

MONITORING HYDROGEN GAS PRESSURE IN SOLID OXIDE FUEL CELLS

Overview

Stationary Fuel Cells Powering the Future

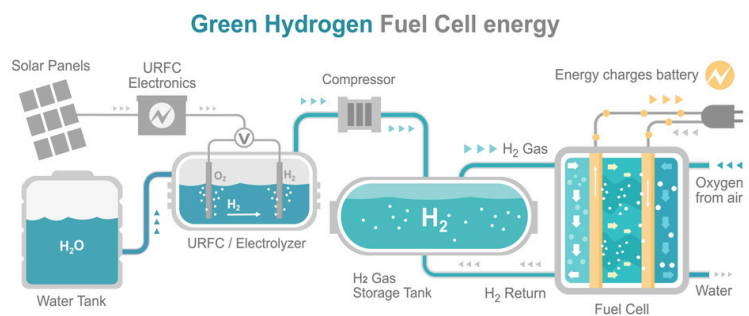
New and innovative energy production technology is transforming the Energy market with cutting-edge stationary fuel cell systems, becoming the go-to for dependable & reliable backup power, replacing conventional bulky diesel generators in the foreseeable future. Hydrogen can be extracted from fossil fuels or can be produced by using the process of electrolysis to split water into hydrogen and oxygen resulting in carbon-free hydrogen production. These systems are taking off, providing reliable backup electricity for businesses and homes alike, reducing the carbon footprint. Complex hydrogen stationary fuel cells make us adhere to the sustainable energy sources with zero emissions compared to diesel generators releasing 2.67kg of CO₂ per liter of diesel fuel. These systems team up with solar panels or wind turbines to form a powerhouse of local and eco-friendly clean energy.

The surplus amount of hydrogen produced can be compressed and stored in specialized tanks and saved for unexpected emergency scenarios and when the time comes, they release their stored reserves, powering everything from vehicles to homes with clean, efficient energy. It's like having a reservoir of possibilities, just waiting to be tapped into.

In order to increase the efficiency & optimizing the energy consumption, it is mandatory to analyze & monitor the system continuously without any downtime or compromise on various segments of hydrogen production, storage, compression, transport & combustion (Fuel Cell). Additionally, circuits responsible for managing water or air demand diligent monitoring and control to ensure the system operates optimally. For Solid Oxide Fuel Cells (SOFCs) to perform at their peak, they rely on precise hydrogen pressure for efficient and fail safe operation. For Proton Exchange Membrane Fuel Cells (PEMFCs), proper water management and pressure should be monitored in order to maintain proper hydration of the polymer electrolyte membrane and prevent dehydration or flooding.



Stationary Fuel Cell System



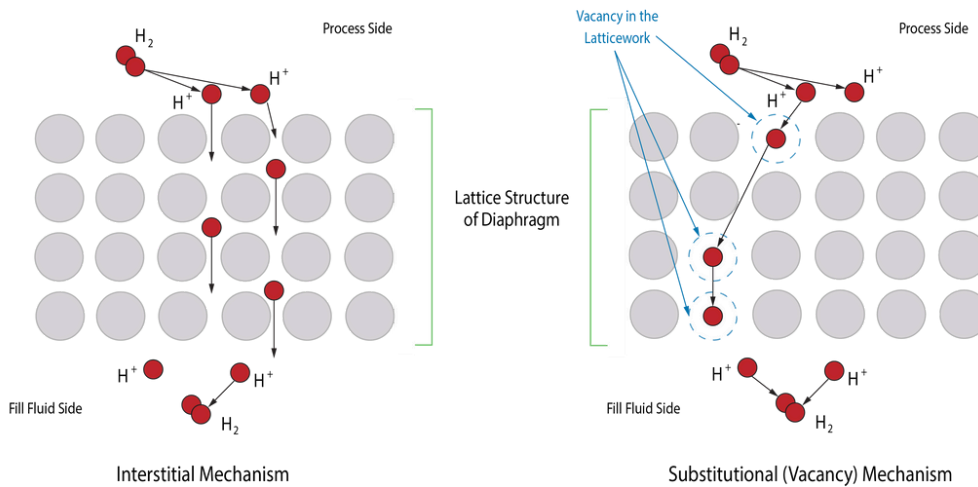
Stationary Fuel Cell System Layout

Challenge

Hydrogen Permeation on Metals

Hydrogen permeation is the diffusion of hydrogen ions through the thin metal isolation diaphragms used in pressure transmitters either through interstitial or substitutional (vacancy) mechanisms. Hydrogen breaks down in the process medium into hydrogen ions, diffuses through the diaphragm, and reforms into hydrogen molecules in the fill fluid. Over time the fill fluid becomes saturated, and hydrogen bubbles form.

