Oil and leakage-free diaphragm compressors help to shorten the refueling times at hydrogen filling stations.

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Dry-running high-pressure compressors are key components for the energy transition

Melanie Maier

Hydrogen is regarded as an environmentally and climate-friendly alternative to fossil fuels such as oil or coal, because its combustion produces only harmless water. This is why its use in transport, heat generation and also in industrial processes such as the chemical industry is increasingly being considered. In addition, hydrogen can be used to store excess energy electrochemically and make it available for other applications. Today, technologies for the production and processing of hydrogen are therefore often the focus of research and development. One key to exploiting the potential of hydrogen is dry-running high-pressure compressors.

High demands on compression

There are several ways to produce hydrogen. In most cases it is produced by electrolysis by splitting water into hydrogen and oxygen, which requires large amounts of electricity. However, hydrogen can also be produced from biomass via a synthesis gas or by reforming from natural gas. Each of these production processes places high demands on the technical equipment for the compression and efficient use of the energy carrier. The absence of oil is of great importance here, as only this guarantees the purity of the explosive gas. Equally important is the absolute absence of leaks in the compression process, because hydrogen is an extremely light and volatile gas. However, regardless of how hydrogen is produced, compressors are always a core component in the production and processing of this future-oriented energy carrier due to the pressure difference during production and the required pressures during further use.

For example in the steam electrolysis process: To ensure that the steam-saturated gas produced does not destroy the compressor, the water particles must be eliminated during operation. A special design of the compressor packages with automatically operating units for condensate removal enables a step-by-step separation of these water particles. A drying and cleaning stage downstream of the process then ensures the final gas quality. In this way, the compression of hydrogen saturated with water vapour can be easily achieved. Sunfire GmbH, supplier of electrolysis plants for the production of hydrogen and synthesis gas, for example, integrated such compressors into its electrolysis system in 2018. For the energy

