EFFECTS OF ENVIRONMENTAL VARIABLES AND STRESS CONCENTRATION ON CRACKING OF SPALLATION TARGET MATERIALS

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Transmutation refers to the elimination of long-lived actinides and fission products from spent fuels discharged from operating nuclear reactors. An important component of the transmutation facility is a subcritical-target, which produces an intense neutron flux by impingement of accelerator proton beam onto it by a process known as spallation. This process can produce hydrogen causing environment-assisted cracking of target material. This paper presents the results of stress corrosion cracking (SCC) studies of two martensitic target materials, namely Alloy EP-823 and Type 422 stainless steel. The susceptibility to SCC was evaluated by using constant-load and slow-strain-rate (SSR) test techniques in neutral (pH: 6-7) and acidic (pH: 2-3) aqueous solutions at ambient temperature and 90°C. A proof ring was used to apply tensile load to the smooth cylindrical specimen for 30 days in constant-load testing. For SSR testing, the specimen was strained in tension until fracture at a strain rate of 3.3 x 10^{-6} sec^{-1}. A few SSR tests were also performed using notched tensile specimens. The cracking susceptibility under constant load was expressed in terms of the threshold stress (σ_{th}) below which cracking did not occur in 30 days. The cracking tendency in SSR testing was characterized by the time-to-failure (TTF), percent elongation (%El), percent reduction in area (%RA), and true failure stress (σ_f). The extent and morphology of cracking were analyzed by scanning electron microscope (SEM). For Alloy EP-823, a σ_{th} value of 105 ksi was observed in the 90°C acidic solution. The results of SSR tests indicate that with smooth specimen, the magnitude of σ_f, TTF, %El and %RA were significantly reduced (Figure 1) in the 90°C acidic environment showing a synergistic effect of pH and higher temperature for both materials. A similar behavior has been reported elsewhere[(1)]. The presence of notch further reduced the values of %RA, %El and TTF for Type 422 stainless steel, as expected. However, the magnitude of σ_f in this material was increased to some extent in the presence of a notch primarily due to a smaller area at the root of the notch. SEM micrographs (Figure 2) of the primary fracture faces in both alloys showed ductile failure (dimples) at ambient temperature, but intergranular brittle failure at 90°C in both environments. SCC tests under applied cathodic potential are in progress to study the effect of hydrogen on cracking.

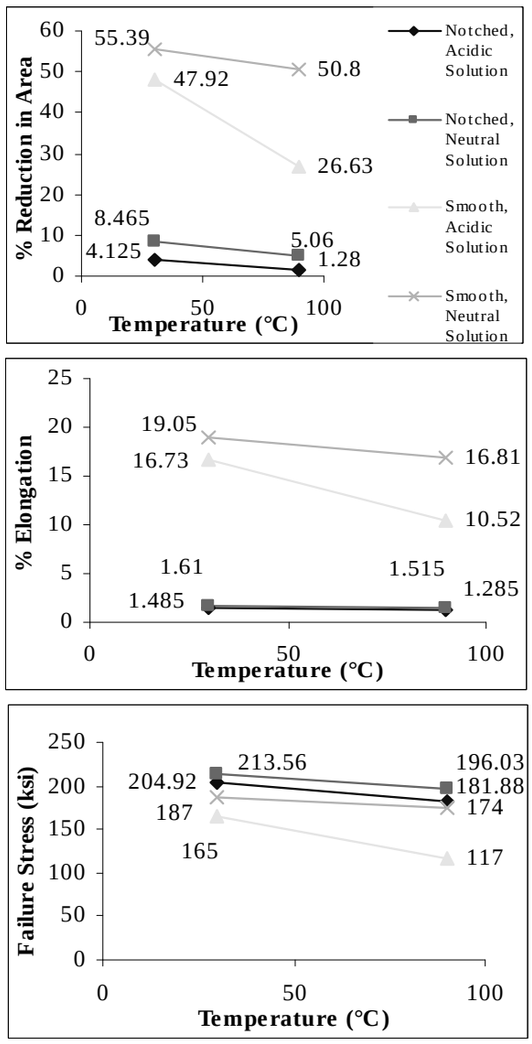

Figure 1. Effect of pH and Temperature on %RA, %El and σ_f for Type 422 Stainless Steel.

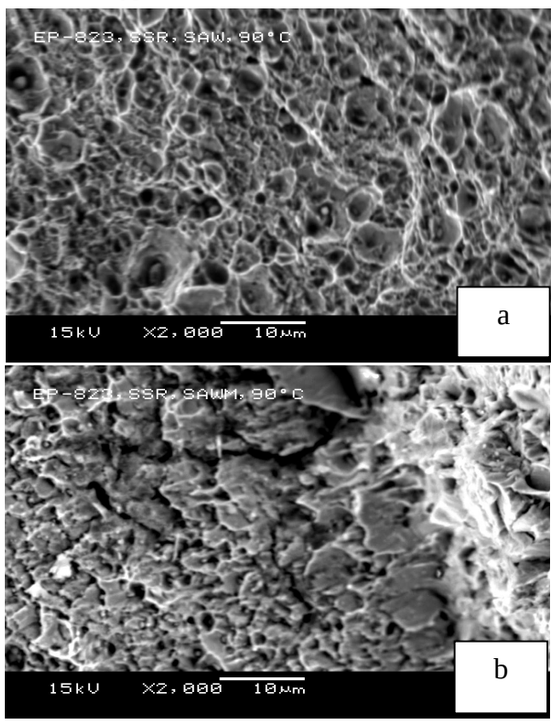

Figure 2. SEM Micrographs of Alloy EP-823 Failures in (a) Neutral and (b) Acidic Solution at 90°C.

Reference:

(1) Corrosion , ASM International, Vol. 13, Ninth Edition