DETERMINATION OF OPTIMIZED HYDROGEN REFUELING STATIONS USING NUMERICAL OPTIMIZATION METHODS

Torben Struve

Institut für Thermodynamik, TU Braunschweig

t.struve@tu-braunschweig.de

The use of hydrogen has the potential to reduce greenhouse gas emissions in the transport sector. Advantages can be exploited especially in heavy duty applications. One possibility is the use of hydrogen in fuel cell trucks. In such vehicles the required hydrogen is usually stored in gas tanks under a high pressure of 700 bar. A stored mass of 80 kg hydrogen results in a range of about 1200 km for a fuel cell truck.

One challenge of a hydrogen-based mobility is the necessary infrastructure. Hydrogen refueling stations (HRS) enabling the high pressure in the vehicle tank are complex. At HRS hydrogen is usually compressed by a compressor and stored under high pressure in so-called buffer banks. The refueling process is driven by the pressure difference between the buffer banks and the vehicle tank.

HRS and especially the configuration of the compressor and the buffer banks must be designed in an optimal way to ensure profitability. HRS should be designed in a way that satisfies the wish for low investment and operating costs while meeting certain requirements regarding the refueling.

In my work the approach of a software-based determination of optimized HRS for fuel cell trucks was applied. For that it was examined whether and how an optimal design of a HRS considering constraints can be achieved by using numerical optimization methods. To decide whether the configuration of a HRS is optimal a description of the quality of the HRS is necessary. For that a so-called cost function depicting the life cycle costs of a HRS in a simplified way was developed. Optimization algorithms from *SciPy* were used to minimize the cost function by changing different parameters of the HRS. The chosen optimization parameters were the compressor size and the pressure levels as well as the volumes of the buffer banks. Furthermore, the number of buffer banks was varied. For evaluating the cost function in an optimization step a simulation of the HRS in its current configuration is necessary. For that an existing model of a HRS was connected to the optimization algorithm.

Results of the optimizations show that it is possible to determine optimized HRS using numerical optimization methods, but with restrictions. Simplifications must be made. Derivative-free optimization algorithms are best suited for these optimization problems. Regarding the configurations, different statements can be made. The size of the compressor should always be chosen as small as possible due to high investment costs. This also influences the dimensions of the buffer banks as the results show configurations that make it possible for the compressor to be chosen small. In this context, the operation strategy for emptying and refilling the buffer banks has a huge impact. Regarding the buffer banks, results and literature research indicate that the simplification of the same volume for all banks regardless of the pressure level can be made without major incline in costs. All in all, the optimization of HRS using suitable optimization algorithms and appropriate simplifications is possible and can accelerate the development of future refueling stations.

Picture of Author	Short Biography of Author
	• 10/2021 – 12/2021: internship at IAV GmbH (Gifhorn) – development and testing of a model library for simulating hydrogen applications • Since 10/2018: mechanical engineering student at TU Braunschweig, focus area: energy and process engineering; bachelor thesis: Determination of optimized hydrogen refueling stations using numerical optimization methods