

EVOLUCIÓN DE LA MICROESTRUCTURA DE ACEROS INOXIDABLES MARTENSÍTICOS SOMETIDOS A FATIGA

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Martensitic stainless steels are very attractive alloys, widely used because of their outstanding corrosion-resistance and high strength properties. These steels are considered for high temperature applications, mainly in power generation plants and fusion reactors technology. In service, all these alloys will be subjected to complex thermo-mechanical cyclic loading. Such loading can be simulated by isothermal strain-controlled fatigue experiments. Concerning fatigue investigations, one of the most interesting aspects to consider is the mechanisms of deformation and accumulation of damage leading to material failure.

AISI 410 is the precursor of the commercial low-carbon martensitic stainless steels. The study of the martensitic structure and its evolution in this type of alloy has assumed great significance due to their influence on the mechanical properties.

The martensitic structure of the quenched and tempered AISI 410 consists primarily of a high density of dislocations arranged in lath structures, parcels and blocks [1]. In the present study we make an attempt to explain the evolution of the different level of martensitic structure through the analysis of the most favorable slip systems related to the Schmid factor. Figure 1 shows the cyclic softening behaviour of this material subjected to low-cycle fatigue at room temperature. Microstructural observations show that dislocation annihilation and rearrangement occur during softening leading to a softer martensite laths and to the gradual development of an equiaxed substructure [2]. The initial high strength of hardened steels can be seriously compromised even after a low number of loading cycles, reducing their original strength. However, the evolution seems to be most complex. In this work the dislocation structures were studied by TEM. In order to analyze the orientation of the dislocation structure with the tensile axis of the fatigued specimen, special care has been taken to mark this axis in the thin foils

The analysis of the dislocation structure developed in the tested specimens reveals different degree of evolution. Three differentiated microstructural features were observed in the AISI 410. The first type, see Figure 2, is an equiaxed subgrain structure almost free of dislocation. In this high developed structure, two different slip system $\{112\}\langle 111\rangle$ and $\{110\}\langle 111\rangle$ with a common $\langle 111\rangle$ slip direction could be identified. Both slip systems have a Schmid factor close to the ideal value as it is reported in Table 1. Few dislocations have been observed laying on slip planes not favorable oriented related to the Schmidt factor (see small arrow in Figure 2).

The second type of microstructure is characterized by a poor-developed structure because of the resemblance to the original martensitic lath, Figure 3. In this micrograph it could be recognize only one active slip system $\{112\}\langle 111\rangle$ with a Schmid factor that differs from the ideal value in about 20% (see Table 1)

The third type of characteristic microstructure observed by TEM denotes an intermediate degree of lath development towards equiaxed subgrain as it was shown in Figure 4. In this area it was identify slip systems $\{112\}\langle 111\rangle$ and $\{110\}\langle 111\rangle$ with a common $\langle 111\rangle$ slip direction with common slip direction with stress intensity and no favorable Schmid factors and slip systems $\{112\}\langle 111\rangle$ with Schmid factor of up to 0,3 or more than 0,6 as it was detailed in Table 1

From the analysis of this preliminary result, it is proposed that the developed of the equiaxed microstructure in martensitic steel is strongly conditioned by the activation of slip systems with a common slip direction that favored the cross slip on screw dislocation.

References

- [1] A. R Marder, G. Krauss, Transactions of the ASM, 60, (1967) 651–660.
- [2] A.F. Armas, C. Petersen, R. Schmitt, M. Avalos, I. Alvarez-Armas. Journal of Nuclear Materials 307 – 311 (2002) 509 - 51

Table 1. Typical slip systems and intensity factors in different microstructural zones.