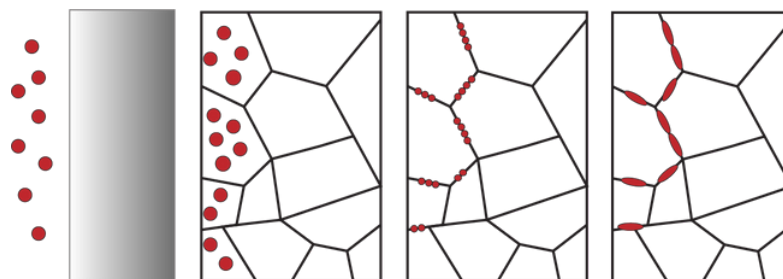
If enough of these bubbles form, the zero and span shifts, causing the transmitter to drift. In extreme cases, the hydrogen bubble can build up enough volume to force the isolation diaphragm to expand outward causing cracking of the diaphragm.



Hydrogen Permeation

Metal Embrittlement by hydrogen

Embrittlement is a phenomenon that causes loss of ductility and, consequently, brittleness in a material when in contact with hydrogen for a longer duration. Highly susceptible materials include high-strength steels, titanium and aluminum alloys, and electrolytic tough-pitch copper. When hydrogen infiltrates the material's structure, it causes degradation of its mechanical properties and, ultimately, mechanical failure. Austenitic stainless steels suffer only minor, low-temperature embrittlement so for hydrogen applications austenitic steels like 316Ti or 316L are best suited.



Hydrogen Embrittlement

Solution

Barksdale's BHyT Fuel Cell hydrogen pressure transducers are the silent guardians of fuel cell systems. By constantly monitoring and adjusting hydrogen pressure, they ensure safe and efficient operation, maximizing performance and lifespan in applications like cars and power plants.

BHyT Hydrogen Pressure transducers employ two kinds of sensing technologies, the industry-standard Gold Plated Piezoresistive transducers and the new 316L One-piece Monolithic transducers. Gold-plated piezoresistive transducers offer excellent resistance to hydrogen permeation due to the dense and inert nature of gold, enhancing transducers durability and accuracy. Meanwhile, 316L one-piece monolithic transducers provide robust performance with reduced risk of hydrogen embrittlement and simplified installation, thanks to their weld-free design and thick metal diaphragm.

BHyT Fuel Cell transducers are pressure tested during manufacturing to withstand high pressure spikes without any compromise. In order to prevent the Hydrogen Embrittlement effect, appropriate materials in direct contact with Hydrogen have to be chosen. As a standard austenitic steels like 316L or 316Ti are preferred. The BHyT fuel cell comes with wetted material made of 316L making it more compatible with hydrogen applications.



Gold-plated Sensor



Monolithic Sensor

Transducer Specifications

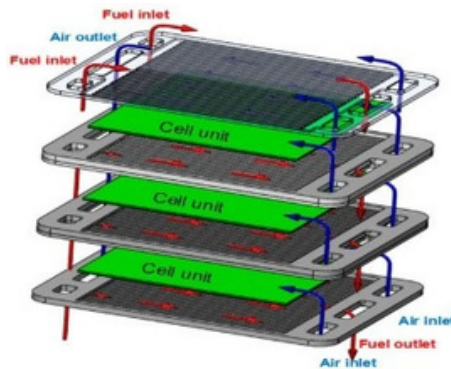
- Pressure Range: 0-10,000 PSI (689 bar)
- Accuracy: $\pm 0.1\%$ FSO (Full Scale Output)
- Temperature Range: -40° to 125° C
- Wetted Material: 316L Stainless Steel
- Response Time: < 3 ms
- Proof Pressure: 2x
- Burst Pressure: 3x
- Agency Approvals: UL, CML, CSA, EMI/EMC
(as per IEC 61000)



