Microstructural evolutions and their consequences on the mechanical properties of a niobium-stabilized austenitic stainless steel

Nicolas CLICHE

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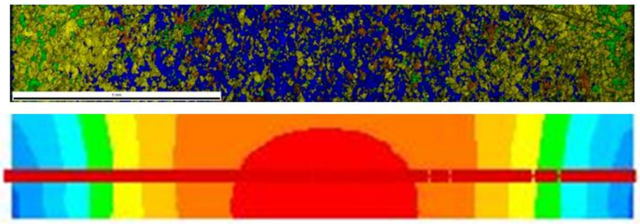
Partners: CEA Valduc, Aubert & Duval, Naval Group, DGA
Supervisors: Anne-Françoise Gourgues (Mines Paris Tech) and Sylvain Ringeval (CEA Valduc)



Grain orientation spread map from EBSD compared to simulated deformation map of a uniaxial compression sample (compression direction is horizontal)

- Stabilized austenitic stainless steel
- Thermomechanical experiments
- Recrystallization with EBSD observation and its modelling

Abstract:

The French Alternative Energies and Atomic Energy Commission (CEA), Valduc center, in collaboration with École Nationale Supérieure des Mines de Paris and partners (Aubert & Duval, Naval Group and DGA), have launched a PhD project about the study of the microstructural evolutions and of their consequences on the mechanical properties of a niobium-stabilized austenitic stainless steel, namely, the 316 Nb steel. This steel is used in the manufacturing of components which undergo thermomechanical loading (temperature and pressure) during very long time.
Previous work showed the effect of some hot forming parameters (thermomechanical loading and annealing) on the final microstructure of the material. The goal of this PhD project is, on the one hand, to assess the impact of the remelting process of the steel and, on the other hand, to get deeper understanding of the effects of the microstructural changes brought by each processing step on the final mechanical properties of the material. A numerical modelling of theses microstructural changes will be developed.
The previous PhD work (A. Hermant, MINES ParisTech, 2016) focused on a 316 Nb steel elaborated under air atmosphere, then electro-slag remelted (ESR). It revealed several links between the thermomechanical path and microstructural evolution (in particular, recovery and recrystallization phenomena), through hot torsion tests. A first link with the hot forming parameters (temperature, strain and strain rate, multi-pass character, cooling rate) was established.
The first step of the present PhD project was to perform similar torsion tests in order to measure the impact of a change in the solidification process of the steel, and in particular the use of vacuum arc

remelting (VAR) which leads to a slight change in N and Mn contents that could influence the competition between recovery and recrystallization phenomena.

In the sequel, the doctoral student focused on the relationships between the microstructural evolutions found during the manufacturing process and the final mechanical properties. To do so, several thermomechanical paths on blanks obtained from the two different remelting processes have been applied e.g. pancake forging. These tests enable to get closer to the actual parts, both concerning the size and the strain heterogeneities and to get enough hot deformed material to extract mechanical testing specimens from, in order to access local mechanical properties (such as uniaxial tensile behavior and impact toughness).

In order to assess the evolutions of microstructure, an extensive use of EBSD technique on a FEG-SEM is being done. It enables a quantification of recrystallization, grain size and other parameters of interest such as texture.

Up to now, the partners have no numerical models to assess links between the processing parameters, the local thermomechanical path, the microstructure and the mechanical properties in a continuous manner. The above presented experimental work, along with the already available data, provides a substantial experimental database on which the doctoral student is working to be able to develop, test and even optimize a metallurgical post-treatment model in order to take the specificities of the 316 Nb steel into account.