Crevice Corrosion of Ni-Cr-Mo Alloys

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Ni-Cr-Mo alloys were developed for their exceptional corrosion resistance in a variety of extreme corrosive environments. An alloy from this series, Alloy-22, has been selected as the reference material for the fabrication of nuclear waste containers in the proposed Yucca Mountain repository located in Nevada (USA). A possible localized corrosion process under the anticipated conditions at this location is crevice corrosion. Therefore, it is necessary to assess how this process may, or may not, propagate if the use of this alloy is to be justified. Consequently, our primary objective is the development of a crevice corrosion damage function that can be used to assess the evolution of material penetration rates. We have been using various electrochemical methods such as potentiostatic, galvanostatic and galvanic coupling techniques. Corrosion damage patterns have been investigated using surface analysis techniques such as scanning electron microscopy (SEM) and optical microscopy. All crevice corrosion experiments were performed at 120°C in 5M NaCl solution. Initiating crevice corrosion on these alloys has proven to be difficult; therefore, we have forced it to occur under either potentiostatic or galvanostatic conditions.

In potentiostatic experiments creviced Alloy-22 and Alloy-4 specimens were polarized at +200mV and 0mV respectively for approximately 1 day. For both Alloy-4 and Alloy-22, the measured current was high (mA's) suggesting very little anodic limitation on crevice propagation. The measured current decayed in an oscillating pattern eventually to zero (figure 1). An optical micrograph of Alloy-4 (figure 2) showed that the corrosion damage penetrated to a limited depth in the form of tiny pits connected in rows (also seen for Alloy-22). Corrosion damage appeared as a channel excavated around the outer perimeter of the crevice which eventually progressed to the middle of the creviced area.

Crevice corrosion was also initiated galvanostatically before switching to galvanic coupling to an external counter electrode (made of the same material as the working electrode) in order to measure currents supported by the natural reduction of O_2 on Alloy-22 at sites outside the crevice. Often, on switching to galvanic control, repassivation occurred but, on occasion, propagation was sustained at low currents (~ 1- 10 µA) for up to one month. The potential over this period remained relatively constant with no apparent potential transients suggesting no additional film breakdown/repassivation events. Eventually, the current decayed to zero and the corrosion potential increased, indicating repassivation. Corrosion damage initiated and traveled laterally on the outer edge of the creviced area. SEM micrographs and optical microscopy of the corroded sites indicate corrosion attack along the grain boundaries and etching of the metal near the corroded regions that enhanced the grain boundary features.

In a third series of experiments, propagation was controlled galvanostatically at 20 µA. The accumulation of corrosion damage was again seen at the creviced edge and appeared to occur predominantly laterally rather than vertically.

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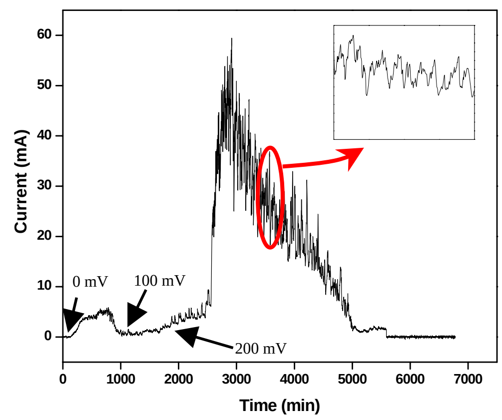

Figure 1: Current vs. time plot for the polarization of an Alloy-4 creviced specimen

Figure 2: Image of a crevice corroded Alloy-4 specimen