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Innovative Valve Technology

New valve series for natural gas filling stations and for the hydrogen technology

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The topic "fuel for the future" is also an issue for manufacturers of high-quality valves. Because the alternatives to mineral oil are in the gaseous state the filling and refueling systems must be operated at high pressure under highest safety requirements. The focus of this discussion is – today – on natural gas and – in view of the future – on hydrogen. For both media, GSR developed new valve series which is presented in this paper.

It has been known for a long time that the resources of mineral oil are limited. But only since the cost for raw oil has jumped sky-high, the consumers, i. e. the car buyers, took real consequences from this fact. They demand increasingly for energy-saving vehicles and also for new engine concepts.

A renowned and available concept is the natural gas engine. In Germany, to date only about 65,000 cars are natural gas fueled, but the number is increasing fast. Worldwide there are already more than 9.3 millions, also with a distinct strong increase. There are good reasons for it: Natural gas will remain available for much longer than petroleum, it combusts "cleaner" in the Otto engine (requiring only minor modifications), and it is cheaper than mineral oil based fuel.

Correspondingly the demand for natural gas filling stations increases, which usually deliver natural gas at three pressure levels. With today's technology, the valves at the petrol pumps are designed as single valves. They require a higher effort on tubing and consequently also careful maintenance. This maintenance is not only a cost issue. In some countries, in which natural gas is the predominant fuel but which do not have

an established service infrastructure, it is also hard to ensure. This is for example true for the Iran. There, 850,000 natural gas vehicles are on the road, supplied by 600 filling stations. For comparison: Germany has less than a tenth of the vehicles but around 800 natural gas filling stations. The filling stations in the Iran are thus highly frequented, and a petrol pump failure is a real nuisance.

Natural gas high pressure valves in block design

The engineers at GSR have faced this problem and found a solution characterized by a significantly higher availability. The new natural gas high pressure valves as presented by the company at the Achema 2009 have a cartridge design (**Figure 1**). They are screwed into a valve block thus eliminating the need for tubing. The no-return valves are also integrated into the block, as well as the easy to replace filter unit in the pressure input.

This solution convinces by a design completely without tubing and by a very compact and maintenance-friendly construction. The valve blocks are available as triple or sixfold version. They are suitable for a maximum pressure of

450 bar and operate in a temperature range of -40 to +80°C, i. e. they are also suited for outdoor service. Optionally the valves can be equipped with ATEX-suitable solenoids.



Fig. 1: On the Achema 2009, GSR presented natural gas high pressure valves in cartridge design

Test runs prove: much higher reliability

First test runs show that the block design significantly increases the reliability of the natural gas petrol pumps, with minimum service effort. Hence, the cost of ownership is clearly lower compared to conventional valves. For these reasons, the new valve series has already been met with interest by manufacturers and operators of natural gas refueling systems.

GSR foresees a high demand for the new valve blocks, because of the rapidly increasing number of natural gas driven vehicles and the resulting rising number of natural gas filling stations. In Italy, the number of natural gas vehicles rose by 70,000 to about 600,000 in the past year. In Germany, more than 10,000 natural gas vehicles are sold annually, and the filling station network which currently comprises about 800 locations is extended rapidly. In the past years, almost 100 filling stations per year have been newly opened.

High pressure valves for the hydrogen infrastructure

While there is already a functioning infrastructure for natural gas as a fuel, this development has still to take place for hydrogen. Experts agree that hydrogen will play a major role as energy suppli-

cant and fuel in the future. This refers both to mobile and stationary fuel cell technology and to hydrogen-driven combustion engines: There are some promising development projects in this field.

Experience with 450 bar valves

For these reasons, a supply infrastructure for hydrogen is to be planned and implemented in the coming years. However, we have to face some technical challenges. Currently gaseous hydrogen is stored at pressures of 200 to 300 bar. For the corresponding filling systems, GSR Ventiltechnik has developed high pressure solenoid valves that prove their worth in practice and are suitable for pressure up to 450 bar (Figure 2).

Developer's challenge: 700 bar

In order to achieve a higher driving range of the vehicles, the developers want to store the hydrogen at a pressure of 700 bar in future – both within the vehicle and in the filling station. The required storage technology is already in development. A special challenge is the development of valves for this pressure range.

