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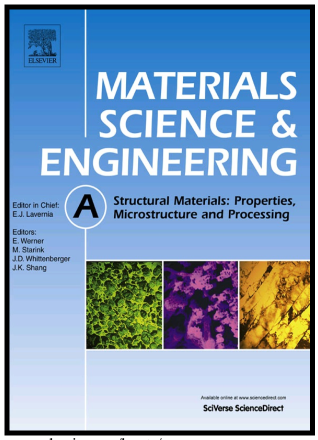

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Claudio Gennari, Luca Pezzato, Enrico Piva, Renato Gobbo, Irene Calliari

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Influence of small amount and different morphology of secondary phases on impact toughness of UNS S32205 Duplex Stainless Steel

Claudio Gennari[1], Luca Pezzato[1], Enrico Piva[3], Renato Gobbo[2], Irene Calliari[1]

[1]Department of Industrial Engineering, University of Padua, Via Marzolo 9, 35131 Padova
[2]Department of Industrial Engineering, University of Padua, Via Gradenigo 6/A, 35131 Padova
[3]Acciaierie Valbruna S.p.a., Via della Scienza 25, 36100 Vicenza

Abstract

Duplex Stainless Steels (DSSs) are biphasic austenite-ferrite stainless steels, with higher mechanical properties and corrosion resistance than the other stainless steels grades. Impact toughness is a very important mechanical property and even though DSSs have a lower impact toughness as compared to the austenitic grades, the transition to ductile to brittle behavior is more gradual and it occurs at lower temperature than ferritic grades. On the other hand, DSSs suffer from embrittlement due to secondary phase precipitation, which affects all mechanical and corrosion properties, in particular impact toughness, even in low amount.

In this research paper, the influence of a small amount (<2%) and different morphologies of secondary phases (coarse and finely dispersed) on the ductile to brittle transition of standard duplex stainless steel UNS S32205 was studied. Two isothermal heat treatments were conducted on the solubilized DSS in order to precipitate the same amount but different morphologies of secondary phases. Charpy tests were conducted on a temperature range between 20 °C and -196 °C.

The wrought material retained a very good impact toughness even at -90 °C (100 J), but a small volume fraction affected the impact toughness even at room temperature. Coarser secondary phases affect the impact toughness largely as compared to small and finely dispersed particles.

Keywords:
Duplex stainless steel, impact toughness, secondary phases, transition temperature, Isothermal heat treatment, ductile-to-brittle transition

Introduction

Duplex Stainless Steels (DSSs) are known for their high mechanical and corrosion resistance thanks to the biphasic ferritic-austenitic microstructure. In fact, DSSs are widely used in aggressive environments, like chemical, petrochemical and nuclear plants, oil and gas offshore applications, and pulp and paper industries, as an alternative to the austenitic grades [1–4].

Unfortunately, as compared to the austenitic grades, DSSs suffer from brittle to ductile transition behaviour because of ferrite in the microstructure. In fact, the presence of the BCC ferritic phase in DSSs enhances the tensile properties but decreases the impact toughness, which is directly linked to the ductile to brittle transition behaviour of the BCC crystal structure. On the other hand, as compared to the ferritic grades, the presence of the FCC austenitic phase increases the impact toughness because it accommodates plastic deformation retarding the cleavage fracture of the ferritic phase. The BCC crystalline structure suffers from ductile to brittle transition because the dislocation motion is a thermally activated phenomenon [5]. By contrast, the FCC crystalline structure's dislocation motion is less temperature dependent [2,3].

The characteristic biphasic microstructure of DSSs is not thermodynamically stable; in fact, they are prone to secondary intermetallic phase precipitation. The most common secondary