Determination of phase equilibria in Fe-C-Mn-Al alloys for 3rd generation duplex steels

A. Mestrallet[a], A. Antoni-Zdziobek[a], J. Emo[b], P. Maugis[b], B. Hallstedt[c]

[a] Univ. Grenoble Alpes, CNRS, Grenoble INP, SIMaP, F-38000 Grenoble, France
[b] Aix Marseille Université, UTLN, CNRS, IM2NP, 13000 Marseille, France
[c] RWTH Aachen University, IWM, 52062 Aachen, Germany

Fe-Mn-Al-C alloys based on medium Mn, medium Al steel grades with duplex structure are promising candidates to obtain lightweight automotive structures combining high-strength and high formability. The knowledge of the corresponding quaternary phase diagram serves as a roadmap for the choice of compositions and the elaboration conditions optimization. A reliable and precise thermodynamic database is therefore required.

The objective is to obtain an accurate characterization of the phases in equilibrium, typically ferrite (α), austenite (γ) and carbide $(Fe,Mn)_3AlC$ (κ), their compositions and proportions using thermodynamic calculations coupled with experiments. In order to determine the annealing duration for the establishment of the thermodynamic equilibrium at the investigated temperatures, the development of microstructures is studied for Fe-0.2C-5Mn-2Al (mass %) at 800°C between 2 min and 4 months. A kinetic model (DICTRA) is proposed to support the experimental evolution of phase fractions and compositions.
Some selected alloys are characterized between 700 and 1000°C in order to specify the stability fields of γ and κ by the determination of the α/γ, α/κ, α/γ/κ tie-lines. Characterization is done by using X-ray diffraction (XRD), scanning electron microscopy (SEM), field emission gun scanning electron microscopy (FEG-SEM) and electron probe microanalysis (EPMA-WDS). Due to the low C content, particularly in the α-phase, a specific methodology for EPMA measurements of this element is applied according to the standard ISO16592:2006 [1]. Our new experimental data are used to obtain a better set of consistent parameters for the thermodynamic description of the quaternary system.

[1] Robaut F. et al., *Microsc. Microanal.,* 12 (2006) 331-334

Acknowledgements. This work has been supported by the French National Research Agency "MatetPro" and MATERALIA within the project MeMnAl Steels (project ID: ANR-13-RMNP-0002). The authors wish to thanks ArcelorMittal for useful advices and for provide alloys.

Aurore Mestrallet

University Grenoble Alpes, PhD 3rd year *"Thermodynamics of new solutions of 3rd generation duplex steels for automotive applications"*
Research at SIMaP laboratory (Science et Ingénierie des Matériaux et Procédés)
Interests: metallurgy, phase equilibria, industrials applications, experimental characterization