Microstructural zone	Slip systems	Schmid factor
First type	$\{112\}\langle 111\rangle$ $\{110\}\langle 111\rangle$ common $\langle 111\rangle$	0,5 – 0,6
Second type	$\{112\}\langle 111\rangle$	0,65 up
Third type	$\{112\}\langle 111\rangle$ $\{110\}\langle 111\rangle$ common $\langle 111\rangle$ $\{112\}\langle 111\rangle$	0,75 – 0,8 0,2 – 0,3 or more than 0,6

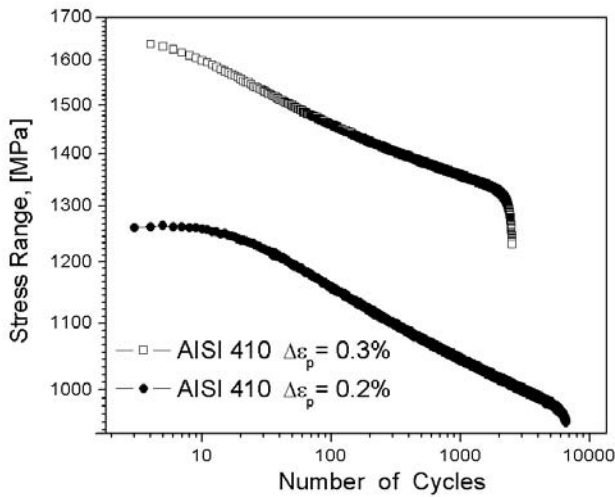


Figure 1: Cyclic softening curves of AISI 410

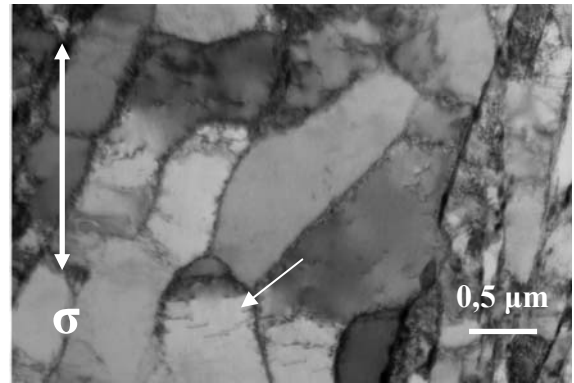


Figure 2: Typical first type microstructural zone observed in samples of AISI 410 ($\Delta\epsilon_p = 0,2\%$). Stress axis is indicated.

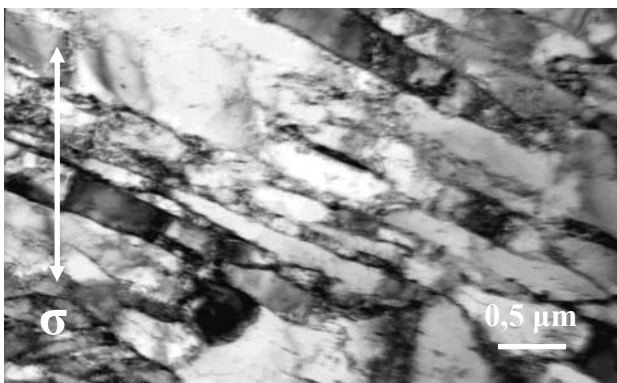


Figure 3: Typical second type microstructural zone observed in samples of AISI 410 ($\Delta\epsilon_p = 0,2\%$). Stress axis is indicated.

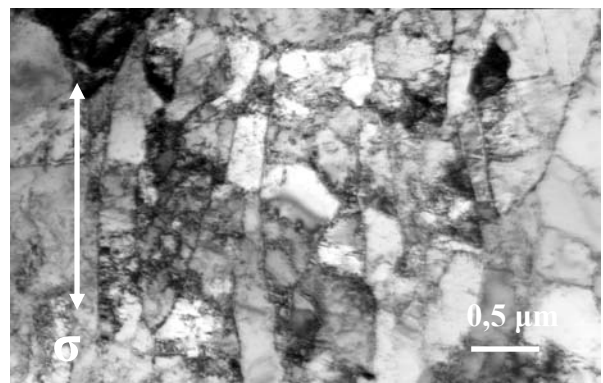


Figure 4: Typical third type microstructural zone observed in samples of AISI 410 ($\Delta\epsilon_p = 0,2\%$). Stress axis is indicated.