Influence of welding on the ductility of a Fe-Nb-V-C microalloyed steel

L. Soriano[a], S. Cazottes[a], T. Chaise[b], P. Todeschini[c], F. Roch[d], M. Perez[a]

[a] Univ Lyon, INSA Lyon, UCBL, CNRS, MATEIS, UMR 5510, 69621 VILLEURBANNE France

[b] Univ Lyon, INSA Lyon, CNRS, LaMCoS, UMR 5259, 69621 VILLEURBANNE France

[c] EDF-R&D-MMC, 77818 MORET SUR LOING CEDEX

[d] Framatome, Tour AREVA, 92400 COURBEVOIE France.

Micro-alloyed (MA) steels are used in the automotive and energy industries for their interesting strength properties, partly due to the presence of nanometric (Ti,Nb,V)C precipitates.

During the welding process, there is a significant decrease in ductility of these steels in the Heat Affected Zone. Welding indeed changes the precipitation state, thereby altering the mechanical properties of the material. The objective of this work is to better understand the mechanisms leading to this loss of ductility.

Therefore, a coupled experimental and simulation approach was applied aiming at describing both the precipitation state and associated mechanical properties evolution during heat treatments.

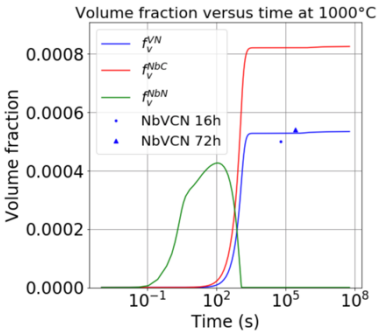

Figure 1 : Simulation of the precipitation state

Three laboratory castings of different composition (V, Nb, V+Nb) were elaborated. Firstly, in order to calibrate the precipitation model, isothermal heat treatments at 700 and 1000 °C are performed and the precipitation state in ferrite and austenite for each grade was characterized. Secondly, anysothermal heat treatments performed in the thermomechanical simulator Gleeble allow to reproduce experimentally the welding cycles at different distances from the weld (0.5 and 4 mm).

The nature and size distribution of precipitates was characterized by means of Transmission Electron Microscopy (TEM) using Carbon replicas. Precipitation kinetics in the austenitic domain, as well as in the ferritic domain was fully described using Kampmann and Wagner Numerical model approach. Charpy tests were performed on all studied samples.

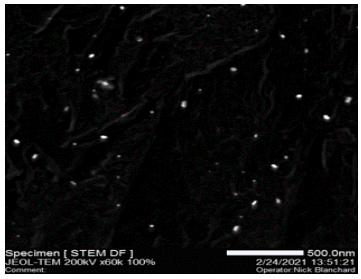

Figure 2 : Precipitates of NbC

Mixed carbonitrides precipitate in both ferrite and austenite. The precipitation model, validated on isothermal treatments was used to predict the precipitation state after various non-isothermal treatments. The localization, density and volume fraction of precipitates was correlated with resilience in the heat affected zone.