

Post-doctorate position in LIMATB
Starting in February 2015

Title: Modeling plastic instabilities (PLC type) developing under various strain paths

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Starting date: 01/02/2015
Duration: 11 months

Salary: 2000 € per month

Keywords: plastic instabilities; metallic materials; modeling; finite element simulation

Aims: The research team has worked for a few years on the experimental characterization of plastics instabilities that develop in aluminium alloys under some combinations of strain rate and temperature. In some metallic alloys, plastic strain occurs in a localized mode, in bands that propagate throughout the gauge area of the sample. Such a phenomenon, called Portevin-Le Châtelier (PLC) effect, has been extensively investigated, both from an experimental and theoretical point of view, in Al-Mg alloys but also in other aluminium alloys as well as Ti-Mo alloys [1]. PLC effect is characterized by plastic instabilities, i.e. repeated load drops due to localized plastic strain. This last phenomenon is due to dynamic strain ageing (DSA), an interaction between solute atoms of magnesium and mobile dislocations.

Deformation mode used to investigate PLC effect was mostly uniaxial tension and indentation. Recently, Coër [1] presented experimental results related to PLC effect in simple shear for AA5754-O alloy. The geometry and displacement of the bands as well as their kinematics was analyzed using Digital Image Correlation device, at room and warm temperatures. One of the advantages of simple shear is to perform cyclic tests on sheet sample and PLC effect was also analyzed under reloading conditions after a loading in the opposite direction. Moreover, PLC effect was evidenced during a deep drawing test with the continuous recording of the strain field. Also, Zhang et al [4] have developed a biaxial tensile test on cross specimen and instabilities were observed under such a deformation mode. Therefore, an original database of experimental results on the specificities of PLC effect under several deformation modes was established and **the aim of this post-doctoral position is to work on the modeling of this phenomenon.**

A popular model for PLC was developed by McCormick (e.g. [3] for a recent state of the art), which takes into account some microstructural features. Another approach, from the macroscopic point of view, was proposed in [3]. Johnson-Cook model, associated to a negative strain rate sensitivity, which is also a characteristic of PLC effect, was used to represent the mechanical behavior of the material at several temperatures. It was shown that both models, implemented in finite element software, were able to reproduce PLC effect in simple shear, when material parameters for hardening were identified also in simple shear.

Expected results: The aim of this post-doctorate position is to work on the modeling of PLC effect in order to reproduce it **at different temperatures and under several deformation modes:** uniaxial tension, simple shear, both monotonous and cyclic, biaxial tension and deep drawing test, using both McCormick and Johnson-Cook models. Improvement of the models is expected, in order to represent correctly the mechanical behavior under several

strain paths. As a starting point, the routines already developed will be used to simulate the different tests, then post-treatment procedures will be developed in order to output comparable data, in particular regarding the time scale and material parameter identification, with the dedicated software SiDoLo, will be performed. The dependence on the temperature should also be taken into account, because at the moment only data at room temperature was considered, though experimental data at warm temperatures was already established. The final step should be the improvement of the models in order to obtain a good representation. Of the mechanical behavior.

An important point would be the writing of scientific papers (two are expected on the subject), which demands a good level in English.

The use of Johnson-Cook model for PLC effect will be performed in collaboration with Pr. Jeong W. Yoon from Deakin University in Australia.

Skills/knowledge: computational plasticity – anisotropy – viscoplasticity - finite element simulation (Abaqus software)

References

- [1] P. Castany, S. Thuillier, M. Huot, Investigation of the microstructure and mechanical behavior of Ti-Mo alloys, to be submitted in MSEA (2015)
- [2] J. Coër, Mise en forme par emboutissage en température d'un alliage d'aluminium AA5754-0, PhD University of South-Brittany (2013) – In French
- [3] Kinematics of Portevin–Le Chatelier bands in simple shear, PY Manach, S Thuillier, JW Yoon, J Coër, H Laurent, International Journal of Plasticity 58, 66-83
- [4] Influence of prestrain on the occurrence of PLC effect in an Al-Mg alloy, PY Manach, J Coër, H Laurent, C Bernard, S Thuillier, NUMISHEET 2014: The 9th International Conference and Workshop on Numerical
- [5] S. Zhang, L. Léotoing, D. Guines, S. Thuillier, S. Zang, Calibration of anisotropic yield criterion with conventional tests or biaxial test, International Journal of Mechanical Sciences 85 (2014) 142-151

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