WHITE PAPER

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Keeping the World Flowing
for Future Generations

Advancing green hydrogen production - the role of modular systems, automation, and intelligent actuation

Introduction

The Paris Agreement set targets to limit global warming to well below 2°C [1] above pre-industrial levels, but this will require a major shift in the way we produce energy. Green hydrogen has, therefore, become an increasing focus for governments.

Green hydrogen is produced using clean energy sources like wind, solar and hydroelectric power and is expected to play a critical role in decarbonising hard-to-abate industrial processes such as chemical and steel production. However, project investment has fallen behind expectations because of the high cost of developing major hydrogen projects on greenfield sites.

Industries are struggling with increased input costs, technology hurdles and a lack of long-term off-take agreements that will pay a green premium. Because of this, the trend is to focus on switching to smaller, modular hydrogen generators that can be integrated onto existing plants and be scaled up gradually. These prefabricated units can be easily transported and assembled on-site, simplifying construction and reducing installation time without impacting production.

To be successful they must be safe, flexible and easily integrated into existing processes. Rotork electric actuators can play a significant role because of the wide range of specifications available to support easy integration and compatibility with a plant's existing systems. They also enhance safety, increase process efficiency, reduce emissions and offer industry-leading reliability. With a tailored maintenance programme, operators can increase asset availability and reliability while reducing downtime.

Producing hydrogen derivatives

Green hydrogen is produced by electrolysis, passing an electric current through water to split it into oxygen and hydrogen. However, most hydrogen is currently not green and is produced mainly by steam methane reforming (SMR). Without carbon capture and storage – which is used to produce a cleaner product known as blue hydrogen – this is the least environmentally desirable option.

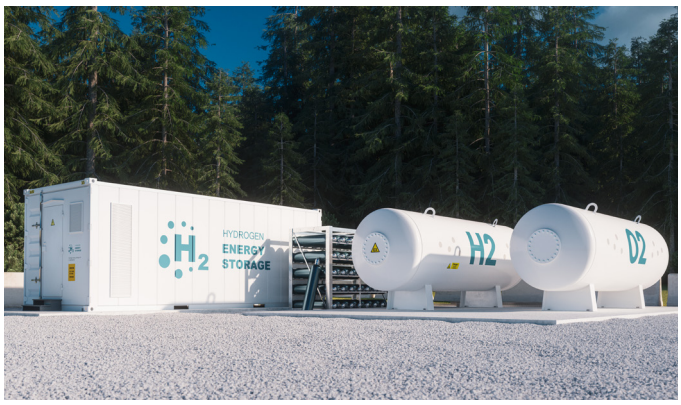
Both green hydrogen and hydrogen produced by SMR are used to power industrial processes or in the production of valuable hydrogen derivatives. Products like ammonia are created using hydrogen as a feedstock and combined with nitrogen. Energy use and CO_2 emissions are high in this process and co-generating green hydrogen would be a significant step in decarbonising this industry. Although primarily used in the fertiliser industry, ammonia is also being explored as a clean fuel for shipping and power generation.

Another derivative, methanol, is produced from hydrogen and carbon dioxide and is used for transport applications and as a feedstock for the petrochemical industry. It can be worked into aviation workflows for cleaner fuels. These synthetic biofuels can, therefore, be used in transport where electrification is challenging, such as long-haul aviation and shipping. Finally, green hydrogen production can also be used to help decarbonise both steel and the cement industries and play a key role in energy back-up, storage and peaking in many small- and medium-scale operations.

To limit emissions and manage the costs of the processes involved, companies using small modular systems can choose to introduce and substitute a proportion of green hydrogen alongside hydrogen produced by SMR. Alternatively, carbon capture (blue hydrogen) can be used to create e-Fuels or be safely stored to allow green hydrogen to be scaled up as costs come down and technology uptake increases.

Automation and monitoring of processes are key to managing the flow of liquids and gases within small modular systems to ensure both safety and efficiency. Energy efficient Rotork actuators and Rotork's Intelligent Asset Management (iAM) cloud-based system are ideal for this role and are already widely used within the hydrogen sector.

They are, for example, being used in a project developing hydrogen fuel cell technologies for zero-emission passenger ships. Furthermore, they were recently selected to control valves in the carbon capture units of innovative blue ammonia projects in the USA and Australia.



Ensuring safety in hydrogen production

Hydrogen is highly flammable and causes embrittlement. Thus, production, handling and use need to be carefully

considered. Some actuators are fitted with data loggers, which feed information on the performance of valves to a common control point. This provides the control system with the information it needs to not only operate the valve, but to alert operators to potential faults before they become a significant containment issue. Some actuators also include fail-safe mechanisms that can return the valves back to their safe positions.

Many electric actuators can also gather valuable data. Rotork has included a data logger in its IQ range since 2000, making them suitable for use in asset maintenance systems. These intelligent solutions are designed to provide reliable and repeatable performance in dynamic and challenging environments. They monitor temperature, torque, and voltage to ensure the unit's integrity and operating performance, resulting in a longer product lifespan.

