Collaborating to better understand metal degradation

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Southwest Research Institute and The University of Texas at San

Antonio are working together to understand the susceptibility of additively manufactured materials to hydrogen embrittlement, a common problem that can lead to mechanical hardware degrading and losing functionality. The project, led by W. Fassett Hickey of SwRI's Mechanical Engineering Division and Brendy Rincon Troconis of UTSA's College of Engineering, is supported by a $125,000 grant from the Connecting through Research Partnerships (Connect) Program.

Additive Manufacturing (AM) is an increasingly popular method of creating meticulously designed metallic parts through 3-D printing. The method's applications are practically endless, but Hickey and Troconis are particularly interested in additively manufactured material performance for the aerospace and oil and gas industries.

Hydrogen sulfide (H_2S) is a gas that is commonly encountered during the drilling of oil and natural gas. The atomic hydrogen in hydrogen sulfide is liberated and absorbs into the pipeline material and down-hole tools, which leads to degradation in material performance. This is also known as hydrogen embrittlement.

In 2014, Kazakhstan's largest oil field was shut down for two years for repairs because of hydrogen embrittlement, which caused large cracks in its pipelines.

"Atomic hydrogen is an unintended alloying element that can wreak havoc on even the most advanced and modern alloy systems," Hickey said.

The central focus of the project will be an effort to understand the mechanisms of hydrogen embrittlement in additively manufactured nickel-based alloy 718, so that in the future it will be possible to design AM parts that are less susceptible or even immune to these dangers.

To do this, Hickey and Troconis will study hydrogen embrittlement on a molecular level to see how the location of the hydrogen atoms affects the integrity of the metal material under the high pressures and elevated temperatures typical of drilling environments. This will be accomplished in SwRI's unique testing facilities, which allow for mechanical testing in gaseous hydrogen up to 3,000 PSI and 500 degrees Fahrenheit. UTSA's thermal desorption spectrometer and scanning kelvin probe force microscope will be used to further understand the hydrogen-alloy interaction and spatially resolve where the hydrogen resides within the alloy microstructure.

"Additive manufacturing brings a lot of exciting new possibilities," Hickey said. "We're working with new designs that weren't possible with traditional machining and fabrication methods. If we can better understand the underlying mechanisms of hydrogen embrittlement in AM materials, the AM fabrication parameters and post-processing parameters of the AM parts can be designed to prevent hydrogen embrittlement, then ultimately the possibilities and applications for these AM materials are even greater."

Provided by Southwest Research Institute