Safe, 4-offset eccentric butterfly valves for hydrogen

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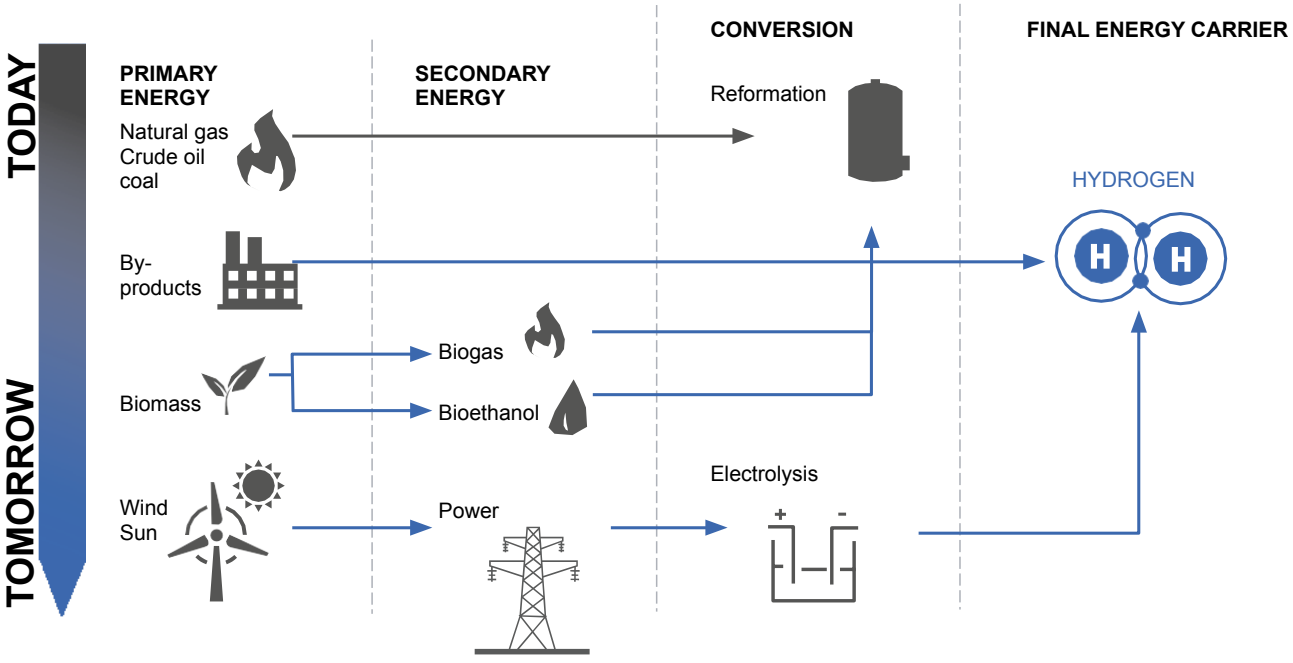
The global economy shall become greenhouse gas-neutral between 2050 and 2100. That is what is envisaged by the Paris Convention which was decided by the United Nations for climate protection and came into force in November 2016. The expansion of renewable energy sources alone, however, is not sufficient to achieve the set objectives. Rather, a reform of today's energy system is indispensable. In the process, not only the energy sources will change, but also the energy carriers. The most promising and currently undisputed energy carriers of the future include hydrogen. High-quality butterfly valves are used for the safe handling of the medium. In the following, the authors of the manufacturer Müller Quadax will report what role butterfly valves play in the energy system transformation and what particular challenges hydrogen places on industrial valves.

Today, hydrogen (H_2) is primarily used for the production of nitrogen fertilisers or while cracking hydrocarbons in oil refineries. Hydrogen plays an equally important role in the production of synthetic fuels. Gas, coal or biomass are used for this as primary energy. In the future, hydrogen-alimented fuel cells as an environmentally friendly energy converter will become more and more important in electric mobility.

Moreover, H_2 will prevail as a future energy carrier for transport vehicles. Steam reforming is currently the most significant large-scale process for the production of hydrogen made from carbon-containing energy carriers and water. In the process, natural gas is the most important raw material for steam generation, with butterfly valves from Quadax being successfully used both in natural gas and in steam at temperatures from 250° C to 300° C and pressures up to 100 bar.



Picture 1: Conversion process today and in future

Picture 2: Gas detector: Fugitive emissions of H_2 are imperceptible for human beings

In countries with high resources of coal, it is equally used as fossil raw material for the production of hydrogen. This thermochemical conversion of carbon-containing energy sources is neither sustainable, because no renewable energy sources are used, nor are they climate-neutral, since the production emits a significant share of CO_2 into the atmosphere. As of today, steam reforming has a market share of 80% to 90% of the production of hydrogen, depending on the sources of information. This will change in the coming years (Picture 1).

