PhD proposal

Cyclic behavior of metallic materials: effect of temperature and strain path on the strain hardening memory.

Material Physics Group, Rouen, France

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Key words :
cyclic behavior, plasticity, dislocations, fracture, memory effects, cyclic softening

Context :
The mechanical behavior during a cyclic test is known to deeply depends on the initial metallurgical state of the metallic material. For an annealed sample, a strain hardening is generally observed during a fatigue test whereas, for an initially plastic strained sample, a strain softening is reported. For the case of these pre-strained samples, this softening of the stress level is related to the annihilation of part of the dislocations generated during the preloading phase as well as a modification of their structures [1,2]. Depending on the materials and the loading conditions, the softening may be insufficient to recover the behavior leading to an over-hardening compared with a virgin sample. These phenomena of partial softening and over-hardening reflect the existence of a hardening memory effect. This memory may then be detrimental to the fatigue life due to early damage related to the pre-work hardening step.

Various studies carried out in the Material Physics Group [1-4] have shown the dependence of the strain hardening memory effect on several parameters like: (i) the characteristics of the preloading (monotonic or cyclic) as well as its intensity, (ii) the characteristics of control of the cyclic loading: (stress or deformation) and (iii) the dislocation slip characteristics of the material.

However, several aspects need to be investigated:

1.The mechanisms and the kinetics of the cyclic softening are to be specified, in particular the role played by the mean stress generated during the pre-hardening phase and the amplitude of cyclic deformation. In particular, the evolution of dislocation structures during cyclic loading will be investigated by transmission electron microscopy.

2. the role played by the temperature on the softening due to the thermal activation of cross-slip, especially for materials of intermediate stacking fault enery. Pre-hardening at room temperature followed by cyclic loadings at different temperatures will be performed.

3. the influence of the strain path of the prehardening on the strain softening during a tension/compression cyclic loading. Previous works highlighted the influence of a change of the stress direction between the prehardening and the cyclic loading for a 304L sample. In this case, the overhardening is enhanced by the change in stress direction. The prehardening will be performed on several directions in order to characterize the effect of this parameter on the strain softening in tension/compression. These tests will be performed for two different materials, pure copper and austenitic stainless steel 316L.

The overall objective of the PhD is to better understand the memory effect linked to the pre-hardening test and, in particular, the influence of the dislocation slip characteristics and the thermomechanical loadings. This understanding of the origin of the memory effect will help to improve the modelling of the cyclic behavior of the metallic materials.

The PhD is then fundamentally oriented towards experimental characterization. The facilities of the Material Physics Group in terms of mechanical characterization (several servo-hydraulic testing machines) and microstructure characterization (Scanning and transmission electronic microscopes, EBSD) will be employed. The applicant should be graduated with a master degree in material science or in mechanics of materials. Skills in mechanical testing and electron microscopy will be appreciated. Fluent english (written and oral) is needed.

Dead line for application : July 2018

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