PhD project proposal at Institut Jean Lamour (collaboration IJL/ArcelorMittal)

Quantitative understanding and modelling of retained austenite mechanical stability in TRIP-aided steels

Retained austenite can significantly enhance strength and ductility through deformation-induced transformation of metastable retained austenite to martensite, referred as “TRIP effect”. Thus, TRIP steels consisting of ferrite, bainite and retained austenite [1] and Q&P steels comprising of a dual-phase microstructure of lath-martensite and film-like retained austenite [2] have been developed. It is shown from the numerous literature data in the two last decades that the control of retained austenite mechanical stability is a key point to optimize final strength-ductility combination, formability, H embrittlement and crash ductility in advanced high strength steels. However, the mechanical stability control of retained austenite in the microstructure is a very complex subject, since many factors may influence the austenite stability: its chemical composition, its microstructural parameters like size, morphology (blocky or filmy), internal stresses, crystallographic orientation, dislocation density and its surrounding phases in the microstructure [3-8], as well as the deformation temperature, the strain rate and the stress triaxiality. Even if the influences of these parameters are more or less qualitatively known, there is a lack of quantitative understanding of their effects on austenite stability due to the difficulties to dissociate the effect of each parameter.

The objective of this PhD project is to acquire quantitative knowledge on the mechanical stability of retained austenite in order to improve the current advanced mechanical behavior law for 3rd generation TRIP steels. For this purpose, some specific chemistry will be chosen in order to produce model microstructures. Theses microstructures will be finely characterized using various advanced techniques like FEG-SEM, X-ray diffraction, EBSD, TEM, micro-probe and atom probe etc. In-situ techniques such as in-situ synchrotron X-ray diffraction and in-situ magnetic measurements will be applied to follow the austenite evolution during deformation. Based on the quantitative understanding of the relationship between chemical and microstructural parameters of retained austenite and its mechanical stability, a physical description of the austenite destabilization kinetics during mechanical loading is expected to be established.

If possible, the PhD project can be proposed as CIFRE thesis. After the PhD work, the student has the potential to be employed by R&D ArcelorMittal Maizières.

For more details and to apply for the position, please contact: sebastien.allain@univ-lorraine.fr or/and Kangying.zhu@arcelormittal.com.

[1] E. Girault et al., Materials Science and Engineering A, 273 (1999) 471–474.
[2] J. Speer et al., Acta Mater., 51 (2003) 2611–2622.
[3] H.S. Park et al., Materials Science & Engineering A 627 (2015) 262–269
[4] D. De Knijf et al., Materials Science & Engineering A 638 (2015) 219–227
[5] Sybrand van der ZWAAG et al., ISIJ International, Vol. 42 (2002), No. 12
[6] S.Y.P. Allain et al., Materials Science & Engineering A 710 (2018) 245–250
[7] JACQUES et al., Acta mater. 49 (2001) 139–152
[8] S.Y.P. Allain et al., Materials Science & Engineering A 710 (2018) 245–250