NEW PROCESSES FOR THE PRODUCTION OF H_2

Today's energy policy calls for a rethink towards decarbonisation of the energy sector. In the process, hydrogen, which is produced low in CO_2or still better without CO_2will come increasingly to the fore as energy carrier. New technologies for the production of so-called green hydrogen are under development. Green, because the primary energy stems from a renewable and climate-neutral source. The process of water electrolysis is already proven in pilot projects and so advanced to produce hydrogen from entirely renewable energy in large quantities in a CO_2neutral way. The so-called power-to-gas is about an electrochemical process.

Here, efficiency levels from 70% to 80% are meanwhile achieved. Currently, there are projects where the electrolyser is directly supplied by wind turbines or hydroelectric power plants.

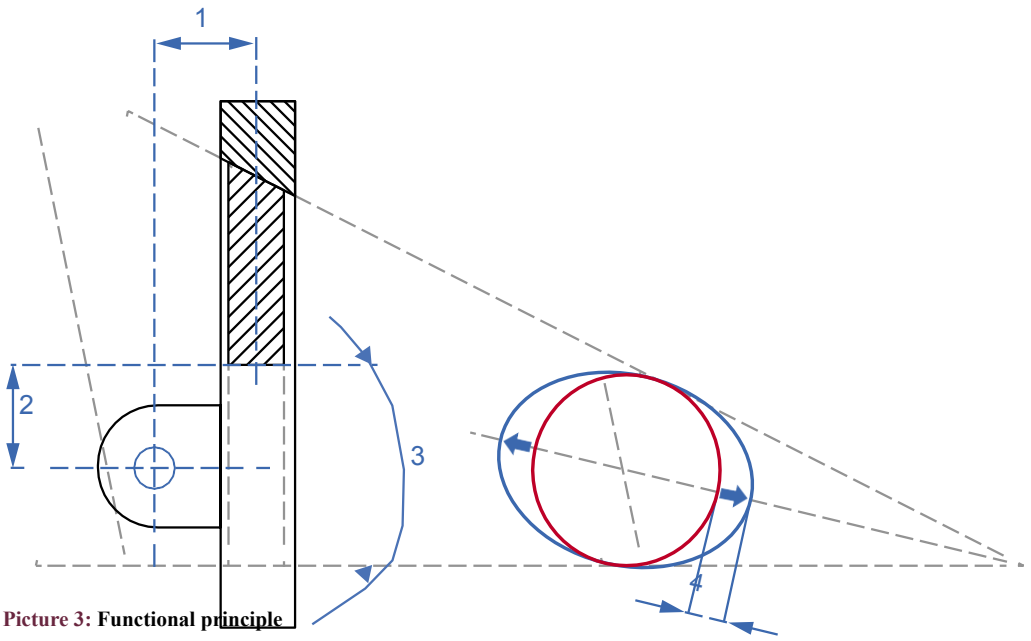
So that the increasing production capacity can be better adapted to the fluctuation demand, enormous hydrogen stores will be necessary in the future. For this purpose, the gaseous hydrogen is cooled down to minus 253° C, condensed in liquid form and then stored in liquid gas stores.

THE CHALLENGE

In order to asses which check and control valves are especially suitable for application with hydrogen, certain criteria have to be observed. Because due to chemical and physical characteristics, the handling of hydrogen differs substantially from other energy carriers such as liquid gas (LPG) or liquid natural gas (LNG):

- Hydrogen is colourless, odourless and tasteless, and depending on the relevant concentration, it reacts flammable or even explosive in connection with the gas mixture of the ambient air. It is delicate, above all, because the emission of gaseous hydrogen cannot be perceived with human senses (Picture 2).
- The enthalpy of combustion, namely the measure of energy in the thermodynamic process, with hydrogen is lower in comparison with many hydrocarbons and has thus a lower volume-related energy density than natural gas, for example. Thus, in order to be able to store the same amount of energy, either three times as large tanks or three times as high pressure are required as for natural gas.
- The density of gaseous H2 is merely 0.09 kg/m^3 and is therefore the element with the lowest density. Consequently, hydrogen diffuses relatively well through a variety of materials. High temperatures and high operating pressures reinforce additionally the danger of diffusion. Steels with a high carbon content are therefore not suitable for this medium, because hydrogen atoms become brittle, with the components thereby loosing their strength.
- For the liquefaction of hydrogen at atmospheric pressure, a temperature of minus 253°C is necessary as opposed to LNG with "only" minus 162°C. Liquid hydrogen weighs only 0.071 kg per litre. For clarification: Liquid natural gas (LNG) weighs approximately 0.41 kg to 0.5 kg per litre and is thus 5.8 times to 7 times denser than H2.

