Hydrogen Effects in Steels and SS Steels and Their Impacts on Service Safety of Hydrogen Pipings and Vessels

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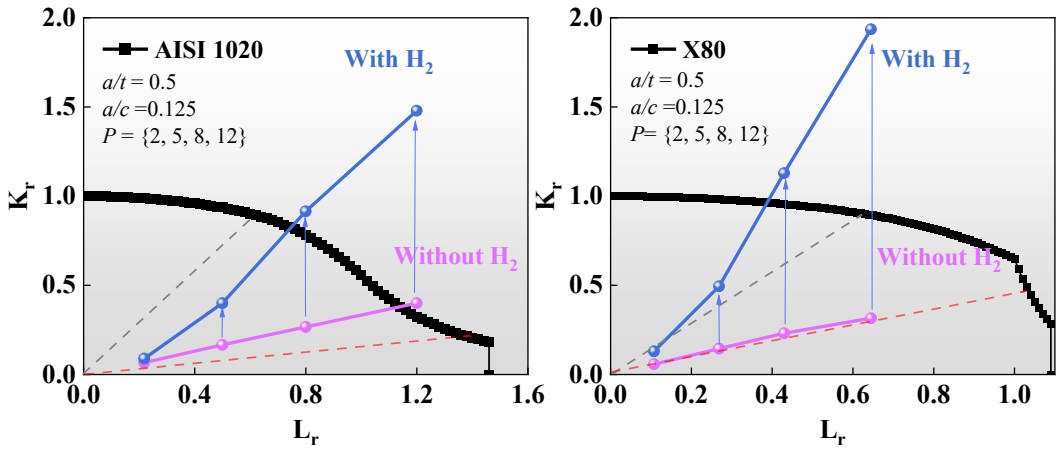
The effects of hydrogen on the mechanical properties of steels and stainless steels (SS) have been long recognized. However, when it comes to design and construction of specific components such as piping and vessels for high pressure hydrogen service, materials selection and validation need to be based on reliable, often using high-pressure hydrogen gas, testing results. Testing conditions such as loading rate and frequency, alloy composition and structure, the amount of hydrogen allowed to enter the test specimens, all affect test results.

Industry relies on hydrogen compatibility standards/requirements (such as tensile, fatigue and toughness) in their materials selection. However, current test conditions in national and international standards (such as ASME B31.12) were based on pressure-vessel designs of limited capacities. Therefore, some of the test results can be non-conservative when used for current hydrogen applications. An example will be the fracture toughness of hydrogen pipelines: Toughness property data is often relied on in service safety analysis using Failure Assessment Diagram (FAD), and non-conservative toughness data can lead to unreliable safety boundaries in FAD.

Graphical Abstract



The effects of hydrogen on the safety boundaries as defined using FAD