



	Experiment title: <i>In-situ monitoring of austenite stabilization by quench and partitioning and resulting transformation-induced plasticity by HEXRD.</i>	Experiment number: MA3616
Beamline: ID11	Date of experiment: from: 23/08/2017 to: 26/08/2017	Date of report: 05/03/2018
Shifts: 9	Local contact(s): Pavel SEDMAK	<i>Received at ESRF:</i>

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Quenching and partitioning (Q&P) is an effective way for retaining austenite at room temperature. The applied thermal cycle makes its study complicated as various phenomena occur throughout the heat treatment. In the present work, various Q&P heat treatments on an *industrial* steel grade were analyzed by in-situ High Energy X-Ray Diffraction experiments. As an example, **Figure 1** illustrates the evolution of the diffractograms obtained at different key moments of a Q&P process ($Q_T = 360^\circ\text{C}$): soaking at 900°C , the initial quench to 360°C , the beginning and the end of the partitioning. The characteristics (i.e. position, intensity, shape) of the diffraction peaks reveal useful information regarding the microstructural evolution taking place during the process.

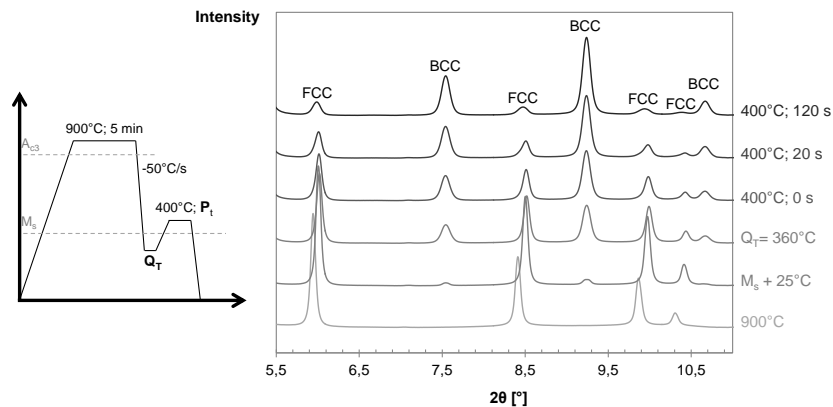
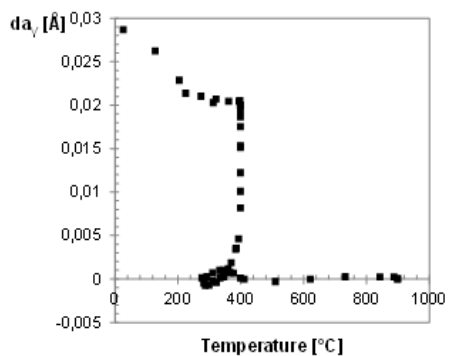


Figure 1: 1D diffractograms obtained throughout an entire Q&P heat treatment.

The present work investigation was aimed at clarifying the following issues which are under debate:

- 1) The mechanisms responsible for the carbon enrichment of austenite, the evolution of its carbon content, its dislocation density and its stress state during an optimized Q&P treatment. **Figure 2** presents the evolution of the austenite lattice parameter minus the thermal contribution throughout an entire given Q&P heat treatment ($Q_T=280^\circ\text{C}$). This is done by assuming that the austenite thermal expansion coefficient is not dependent of any chemical or thermal changes. As can be seen, two distinct Q&P steps contribute to the austenite lattice parameter evolution: the reheating stage and the partitioning step.



contribution during Q&P

Figure 2: Evolution of the austenite lattice parameter minus the thermal

- 2) The silicon content required to stabilise a sufficient amount of austenite at room temperature in an industrial-like 0.2C-2.3Mn grade. Silicon is an essential alloying element as it suppresses/delays the precipitation of cementite. The latter acts as a carbon sink as the carbon is not available for stabilizing the austenite during the partitioning step. However, high silicon contents have an adverse impact on several stages of the industrial process and should therefore be kept as low as possible. As can be seen in **Figure 3**, the volume fraction of FCC phase decreased in all cases (three different silicon contents: 0.4, 0.8 and 1.5 wt.% of silicon) during the partitioning step. However, the extent of the decrease depends on the silicon content. The drop of FCC volume fraction during partitioning clearly increases when the silicon content decreases and almost all of the residual austenite is consumed at the end of partitioning in the 0.4Si steel grade.

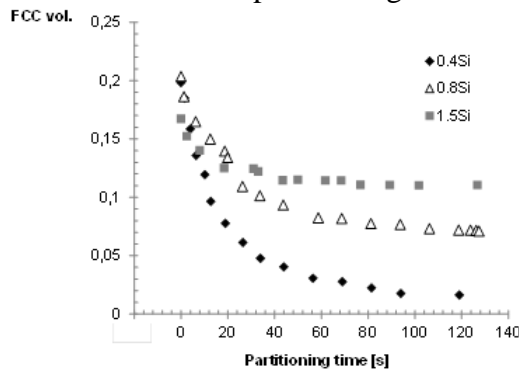


Figure 3: Evolution of the FCC volume fraction during the partitioning step at 400°C

- 3) The impact of a ferrite fraction present prior to the martensite transformation has been investigated. The change in austenite grain size, carbon content and the possible formation of pronounced carbon concentration gradient in the austenite grains following the ferrite transformation may influence the martensite transformation and the austenite stabilization process. As can be seen in **Figure 4**, the prior ferrite formation slightly shifts the martensitic start transformation temperature to lower values.

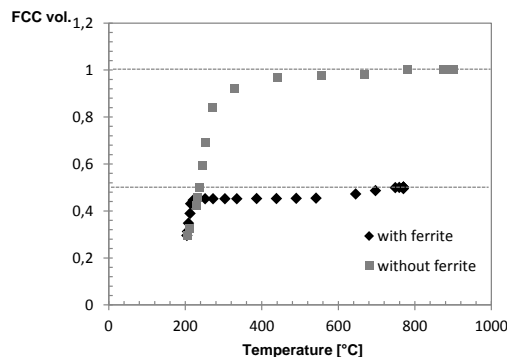


Figure 4: Evolution of the FCC volume fraction during the initial quench from -900°C or 770°C- to Q_r .

- 4) The efficiency of TRIP effect provided by the retained austenite stabilized at room temperature using the Q&P treatment. More specifically, the influence of austenite fraction, its carbon content and stress state on the TRIP effect are depicted. As can be seen in **Figure 5**, the retained austenite is consumed during tensile tests.

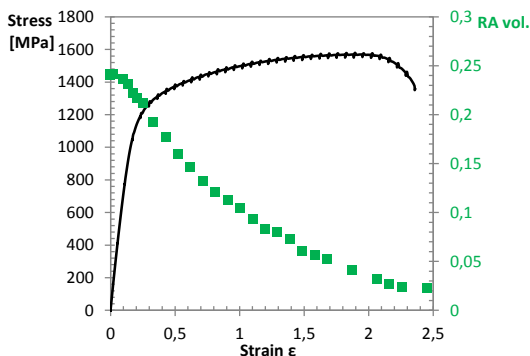


Figure 5: Austenite volume fraction as a function of strain.

These results are only a very small part of the data collected at the ESRF during our work. The rest of the results are still under investigation and further in-depth analysis is still required. The present investigation should result in the publication of scientific articles in a near future. Hence, the 9 allocated time shifts allowed us to achieve 10 different Q&P heat treatments and more than 30 in-situ tensile tests.