So on the one hand, the challenge for manufacturers of tank and valvesconsists in using sustainable H_2compatible materials and to adapt their sealing systems because of the high diffusion behaviour of H_2 on the other hand.



Picture 3: Functional principle

This is not an easy task, considering that there is a temperature fluctuation of more than 300°C between the liquid state when storing it in cryogenic conditions of -253°C up to a transport or gaseous distribution temperature of up to +50°C.

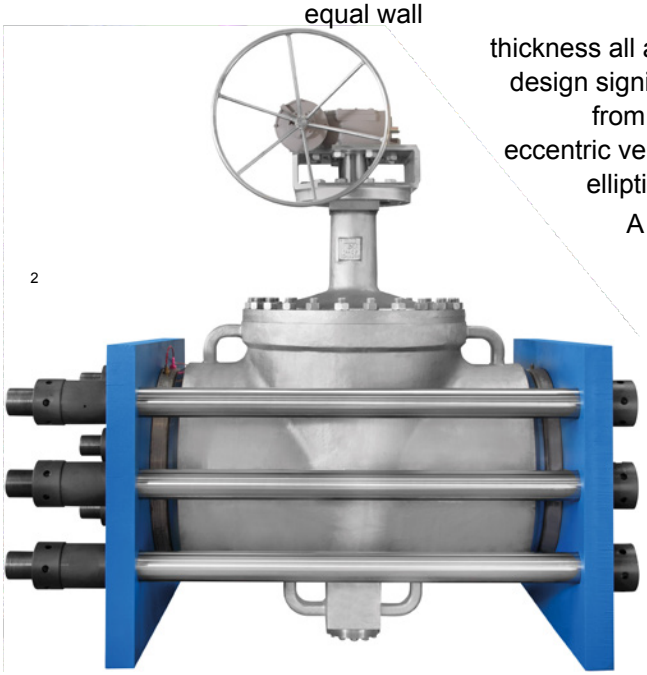
THE SOLUTION

As one of the leading valve manufacturers in demanding applications, Quadax® intensively concentrates on the topic of hydrogen with its many opportunities.

On the one hand, the challenges for the manufacture of high-quality valves for the hydrogen sector lie in the high pressures of up to 100 bar depending on operating conditions, and on the other hand, in the storage temperatures of liquid H_2 at -253 °C. So that absolute tightness is also ensured under these conditions, the company operates with its valve using the so-called 4-offset eccentric design principle (Picture 3). This principle is characterised by the fact that the butterfly valves have a round tight fit with an equal wall thickness all around. This way, the design significantly distinguishes from the common 3-offset eccentric versions which have an elliptical tight fit (Picture 3).

Actually, material extensions due to high temperature fluctuations act homogenously on the entire sealing surface and thus ensure optimal tightness. This was recently proven in a performance test with helium by an independent testing institute (see technical report Zegers in this edition).

Picture 4: Butterfly valve in top-entry version



Picture 5: Ready for highest requirements

ABOUT THE COMPANY

müller quadax has its company headquarters in the Baden-Wuerttemberg town of Forchtenberg and has 50 employees (Group 300). The products of our company are applied worldwide - wherever uncompromising quality and highest requirements have to go hand in hand due to high pressures and extreme temperatures. The müller quadax gmbh sees itself as a driver of innovation, who with a lot of experience and reliability is approachable for its customers. As a member of the Müller CO-AX group who act as world market leader, the company harnesses this environment and can thereby implement global projects in any size. The company's motto is: Think Global, Act Local. The 4-offset design principle for butterfly valves that was developed within the company is implemented using high-quality materials on up-to-date 5-axis processing centres. The production of valves takes place completely in Germany. But the valves are ready for operation worldwide.

What is more, the Quadax®-H valve is equipped with a special seal ring in a special material in order to properly function even at these extremely low temperatures. Since the washer smoothly moves into the seat, the wear and tear is significantly reduced. When selecting materials, the müller-quadax gmbh bets on alloys with a nickel content from 10 per cent to 30 per cent. In contact with hydrogen, these alloys show only very little brittleness and the components do not lose any strength.

FOR EXTREME OPERATING CONDITIONS

Thanks to the 4-offset eccentric design and the latest production technology, the butterfly valves from Quadax® meet extremely high sealing requirements according to common standards. Extreme temperatures from -270 °C to +800 °C are not seldom with many users of butterfly valves of this manufacturer.

Apart from Linde and Air Liquide, references include, among others, notable users in the space sector. Their applications are very demanding and require enormous requirements on quality and safety. The fuels consist of liquid hydrogen in connection with other chemical substances.

When producing and storing liquid rocket fuels and also when fuelling the rocket with cryogenic fuel components, which have a temperature of partly colder than -220°C, reliability and thus safety rank first, because smallest leakages can have devastating consequences.

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