What happens to a hydrogen tank during a collision?

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Credit: Engin Akyurt from Pexels

Vehicle emissions contribute significantly to global warming effects, although technologies such as hybrid and fully electric vehicles have been introduced in recent years to reduce vehicle emissions. Hydrogen-fueled vehicles also offer the potential to reduce harmful emissions. In these vehicles, hydrogen must be stored at high pressure, which requires storage tanks that are mechanically strong and do not rupture easily during a crash. Ph.D. candidate Ruben Weerts investigated how hydrogen tanks are damaged when subject to controlled impacts. Weerts defended his Ph.D. thesis at the department of Mechanical Engineering on September 9th.

The issue with hydrogen tanks

Modern hydrogen vehicles use fuel cells to produce electricity that is then used to power the vehicle. These fuel cells convert hydrogen and oxygen into electricity with the by-products being water vapor and waste thermal heat. The required oxygen is extracted from the air and the hydrogen is stored in hydrogen tanks in the vehicle.

In these tanks, hydrogen is stored under a high pressure of up to 700 bar, which is much higher than a conventional LPG (liquefied petroleum gas) tank. Hydrogen tanks must be strong to withstand this high internal pressure while concurrently being lightweight. As a result, they are made from a composite material, carbon-fiber reinforced polymer to be precise. To ensure the safety of hydrogen vehicles, the tanks need to fulfill a large series of requirements and tests before they are approved for use in vehicles.

Testing hydrogen tanks

To further improve the safety of hydrogen vehicles, it is vital to understand what happens to a hydrogen tank during a vehicle crash. As

part of his Ph.D. research, which was funded by BMW and supervised by BMW and TU/e, Ruben Weerts conducted experimental tests which helped to determine when and in what way a tank is damaged when subject to an impact.

"After the impact, the tanks were then studied using CT (computerized tomography) scans, which provided a visualization of the damage caused by the impact," says Weerts.

After the impact tests, the same tanks were subject to so-called burst tests where the internal pressure in the tank was gradually increased until the structural integrity of the tank fails. "We compared the internal pressure at which a damaged tank bursts to the maximum pressure at which an undamaged, new tank bursts," says Weerts. "Typically, the impact reduced the strength of the tank and the burst pressure dropped significantly."

Turning to simulations

These experimental observations were then used to develop simulation models, which could be used predict whether and in which way a tank is damaged due to an impact.

"The model predicts the mechanical response of tanks during impact quite well," notes Weerts. "Such models can help reduce the material costs and the extent of future experimental investigations on tanks while at the same time assist in the vehicle's design and development process. And of course, these models can be used to further improve the safe integration of hydrogen tanks into vehicles."

More information: The impact behavior of thick-walled composite-overwrapped pressure vessels. research.tue.nl/en/publication …-overwrapped-pressur

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