

Record Rapide

Aston Martin's Rapide S became the first car to complete a qualifying lap of the Nürburgring Nordschleife on hydrogen power alone. And it didn't stop there...

Aston Martin's Rapide S model set a landmark at the Nürburgring 24 hours when company CEO Ulrich Bez completed the first lap in the competition running on hydrogen power alone.

Driving a Rapide that has been converted with renewable experts Alset Global to run on hydrogen, gasoline, or a blend of the two, Bez completed a qualifying lap on the fuel, and went on to complete 40km before reverting to gasoline power to return to the pits. The car went on to compete in the 24 hours in the E1-XP2 category for experimental technology.

emission standards in 2020 without disrupting the industry. The hydrogen, produced at the Ulde plant in Germany, is manufactured from raw glycerol, a byproduct of biodiesel manufacturing. Advanced to industrial scale, this production path has the potential to reduce greenhouse gas emissions by between 50-80 per cent compared to conventional hydrogen production processes.

Hydrogen has a wide ignition range, which allows very lean combustion. It burns six times faster than gasoline which - together with mature injection and combustion

"Hydrogen combustion can be up to 30 per cent more efficient than the gasoline equivalent"

control technology - means that hydrogen combustion can be up to 30 per cent more efficient than the gasoline equivalent.

Alset believes that this could be the future of production car technology, allowing cars to be classified as zero emission under current regulations, and which can be run for between 100km-200km between fills, substantially further than the Porsche 918 or the Toyota Prius. "If you add 100km or 200km, rather than looking for 400-500km



before you switch back to gasoline, you are not looking for a large tank size," says Alset's vice president of operations, Markus Schneider. The Rapide S ran at the Nürburgring with four hydrogen fuel tanks placed next to the driver and in the boot of the car, although in production the system will be more refined.

Already the system, which can be fitted to existing cars, has attracted manufacturer interest, with a Chinese delegation of VIPs shown around the car at the

Nürburgring. The system will add around 10 per cent to the car's price, which is nothing when you look at the amount some people spend on their satellite navigation systems today.

Having been the first to run the technology in competition, Alset plans to produce the system for road cars, making use of the fuel stations in major cities. "If you want to drive your car in a city on zero emissions, you can," says Schneider. "If you want to drive

to Italy, you don't need a second car. You can do it on the regular gasoline fuel, which is a big bonus."

ENGINE UPGRADES

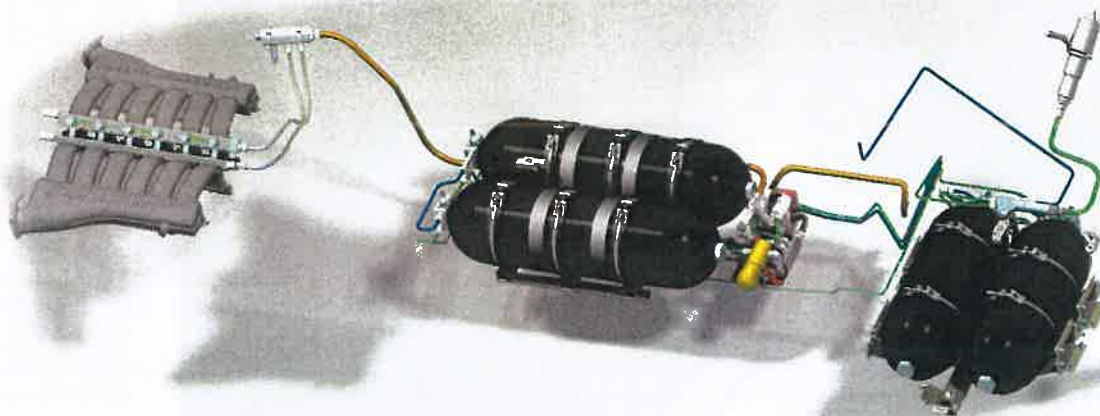
Hydrogen burns faster and at a higher temperature than normal gasoline, which means that changes had to be made to the V12 engine. The first step was to fit twin turbochargers to the 6-litre V12 engine before fitting the four Magna Steyr-built carbon tanks.

The two exhaust-driven turbochargers are used when the car is burning hydrogen to improve the mixture heating value of the charge, forcing more air/fuel mixture into the combustion chamber. The gas takes up a lot of volume, says Schneider. The fuel air mixture in the manifold doesn't have the same density as a liquid, so you are losing power. To get that back, we had to turbocharge the engine."

