Maximum Power Targeting for the PEM Fuel Cell using an NMPC Framework

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Fuel cells are part of the most promising environmentally friendly and benign technologies that has attracted the attention of both industrial and basic research in the recent years. Due to material limitations, the power of the fuel cell cannot be arbitrary used without prior consideration on the internal effects such as the condition of the membrane (humidity), the provision for fuel and oxidant supply, temperature gradients and so forth. The choice of the operating region leads to different characteristics for the unit regarding its profitability, effectiveness and safety.
An integrated framework that consists of an online maximum power point prediction and a non-linear model based control scheme that aims the previously calculated target, is presented using a nonlinear dynamic fuel cell model. The model is constructed and validated using experimental data based on a specific application, consisting of a high temperature PEM Fuel Cell (FC) working at a constant pressure and a Power Conversion Device capable of controlling the current drawn from the FC. An online optimization with weighted objective functions of power targeting and oxidant excess ratio was used in order to calculate the optimum value of the current density, which is the manipulated variable. Taking into account the measurements that derive from the application of the manipulated variable on the unit the model is adjusted through parameter estimation of activation and concentration losses and a new maximum power point is calculated and sent to the NMP controller.
Although such a scheme may seem quite complicated, however it guarantees that the PEMFC performs within its operating objectives. The performance of the model-based control scheme that was applied outperformed any linear scheme. Mathematical simulation results showed significant improvement in the handling of an important control problem that will lead to more efficient use of fuel cell systems.

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