San Antonio researchers seek to prevent aerospace failures and oil spills disasters

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Professor 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. Credit: UTSA

In 2014, Kazakhstan's newest and largest oil field was slated to become a major contributor to the global supply. But within a month of operation, a total shutdown occurred. Without warning, large cracks appeared in its pipelines. For the next two years, the field remained idle due to costly repairs. The cause: embrittlement of the pipelines.

Like bones, oil and gas pipelines suffer from fragility and cracking. Now a group of researchers at The University of Texas at San Antonio (UTSA) and Southwest Research Institute (SwRI) propose to examine how hydrogen embrittlement conditions develop. Their research is focused on an alloy used in the oil and gas industry, but fabricated through additive manufacturing (AM).

"The operational conditions in the oil and gas industry can lead to hydrogen embrittlement. This phenomenon causes the premature failure of structures as result from hydrogen intake in the material. Hydrogen once inside the material interacts with the alloy microstructure degrading its mechanical performance and resulting on brittle fracture without any warning sign," said assistant professor Brendy Rincon Troconis in the UTSA Department of Mechanical Engineering.

AM has been embraced for many reasons on the factory floor. With the use of AM, more complex designs and materials can be created one layer at a time. AM also reduces overhead costs since parts can be assembled quickly on site, rather than keep a large expensive inventory.

Although many industries are quickly adopting AM, the researchers are concerned that there hasn't been enough testing of how hydrogen embrittlement impacts the material performance of this particular metal. The San Antonio researchers will focus on the nickel-718 alloy because it can be used in critical conditions where high mechanical properties and corrosion resistance is desired.

Professor Rincon Troconis' research not only impacts the oil and gas industry. More and more AM metals are introduced in aerospace. Airbus Defense has tested AM materials in its propulsion systems. Space X already uses AM materials to fabricate some parts of the Falcon Rocket 9 and the Super Draco engine chamber. DNV-GL, an international provider of risk management and quality assurance services, is already promoting an initiative to set up guidelines and certifications for how AM parts will be utilized in offshore applications.

Although safety measures are of essence, without enough testing data to understand the effect of hydrogen embrittlement on AM alloys performance, the safety of AM fabricated systems remains unknown.

Professor Rincon Troconis and W. Fassett Hickey of SwRI's Mechanical Engineering Division will work to understand how the AM nickel-718 integrity is impacted by hydrogen embrittlement. Troconis and Hickey 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 will utilize its thermal desorption spectrometer (TDS) and scanning kelvin probe force microscope (SKPFM), one of few university laboratories in the country with the combination of these advanced technologies.

The hydrogen embrittlement study is made possible by the Connect Program, a jointly-funded collaborative initiative between UTSA and SwRI. The researchers hope to have data available by the summer of 2020 to provide better guidance to industries about how to design AM parts that are less susceptible to hydrogen embrittlement. Currently, few national labs are working on this type of research.

"By understanding more about hydrogen embrittlement of AM materials, we can provide crucial information, with more confidence, to optimize the AM and post-fabrication processes and prevent brittle fracture of future and current systems, while advancing the AM technology, which will all lead to better protection of the community, its assets, and the environment," said Rincon Troconis.

Provided by University of Texas at San Antonio

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