Life as a fuel cell engineer

A student team project can be a very valuable experience, as **Sjoerd van Empelen** explains.

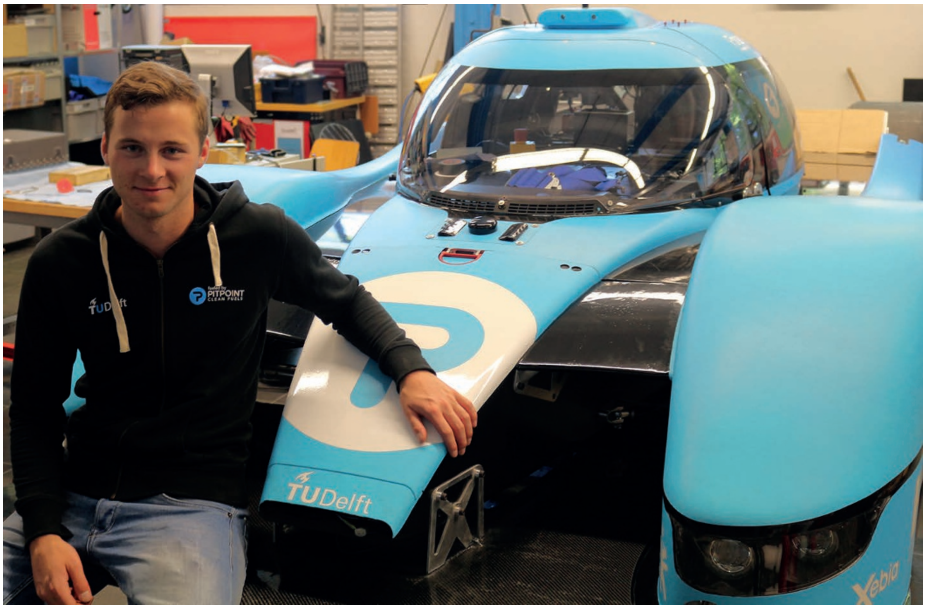
My story started two years ago, when I first set foot in the Forze office and workshop at the University of Delft. There I was greeted by Forze VI, one of the first full-scale hydrogen sports cars on the planet. From the moment my eyes met the Forze VI, I was sold. The sleek blue lady was a beauty to look at. What struck me most were not her looks, but the apparent complexity of the systems hidden beneath the bonnet: a vast number of tubes and hoses connected the various components in the car. To me, it was almost unbelievable that students could design something this complicated.

From that moment on I have been a member of the Forze team — at first part-time, then as chief fuel cell board member. My job consisted of redesigning and improving the fuel cell system of the car, a task requiring full-time involvement with the team.

When I started, the Forze VI was a fully functioning car that acted as a driving test bed for all internal systems. The goal now was to enter an official petrol powered competition and display the potential of hydrogen as an energy carrier in the automotive industry. For this, a new car had to be designed. And so we started working on Forze VII.

As a student team, Forze does not possess the knowledge and experience to produce the fuel cell stack in-house. Therefore, we bought one: a 100 kW stack (one of the few available at the time). We focused instead on optimizing the systems around the fuel cell, which consisted of a high-pressure container for hydrogen storage, an e-compressor for air supply, a humidifier for incoming air, a pump to recirculate surplus hydrogen, and a device to control the flow of fresh hydrogen going into the stack. When combined with a number of sensors and actuators controlled by an embedded software system developed in-house, all these components enable the stack to operate at optimum conditions.

The selection of system components is only part of the task — everything needs to fit inside the chassis of the car in a volume-efficient manner. To accomplish this, we produced a CAD model with millimetre accuracy. The production period is a stressful time because the entire computer design comes to a practical realization and small mistakes in the model can result in ergonomic blunders that require a complete redesign. For instance, I learned the hard way that empty spaces in the CAD model always look larger than in real life.



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Finally, all the work resulted in a system that continuously outputs over 100 kW (135 bhp) in electric power. This might not seem much for a car that weighs around 1,100 kg. However, a supercapacitor buffer, in which energy is stored when not needed for the wheels, enables the total amount of traction power to reach 200 kW, making Forze VII competitive in the slower classes of the Supercar Challenge competition.

At this point, the biggest challenge we faced consisted of running the system for prolonged periods of time — a problem connected to the water management and hydrogen storage limitations of the car. Even though the stack is roughly 50% efficient, there is still 100 kW of waste heat to cool, through radiators. Moreover, some fuel cell waste water has to be used to keep the membranes from drying out without flooding them. Finally there is a limit to the amount of compressed hydrogen gas that fits inside a reasonable amount of space. Currently Forze VII is designed to carry up to 5.5 kg of hydrogen, which enables racing for up to 45 minutes at full power. Forze VII can reach speeds of up to 200 km h^{-1}, and, importantly for competitive lap-times, boasts a 0–100 km h^{-1} acceleration time of under 4 seconds.

Managing a team with over 40 active members (most of whom are part timers with irregular working hours) was a challenge in itself. My goal was to oversee the tasks ahead and utilize everyone's skills to their full potential. When the designs were too complex to produce ourselves we relied on the machine shop. This taught me to appreciate the skill involved in welding and machining, and made me realize the great value craftspeople bring to industry.

Over the last year I have gained a lot of practical knowledge about fuel cells, hydrogen storage, pumps, valves and cooling systems. Even though my bachelor's degree in aerospace engineering was not fully relevant to my job at Forze, it was very motivating to see how knowledge acquired in university courses could be transferred and used to design something truly amazing.

As is customary, the board of Forze is completely renewed every year and I have now stepped down. But I would encourage every student that is offered the chance to work on a project like this to grasp the opportunity with both hands. ❐

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