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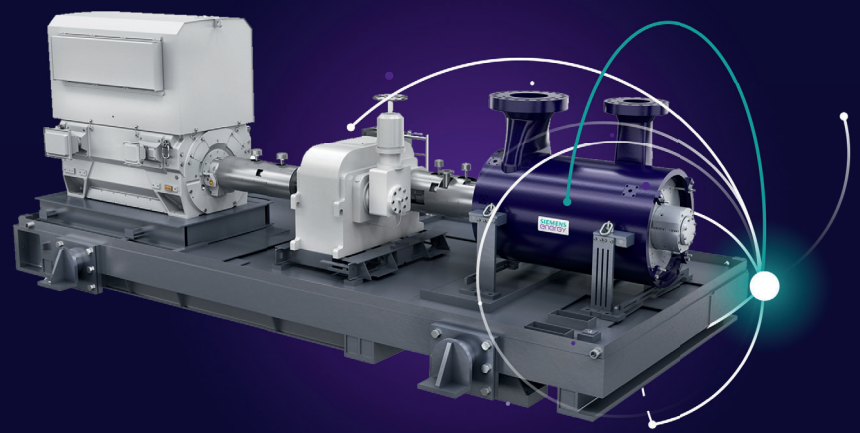
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SIEMENS energy

Hydrogen compression for the future:

Innovating a new design for an established process – enhanced for tomorrow's energy market



Hydrogen’s growing role in the energy transition



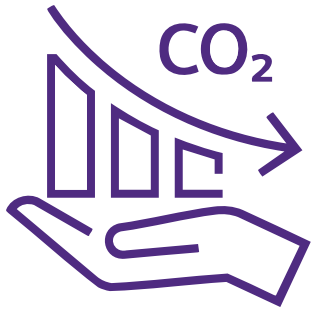
Hydrogen (H_2) is the most abundant element in nature, and it’s not new in industry either. For decades, it has been a cornerstone of industries such as refining, ammonia production for fertilizers, methanol synthesis, and various chemical processes. Today, however, hydrogen is being positioned as a key solution for the energy transition, with applications spanning power generation, transportation, and industrial heating. Governments and companies alike are investing heavily in hydrogen production, aiming to replace conventional fuels in multiple sectors.

The scale of hydrogen production is set to increase dramatically. The International Energy Agency (IEA) estimates that global hydrogen demand, currently around 94 million metric tons per year, could grow significantly in the coming decades. This expansion brings new challenges, particularly in handling, transporting, and compressing hydrogen at unprecedented volumes and pressures. One of the most critical aspects of integrating hydrogen into new industries is compression. Historically, hydrogen compression was a well-understood process, but the scale and variability of future applications demand a new approach.



How is hydrogen compressed today?

As a global leader in hydrogen compression, Siemens Energy has been at the forefront of compression technology since 1898. With a fleet of over 9,000 high-speed and process reciprocating compressors worldwide, Siemens Energy compressors are responsible for 39% of all hydrogen-related installations today.



Traditionally, most hydrogen compressors have been used in refineries. In these applications, reciprocating compressors have been the industry standard due to their ability to handle low and steady volumes. Reciprocating compressors operate using positive displacement compression, meaning they physically trap a set volume of gas and reduce its volume to increase pressure—similar to how a piston in an engine compresses air in a cylinder. This method has been particularly effective for hydrogen due to its light molecular weight and high compressibility.

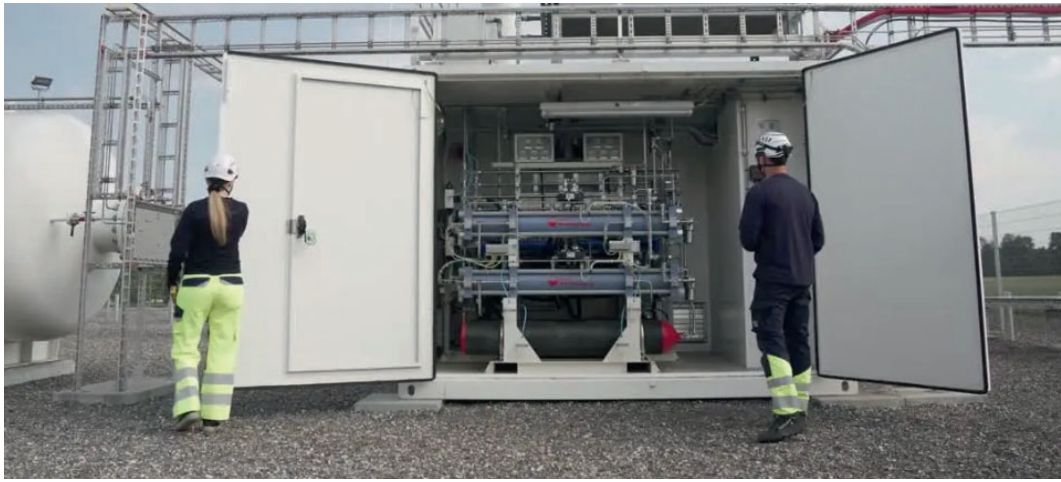
However, there's another type of compression: dynamic compression, which is used in centrifugal compressors. These compressors use a rotating impeller to accelerate the gas, converting velocity into pressure. This method is the industry standard for large gas flows in oil & gas, LNG, and pipeline applications.

