rexroth
A Bosch Company

With turnkey solutions for a comprehensive refueling infrastructure

CryoPump stations from Bosch Rexroth enable refueling of heavy-duty trucks in ten minutes

One challenge in the transition of long-distance truck transportation to green hydrogen is the associated infrastructure: as soon as the first heavy vehicles are registered for the road, they will need refueling facilities where they can fill up within minutes. Bosch Rexroth has now developed an important technical milestone for this: The turnkey CryoPump station reduces operating costs by up to 70 percent to an economical level and shortens refueling processes for heavy trucks to around ten minutes.

The development of a green hydrogen economy is regarded worldwide as an important solution for decarbonizing energy-intensive mobile applications such as heavy-duty long-distance transport. However, the hydrogen economy requires a completely new value chain – from the production of green hydrogen with renewable energies, storage and distribution of gaseous or liquid hydrogen through to hydrogen-capable "end devices."

The new cryopump from Bosch Rexroth meets the requirements for start/stop stability, prevents boil-off, uncontrolled evaporation of deep-cooled H_2, and achieves the economically necessary flow rates of 600 kg/h.

Bosch is committed to developing an H_2 economy and is active along the entire hydrogen value chain: Firstly, the technology company is working on technical solutions for the production of green hydrogen. On the other hand, several Bosch business areas are working on developing corresponding applications, such as fuel cell drive systems or H_2-capable combustion engines. For several years, Bosch Rexroth has been focusing on technical solutions for refueling hydrogen-powered vehicles.

FROM 25 KG PER DAY TO 600 KG PER HOUR

"In 2007, it was possible to refuel around 25 kg per day at the first hydrogen refueling stations. Today we are talking about 600 kg per hour," calculates Andreas Günder, project manager and head of the Hydrogen Center of Competence at Bosch Rexroth. However, increasing volumes is only part of the challenge. "Deep-frozen LNG gas has been pumped in the process industry for decades, but continuously at a fixed speed," he explains. "Short-stroke pumps with crankshaft are successfully used there and do a good job. When refueling vehicles, however, we are talking about higher pressures, larger quantities and more than 100 start/stop processes per day. In this respect, hydraulics offer significant advantages in terms of performance and service life."

DEVELOPMENT FOR PILOT CUSTOMERS

Bosch Rexroth has been working with operators of hydrogen refueling stations since the start of the development work in order to gain a better understanding of the specific requirements and to utilize practical application experience. While small and medium-sized quantities, such as for refueling passenger cars or forklift trucks, are likely to be operated with gaseous H_2 (see info box), the large tanks of heavy trucks and commercial vehicles require a different approach. Here, the frozen liquid H_2 is compressed to gas at 900 bar and refueled directly into the vehicle. This means that these heavy vehicles can absorb the typical 50 kg H_2 tank capacity within ten minutes. Previous solutions require an hour or more. This is not acceptable for freight carriers.

ELECTROHYDRAULICS IS THE KEY

This is why Bosch Rexroth is launching a completely new technical concept. Together with the market leader for the commercial operation of liquid hydrogen refueling stations in the U.S.A., FirstElement Fuel in California, a local team is developing an innovative approach with high disruption potential. The heart of the system is an electrohydraulic solution with an infinitely variable hydrostatic gearbox. “The hydraulics absorb shocks in start-stop mode without wear and achieve a long service life,” affirms Günder. Long-travel, certified compressor cylinders increase the flow rates through end-position-optimized control. The connection power of the pumps is 280 kW.The concept of the cryopump has proven its worth in tests since last year. It meets the requirements for start/stop stability, prevents boil-off, uncontrolled evaporation of deep-cooled H_2 and achieves the economically necessary flow rates of 600 kg/h.

TURNKEY SYSTEM INSTALLED USING CRANE HOOKS

“We have developed a turnkey system that significantly reduces the project efforts for the operator and its investment and operating costs,” emphasizes the project manager. All components for the CryoPump station are housed in a six-meter long housing. The station only requires a connection to the power supply and the hydrogen tank. The long-stroke compressor operates in a certified room. The electrohydraulic components and the control unit are separate from this and freely accessible.

Compressor drives for every scenario

The application scenarios for H_2 tank systems are very different. For small and medium quantities, operation with gaseous H_2 is emerging. The CytroForce servo-hydraulic axes from Bosch Rexroth with integrated fluid circuit are suitable for quantities up to 10 kg H_2/h. The customer-specific compressors are mounted directly on the cylinder.

For medium outputs, Bosch Rexroth offers a solution for the compression of both liquid and gaseous hydrogen with the ready-to-connect CytroCore drive system for compressors. The compressor drives require less than one square meter of installation space and are considerably quieter than conventional drive systems.

For high outputs of 600 kg H_2/h, the cryopump sets the standard for efficiency, service life and compactness.

Together with partner companies from the hydrogen economy, Bosch Rexroth has developed a scalable portfolio of servo-hydraulic drives for compressors in the power range between 10 and 280 kW.

The station doesn’t require a construction pit or other special construction work. “This means that the CryoPump station can also be added to existing filling stations to save space,” says Günder, describing an important customer requirement. Space is a decisive cost factor in metropolitan regions in particular. The low installation costs significantly reduce the investment requirements, especially since operators can start with one station and add more when the market ramps up.

LIQUID-LIQUID CRYOPUMP ADDRESSES MORE USE CASES

In addition to the cryopump presented last year, the hydraulic specialist is also presenting a liquid-liquid variant of the cryopump, which can be integrated into the station as an additional module. While the first stage fills liquid H_2 as compressed gas into commercial vehicle tanks, the liquid-liquid cryopump maintains the physical state of the hydrogen and can be used for refueling much larger tanks, such as ships.

The hydraulically driven piston pump compresses the liquid hydrogen to up to 16 bar and, by shifting the boiling point, ensures subcooled liquid hydrogen. This allows the hydrogen to be stored in the vehicle for longer without boil-off. Due to the optimized design of the piston pump compared to previous centrifugal pumps, the subcooling level (distance to boiling point) and the value of the liquid hydrogen are increased. This makes the CryoPump station also suitable for hydrogen filling stations of the future, which provide both liquid hydrogen and gaseous high-pressure hydrogen. In addition, the liquid-liquid cryopump ensures fast and evaporation-free filling of the filling station.

COMPACT, QUIET AND VERSATILE

Filling stations use in densely populated areas poses additional challenges. “Our solution meets all safety regulations and is even approved for direct attachment to existing buildings,” explains Günder. This also includes low noise emissions. The CryoPump station is insulated so that the sound pressure level is below 65 dB(A). In addition, regional building regulations often apply in California, which prescribe an adaptation to the typical local appearance.

OPERATING COSTS REDUCED BY UP TO 70%

The pump station can be integrated into standard filling station systems with open interfaces. The CytroConnect digital service enables remote maintenance of the solution - a crucial prerequisite for high availability of decentrally installed systems. System specialists can diagnose errors without travel times and, in some cases, correct them online. Overall, the turnkey solution reduces operating costs by up to 70%.

Bosch Rexroth and FirstElement Fuel will be commissioning the first CryoPump station this year.

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