The Rapide S uses a Pectel engine management system

from Cosworth as the project required a bespoke unit. The hydrogen injectors, supplied by AFS, are similar in design to natural gas injectors found in OEM CMC applications. There are small differences needed for the different requirements, including high durability seals and materials. In the case of the Aston Martin Rapide, those injectors are fitted to the intake manifold, upstream of the regular gasoline injectors. The hydrogen is delivered to

the fuel rail in a constant flow at between 4 and 5 bar. The mixture formation system was redesigned and a hydrogen rail, injectors and a turbocharger unit were integrated, considering the specific thermodynamic properties of the hydrogen combustion process. Since the modification effort of the base engine is low, it is feasible to retrofit virtually any engine, including direct injection engines. In gasoline-only form, the engine produces 400kW of power,



A 3D rendering of the complete Rapide S Hybrid Hydrogen fuelling system

the hydrogen 20 per cent less, at 320kW in hydrogen mode only. The gasoline is mixed with the hydrogen, adding around 10 per cent, meaning that the car can produce around 90 per cent of the overall power while reducing emissions.

A new exhaust manifold was fitted, as well as new pistons and new cylinder head gaskets, while the higher temperatures mean that, as a fail-safe, the exhaust valves were replaced with ones made from Inconel, although Alset admits that the production valves probably would be able to cope.

The Alset system was developed in just eight months, 10 months faster than the original schedule, but one that brought it out in time for the race, held in Aston Martin's centenary year. As such, it may not be the prettiest system in the Rapide S, and Alset believes that the system can be optimised. 'Some of the machining was a one-hit, which worked,' said Schneider. 'I think that we can improve on the 320kW of power with a bit of development, and expect a minimum improvement of around 10 per cent, which means the hydrogen would run at 90 per cent of the power compared to gasoline.'

MASS STORAGE

The four carbon-fibre storage tanks hold a total of 3.2kg of hydrogen, equivalent to 12 litres of gasoline. In the race version of the car, the hydrogen is stored at a pressure of 350 bar for simple and quick refuelling.



The hydrogen system adds around 100kg to the weight of the Rapide S, around 70 per cent of which is added by the fuel tanks and plumbing

During the race, the car had two stops to refuel, the first for the hydrogen only at the start of the pit lane from a 35 tonne, 14-metre long TrailH₂ - gas mobile hydrogen refuelling truck which stores two separate high pressure couplings for gaseous hydrogen, and stores the gas at 300 and 450 bar in cylinder packs. The second was a regular service, for gasoline and - if necessary - driver and tyre changes. In a production version of the vehicle, however, 700 bar pressure storage is possible and allows for smaller packaging or for higher amounts of fuel to be stored. The Rapide S race car is equipped with a 100-litre motorsport-specified gasoline tank in its regular position, providing a total combined range of nine laps on the Nordschleife and resulting in no range disadvantage during the race.

The hydrogen system, together with assorted engine

enhancements, adds around 100kg to the weight of the car, around 70 per cent of which is added by the fuel tanks and the plumbing system, which includes holding brackets for the front and rear, tubes and a pressure regulator unit.

The 350 bar hydrogen tanks are fully wrapped composite cylinders with an aluminium liner with a 15mm thickness. The cylinders, developed together with Magna Steyr, are denominated Type III. The packaging was specially designed to meet all safety regulations and to avoid any sort of damage during the race.

An ECU, developed together with partner Gigatronik, monitors and manages the Hybrid Hydrogen safety and tank system on the car. A safety concept has been developed that considers the specific properties of hydrogen as a fuel and ensures maximum

safety in all racing conditions. The ECU is connected to four hydrogen sensors, which continuously monitor the gas system, as well as crash sensors. In the event of one of the sensors detecting a trace of hydrogen, or if there is a crash, the hydrogen supply will immediately shut off. A valve between the tank and the pressure regulator closes and all the hydrogen, beside the amount left in the pipes, is retained within the extremely robust carbon fibre composite storage cylinders.

Crash safety has been ensured by carrying out crash tests of the conventional Rapide S as a part of the standard homologation process. Relevant modifications of the conventional vehicle were developed according to the results of crash simulations.

'Hydrogen is as safe, if not safer, than normal gasoline engines,' says Schneider. 'It has different properties, but the burning process means that, if you had an accident and were able to rupture a tank, which is difficult, you would not have toxic fumes and a high heat transfer that you have with a gasoline fire. You would have a rapid release of gas, so no build up, and if you were unconscious you would not be inhaling the fumes.'

The car finished in 115th position overall at the Nürburgring, but given the interest that the system has already generated, this technology could have a long-term future.

"We can expect a minimum improvement of around 10 per cent, meaning that we could run on hydrogen at 90 per cent of the power of gasoline"