Material Testing and Analysis of Metals in Hydrogen Gas Environments

In response to global climate change, there has been a significant acceleration in the pursuit of decarbonization and carbon neutrality to address this urgent issue. Many countries have made commitments to achieve carbon neutrality within specific timeframes, with targets set, such as by the year 2050. Hydrogen energy is considered one of the most promising solutions. Unlike fossil fuels, which release carbon dioxide when burned, hydrogen combustion causes minimal environmental impact as it does not emit carbon dioxide. Moreover, hydrogen demonstrates exceptional capabilities in energy conversion, making it a valuable resource for electricity generation. Recognizing the significance of hydrogen energy, we, Kobe Material Testing Laboratory Co., Ltd., have been actively developing technologies for various material tests in hydrogen environments. We would like to share our testing accomplishments and provide insights into our ongoing efforts for further technological advancements.

Aiming for realizing a hydrogen-based energy society

Hydrogen energy: Production → Transport / Storage → Utilization

The demand for structural materials in hydrogen environments is growing, but there are remaining challenges to address.

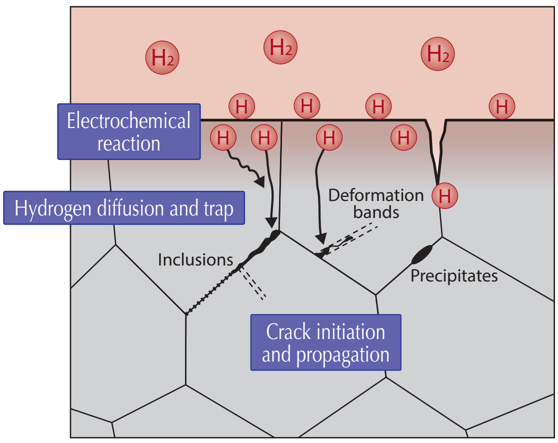
Design-related issue

- Is it appropriate to apply conventional design criteria?
- Is design consideration for hydrogen impact necessary?

Concern in structural design

Hydrogen embrittlement

Solute hydrogen diffuses into metallic materials, leading to a decrease in various strength properties.



- Delayed fracture
- Ductility loss
- Degradation of fatigue life and fatigue limit
- Acceleration of fatigue crack growth
- Decrease in fracture toughness

To evaluate the hydrogen compatibility of metallic materials, material testing in hydrogen environments is essential and indispensable.

Technical obstacles

- Handling hydrogen gas, which is flammable, requires knowledge and strict adherence to scientific safety measures.
- Material testing in hydrogen gas environments necessitates extensive explosion-proof facilities, resulting in significant costs.
- High expenses for outsourcing material testing services also pose obstacles to the development of a hydrogen energy society.

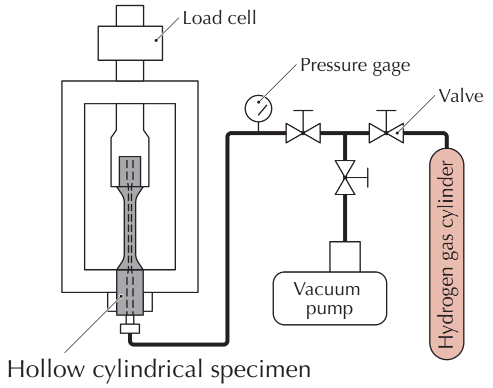
Please refer to the next page for the **solutions** we propose.

Solutions Strength Tests using Hydrogen-Gas-Sealed Hollow Specimens

Benefits 1 Strength testing while exposing the material's surface to hydrogen gas.

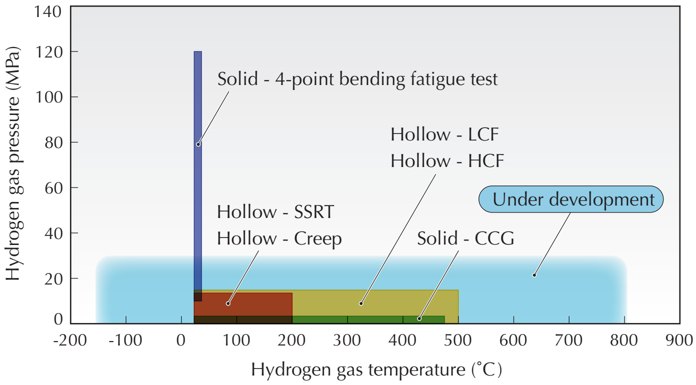
Benefits 2 Minimal amount of hydrogen gas, ensuring safety even if gas diffuses outside the test specimen.

Benefits 3 Budget-friendly solutions integrated with KMTL's core testing technology for various testing needs.



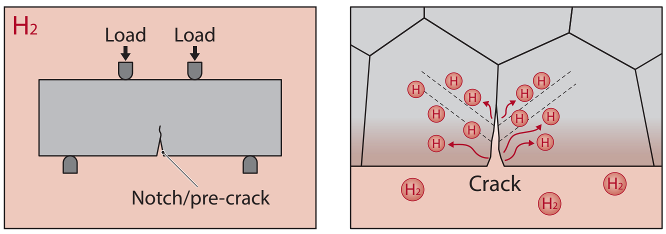
Our lineup for hydrogen material testing services

Specimen	Test	Pressure (MPa)		Temperature (°C)	
		Min.	Max.	Min.	Max.
Hollow	SSRT (Slow strain-rate test)	0.1	13.5	23	200
Hollow	Creep	0.1	13.5	23	200
Hollow	LCF (Low-cycle fatigue)	0.1	13.5	23	500
Hollow	HCF (High-cycle fatigue)	0.1	13.5	23	500
Solid	CCG (Creep-crack-growth)	0.1	0.1	23	475
Solid	4-point bending fatigue	10	120	23	23



Testing in ultra-high pressure (120 MPa class) hydrogen gas environment at room temperature

- Evaluating components with stress concentration areas or cracks
- Fatigue crack propagation characteristics, fracture toughness, and fatigue limits data acquired through 4-point bending testing
- Dedicated explosion-proof testing room
- Small pressure-vessel with a unique structure installed into general-purpose fatigue testing machine
- Exceptionally competitive pricing for ultra-high pressure hydrogen gas fatigue testing
- Specimen dimensions: 10 mm × 10 mm × 80 mm (maximum)



4-point bending fatigue testing using notched specimen

High-resolution hydrogen concentration analysis

- Hydrogen adsorption depends on each material and environmental condition.
- Obtaining the amount of hydrogen absorbed in a product in its operating environment is crucial.
- Hydrogen concentration measurement is available as precise as 0.00001 mass% (0.1 mass ppm).
- Sample size: 10 mm × 20 mm × 4 mm (maximum).
- Heating rate: 5˚C/min to 10˚C/min
- Concentration measurement range: 0.1 to 100 mass ppm

AI analysis for fracture surface

- The fracture mechanisms change in hydrogen environments.
- Fracture surface photographs are captured with a scanning electron microscope (SEM).
- AI analyzes the images and provides reports on fracture characteristics.
- Valuable insights are obtained from specimens fractured in hydrogen environments.

Scan to learn more.

At KMTL, we are committed to expanding the boundaries of hydrogen environment testing.
Our focus on higher-pressure, higher-temperature, and lower-temperature conditions will enable us to meet the evolving needs of the growing hydrogen energy society and our valued customers.

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