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Design and performance simulation of coupled electrolyzer-metal hydride hydrogen compressor system as a part of hydrogen refueling station

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Abstract

Metal hydrides have shown to play an important role in the "hydrogen economy" infrastructure for various applications including hydrogen/thermal energy storage systems, hydrogen compression, etc. [1].

The deployment of hydrogen-powered electric vehicles is hampered by many challenges including on-board hydrogen storage and hydrogen refueling. As an example, hydrogen refueling stations (HRS) stand as the most complex system in the hydrogen infrastructure pathway. An HRS comprises of two main components: a hydrogen production and a hydrogen compression device to provide hydrogen to end-users at high pressure [2]. Although there are many hydrogen production methods, hydrogen production via water electrolysis is the most promising option. However, water electrolysis becomes cost-effective only if high-grade energy (electricity) is provided by an excess, renewable and free source (Solar PV, wind turbine). On the other side, the hydrogen compression is also a conundrum in HRS design and implementation. The use of available mechanical compressors makes the HRS cost-prohibitive since they account for more than 40 % of the total installed cost [3]. To alleviate this hurdle, an interest to thermally driven metal hydride hydrogen compression (MHHC) has dramatically risen. This was due to simplicity in design and operation, safety and reliability, and a possibility to use low to medium-grade waste heat, instead of electricity, for hydrogen compression [4].

In this work, we develop and validate a computational model under Mathlab-Simulink environment, describing the transient behavior of an HRS for fuel cell utility vehicles. A specific system (as shown in Figure 1), which consists of a PEM electrolyzer (2 stacks @ 8.6 kW) producing 2Nm^3/h (~179g/h) of hydrogen coupled with a 3-stages metal hydride hydrogen compressor (MHHC) with a productivity up to 5Nm^3/h, is analyzed and discussed in detail. The MHHC is driven by two thermal sources where the heat transfer fluid (HTF) temperature ranges from 120-150 °C and 15-25 °C for hot (steam) and cold (water) sources, respectively [2]. The key parameters of the model will be calibrated with the experimental data extracted from the separate experimental tests of the components. Also, using a parametric study, the

effects of varying the operation conditions of each component on the performance of the system as a whole are examined.

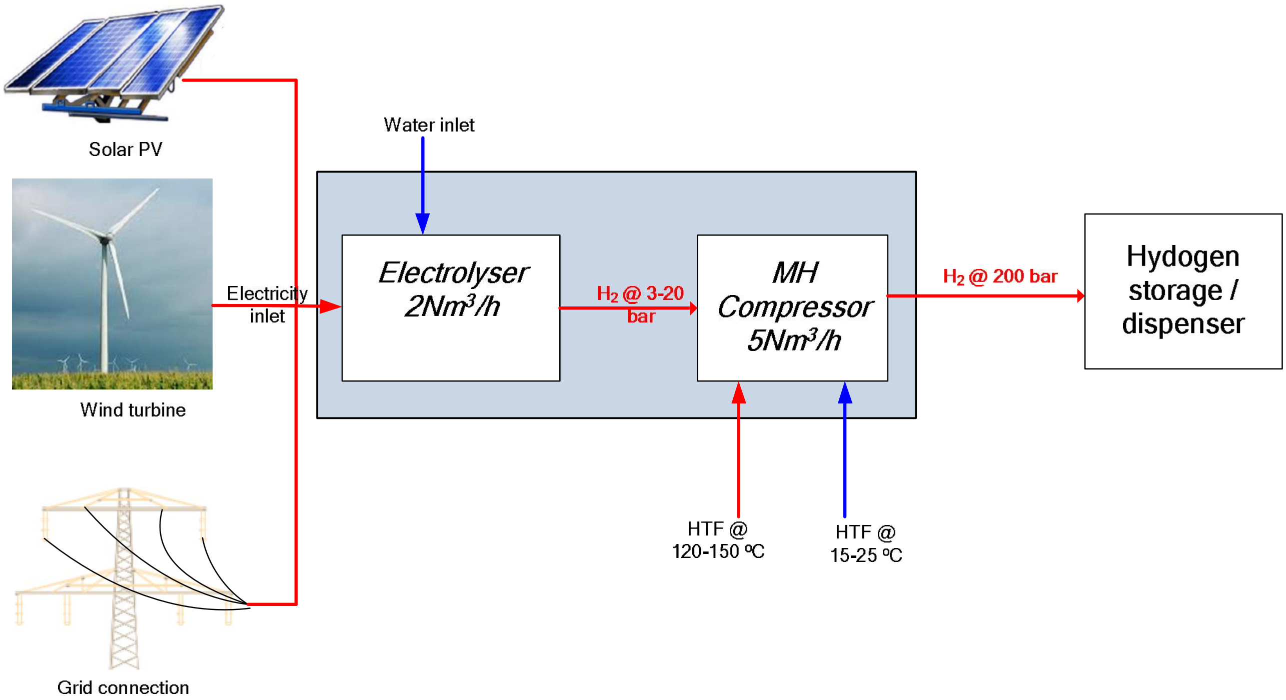

Figure 1. Layout of the modeled system comprising a PEM electrolyzer and a MHHC

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References

[1] J. Bellosta von Colbe, et al. "Application of hydrides in hydrogen storage and compression: Achievements, outlook and perspectives", Int. J. Hydrogen Energy, 44, 2019, 7780

[2] M. Lototskyy, et al. "Hydrogen refuelling station with integrated metal hydride compressor: Layout features and experience of three-year operation", Int. J. Hydrogen Energy, in press; https://doi.org/10.1016/j.ijhydene.2019.05.133

[3] E. Stamatakis, et al. "Metal hydride hydrogen compressors: current developments and early markets" Renew. Energy, 127, 2018, 850

[4] M.V. Lototskyy, et al. "Metal hydride hydrogen compressors: a review", Int. J. Hydrogen Energy, 39, 2014, 5818