Multistage Fatigue (MSF) Modeling of Magnesium in a Corrosion Environment

Mark F. Horstemeyer

Extended Abstract

This work presents an overview of using the multistage fatigue model with a corrosion model to capture the behavior of magnesium alloys. One can argue that magnesium alloys used for structural components are always in a corrosive environment as no real practical structural component operates in a vacuum. As such, different magnesium alloys are analyzed in the context of their fatigue incubation, microstructurally small crack (MSC), and long crack regimes under a vacuum, air, and saltwater environments. The different magnesium alloys analyzed, including AE44, AM30, AM50, AM60, AZ31, AZ61, AZ91 alloys. These alloys were fabricated under different methods and each had different heat treatments. The levels of corrosion pitting, general corrosion, and filiform corrosion were quite different for each alloy, meaning that the interdependence of the different corrosion mechanisms interacted differently with each alloy's incubation, MSC, and LC fatigue lives.

General corrosion, illustrated in Fig. 1 for pure magnesium and magnesium–aluminum alloys, occurs along with pitting, and filiform corrosion occurs for magnesium and its alloys. There is an associated hydrogen release from the chemical reaction that can be quantitatively measured as per Fig. 2 so the association cause–effect relation of the microstructure–property relationship can be known. When you apply the fatigue environment with the corrosion environment, different strain–life curves arise as per Fig. 3. It is these differences that the multistage fatigue (MSF) model combined with the internal state variable (ISV) corrosion model can be used to address the behavior of the material.

M. F. Horstemeyer (✉)
School of Engineering, Liberty University, Lynchburg, VA 24515, USA
e-mail: mfhorstemeyer@liberty.edu

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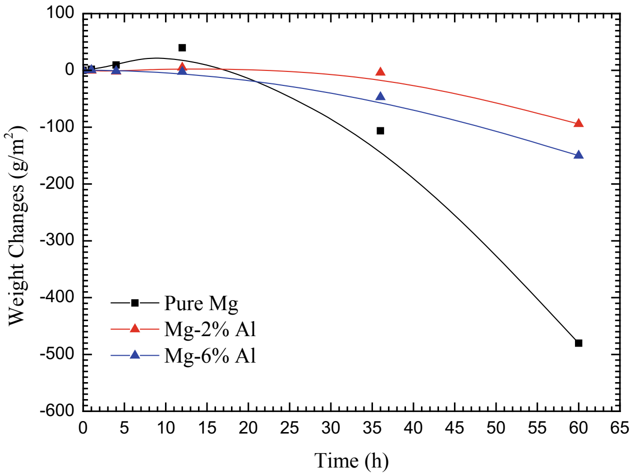

Fig. 1 Weight change of magnesium versus time illustrating general corrosion for differing amounts of aluminum in solution of magnesium

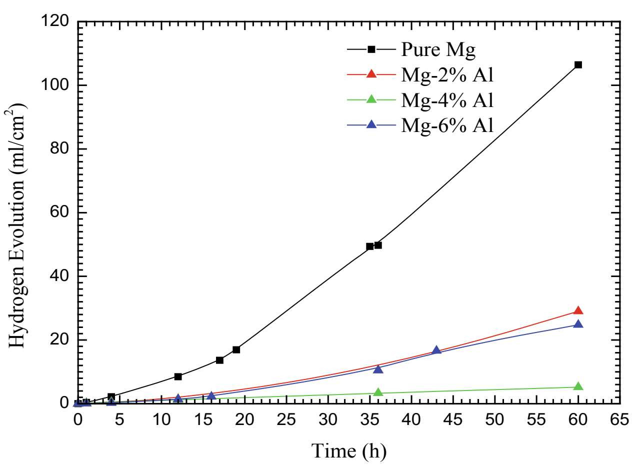

Fig. 2 Hydrogen release versus time under immersion corrosion environments associated with the general corrosion of Fig. 1

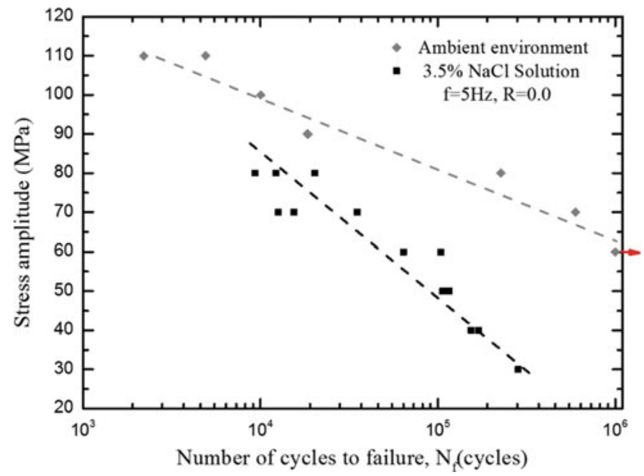

Fig. 3 S–N curves for an extruded AM30 magnesium alloy tested in laboratory ambient environment (30–45% RH) and 3.5 wt% NaCl solution environment. Fatigue specimens for both environments were tested with a frequency of 5 Hz and a stress ratio of 0.0. Large variation in corrosion fatigue life was present at stress amplitudes higher than 60 MPa. The fatigue run out stress level was 60 MPa in the air environment and was not found in the 3.5 wt% NaCl solution environment