Application Story

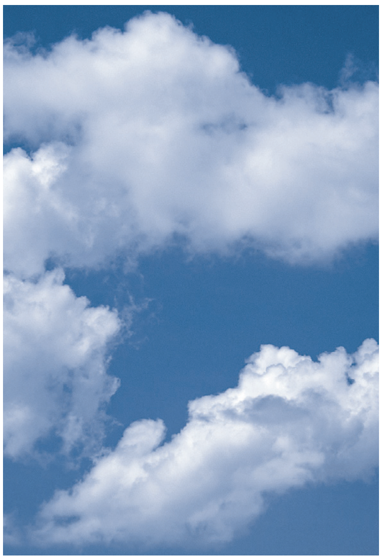
Hydrogen refueling

A SMALL CONTRIBUTION TO RENEWABLE ENERGY

Renewable energies, obtained from wind, water and sun, represent the future of energy supply. With more than 50 years of experience in measurement and control technology, we, KEM Küppers Elektromechanik GmbH, are proud to make our contribution to renewable energy and climate protection.

With the Paris Accord of 12 December 2015, 196 states decided to reduce emissions. The transition to renewable energies is crucial for reaching the objectives. One of the aims is to achieve a sustainable reduction in greenhouse gases in the transport sector.

Battery-powered electric vehicles or fuel cell vehicles (hydrogen) are currently available as possible technologies for this purpose. Whether charging infrastructure for battery-powered vehicles or the necessary infrastructure for fuel cell vehicles; the result is that both technologies are necessary for a successful turnaround in transport, but in the long term a charging station network is more cost-intensive than hydrogen filling stations.



The distribution infrastructure for hydrogen needed for daily operation is now well under way. In Germany alone, 83 hydrogen stations are in operation as of April 2020. Several hundred filling stations are already in use worldwide and the upcoming projects for expansion are extensive.

The infrastructure is one of the key factors for the success of fuel cell technology in vehicles for hydrogen refueling. If there are no cars with fuel cell technology, there is no need for filling stations. The same applies vice versa. Currently, a rethinking is taking place. The filling stations are built today without a counter calculation for required vehicles. It is no longer just about the car fleet. In the meantime, bus and truck fleets are also being equipped for fuel cell operation worldwide. This increases the demand for filling stations considerably.

In Germany, H2 MOBILITY GmbH is responsible for the creation of a nationwide infrastructure in cooperation with world market leaders in vehicle construction, gas production and dispensing system suppliers.

OUR HYDROGEN METER:
MI 002 (OIML R 137) CERTIFIED

Note: The following text describes the challenges for car refueling. This is embedded in an SAE directive (Society of Automotive Engineer) and clearly regulated. Although refueling for buses and trucks' takes place under very similar conditions, with pressures varying between 350 and 700 bar, there is not yet a clear directive on refueling.

What does all this have to do with measurement technology?

Measurement technology is needed to bill the dispensed hydrogen. This is a challenge for the entire measurement chain, which is regulated by SAE J2601. For fuel cell vehicles (only for cars not for HDV (Heavy Duty Vehicles)), all vehicle manufacturers now prefer a supply of 700 bar and -40 °C [-40 °F] pre-cooling. In these conditions a refueling at 700 bar takes less than 3 minutes with a tank filling of 3 - 4 kg. At the same time, an exact billing of the refueling is expected.

The accuracy requirement for the flow measurement technology used is regulated in the legal regulation by EU Directive 2014/32/EU Annex IV (MI 002) “Gas meters and volume correctors”. Applied harmonized standards or normative documents: OIML R 137

With this challenge, we started the development of our Coriolis Mass Flow Meter, together with a well-known gas producer. This goes back in 2014. The scope of the challenge only became clear after extensive testing under real conditions. After the hydrogen is compressed up to 900 bar using a defined pressure ramp, as defined by SAE J2601, it is ready to be fed to the vehicle for refueling after a defined pressure ramp.