BHyT Hydrogen Pressure Transducers

Application #1 Solid Oxide Fuel Cell

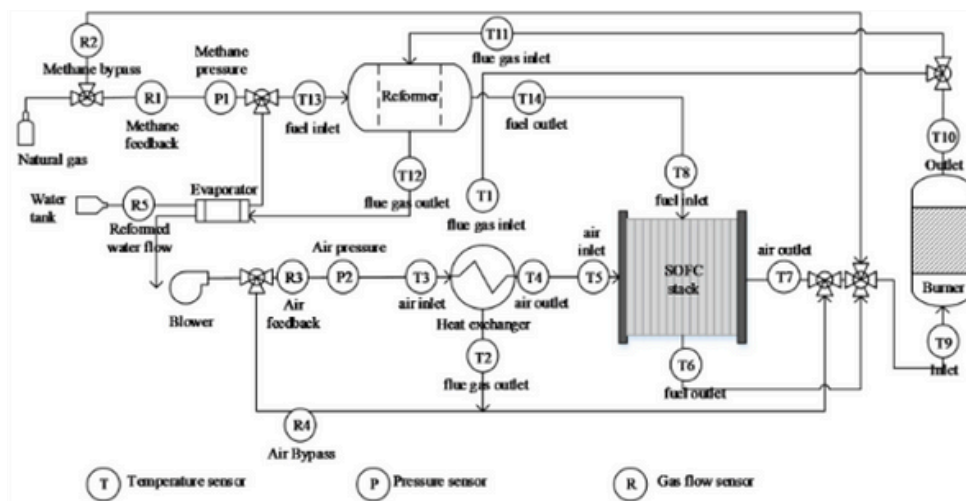
Pressure transducers play a critical role in monitoring the pressure of the fuel (commonly hydrogen or natural gas) entering the SOFC stack. Ensuring a stable fuel pressure is essential for maintaining efficient electrochemical reactions within the fuel cell. This consistent pressure not only optimizes the performance and efficiency of the SOFC but also helps prevent potential damage to the system, thereby enhancing its durability and reliability.



SOFC Stack Arrangement diagram with Air & Fuel inlet & outlet directions.

Application #2 Solid Oxide Fuel Cell

Pressure transducers are utilized to monitor the pressure in both the fuel and air manifolds that supply gases to each cell within the SOFC stack. This monitoring is crucial for ensuring uniform gas distribution, which in turn maintains consistent performance across all cells in the fuel cell. By maintaining the proper pressure balance, the system can achieve optimal efficiency and reliability, preventing variations that could lead to uneven cell performance or potential damage.

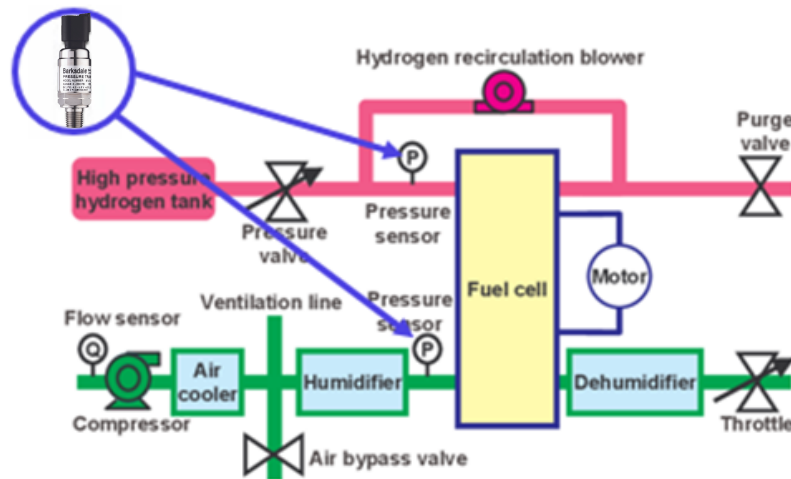


SOFC Process Diagram with application Pressure/Temperature & Gas flow Sensors for monitoring purpose.

Real-World Application

Barksdale's BHyT Fuel Cell Transducers have been used for the past four years in hundreds of hydrogen powered forklifts and public transit buses.

Hydrogen powered buses require pressure transducers for both storage tanks and fuel cells. The roof racks contain hydrogen storage tanks where Barksdale transducers are ensuring safe pressure measurement at up to 6,500 PSI (448 bar) using monolithic sensing technology. In the rear, transducers for low-pressure are used to monitor hydrogen intake into fuel cells at up to 200 PSI (14 bar).



Conclusion

In conclusion, the future of hydrogen sensing lies in the continued development and adoption of innovative materials and sensor designs. These advancements are crucial for ensuring the safe and efficient utilization of hydrogen, thereby supporting its pivotal role in the transition to a sustainable energy future. By addressing the technical challenges associated with hydrogen applications and environments, we can unlock the full potential of hydrogen as a clean energy carrier, paving the way for a greener, more sustainable world.



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