A dynamic 1D+1D physical model of the PEMFC hydrogen stack for embedded systems

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Fuel cell technologies are rapidly developing in recent years to decarbonize heavy transports with the use of hydrogen[1]. However, the automated control of these systems is generally based on dynamic 0D models that consider fuel stacks as black boxes, sacrificing accuracy for simplicity and short computation times[2]. Other models in the literature are generally 2D or 3D, which offer accuracy, but require a lot of computing time and power[3], and therefore cannot be used for embedded systems. Models based on artificial intelligence (AI) are also being developed, which offer a combination of accuracy and speed, but are ineffective when it comes to extrapolating operating conditions that are too different from those for which they were trained[4], which bring risk.

To address this issue, the team proposes a dynamic 1D+1D model which consists of two dynamic 1D modules in two different spatial directions. The first one analyses the evolution of matter in the stack by considering its thickness only. The second module then examines the matter's behaviour along the bipolar plate's channel only. Combining the two modules gives a 1D+1D model which offers a good compromise between time, computational power, scientific complexity, and accuracy. This is ideal for embedded systems.

The model's validation is also essential. In the current literature, most models are considered valid when they give results consistent with the experimental data of a single polarisation curve. However, this procedure is not sufficient since it is necessary to adjust some model parameters to the real system. Thus, at least a second comparison with different experimental data, after this adjustment and on the same stack, should be added to ensure the validity of the model[5].

Finally, a two-step experimental validation has been successfully performed for the 1D module in the thickness direction, and the 1D+1D model is currently in construction.

References:
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