Influence of nitrogen content on the stacking fault energy and twinning probability as a function of deformation in Hadfield steel.

C. Iglesias(1)*, C. Aguilar(2), B. Schulz(1), P. Lara(1), G. Solórzano(3), R. Leiva(4)

(1) Departamento de Ingeniería Metalúrgica, Universidad de Santiago de Chile, Av. Lib. Bernardo O'Higgins 3363, Santiago-Chile. email: carlos.iglesias@usach.cl
(2) Instituto de Materiales y Procesos Termomecánicos, Universidad Austral de Chile, General Lagos 2086, Valdivia-Chile.
(3) DCMM, Pontifícia Universidade Católica do Rio de Janeiro.
(4) Elecmetal Chile.
* Corresponding author.

Abstract – The objective of this work was to study the influence of nitrogen content and deformation on stacking fault energy and twinning probability in Hadfield Steel. Samples were analyzed by means of x-rays diffraction, optical microscopy and transmission electron microscopy, and the results were correlated with mechanical properties. Three Hadfield steels with different nitrogen content were studied: Hadfield steels low nitrogen (HSLN) with 71 ppm N, Hadfield steels standard (HSST) with 130 ppm N and Hadfield steels high nitrogen (HSHN) with 720 ppm N at different levels of deformation under compression.

The Hadfield steel (HS) samples were obtained by adjusting the chemical composition in conventional melting using classified scrap of mild steels and standard silicon and manganese ferroalloys. Three Hadfield steels with different nitrogen contents were studied: Hadfield steel low nitrogen (HSLN) with 71 ppm N, Hadfield steel standard (HSST) with 130 ppm N and Hadfield steel high nitrogen (HSHN) with 720 ppm N. Casting was performed in an industrial facility in order to obtain a base HS under metallurgical conditions similar to those for pieces for mining or wear applications. The samples were heat treated together in order to obtain the austenitic microstructure without precipitation of carbides and similar grain size distributions and average sizes in every sample obtained from every alloy. Then, the HS samples were tested under compression at different levels of deformation. These same samples were used for x-ray diffraction (XRD) peak profile analysis. In order to obtain the stacking fault energy (SFE) and twinning probability (β) values as a function of deformation and nitrogen content, whole patterns were measured over an angular range of 2θ = 40–105 using the Warren-Averbach (WA) method. In addition, using particular conditions of HS (HSLN 40%, HSST 5% and 45%, and HSHN 15%), were obtained thin foils for transmission electron microscopy (TEM).

In general, the changes in microstructural and texture evolution in fcc metals occurs in different fibers texture like {100}, {110} and {111}. The ratios among these fibers have a close correlation with the value of SFE. Actually, the sharp drop in the {100} fiber component of fcc metals with low SFE under simple compression has been attributed to primary twinning in HS [1] and other comparable metals [2,3]. It is possible to observe that the twinning effect on the mechanical behavior of fcc metals has a relevant significance, particularly in HS, where nitrogen content influences the mechanisms of deformation [1]. Additionally, when twinning is activated, it acts as a strong stacking barrier to dislocation movement, producing a great increment of work hardening coefficient (n). The nature of these microstructures was characterized by optical microscopy and correlated with grade of deformation, SFE, β and nitrogen content. TEM have been used to complement the microstructural evolution and SFE and β calculated values by XRD.

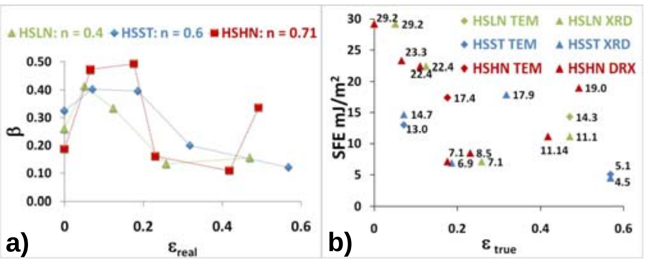

Figure 1:.a) Twinning probability (β) as a function of deformation at different nitrogen content and work hardening in compression (n).

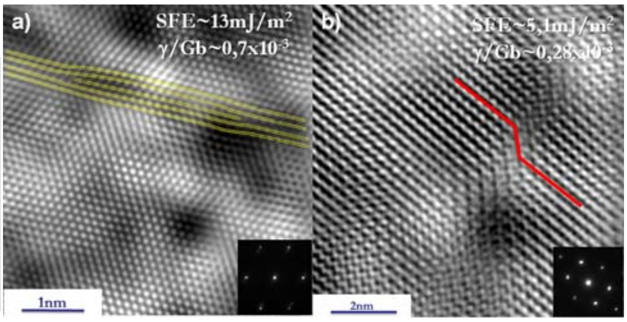

Figure 2: HRTEM Micrographs of HSST at a) 5% deformation. b) 45% deformation.

References

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