PhD Position 2023 at CEMEF in October 2023

Microstructure evolution during HFQ of AA2219 (CEMEF, CMAT and Airbus)

General context

In the context of necessary carbon emissions reduction, development of new alloys and processes for materials forming in the aeronautic industry are prolific research topics. Hot Forming Quench (HFQ) is a disruptive forming technology which enables to obtain complex shapes at lower cost compared to traditional aluminum manufacturing processes. It allows designers and engineers to create freely complex shapes of the parts with high geometrical and aerodynamic performance tolerance using thin wall Ultra High Strength aluminum (2xxx, 6xxx, 7xxx alloys). HFQ is an alternative to conventional deep drawing process combined with heat treatments which allows simplified complex manufacturing routes, hence highly reducing carbon emissions of the process.

Figure 1. HFQ represents an efficient alternative process for different parts of planes' structure

Airbus is a strong advocate of innovative technologies to reduce Buy-to-Fly ratio, to improve integration & cost saving. HFQ is considered to be an important technology pathway to achieve this ambition. However, because of its novelty, the understanding of the mechanical and metallurgical aspects of the HFQ process needs to be developed.

As a first step in a global collaboration strategy between CEMEF (Mines Paris) and Airbus, two PhD positions are proposed. The research topics are briefly described since only few informations on the HFQ process and Airbus parts of interest can be presented for confidential reasons. The originality and success of the overall project relies on the complementarity between the two PhD projects. **The candidates will have the opportunity to develop advanced skills in aluminum metallurgy, thermomechanical design of laboratory experiments and numerical simulations applied to the development of new parts for future zero-emission Airbus aircrafts.**

This PhD aims at investigating microstructural evolution during HFQ. Samples obtained from PhD1 using lab scale tests with well-controlled thermo-mechanical conditions will be analyzed with quantitative microstructural investigation applying different complementary techniques (hardness measurements, EBSD, TEM, DSC and XRD[1]). Therefore, the effect of HFQ processing conditions on further microstructure evolution will be established for an 2**** alloys and can be presented as processing-like map.

The activated physical mechanism and their interactions will be accessed through the analysis of microstructure evolution during the HFQ process with several microstructural quantities (grains size and orientation spread, dislocation density and sub-structures, second phase particle size distribution and volume fraction, crystallographic texture…). Those mechanisms will then be modeled for microstructural predictions and coupling with mechanical behavior.

The main challenges rely on the analysis of interaction between precipitation of hardening phases and plasticity which may involve a number of phenomena: heterogeneous nucleation, faster growth and coarsening of precipitates, recovery and dynamic recrystallisation. The experimental plan was carefully established to get insight into mechanisms which control microstructure evolution of 2*** alloys during HFQ.

- **Keywords:** thermomechanical processing, plasticity, hardening precipitation, recrystallisation and recovery, microstructure characterization
- **Candidate profile:** Master or engineering degree in materials science with good knowledge of phase transformations and plasticity mechanisms in metallic alloys. Motivation for experimental work.
- **Localization:** This PhD will take place in CEMEF in Sophia Antipolis (18 months) and CMAT in Evry (and Versailles from 2025) (12 months) and the last 6 months at Airbus Nantes
- **Salary**: 2700 €/month (gross salary)
- **Application:** Candidates applications should be sent by email and should include a CV, academic reports for the last 3 years and 1 or 2 recommendation letters from internship advisors or Professors.
- **Contacts:** charbel.moussa@minesparis.psl.eu & vladimir.esin@minesparis.psl.eu

Application online only : fill in the form on line : https://applyfor.cemef.mines-paristech.fr/phd/

[1] Electron BackScatter Diffraction, Transmission Electron Microscopy, Differential Scanning Calorimetry and X-ray Diffraction respectively)