HYDROGEN TANKS FOR MOBILE USE

Fuel cell vehicles contribute to fossil-free mobility. They use hydrogen as fuel, which must be stored in a suitable tank (pressurized vessel). The Western Swiss startup New Generation Tanks has developed a prototype of a pressurized storage vessel that can be more easily integrated into vehicles, is made from recyclable materials, and weighs less than conventional or state-of-the-art models.

Gilles Rocher (right, founder of NGT) and Eric Amaral (left, head of R+D at NGT). Photo: NGT

A technical report about the results of two research projects in the field of hydrogen, which are financially supported by the Swiss Federal Office of Energy. The report has been published in the technical magazine Strassenverkehr Schweiz (issue November 2024).

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Fuel cell vehicles are powered by an electric motor. They draw power from a fuel cell, which generates electricity directly in the vehicle from hydrogen. Of all fuels, hydrogen has the highest mass-based (gravimetric) energy density, but its volumetric energy density at atmospheric pressure is extremely low, at around 80 grams per cubic meter. To reduce the volume, vehicles use hydrogen in compressed form at high pressures of 350 or 700 bar.

Lightweight tanks increase transport capacity

Founded in 2018, the start-up New Generation Tanks (NGT) based in Renens (VD) aims to develop novel hydrogen tanks for fuel cell vehicles. "The hydrogen tanks currently used in vehicles are heavy, bulky, cannot be optimally integrated into vehicles, and are not recyclable," says company founder Gilles Rocher.

As a driver, one imagines a tank as a steel container with a lid. Hydrogen tanks for mobility applications are far more complex. To store the non-toxic, colorless, odorless but highly flammable substance, hydrogen tanks must meet several essential requirements: They must be tight, take up as little space as possible, show little material fatigue even after many refills, and – for mobility applications – be light as possible. In fuel cell vehicles, Type-4 tanks are typically used (see text box p. 3).

Plastic instead of steel

Type-4 tanks – developed since the 1990s – are made entirely of plastic. The inner tank – called the liner – is made of thermoplastic polymer, and the outer shell is made of a composite material of epoxy resin and carbon fibers. This is where NGT's developers come in: They want to further improve the Type-4 tank by replacing the non-recyclable and difficult-to-process epoxy resin with a thermoplastic polymer.

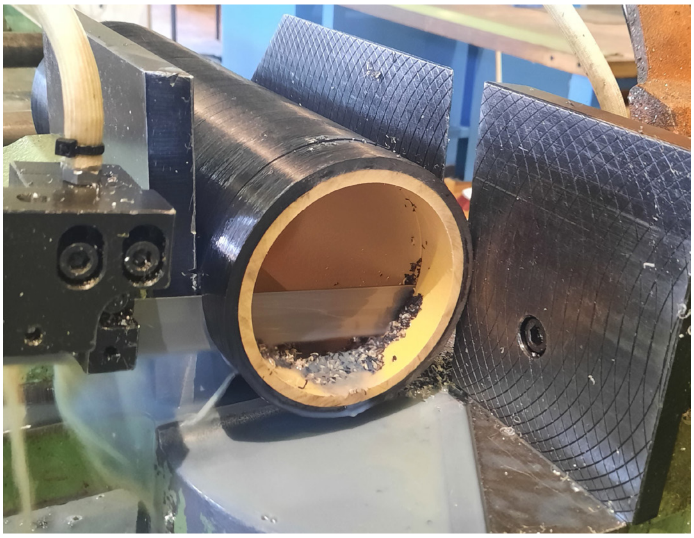
As part of the SFOE project POSSHYS, involving NGT and the COMATEC laboratory at the University of Applied Sciences in Yverdon (HEIG-VD), a high-performance and cost-effective thermoplastic polymer was identified that is suitable for NGT's concept. The selected polymer is used for both the liner and in the outer shell. It replaces the epoxy resin and together with the carbon fibers, forms a thermoplastic composite material. The polymer has thermoplastic properties, meaning it can be reshaped repeatedly by heating and can therefore be reused. Epoxy resin, on the other hand, is a thermoset: Once the plastic has solidified into the desired shape, it can no longer be altered by heating.