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Source: Mehrer

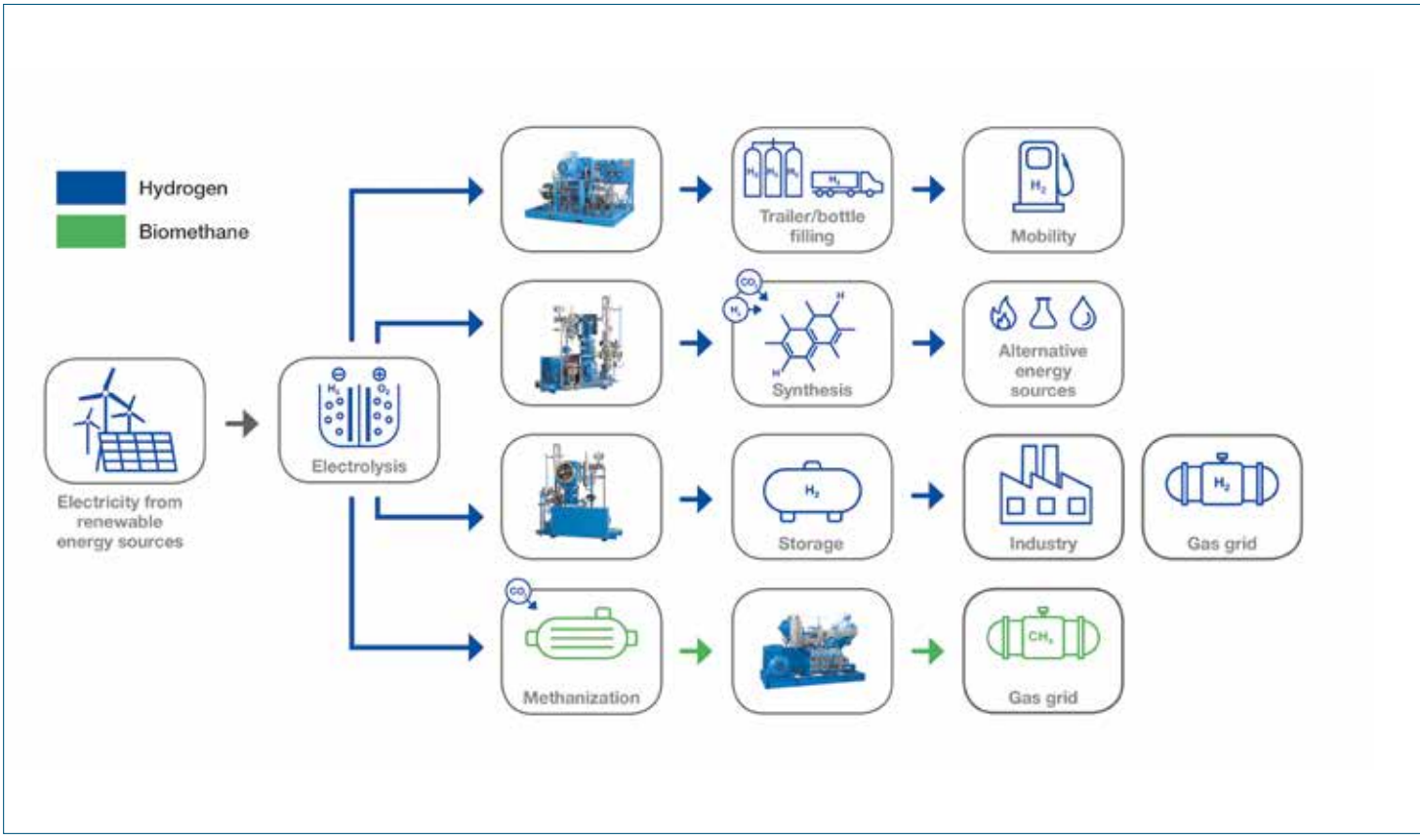


Fig. 1: The different production processes and end applications of hydrogen become special challenges for the compressor technology used

Source: Mehrer

Fig. 2: Sunfire GmbH uses compressors for a further compression stage of hydrogen in fuel cells in vehicles.

experts from Dresden, it was crucial that the compressor solutions can operate with little or even no inlet pressure. In addition, it was important for them that the compressors can handle a low volume flow of 0 to 6 Nm³/h because they are used in small demonstration plants at the Karlsruhe and Duisburg research facilities.

Single- and multi-stage dry-running piston and diaphragm compressors also offer optimum efficiency for end applications in the hydrogen sector.

Since sealing materials developed over many years are used in reciprocating compressors, which do not differ from seals for moist gases in terms of their wear behaviour, applications in which the hydrogen is present in a particularly dry gas state can also be realized. This is the case, for example, when compression takes place directly after gas drying.

Due to the different types of electrolysis established on the market, new demands on the compressors are constantly arising. Diaphragm compressors are also suitable, among other things, for use in the extraction of hydrogen using a high-pressure electrolyser. The extremely high suction pressures of 30 to 100 bar that arise here place special demands on the downstream compressor system. The compressors convert final pressures of more than 850 bar from these pressures in order to be able to transfer the extracted hydrogen into a separate refuelling system.

Hydrogen can be used in many areas

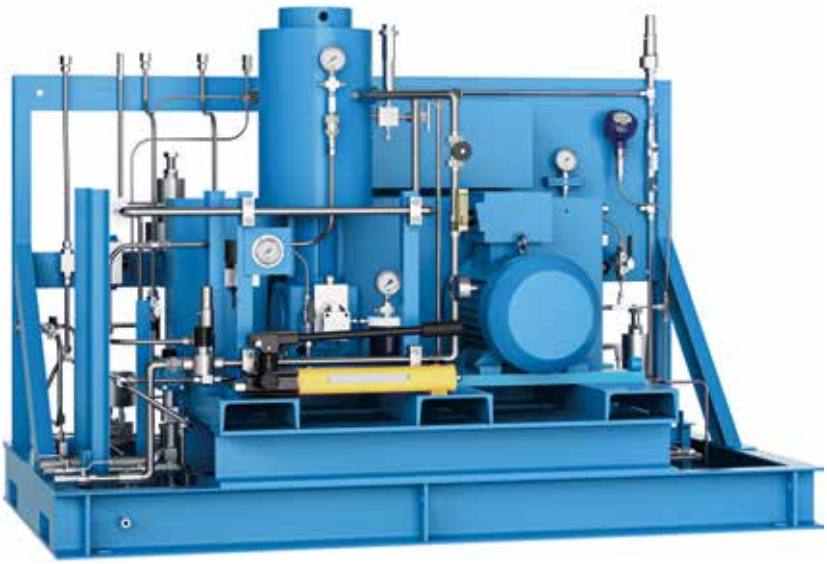
Single-stage and multi-stage dry-running piston and diaphragm compressors offer optimum efficiency also for end applications in the hydrogen sector thanks to their process- and user-specific design. Due to their modular design and drive capacities from 3 to 350 kW, they can be integrated into a wide variety of plant systems. The compression systems can be used both in the low-pressure range and in applica-