At this point it must be said that in the early days, flow measurement technology was used before the heat exchanger. Thus, the flow meter was pressurized, but did not have to master the challenge of the cooling to -33 °C [-27 °F] in less than 30 seconds. At higher temperatures the refueling process would take correspondingly longer. Avoiding overheating is the top priority.

GREEN HYDROGEN THE METER LIKES MOST

In the first phase, the mass flow meter was installed between the container (i.e. after the compressor) and before the heat exchanger. Different scenarios clearly showed the challenges during refuelling. The difference of the pressure P1 at the start and the pressure P2 during completion of refuelling influenced the measurement result:

- P1 ~ P2: The hydrogen quantity billed corresponds to the quantity actually refuelled.
  Reason: The hydrogen quantity present in the pressure line before the refuelling is replaced by the same quantity after the refuelling.
- P1 > P2: More hydrogen is dispensed than actually billed.
  Reason: Less hydrogen quantity is replaced in the pressure line at the end of the refuelling.
- P1 < P2: Less hydrogen is dispensed than actually billed.
  Reason: More hydrogen quantity is replaced in the pressure line at the end of the refuelling.

In the second phase, they focused on using the flow meter after the heat exchanger to solve the problems described above. The measuring distance between the flow meter and the dispenser is shorter, the pressure is constant and therefore the accuracy of the refueling is better. However, this increased the challenge for the flow meter considerably. Now both the high pressures and the temperature gradient had to be processed, a special challenge for the zero point stability of the flow meter. The results were good, but still not entirely satisfactory for the application requirements.

In the third phase, the flow meter is now installed directly in the dispenser, upstream of the heat exchanger and at constant pressure. Thus, there is no more undefined gas volume in the pipe system, the flow meter is not exposed to the temperature gradient. Herewith the best accuracy during refueling is currently achieved.

Our Coriolis mass flow meter has now its 6th birthday and it has successfully experienced all three phases and has developed with them. Read more about our thoughts to this topic.

Coriolis Mass Flow Meter
(TRICOR SPECIALITY Series)

FURTHER THOUGHTS ON HYDROGEN

Despite all the climate considerations, it should not be forgotten that a project of this size only has a chance of being implemented sustainably if the entire value chain can make a profit in the long term. Fortunately, this is becoming more and more probable, strongly supported also by governmental agencies.

Grey, blue or green? This is where the value chain of hydrogen technology begins.

The gray hydrogen is mainly obtained from STR (Steam Reforming). The CO_2 content is still high. The kilogram of hydrogen produced from this process is about one third cheaper than the blue hydrogen and today even two thirds cheaper than the green hydrogen.

The blue hydrogen is produced in a similar way as the gray hydrogen. However, more CO_2 is separated by an ATR process (autothermal reforming). By means of CCS (Carbon Capture and Storage) the CO_2 is stored underground in so-called UGS (Underground Gas Storage). Germany has the most deposits in Europe. The disadvantage is the complex infrastructure and the costs of operating the storage facilities.

The cost of green hydrogen production and the idea of an emission-free production chain for hydrogen, is today only possible through (so far) cost-intensive electrolysis. Particularly worth mentioning here is certainly the hydrogen produced by electrolysis from natural run-of-river power plants. Switzerland is the pioneer here. The hydrogen filling stations in Hunzenschwil and Duebendorf are the godfathers of green hydrogen refueling.

Further KEM applications that contribute to renewable energy:

- Reduction of emissions (VOC)
  - TCM Coriolis Mass Flow Meter in use for electrostatic surface coating for paints with high water content.
  - ZHM Gear Meter in use for electrostatic surface coating for paints with low water content.
- Precise determination of emissions (CO_2) in the context of EU-MRV (EU Monitoring Reporting Verification regulation) and IMO-DCS (International Maritime Organization Data Collection System)
  - TCM Coriolis Mass Flow Meter in use for fuel consumption measurement on ships.
- Renewable energy sources
  - SRZ Helical Meter in the manufacturing process of wind rotors.
  - SRZ Helical Meter in the production process of battery production for electric mobility.