TWO ACADEMIC PARTNERS

Two academic partners were involved in the HYTMOB project: The Institute of Mechanical Design, Materials Science and Packaging Technologies (COMATEC) at the Vaud School of Engineering and Management (HEIG-VD) in Yverdon, which developed a simulation model to define the thickness of the liner and composite layers. The Institute for Applied Research in Plastics Technology (iRAP) at the Fribourg School of Engineering and Architecture (HEIA-FR) carried out, among other things, a simulation of the manufacturing process to ensure that the liner could be produced. The institute also defined the recycling process and demonstrated that the material from recycled storage vessels has a similar level of performance to non-recycled "original material" available on the market.

Long cylinders with high storage efficiency

Using the thermoplastic polymer, NGT has developed the prototype of an innovative Type-4 hydrogen tank over the past two years as part of the SFOE project HYTMOB, in collaboration with the iRAP laboratory at the University of Applied Sciences in Fribourg (HEIA-FR) and the COMATEC laboratory



First step of the recycling process: The pressurized storage tank is sawed into pieces. The parts are crushed into chips, which are then heated and compacted. The resulting compound can be molded into any type of part for automotive or appliance applications. Photo: iRAP

FOUR TYPES OF HYDROGEN TANKS

Tanks for storing compressed hydrogen have the shape of a short cylinderclosed with domes. They consist of an inner tank vessel, technically referred to as a "liner." The liner is encased in an outer shell, which gives the tanks their resistance to high pressure (see illustration on the right).

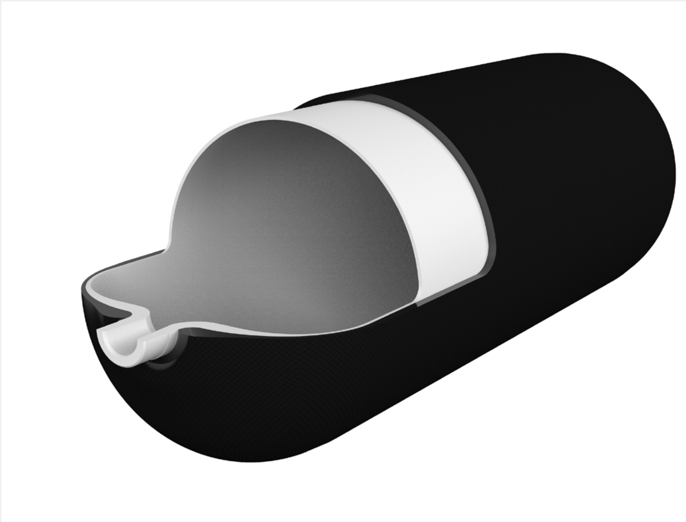


Illustration: Shutterstock

Hydrogen tanks are classified into four types depending on how they are constructed and the material used:

Type 1: Tanks consisting of a robust metallic liner with no outer shell.
Type 2: Tanks consisting of a metallic liner (usually made of aluminum), supplemented in the cylindrical section by an outer shell made of a composite material (e.g. epoxy resin-impregnated glass or carbon fibers). Since the outer shell absorbs some of the pressure, the liner can be made thinner.
Type 3: Tanks with a metallic liner and an outer shell. The pressure is entirely absorbed by the outer shell, so the liner can be made very thin (e.g. from aluminum).
Type 4: Tanks containing a liner made of polymer. The liner is encased in an outer shell of epoxy resin-impregnated carbon fibers.

