In-situ Neutron Analysis of Microstructure Evolution during High Temperature Thermomechanical Processing in Advanced High Strength Steels

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1. Introduction

Retained austenite plays a crucial role in mechanical properties in advanced high strength steels (AHSS), especially for the ductility through transformation-induced plasticity (TRIP) effect. Quenching and partitioning (Q&P) process is an effective approach to control the amount and stability of retained austenite [1], where carbon partitioning from martensite to austenite occurs. Our previous study (Project No.: 2016A0136 and 2016B0252) confirmed that isothermal transformation simultaneously occurred during partitioning, even below martensitic transformation starting (Ms) temperature. Therefore, the retained austenite fraction was not only controlled by partitioning of carbon from martensite to austenite, but also significantly affected by the kinetic of the isothermal transformation. Ausforming affects isothermal transformations including kinetic of phase transformation and carbon partitioning. In order to deepen our understanding on controlling microstructures through the Q&P process, the effect of ausforming on phase transformation and carbon partitioning during the Q&P process were investigated in the present study.

2. Experiment

In-situ neutron diffraction experiments were conducted at the beam-line 19 ‘TAKUMI’ in J-PARC with a thermomechanical processing simulator (Thermecmastor-Z) installed. As illustrated in **Figure 1**, the specimens of 2Mn-0.3C-2Si steel were rapidly cooled down to 550 °C for compression (30 % reduction in thickness) within 3 s after austenitization at 900 °C, and then rapidly cooled down to 280 °C and held for 1.5 hours before cooling to room temperature. The kinetics of phase transformations and carbon partitioning were evaluated by analyzing the neutron diffraction profiles using Z-Rietveld.

3. Results

The *in-situ* neutron diffraction experiments were successfully performed and corresponding diffraction profile obtained is shown in **Figure 1**. After ausforming, martensitic transformation occurred at the cooling stage when the temperature of the specimen became below approximately 330 °C. The intensity of the (111) FCC peak decreased accompanying with the increase of the (110) BCC peak, which indicates that an isothermal transformation occurred in the present ausformed specimen similar to that in the non-ausformed specimen investigated in 2016B0252.

Kinetics of phase transformation in the ausformed specimen and the non-ausformed specimen (measured in 2016B0252) are compared in **Figure 2**. It is assumed that the martensitic transformation is athermal, i.e. time-independent. The volume fraction of martensite is 54.7 % in the ausformed specimen, which is lower than that in the non-ausforming one (61.6 %), which is attributed to the so-called mechanical stabilization of austenite [2]. At subsequent isothermal holding stage, austenite transformed to BCC phase continuously at a similar transformation rate both in the ausformed and non-ausformed specimens. The isothermally transformed phase was determined as bainite by microstructure observations. After cooling to room temperature finally, larger amount of retained austensite was obtained in the ausformed specimen.

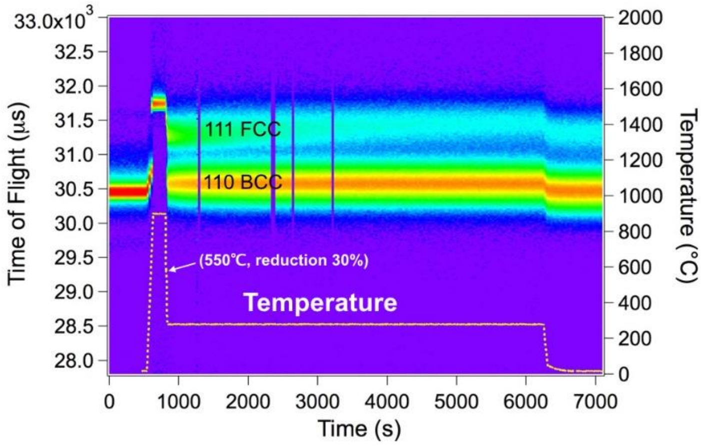

Figure 1. Thermal histroy and corresponding evolution of (111) FCC and (110) BCC profiles.

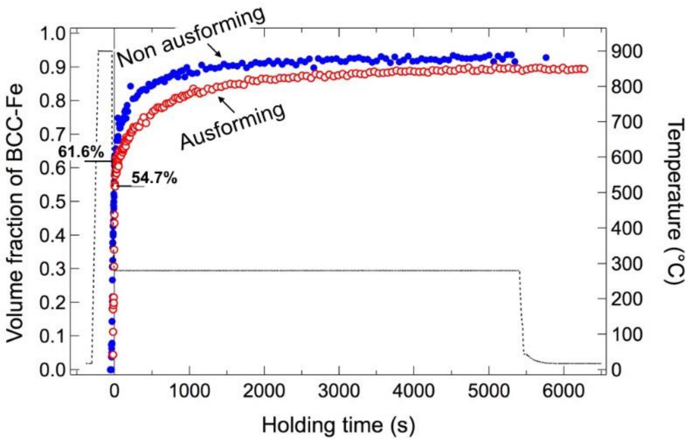

Figure 2. Comparison of kinetics of phase transformations in ausforming and non-ausforming specimens.

4. Conclusion

(1) Ausforming suppressed martensitic transformation but showed little effect on the subsequent bainite transformation.

(2) Large amount of retained austensite was obtained through ausforming.

References:

[1] Speer, J. G., Assunção, F. C. R., Matlock, D. K., Edmonds, D. V. 2005. The" quenching and partitioning" process: background and recent progress. Materials Research, 8(4), 417-423.

[2] Bhadeshia, H. K. D. H. 2001. Bainite in steels: transformation, microstructure and properties. London: The Institute of Materials, University of Cambridge, 377-382.