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Influence of diffused hydrogen on the surface response of 316L stainless steel under cavitation-induced loading

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It has been established that hydrogen diffusion can significantly influence the mechanical response of metallic materials under various loading conditions. This phenomenon is particularly evident in reducing the ability for plastic deformation. The formation and collapse of bubbles inside a fluid, i.e., cavitation near a solid surface generates one of the most complex loading scenarios. The characteristics of localized, high-velocity, and cyclic loading inherent to this process may lead to material removal from the surface, a phenomenon known as cavitation erosion. The mechanical properties of the metal surface, affected by hydrogen, may alter the resistance against erosion wear under cyclic loading conditions during cavitation. In this research, 316L stainless steel samples were electrochemically charged in 0.05 M H2SO4 solution to reveal the effect of diffused hydrogen on mechanical behavior as determined through tensile testing. The cavitation erosion experiments were conducted on hydrogen-charged and uncharged samples in an ultrasonic cavitation test rig. The findings showed that hydrogen charging in H2SO4 resulted in a significant reduction in cavitation erosion damage of approximately 80% after 5h testing compared to the uncharged sample. After 2 hours of cavitation exposure, notable plastic deformation was observed on the eroded surfaces of the uncharged specimens, particularly manifested in the form of raised grain boundaries and slip bands, whereas the surfaces of the hydrogen-charged specimens predominantly retained their integrity. This was attributed to the increased resistance against plastic deformation after hydrogen charging probably due to the dislocation slip impediment by diffused hydrogen atoms.

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