New challenges for hydrogen compression

The way hydrogen has been compressed in refineries and industrial facilities in the past does not align with the needs of emerging applications. The hydrogen market is evolving, and with it comes new technical challenges.

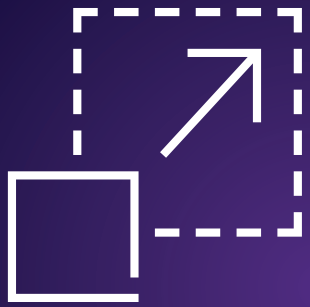
Hydrogen production is scaling up, requiring compressors to handle significantly larger volumes. Unlike traditional applications, where flow rates remain steady, hydrogen production from renewable sources fluctuates, meaning compressors must operate efficiently across a variable throughput range. Additionally, hydrogen generated from electrolysis or biomass conversion is not always pure; byproducts such as water and oxygen vary throughout operation, adding complexity to the compression process.

Another major challenge is purity. Many of the new applications, such as fuel cells or synthetic fuel production, require ultra-pure hydrogen. Traditional oil-lubricated reciprocating compressors, which have been the standard for decades, pose a contamination risk that is no longer acceptable in these applications.



The limitations of traditional compression

Using traditional compressors for large-scale hydrogen compression in new industries presents several fundamental challenges. Since each compressor can only handle a limited flow rate, large hydrogen volumes require multiple units operating in parallel.



Other types of traditional compressors can handle the flow rate, but not the pressure requirement. More compressors mean more points of failure; if a single unit goes offline, the entire system's capacity is compromised. To mitigate this risk, companies often install spare compressors, but this further increases capital expenditure and operational complexity.

With traditional hydrogen compressors, frequent maintenance is often needed, requiring a team of skilled personnel to ensure continued operation. Managing a large fleet of compressors also demands a significant inventory of spare parts, creating logistical challenges, especially in remote or offshore installations where supply chains are already strained.

The Siemens Energy Advanced Rotor Compressor: A game-changer for hydrogen

The challenges facing hydrogen compression today call for a different approach—one that leverages proven technology from other industries. The Siemens Energy Advanced Rotor Compressors, based on centrifugal compression technology, offer a scalable, reliable, and cost-effective solution for the future hydrogen economy.



Newly designed Advanced Rotor

Centrifugal compressors have long been the gold standard for high-flow applications in industries such as natural gas production and liquefied natural gas (LNG). There is no reason why hydrogen should be any different.

They offer extremely high reliability in most industrial applications. This translates into a much higher Mean Time Between Failures (MTBF) and drastically reduced maintenance requirements. The smaller number of moving pieces and modular cartridge design allows for simpler inspections and faster turnaround in the field. Centrifugal compressors can operate with minimal intervention, reducing both labor and downtime.

Cost of ownership is another key advantage. By eliminating the need for multiple units, pulsation dampeners, and extensive auxiliary systems, centrifugal compressors can streamline plant design through their optimized footprint, reducing capital and operational expenditures.

With their ability to handle large volumes in a single machine, hydrogen centrifugal compressors can replace up to five reciprocating compressors, dramatically simplifying plant operations.

Siemens Energy brings decades of expertise in both hydrogen compression and centrifugal technology, making the development of a state-of-the-art hydrogen centrifugal turbocompressor a natural progression.

Our compressors are capable of delivering the required pressures for nearly all hydrogen applications, including large-scale pipeline transmission, without the need for multiple compression stages. The advanced hydrogen turbocompressor is designed to serve pure hydrogen, hydrogen-rich, and other low weight applications. The single shaft not only reduces footprint, but also significantly cuts operational complexity and maintenance costs.

The future of hydrogen compression



As hydrogen production scales up to meet global energy demands, legacy compression technologies are no longer a viable solution.

The increasing volume, variability, and purity requirements of hydrogen projects demand a compression approach that is more reliable, efficient, and cost-effective.

Reciprocating compressors on their own, while effective for traditional refining applications and smaller scale hydrogen projects, do not meet the demands of new hydrogen projects that require high flow rates, minimal contamination risk, and simplified maintenance.

Siemens Energy's Advanced Rotor Compressors provide the next-generation solution the industry needs. It delivers high impeller tip speeds with reduced, or zero emissions and it is made from components optimized for hydrogen duties. By replacing complex, high-maintenance reciprocating fleets with a single, high-performance centrifugal compressor, project developers can reduce costs, increase reliability, and future-proof their hydrogen operations.

As the hydrogen economy expands, the industry must move beyond outdated compression philosophies. Now is the time to embrace a technology that has already proven its worth in large-scale gas applications. The future of hydrogen is here, and it starts with smarter, more efficient compression.

