Controlling hydrogen in fuel cells to reduce global warming

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Hydrogen has an increasingly important role as an alternative energy source to help decrease global warming, thanks to its potential for emissions-free generation and use. Its application is wide-reaching, with stakeholders ranging from governments to aviation manufacturers investing in hydrogen power technology. To ensure the safety and efficiency of hydrogen fuel cell systems, valve control technology will play an important role.

Tony Brennan, Industry Account Manager – Industrial Devices at Bürkert, discusses opportunities with hydrogen as an alternative energy.

Hydrogen is critical to the UK's energy transition *(1)* because it can be converted into an emissions-free fuel. The gas is set to increasingly contribute to the National Grid *(2)*, while manufacturers of cars, aeroplanes, and ships are investing in the technology as an alternative to fossil fuels.

To ensure hydrogen contributes to a zero-emissions energy mix, the gas itself should also be produced with an emissions-free process. 'Green' hydrogen production involves renewable energy, such as solar or wind, to power electrolysis, a process that splits water, enabling the collection of hydrogen. Hydrogen can then be stored for use, whether to power infrastructure or cars and buses.

Hydrogen fuel cell

Typical within vehicles, a hydrogen power system involves a fuel cell that converts hydrogen into electricity. A fuel cell achieves this by reversing the process of electrolysis. Hydrogen gas is fed into the negatively charged anode where its molecules are split into protons and electrons, while on the opposite side of the fuel cell, oxygen enters the positively charged cathode. Between them, an electrolyte allows the positively charged hydrogen protons to pass through to the cathode, while blocking the negatively charged hydrogen electrons. Instead, the electrons are forced to flow through an external circuit, creating an electric current. The only by-product of this process is water, released after the electrons and hydrogen protons combine with oxygen at the cathode. The process can continue for as long as it has a sufficient supply of hydrogen and oxygen.

Controlling the supply of hydrogen into the fuel cell is vital both for system operation and safety. Typically, the system requires a safety shut-off valve on the inlet to prevent hydrogen leaking during system shut down; often, an additional valve is required for redundancy. Downstream, to control the pressure of hydrogen into the fuel cell stack, a proportional control solenoid valve modulates the flow. Finally, the inlet side of the process usually has a purge valve, for clearing the system of any accumulated water and residual hydrogen to enable safe system shutdown.

Valve systems

Designing valves to control the inflow of hydrogen into fuel cell systems, particularly for the automotive sector, requires IP6K9K protection, the very highest ingress protection rating against dust and water and recommended for electrical components in vehicles. Considering the enhanced safety requirement for handling hydrogen, which carries an explosion risk, valve durability is also essential,

particularly for vehicle applications. Hydrogen embrittlement can cause cracks under stress, so to avoid this, the valve body material needs to be made from stainless steel with a low carbon content and a high nickel content of >10%. Seals also have to be highly resilient and able to cope with a wide temperature range, so EPDM seals are used in mobile fuel cells valves as they have the widest operating temperature range and the best resistance.

As the safety requirement with hydrogen fuel cell applications is imperative, it's a key reason to consider valve specification as a system, rather than individual components. A manifold with integrated valves helps ensure that flow and pressure are controlled within safe limits, as well as reducing the potential for leak paths. As a manifold from a valve manufacturer like Bürkert is supplied with the required conformance, this minimises time and cost for integrators in safety testing.

Bürkert also custom designs manifolds in order to fit specific space envelope requirements, another crucial need for vehicle design, and the footprint can be further reduced by incorporating sensors into the manifold itself. A manifold system is also faster and easier to integrate, compared to separately connected components, especially when manufacturing at scale is required.

Hydrogen's potential

As well as use in passenger and commercial vehicles, hydrogen fuel cells are also emerging in use to provide power for boats. More commonly used to energise auxiliary power units onboard large ships, there's also increased potential for hydrogen-powered marine propulsion. Developments in aviation though are taking the headlines in mobile hydrogen fuel cell use, both for its carbon reduction potential, as well as the spectacle of innovation. Already in use, the Hy4 four-seater hydrogen-powered aircraft has a range of over 900 miles, while Airbus plans to

launch a commercial hydrogen-fuelled aeroplane by 2035. There's still development to go however, and sufficient onboard hydrogen storage remains a challenge for both marine and aviation projects.

On stationary applications, Bürkert has been involved with hydrogen-based power generation for 20 years, controlling gas flow for alternative systems including proton-exchange membrane (PEM) fuel cells and solid oxide fuel cells. While development of hydrogen power to directly contribute to the National Grid is in its infancy, a pilot project involving wind power and a hydrogen electrolyser is powering a fuel cell to provide backup at peak demand *(3)*. Meanwhile, The National Grid is contemplating blending 20% hydrogen into natural gas used for heating or cooking as a way of reducing emissions. In the future, all gas boilers could also use 100% hydrogen with a complete removal of natural gas. A decision on whether this will go ahead or not will be made later in 2023. Whichever plans are eventually adopted, incorporating hydrogen into the energy mix is part of the National Grid's strategy to eliminate fossil fuels from our systems by 2050 or sooner *(4)*.

Sources

1. **UK Hydrogen Strategy**
2. **https://ngrid.com/3VqOqzv**
3. **https://bit.ly/3Hj3r0k**
4. **https://ngrid.com/3VqOqzv**

Image captions:

Image 1: To ensure the safety and efficiency of hydrogen fuel cell systems, valve control technology will play an important role.

About Bürkert

Bürkert Fluid Control Systems is one of the leading manufacturers of control and measuring systems for fluids and gases. The products have a wide variety of applications and are used by breweries and laboratories as well as in medical engineering and space technology. The company employs over 2,200 people and has a comprehensive network of branches in 35 countries world-wide.

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