies
- Good communication and team-working skills

The internship is planned for a start from Feb 2025 for a period of about 6 months or from April/May for a period of about 3 months.

Contacts/ Selection process Candidates can send their applications to:

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References

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