Intelligent electric valve actuators can automatically adjust valve positions based on real-time operational conditions. Specialist systems, like iAM can analyse data logs from intelligent actuators to assist with appropriate maintenance actions, ensuring optimum performance, reduced costs and minimised risk to the plant.

This kind of automation is extremely valuable because safety incidents are often caused by human error. In 2019, for example, a company in Santa Clara, California, suffered an uncontrolled release of hydrogen, followed by an explosion and fire after mistakes were made while filling a dual module trailer. [2] Additional automation and design to move humans out of harm's way by introducing remote operations is key to avoiding such incidents in the future.

Furthermore, automated monitoring also ensures there is no interruption in the supply of hydrogen. Because modular systems are likely to be outside of battery limits and closer to other utilities, intelligent asset management provides an important safety check, helping to identify issues such as leaks and automatically isolating valves if the need arises.

Designing products for safety

Many Rotork products are explosionproof and certified for safety applications (SIL2/3) Rotork can also provide a range of explosion and fireproofing options, which enable actuators to continue operating for significant periods in extreme heat.

As described previously, fail-to-position solutions are also widely used to automatically return valves to a predetermined position in case of power loss or emergencies. This improves safety and prevents potential damage to equipment. Electric actuators, such as Rotork's intelligent IQ3 Pro, CMA, and CVA process control actuators feature user-friendly interfaces to make the system easier for operators to understand and control.

Integrating new and existing assets and infrastructure

Integrating new modular hydrogen systems with existing plant and processes may require retrofitting actuation technology to ensure optimum flow control. Rotork has been retrofitting actuators since the 1960s to upgrade sites to new standards, protocols and functionality to meet customer needs. This lowers the total cost of ownership of the asset.

Decades of experience has encompassed projects of all types and sizes. In virtually every case, one of the most important considerations is the successful integration of retrofitted equipment with minimum disruption to plant operations. Rotork intelligent systems can be programmed or upgraded to the latest communication protocol to meet the needs of existing plant infrastructure, ensuring seamless integration with production and power systems.

They use open communications protocols to develop flexible and adaptable data communications to all control points across the hydrogen production value chain and are easily integrated and configurable onsite or remotely.

Sites must consider what medium is being controlled, location, valve size, available power supply, and frequency of operation. A detailed site survey of the existing plant will collect this vital information to design the mechanical components needed for mounting the actuators on the valves, along with associated cable runs and ancillaries.

To meet the growing demands for automation and standardisation, it is essential to assist in rapidly up-scaling solutions in flow control. These solutions are designed to seamlessly integrate into OEM applications, offering significant advantages in both cost and risk management.

By introducing solutions that prioritise efficiency and reliability, customers can streamline their operations, reduce overall expenses, and mitigate potential risks associated with system integration and performance. Furthermore, a consistent supply chain across all continents reduces procurement costs. Finally, Rotork flow control systems are also easily scalable as the production of green hydrogen increases and can be automated to adapt to fluctuating production with minimal re-engineering.

Case study: Rotork aids production of carbon-free hydrogen with CVL actuators on electrolysis skids

Rotork provided CVL linear process control actuators to French equipment manufacturer Elogen where they play a critical role within a hydrogen generator. The company produces hydrogen through electrolysis and requires extremely precise control, a fail-safe action and a high-duty cycle.

Each electrolysis skid has three CVL actuators on globe valves to regulate pressure and the level of water used. The fail-safe functionality (using built-in supercapacitors) is important to prevent potential disaster or loss of power. The actuators were chosen for their high movement frequency, quick reactivity and low power consumption.

CVA actuators meet all international safety requirements and the ATEX IIC certification was essential for this hydrogen environment. They are also, remote telemetry-ready and can easily be retrofitted and upgraded to new communications protocols.

Outlook and challenges

Low-emission hydrogen plays an important role in most decarbonisation scenarios as an energy source and a feedstock in industrial processes, particularly for hard-to-abate sectors. Some technologies are already commercially available, such as alkaline and proton membrane exchange electrolysers and innovation is accelerating.

The global pipeline of hydrogen projects continues to grow with $570 billion of direct investments announced through 2030[3]. The current pipeline would deliver 45 million tonnes of clean hydrogen. The International Energy Agency's 'Zero by 2050' trajectory, however, requires production to rise to 70 million tonnes in the same period.

The high cost of producing green hydrogen, however, presents a significant obstacle to achieving this ambition. A more flexible, cost-effective option is required and small, modular hydrogen solutions may hold the key to both increasing production and developing long-term off-take agreements.

While this route now seems the most likely to help companies spread the cost of adoption, there are issues around safety and efficiency to be considered, as well as the skills that are needed to run a hydrogen plant. Automation, electrification and digitalisation could hold the answer to some of these issues with intelligent actuation at the forefront of technologies that can make modular hydrogen facilities viable.

Source

1. *United Nations Climate Change*
2. *www.gexcon.com/blog/lessons-learnt-from-hydrogen-incidents*
3. *Rotork Annual Report 2023, p53*

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