This task is so ambitious because hydrogen molecules are very small and thus show a capillary effect. This fact makes



Fig. 2: For hydrogen filling systems, GSR developed high pressure solenoid valves suitable for pressure up to 450 bar



Fig. 3: The pilot operated piston solenoid valves are suitable for pressure up to 900 bar

highest precision tests an important requirement for the production of high quality valves for the hydrogen technology, valves that operate reliably and leak-free at a pressure up to 900 bar.

Preparation: Extensive simulations and tests

As a long-term specialist for high pressure valves, GSR has worked intensively on this topic and first done basic development tasks. For example, extensive durability simulations were carried out to select the valve material and to optimize the shape design. Tests with different materials and geometries of the seat gasket have also been carried out. In doing so, the developers had to enter unknown territory. The workload included magnetic field simulations and load analyses as well.

Basing on these simulations and tests, GSR made sample valves which were then again tested and optimized. Afterwards, burst and compressive strength tests are carried out with pressures beyond 2,200 bar.

Pilot operated 900 bar piston solenoid valve

By now, a first pilot lot is available designed for pressures up to 900 bar and thus leaving sufficiently safety margin for the 700 bar technology as that the industry aims for (Figure 3). It is a pilot operated piston solenoid valve made from stainless steel type 1.4462. Ex-

tremely low tolerance limits apply especially for the valve seat which still closes reliably at a pressure of 900 bar. The low switching voltage indicates a mature design: Despite the high pressure and very high wall thickness, the valve can be switched with little energy effort.

The first field tests are currently under preparation. The development happens just in time: To date, Germany shows a low number of hydrogen filling stations, but their number will be increasing soon and rapidly. For the Federal Government plans to provide 500 Mio. Euros in subsidies for hydrogen projects in the transport sector in the next ten years. By the end of this period, there will surely be a nationwide infrastructure of hydrogen filling stations – and many vehicles using this CO₂-neutral fuel.

Investments in demanding test technology

Projects like the development of the 900 bar hydrogen valve can only be implemented if one has extensive know-how in the development of high pressure valves as well as the corresponding highly specialized development tools and test equipment. Therefore GSR recently opened a new test stand for leakage tests at high pressure valves (**Figure 4**). This test stand can detect leakage rates of 10⁻⁶ mbar l/s. That means: It can detect if the pressure of 1 liter volume rises by 1 millionth of a millibar per second. This precision is globally unique.

As this is therefore a technological terra incognita, we first had to do some background work before we were able to build the test stand. Altogether, the development and the construction of the test equipment took two years of intense work.

Demonstration of being quality leaders

The test stand consists of two chambers. One of them serves to detect the internal leakage rates at the valve seat under vacuum conditions. The valve is put under pressure in the closed state, the system measures any leakage rate at the valve output. Unlike the usual "sniffing test" with a measurement probe, this

Fig. 4: Uniquely precise: The new leakage test stand for high pressure valves in the GSR test field



procedure allows for determining the real leakage rate.

In the second chamber of the test stand, the outer leakage is measured, i. e. the tightness of the complete valve to the environment. The test gas in both cases is helium. The results of all measurements are recorded and stored. The documentation of the test results are integrated into the ERP system at GSR Ventiltechnik, hence all measured values can be saved with the article data, and the article-related documentation can always be called up with the complete set of measured values.

For a medium-sized company like GSR Ventiltechnik, the new test stand was a significant investment which makes perfect sense as it proves the quality leadership of the company in technically high developed products. Even leakage rates that in most cases would be considered insignificant are detected reliably. This investment will prove its worth, we at GSR are sure of that. At a special fair in Japan in which GSR recently participated and demonstrated its products and systems for hydrogen and fuel cell technology, the first pilot lot models of the hydrogen valves attracted wide interest.

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The Company

Since 1971 GSR Ventiltechnik GmbH & Co. KG has been developing, manufacturing and distributing valves and fittings for nearly all applications. The strength is the production of special valves according to customers request. Together with its customers the company develops system solutions and engineers them.

GSR's core competency is the fast development of special valve solutions meeting customers' requirements in all fields of valve technology. Over 35 years, the company's engineers have developed more than 3000 special valves which can reliably be fitted in nearly all technologies under different conditions.

Due to the fact that all the core components are produced on modern machines, it is possible to fabricate custom-made items.

However, we are also in a position to manufacture our regular series of valves to the highest quality, at short notice.

All business is performed in accordance with DIN EN ISO 9001 which is continuously controlled and improved by our quality management.