

Efficient electrolysis to optimise hydrogen production: why valve and sensor technology are key

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As the UK accelerates towards large-scale, low-carbon hydrogen production, electrolysis processes are taking centre stage. This is placing increased demand on energy efficiency to optimise the viability and sustainability of hydrogen yield. Valves and sensors designed specifically for the demands of electrolysis are vital to optimise efficiency, and they also have a critical role in ensuring system safety.

Tony Brennan, Regional Business Development Manager for the energy sector at Bürkert, explains.

As the UK government forecasts the growth of low-carbon hydrogen production to around 5GW by 2030, this signals a multi-gigawatt expansion of electrolysis-based hydrogen production. This technique will also extend beyond green hydrogen, as electrolysis is also playing a growing role in hybrid and industrial hydrogen systems as hydrogen supply chains decarbonise.

A key challenge for hydrogen producers is that electrolysis is energy intensive, requiring significant energy to break the strong and stable bonds in water molecules and drive the chemical reaction. As a result, optimising process efficiency is key to cost management, and the system's own sustainability rating.

Efficiency and reliability

Optimising efficiency depends on maintaining close control over flow and pressure, where small deviations can reduce performance, increase electrical demand, and cause system losses. As a result, precision valves and sensors are key across electrolysis techniques, including alkaline electrolysis (AEL), proton exchange membrane (PEMEL) electrolysis, as well as solid oxide electrolysis (SOEL), which relies on steam rather than water as the source.

Valves and sensors are essential for maintaining safety and system reliability, which is vital for maximised productivity and uptime. The stable management of pressure, temperature and gas separation is essential to prevent overpressure, backflow, or unintended mixing of hydrogen and oxygen.

Cooling water, fresh water, and recirculate

The initial stage in electrolysis involves the control of cooling water, fresh water, and recirculate. Electromotive control valves provide automated control driven by an electric motor, offering greater precision and stability compared to pneumatic or hydraulic actuation. A proportional valve can be set to any position within its range to enable precise control, and a direct-acting valve that can achieve a defined opening, such as the Bürkert Type 3280, can hold a set position with zero current, making a significant energy saving.

Continuous flow measurement of the supply is also important to optimise efficiency. Accurately measuring the deionised water supply ensures the electrolyser receives the optimum flow to prevent underfeeding, which would reduce hydrogen yield, or overfeeding, which would waste pumping energy. Meanwhile, in cooling circuits, precise flow measurement allows operators to maintain stable stack temperature, which affects overall energy consumption relative to the yield. A paddle wheel flowmeter suited for use with neutral, particle-free liquids, can provide accurate,

continuous flow measurements in a compact, in-line format. Bürkert's Type 8030 provides the accuracy required, achieving $\pm 1\%$ of the measured value with repeatability as close as $\pm 0.4\%$.

Precise online analysis of the supply will also improve electrolyser efficiency as water quality, considering factors such as conductivity, pH, and dissolved oxygen, directly affects reaction performance, component integrity, and long-term system stability. This is particularly the case in PEM systems where membrane health is highly sensitive to impurities.

The electrolyser

Within the electrolyser itself, maintaining stable and balanced conditions on both half cells is essential. This includes the anode side, where water is split to produce oxygen, and the cathode side, where hydrogen is formed from the resulting ions (or protons in the case of PEM systems). Any mismatch can reduce reaction efficiency, increase electrical losses, and place stress on the separating membrane, potentially leading to gas crossover and reduced hydrogen purity.

Demands on a valve system that can control both the anode and cathode sides of an electrolyser are high, as each environment is hydraulically and chemically different, and operate with different dynamics. This is referred to as back pressure control as the valve regulates outlet resistance to set and stabilise the pressure within each half cell upstream of the valve.

Bürkert's Type 3361 electromotive control valve has been designed to precisely and dynamically control outlet pressure on both the anode and cathode sides. Minimising pressure differentials and associated losses, the valve's stable control ensures the electrolyser operates consistently at its optimal efficiency point even under transient load conditions.

To measure the pressure of hydrogen leaving the stack via the cathode circuit, as well as measuring the pressure of oxygen discharged from the stack via the anode circuit, an accurate sensor is vital. Along with an accuracy requirement meeting levels around 0.1% deviation of the measured value, the need for reliability and durability at the stack outlets are also critical attributes of sensor design. The pressure transmitter should be manufactured from corrosion-resistant stainless steel, and a design including a flush diaphragm guarantees security when working with hydrogen.

Safe shut-off

Above all, ensuring safety in an electrolysis system is critical. In particular, this surrounds the outlets of the electrolysis stack, as well as downstream in gas separation, drying, and purification units, and also at the storage and compression interface. The oxygen outlet from the anode side of the stack is a critical area too. Across each of these locations, as well as other plant control points, shut-down valves are essential.

The Bürkert Type 6240 solenoid valve is suited to hydrogen electrolysis systems as it provides fast, reliable electrical shut-off of gas streams, ensuring safe isolation of hydrogen during start-up, operation, and emergency shutdown conditions. Its direct-acting design enables rapid response and tight sealing, which is critical for preventing unwanted gas migration.

In addition to its safety role, the valve can also support system efficiency by enabling “kick-and-drop” operation, where a brief high-energy actuation ‘kick’ ensures reliable switching followed by a lower holding energy state, reducing overall power consumption while maintaining a secure valve position.

From development to scale

As electrolysis production of hydrogen scales from development through to large-scale yields, precision control will be increasingly relied on to ensure efficiency, safety, and reliability at every stage. Valve and sensor technology will not only optimise energy use and process stability but also help to facilitate faster system integration and commissioning, accelerating time to market for hydrogen projects.

By maintaining optimal operating conditions across both small-scale development units and gigawatt-scale installations, the most efficient and reliable valves and sensors will provide the foundation for hydrogen production at scale as the industry expands.

Images & Captions:

Image 1: Valves and sensors tailored for electrolysis processes are essential for system safety and optimum efficiency.

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