Technical Brief *May 2010*

Hydrogen On-Demand

Simplified High-Pressure Hydrogen Production

EERC Energy & Environmental Research Center®
Putting Research into Practice

NCHT

Hydrogen On-Demand *Simplified High-Pressure Hydrogen Production*

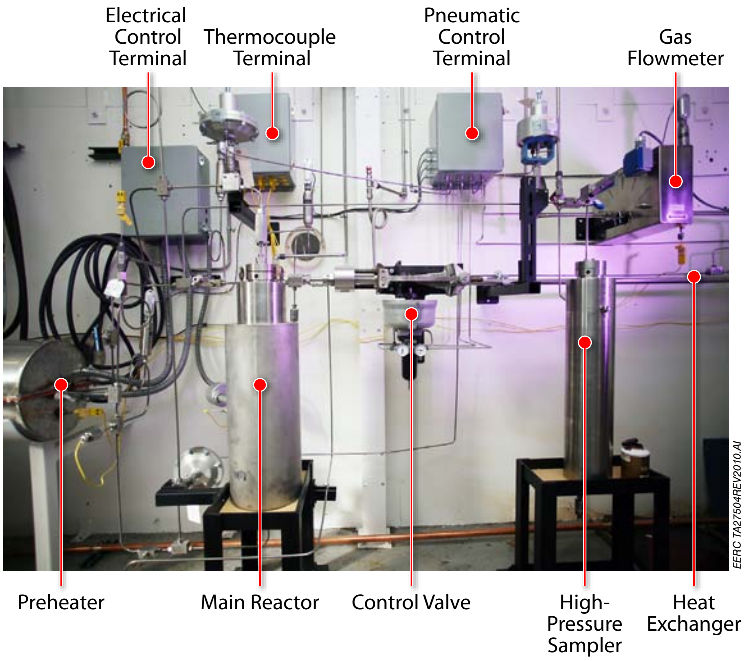
The Problem

Today, hydrogen is typically produced at large centralized locations, compressed or liquefied, and delivered via truck and trailer. Because hydrogen is a very light gas, it is expensive to compress, and the amount of hydrogen transported in each trailer is relatively small (~400 kg). The costs associated with hydrogen compression, transportation, and storage create challenges for small distributed hydrogen applications.

The Solution

Through the EERC's simplified high-pressure hydrogen (SHPH) process, by eliminating the compression and large-volume storage steps, the overall process is simplified and less expensive. Lower-cost hydrogen can be produced on-site, at dispensing pressures, thereby reducing costs and safety concerns associated with compressing, distributing, and storing large volumes of high-pressure hydrogen.

Instead of reforming at low pressure and pressurizing the resulting hydrogen, SHPH transfers the pressurization step to the feedstock and does the reforming and purification at high pressure to yield high-pressure (12,000 psi), fuel-cell quality hydrogen.



Traditional Production

Hydrogen On-Demand

How It Works

Hydrogen On-Demand transfers the compression step from the hydrogen product to the reactants, which is especially advantageous with liquid feedstocks like methanol, ethanol, and other fuels (versus natural gas or other gaseous feedstock) since liquids require significantly less energy and lower-cost equipment to pressurize than gases.

Hydrogen On-Demand can be broken down into four systems:

1. The feedstock storage system contains one tank for liquid organic feedstock and one tank for water. Each feed tank is equipped with a positive displacement pump. Flowmeters measure water and fuel flow leaving the storage tanks.

2. The feedstock preparation system heats the water to steam in a heating coil and mixes it with fuel. After fuel and steam are combined in a common line, the mixture is fed to the bottom of the reactor.

3. The reactor system consists of a vertically oriented vessel. A catalyst is positioned in the center of the reactor vessel. Reactor temperature and pressure are controlled remotely from a computer. To increase pressure, a valve on the exit side of the reactor is partially closed. A multicomponent gas analyzer measures real-time product gas composition.

4. The high-pressure gas purification system removes water, carbon dioxide, carbon monoxide, methane, and any other nonhydrogen gases. The system utilizes a variety of gas separation techniques, which all operate at high pressure.

Benefits

The ability to produce fuel cell-quality hydrogen on demand from liquid feed streams at high pressure is advantageous because it:

- Eliminates gas compression and reduces hydrogen storage requirements. Because Hydrogen On-Demand produces and purifies a continuous stream of high-pressure hydrogen (up to 12,000 psig), the need for gas compression can be eliminated and hydrogen storage requirements are greatly reduced.