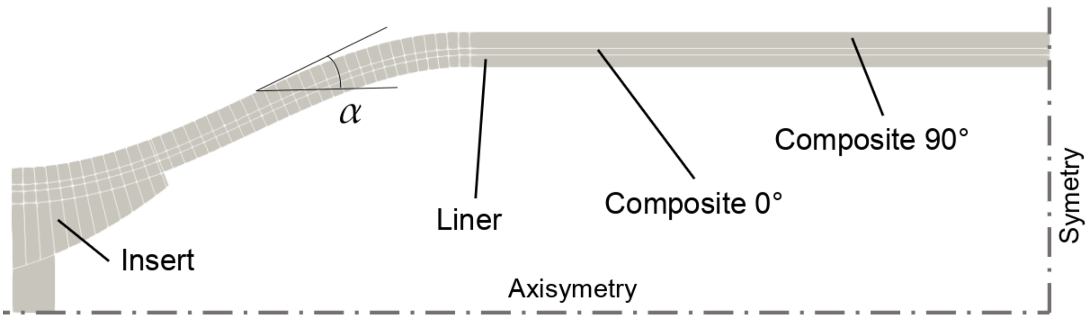
Type 4 tanks weigh approximately 70% less than Type 1 tanks. They are suitable for applications in which hydrogen must be stored under high pressure and the weight of the storage tank must be low, such as in the mobility sector.

(HEIG-VD). Long, narrow cylinders were chosen for the shape of the tanks. NGT is aiming for a storage efficiency of 8 to 10%. This means that the pressurized vessel can store hydrogen with a weight of up to 10% of the storage vessel's weight. Today, the storage efficiency of commercially available tanks is between 5 and 7.5%, depending on operating pressure (350 or 700 bar) and size.

"The innovation of our pressurized vessel is in the novel material, but also in the design we have developed specifically for the two end closures of the tanks," says Gilles Rocher. "Thanks to a special geometry, less material is needed, which is important because the thermoplastic polymer is relatively expensive." NGT's innovation also includes a new manufacturing process for the outer shell, which fully exploits the potential of carbon fibers in terms of tensile strength.

Certification by 2026

The next step for NGT is to design the manufacturing process to mass produce the pressurized vessel, which can store hy-

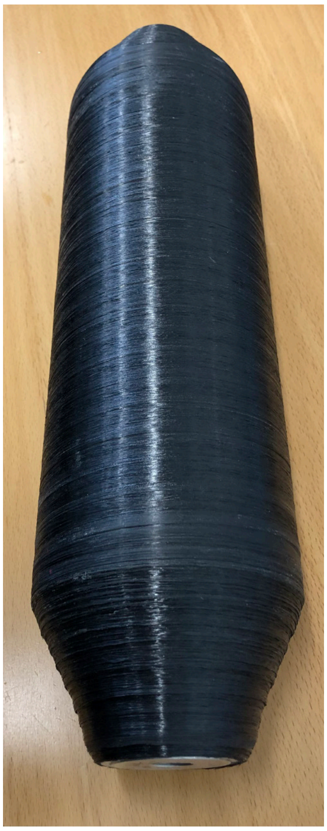


COMTEC has developed a parametric simulation model that can be used to modify and simulate the geometry, material properties and wall thicknesses of the liner and composite layers. Graphic: NGT/edited B. Vogel drogen or other gases. The demanding certification process is expected to be completed by 2026.

- Final report on the **HYTMOB** project: www.aramis.admin.ch/Texte/?ProjectID=51465.
  Final report on the **POSSHYS** project: www.aramis.admin.ch/Texte/?ProjectID=47508.

- **Information** on the project is available from Stefan Oberholzer (stefan.oberholzer@bfe.admin.ch), Head of the SFOE's Hydrogen Research Program.

- Further **technical articles** on research, pilot, demonstration and flagship projects in the field of hydrogen can be found at www.bfe.admin.ch/ec-h2.



Prototype of the NGT pressure storage tank for hydrogen with a diameter of 115 mm and a length of 450 mm. Future storage tanks can be built to lengths of 450 mm (e.g. for drones); 1 to 2 meters (e.g. for light transport vehicles); 2.5 to 6 or even 9 meters (for trucks and buses). Photo: NGT

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