Seminar

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11:00 am

Room 406 ME-EM

Fatigue Crack Growth Modeling of API Pipeline Steels in Hydrogen Transportation Service

Hydrogen is likely to play a key role worldwide in a future clean-energy economy. Although pipeline transmission appears to be the most economical means to transport gaseous hydrogen, fundamental understanding of the deleterious effects of hydrogen on the fatigue and fracture properties of pipeline steels is lacking. Furthermore, engineering tools for design and lifetime prediction of pipeline steels in gaseous hydrogen are yet to be developed and implemented into national codes.

Research performed at the National Institute of Standards and Technology, in collaboration with the U.S. Department of Transportation and the American Society of Mechanical Engineers has resulted in a phenomenological fatigue crack propagation model for API-5L pipeline steels exposed to high-pressure gaseous hydrogen. The semi-empirical model is predicated upon the hypothesis that one of two mechanisms dominates the fatigue crack growth response depending upon the applied load and material hydrogen concentration interaction. The proposed model predicts fatigue crack propagation as a function of applied crack growth driving force (ΔK), load ratio, and hydrogen pressure.

Results of fatigue crack growth tests in gaseous hydrogen as well as fatigue crack growth surface morphology are presented in support of the model. The model correlates well with test results and elucidates how the deformation mechanisms contribute to fatigue crack propagation in pipeline steels in environments similar to those found in hydrogen transportation service. The presentation will focus on the model framework, the future scientific needs to support the model development into a physics-based structure, as well as the simple implementation of the model into the ASME B31.12 Hydrogen Piping and Pipeline standard as an engineering tool.

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