- Provides a portable fuel source. Physically, Hydrogen On-Demand takes less space than the traditional steam methane-reforming (SMR) process. When compared to a system operating at 300 psig, a reforming process operating at greater than 6000 psig can have cross-sectional areas of pipes and volumes of vessels that are 14 times smaller while maintaining the same gas velocities and residence times.

- Improves energy efficiency. Hydrogen On-Demand thermal energy losses are smaller because it operates at moderate temperatures (e.g., 375° to 640°C) compared to traditional SMR processes, which typically operate around 800°C.

- Reduces costs. Hydrogen transportation costs are greatly reduced because hydrogen is produced on-site from liquid fuels, which are less expensive to transport than gases. In addition, Hydrogen On-Demand does not require the postreformer hydrogen compression and storage steps that are required by traditional SMR.

What's Next?

A scaled-up SHPH system is being constructed to demonstrate the entire integrated process (high-pressure hydrogen production, purification, and dispensing). This unit will convert liquid feedstock to high-pressure, fuel cell-grade hydrogen. The fuel cell-grade hydrogen will be routed to a commercial hydrogen dispenser, thereby allowing fuel cell-powered vehicles to utilize the end product.

Partners

Kraus Global designed and fabricated the dispenser and assisted in the design of the prototype Hydrogen On-Demand system.

About NCHT

The National Center for Hydrogen Technology (NCHT) is located at the Energy & Environmental Research Center (EERC) at the University of North Dakota. The EERC was designated as the NCHT in 2004 in recognition of over 50 years of hydrogen research involving fossil and renewable energy. With its 85 commercial partners, NCHT is focused on the production, storage, transport, and end use of hydrogen.

For More Information

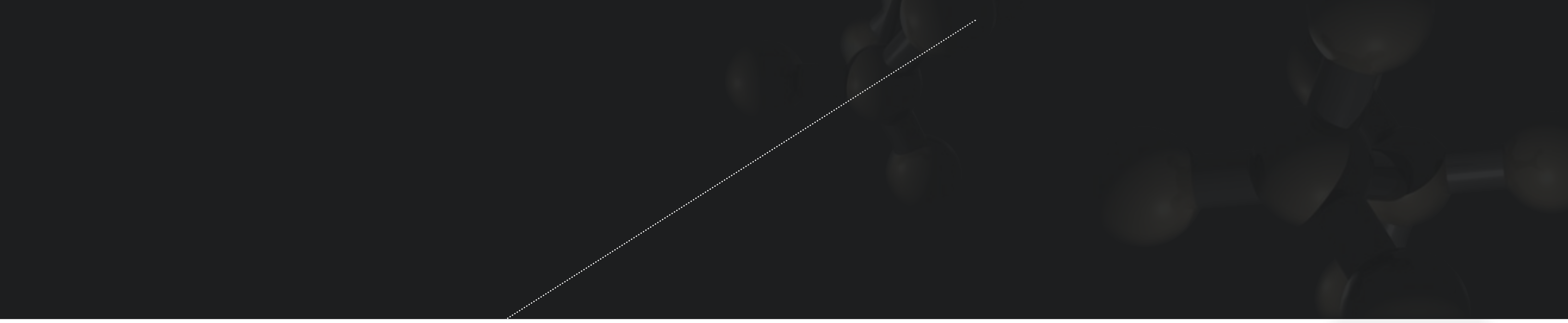
To learn more about Hydrogen On-Demand, visit www.undeerc.org/NCHT or review the journal article "On-Demand Hydrogen Via High-Pressure Water Reforming for Military Fuel Cell Applications," which was published in the Journal of Fuel Cell Science and Technology, Vol. 5, No. 4., November 2008.

For More Information, Contact

Michael Holmes
NCHT Director and EERC Deputy Associate Director for Research
(701) 777-5276
mholmes@undeerc.org

Thomas Erickson
EERC Associate Director for Research
(701) 777-5153
terickson@undeerc.org

Energy & Environmental Research Center
15 North 23rd Street, Stop 9018 • Grand Forks, ND 58202-9018
Phone: (701) 777-5000 • Fax: (701) 777-5181
www.undeerc.org/ncht



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