Models fitting of metal hydride tank based on experimental data

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1. Introduction

Recently, in order to solve the problem of hydrogen storage, researchers have investigated numerous methods of storing hydrogen, one of which is metal hydride hydrogen storage. A number of mathematical models have been developed for metal hydride (MH) storage tanks to analyze the heat and mass transfer during the process of charge and discharge [1-2]. However, it is worth mentioning that in all models, different parameters are included, the values of which vary under different operating conditions and can therefore be considered unknown. To make the established models realistically reflect the dynamic characteristics of MH tanks, the unknown parameters contained in the models must be identified, i.e., model fitting is required.

2. Model fitting methods

The method for fitting the model of the MH tank under different operating conditions based on experimental data proposed in this paper is shown in **Figure 1**. In contrast to the existing model fitting methods in the literature [3-4], the proposed method does not require the acquisition of pressure-composition-temperature (PCT) curve data for the metal inside the MH tank and is suitable for the case where the developed model does not match the experimental data. Specifically:

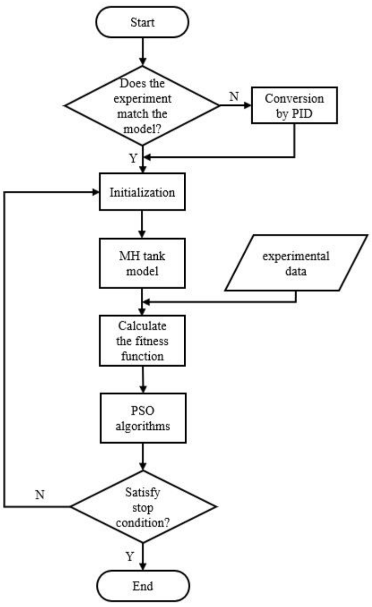

Figure 1. Model fitting method

- This paper adopts a simplified two-dimensional MH tank mathematical model. In the absence of PCT measurement equipment, the mass flow rate of hydrogen $f_{\text{in,exp}}$, the pressure P_{exp} inside the tank, and the temperature T_{exp} during charge and discharge are measured by sensors. In this simplified model, temperature is used as a known variable and is not coupled with other parameters, the mass flow rate $f_{\text{in,exp}}$ is used as input to the model, while the output of the model is pressure P_{model}. Subsequently, the fitness function $F(P_{\text{model}}, P_{\text{exp}})$ is computed based on the model output P_{model} and the experimental data P_{exp}. The Particle Swarm Optimization (PSO) algorithm is then executed to minimize the fitness function until the predetermined stop condition of the PSO algorithm is satisfied. The optimized position of the particle represents the identified unknown parameter. The above processes are implemented in MATLAB Simulink.
- In the simplified two-dimensional MH tank mathematical model, the mass flow rate $f_{\text{in,exp}}$ is the model input and the pressure P_{exp} is the model output. However, in experimental operations, to ensure safety and the pressure inside the tank does not exceed the limit pressure of the MH tank, the pressure at the entrance of the MH tank is usually changed by adjusting the manometer, and the pressure is used as the control input. The model output at this moment is mass flow rate, resulting in a mismatch between the experimental input and output and the model.

Due to the model's complexity and the strong coupling between pressure and other parameters, inverting the mass flow rate by pressure is challenging in this case. As a result, using the model pressure and the experimental pressure to design the fitness function is no longer appropriate. Based on this, in order to avoid large changes to the existing model, this paper converts the input and output of the model through the PID technique, converting the output of the original model, i.e., pressure, into mass flow rate, and designs a new fitness function, i.e., $H(f_{\text{in,model}}, f_{\text{in,exp}})$. The diagram for the conversion of the model inputs and outputs via the PID technique is shown in **Figure 2**.

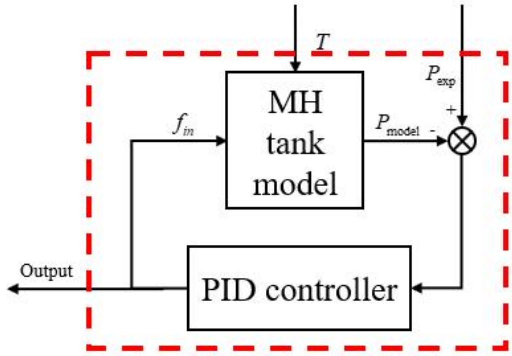

Figure 2. Conversion of model input and output

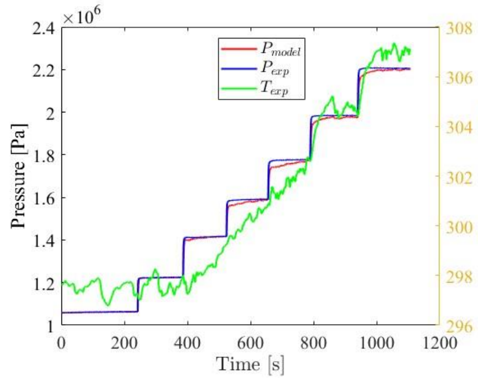

Figure 3. Experimental temperature, pressure and model pressure

3. Experimental results

The experimental temperature T_{exp}, pressure P_{exp} and model pressure P_{model} are shown in **Figure 3.** The result of the model fitting is shown in **Figure 4**. The result shows that the output of the converted model is generally consistent with the experimental data, which validates the effectiveness of the proposed method.

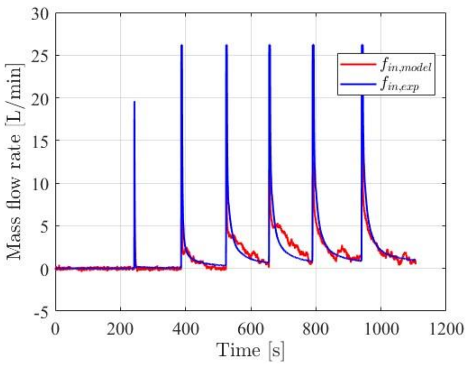

Figure 4. Comparison of model mass flow rate with experimental data

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