Multi-scale and *in situ* study of microstructural evolutions in lath-bainitic steels under isothermal conditions

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Abstract

Bainitic steels are widely used in industry thanks to their good combinations of strength, toughness and ductility. Meanwhile, after obtaining the targeted microstructure, the steel can undergo additional isothermal holdings (either during manufacturing and/or during usage) prone to degrade its properties. The thesis work aims at understanding the microstructural origins of this degradation. To achieve this, we applied controlled heat treatments on model FeNiC and FeNiMnC steel grades.

A first set of heat treatments allowed us to obtain different microstructures; upper and lower bainites, martensite and mixed concepts. These transformation products were characterized and analyzed in detail, particularly by EBSD with improved angular resolution. Data was operated to reconstruct prior austenitic grains and to distinguish the different transformation products according to their crystallographic variant spatial organization. A second set of heat treatments consisted in aging these microstructures by extended isothermal holdings. We show that lath-like bainitic microstructures are not stable under certain isothermal conditions. In the most advanced cases, we observed a « granularization » process of the lath microstructure, associated with high misoriented variant disappearance and carbides ripening. These phenomena were observed for the studied model alloys, even within short holding times (<1h) and at low temperatures (300°C). These highlighted evolutions as well as their kinetics were investigated at different scales, coupling SEM observations, EBSD, TEM and in situ XRD High Energy on large instruments. The initial microstructure and the steel chemical composition affect significantly the « granularization » kinetics. But we have above all put the light on the major role of the presence of an upper bainite fraction (even a residual one) in the initial microstructure, to start the granularization phenomenon, independently of aging temperature. All of these results allow discussing possible mechanisms with their respective driving forces and opening larger discussion about bainite classification.

Key words: Bainites, carbides, dilatometry, isothermal treatments, SEM, EBSD, TEM, High-EnergyXRD, mechanical properties, SIBM, recovery, recrystallization.