Relationship between microstructure and properties in super duplex stainless steel: the influence of phase fraction and topology

Ali LAKHDARI

Supervisors : M. Veron and H. Van Landeghem

Thursday, December 17th 2020 – 12:30 p.m.

Salle Z704 – Phelma Minatec

Jury :

Madame Sabine DENIS - Professeur à l'Université de Lorraine, Présidente
Monsieur Alain HAZOTTE - Professeur au laboratoire LEM3, Metz, Rapporteur
Monsieur Olivier CASTELNAU - Directeur de Recherche aux Arts et Métiers Paris Tech, Rapporteur
Monsieur Laurent DELANNAY - Professeur à l'Université Catholique de Louvain, Examinateur
Monsieur Jean-Denis MITHIEUX - Ingénieur de Recherche, APERAM Isbergues, Examinateur
Monsieur Florent KRAJCARZ - Ingénieur de Recherche, APERAM Isbergues, Invité

Abstract: Duplex grades are two-phase materials consisting of equal parts austenite and ferrite. They show a combination of good mechanical properties and excellent corrosion resistance, which makes them a lower-cost alternative to conventional austenitic steels. Understanding the relationship between the microstructure and the mechanical behavior of these grades is an important step in the optimization of their service properties. The industrial superduplex has a microstructure that differs from other stainless products in many ways: size, morphology, phase fraction and texture. The aim here is to identify the effect of these different characteristics and how their combination leads to the final properties. Thermomechanical treatments have been implemented in order to generate three model microstructures, characterized by different morphologies and distributions of austenite. The texture of ferrite, characterized by the fiber α, shows different intensities of the rotated cube orientations {100} <011> and {111} <011>. All three materials exhibit anisotropic plastic flow resulting from the textures of their constituent phases, which either reinforce or attenuate this anisotropy. The yield strengths of the composite alloy and its constituent phases are closely similar. This leads to the limited influence of the phase ratio on the yield strength of superduplex steel, save for its role in controlling the microstructure size. The texture of ferrite and the size of phases have a major effect on the mechanical behavior, while that of their distribution remains negligible. The ϒ fiber orientations and in particular the {111} <112> orientation improve strength. The influence of size is due to a Hall-Petch effect, exacerbated by the amount of nitrogen in austenite. The potential levers on these dominant microstructural characteristics represent the most promising avenues for improving the mechanical properties of the superduplex stainless steel.