COMPRESSORS: The Unsung Heroes of Modern Industry

How compressors are supporting sustainability and innovation efforts in the industrial sector.

TURBOMACHINERY: What are the biggest challenges manufacturers face when implementing next-generation compressor systems?

RANSOM: For industrial applications, the modern turbocompressor must be both custom engineered (no two applications are alike) and low-cost. This means that robustness and reliability must be built into the design and manufacturing process of each machine, and into each technology applied within the machine (aerodynamic components, rotating components, mechanical elements, etc.).

When we start to look at next-generation systems, which either require the application of existing technology to vastly different operating conditions/systems (i.e. multiple starts/stops per day for green energy applications), or the development of new technology for new applications (i.e. large volume of hydrogen compression), it is challenging to demonstrate robustness and reliability without multiple demonstration projects. And the challenge is compounded by the need to maintain the relatively low cost of the modern turbocompressor. This challenge then becomes an opportunity for innovation in design, continuously balancing the goals of technology advancement with robustness of the end product.

Cost is another important factor whenever you are introducing a new technology or product. On this front, we work closely with customers to understand their unique needs. Making sure that compression packages are optimized for specific boundary conditions is key to providing a solution that delivers the lowest total cost of ownership over the life of the facility.

At Siemens Energy, we have gained a reputation for staying ahead of industry trends and developing new compressor products before the market needs them. A good example is our hydrogen turbocompressors. Siemens Energy's early investments in hydrogen compression technologies, like our advanced rotor platform, which is designed for low molecular weight gases, is supporting decarbonization use cases today that otherwise might not be possible using traditional compressor designs.

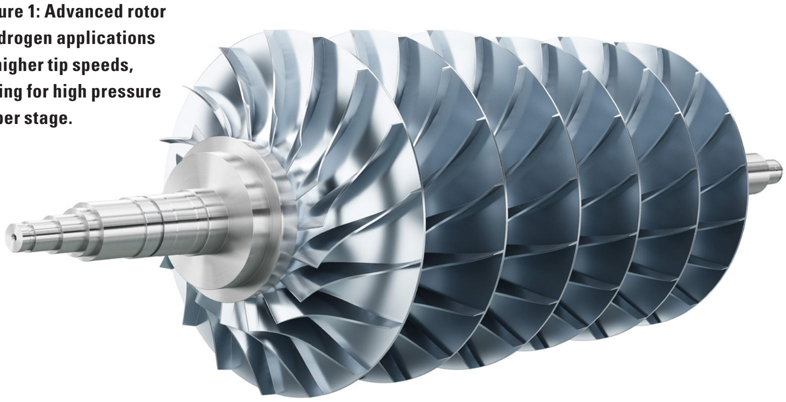
TM: What role do compressors play in the hydrogen economy, and how are they being adapted for hydrogen applications?

RANSOM: Compression of hydrogen gas isn't new. It's been a vital part of the refining industry for many decades. But as the market has shifted and new hydrogen applications have emerged, such as high-volume electrolysis plants and H2 pipelines, the demands placed on compression packages have also evolved, necessitating new designs.

Most technology development efforts we see today are in response to two main areas: one, lowering the cost and improving the capabilities of turbo-compressors; and two, increasing the service interval and capability of reciprocating machines for processing dry hydrogen.

At Siemens Energy, we're using our single-piece advanced rotor technology (**FIGURE 1**) to overcome tip speed limitations often imposed by the conventional shrink fit or even tie-bolt-type rotor construction on turbocompressors. This has allowed us to increase the power density of the machine, leading to fewer compressor stages to achieve final delivery pressures. The technology is an excellent example of how we approach innovation — leveraging modern manufacturing methods with robust and time-proven machine design to enable new compressor capabilities with very little added risk to the end user.

