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Earlier stages of erosive damage during cavitation of austenitic stainless steels: the role of the grain boundary character

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Abstract – Nitrogen bearing (0.9 wt-% N) austenitic stainless steel samples were submitted to vibratory cavitation tests. It was found that cavitation erosion damage initiates both inside the grains and at grain boundaries. Σ-3 CSL (coincidence site lattice), i.e. twin, boundaries, were sharply more susceptible to damage incubation than other CSL and non-CSL grain boundaries.

It has been shown that nitrogen dissolved in solid solution in austenitic stainless steels improves the resistance to cavitation-erosion (CE) damage nucleation and diminishes the wear rate [1-3]. Two preferential sites for nucleation of CE damage in stainless steels have been reported [3], namely (a) slip lines inside the grains and (b) grain boundaries.

In this work it was evaluated the effect of the grain boundary character on the susceptibility of grain boundaries to initiate CE damage in a high nitrogen austenitic stainless steel.

Austenitic High Nitrogen Steel (HNS) samples (wt-%: 22.5 Cr, 5.4 Ni, 3.0 Mo, 1.9 Mn, 0.14 Cu, 0.019 C and 0.9 N) were submitted to vibratory CE experiments in distilled water at 20 °C. Before cavitation tests, samples were crystallographically characterized by electron back-scattering diffraction (EBSD). Wear of the samples during CE experiments was assessed by gravimetric measurements and scanning electron microscopy (SEM) observations. As a comparison material, standard austenitic stainless steel samples of the UNS S30403 specification were also studied.

Figure 1 shows (a) the cumulative mass loss, during the CE test, as a function of exposure time, (b) the percentage of grain boundaries damaged after increasing CE exposure times, for each grain boundary character, and (c) variation of Taylor factor (uniaxial compression) across the grain boundaries most rapidly damaged and the grain boundaries most preserved in CE experiments.

For a specific CE exposure time, the fraction of damaged grain boundaries observed is much greater for Σ-3 CSL boundaries than for the other types. During CE, each crystallographic orientation leads to different values of resolved stress for plastic deformation (yield stress), and grain boundary damage begins preferentially between grains that have rather different values of yield strength. Thus, in Fig. 1c one can see that the greater the difference of TF between adjacent grains the more prone the grain boundaries are to nucleate CE damage.

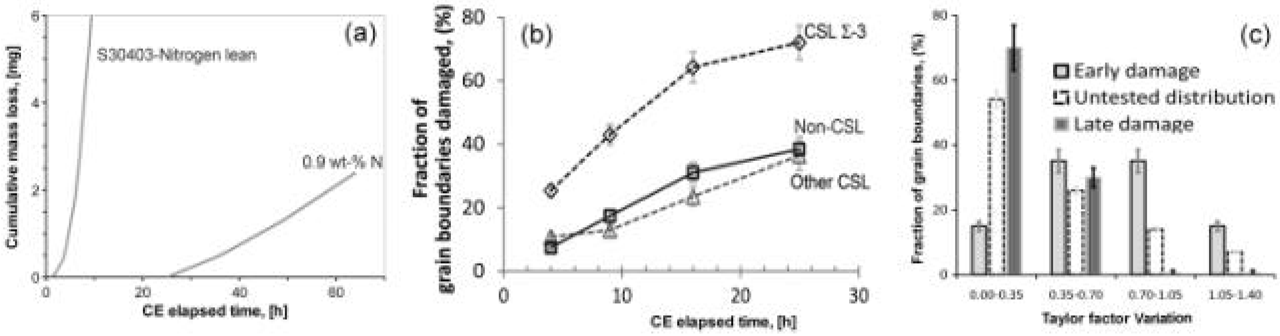

Figure 1: Results. (a) Cumulative mass loss during CE experiments, (b) fraction of damaged grain boundaries, as a function of exposure time, and (c) variation of Taylor factor across the grain boundaries most rapidly damaged and the grain boundaries most preserved in CE experiments (for comparison, the random distribution of variation of Taylor factor across grain boundaries in the sample is also shown).

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