tions with very high final pressures of up to 1,000 bar. This flexibility makes it possible to implement a large number of very different hydrogen applications.

In the field of mobility, oil and leakage-free diaphragm compressors already support the largest hydrogen filling stations worldwide. Here, it is necessary to fill the buffer storage tanks with very high pressures of 350 to 1,000 bar, coupled with high delivery rates, in order to ensure short refuelling times for cars, buses or industrial trucks. The compressor manufacturer is in constant exchange with the manufacturers and plant constructors in order to further optimize the individual components.

In the first **municipal user centre for hydrogen and fuel cell technology** in Herten, Germany, compressors also represent an important link between hydrogen production and storage. In 2017, a system was installed there, delivered as a turnkey solution by the compressor specialists. Since then, the plug & play solution in a sound enclosure has supported alkaline electrolysis with water vapour saturated gas. In addition to a separate control system and an integrated gas sensor, this project required the compressor system to be installed in Ex zone 2.

Compressors are also used in **pilot and demonstration plants** for hydrogen compression. Research institutions such as the e-gas plant in Werlte use the compressors in the field of methanisation (power-to-gas). The hydrogen produced in this process is temporarily stored with the help of compressors and methanized by adding carbon dioxide. This synthetic natural gas, also known as e-gas, is then fed into the natural gas network by high-pressure compressors. If required, the energy from the gas network can be fed back into the power grid. This technology can solve the problem of storing excess wind and solar power in the long term. Conventional natural gas can be replaced elsewhere.



Source: Mehrer

Fig. 3: Oil and leak-free high-pressure hydrogen compressor with suction pressures of 30 to 100 bar and a discharge pressure of up to 850 bar

Source: Mehrer

Fig. 4: Turnkey container solutions in Ex-design can be adapted to the customer's requirements in advance.

Compressors for tomorrow's energy

In other projects for the long-term substitution of natural gas by feeding hydrogen into the existing natural gas grid, such as research projects of major electricity suppliers, hydrogen is in turn produced from renewable energies using high-temperature electrolysis or from the steam generated in industrial processes. The "green" hydrogen produced is then stored in pressure vessels and subsequently compressed. The aim here is also to feed it into gas turbines or natural gas buffer lines. Piston compressors are used for this application. Due to their three-stage design, they are particularly suitable for hydrogen compression from an atmospheric pressure level up to approx. 35 bar.

Due to the absolutely oil-free compression, the user does not need a downstream cleaning process of the gas. Decades of experience in handling humid or particularly dry gases favour the use of the compressors in hydrogen applications. All process-relevant components of the compressors are manufactured in-house. This ensures a consistently high level of quality in combination with a high degree of flexibility in product design, which means that even very special customer requirements can be implemented. Particularly in the field of critical process gases, such as hydrogen, the compressors are always individually designed to meet different customer requirements, for example, strongly fluctuating process parameters.

Based on the manufacturer's broad expertise in handling other flammable and sometimes corrosive process gases, such as biomethane or carbon dioxide, and the long-term stability of the systems, the oil-free compressors are used in many other areas of hydrogen applications. As a process component, the solutions make a significant contribution to the further advancement of sustainable hydrogen projects and thus to the energy transition.

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