▶ **Figure 1: Advanced rotor for hydrogen applications with higher tip speeds, allowing for high pressure ratio per stage.**

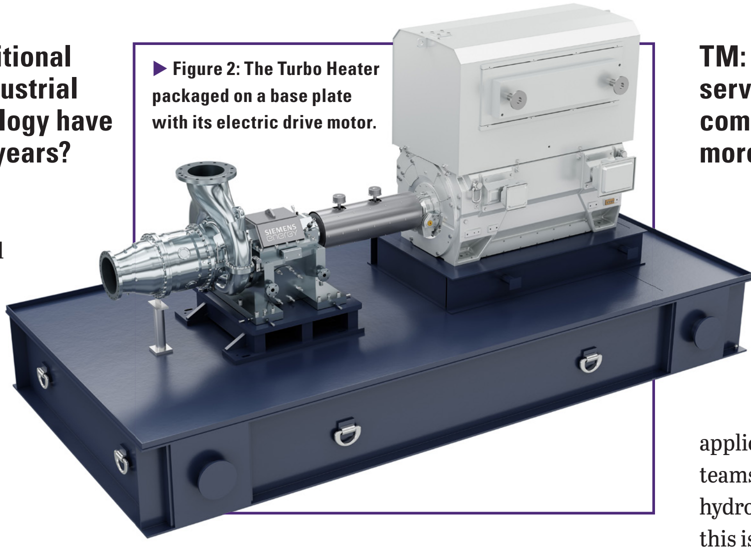


TM: What non-traditional applications for industrial compressor technology have emerged in recent years?

RANSOM: When it comes to non-traditional applications, the growing electrification of industrial process heat comes to mind. On the lower end of the temperature spectrum, the application of heat pumps to industrial processes is still new and in development. Even though they have long been used in residential and commercial buildings, the use of heat pumps in industrial processes is both interesting and challenging. Interesting because it's one of the decarb opportunities that can demonstrate an attractive business case, even without considering any costs associated with carbon emissions. And challenging because, like all other large industrial applications, each system has custom requirements for operating conditions, available footprint, operating fluids permitted, etc.

Since the performance benefits of heat pumps aren't attractive for higher-temperature process heat applications, direct heating with a simpler and more power-dense machine becomes the preferred solution. To address this need, Siemens Energy has developed a novel class of turbomachinery known as the Turbo Heater (**FIGURE 2**). It turns electricity directly into process heat — taking process fluid to temperatures of 700° C and above. This is especially interesting for industrial processes because of the cost benefits of scaling turbomachinery technology.

Thermal/mechanical energy storage (such as compressed air energy storage) is also not new, but it's not as well known or understood as heat pumps, either. In some ways, it is still an emergent technology, mainly due to the limited number of applications. All of these systems rely on compression technology.



▶ **Figure 2: The Turbo Heater packaged on a base plate with its electric drive motor.**

TM: What types of modern tools or technologies are you using to develop new compressor designs?

RANSOM: Over the past 50 years, most advances have had more to do with the engineering design process and less to do with specific innovations in compression. Modern engineering software tools, often called computer aided engineering, have made the development of new components and solutions much more cost-effective. These include software programs for fluid flow analysis, structural analysis, and design optimization. Machine learning is also being leveraged for design purposes. The most significant benefit to these modern tools is a reduced need for experimental validation. But we can't eliminate the need to test entirely, because simulation isn't as conclusive as reality.

But the use of these simulation tools isn't going away, as we're continuously driving toward higher efficiency, more range, more power density and lower costs. That's why, as our ability to model physical phenomena has improved, so too has our demand on the level of fidelity of the design. This then drives the need for more advancements in modeling of the associated physics. We live on the edge of our ability to design, and that requires the ability to experimentally prove out the new designs, which requires developing, maintaining and operating relevant test facilities.

TM: What skills will maintenance service teams need to develop as compressor systems become more technologically advanced?

RANSOM: The first area that comes to mind is learning to safely operate, maintain, and service hydrogen compression systems. While this isn't entirely new, the user base is expanding beyond traditional refining applications. So, maintenance and service teams that normally wouldn't deal with hydrogen may have to learn. I don't think this is a huge hurdle since it's already common to deal with combustible gases, but hydrogen is a little more challenging due to its molecular size, which increases the potential for leaks, and flammability limits.

It's also very likely that industries that don't currently depend on high-speed turbomachinery will find use for them as they increase efforts to decarbonize. In this case, they will need to learn [about] this new equipment or hire experienced staff who are accustomed to operating and servicing the machines. ■

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David Ransom has over 25 years of experience in the turbomachinery industry. He joined Siemens Energy as Head of Technology and Systems in November 2019. His current responsibilities include leadership development; leading and managing technology development; support for operations and services; leading root cause analyses; developing innovative and disruptive technologies; and R&D strategy and planning. Ransom has experience in several technical disciplines, including rotordynamics, thermodynamics, structural dynamics, acoustics, machine design, prototype development and testing and leading people and projects through all phases of a project, from proposal to finished product.