MATLAB is used to train the ANFIS models in this work. Arbitrary precision can be achieved by increasing system. Linguistic variables and parameters which are trained using a neural network to mimic the behavior of a physical system. Accuracy can be achieved by increasing the complexity of the models. The ANFIS function in MATLAB is used to train the ANFIS models in this work.

Four ANFIS models, which uses the temperature of the reformer and the fuel flow as inputs, are trained on data acquired from laboratory tests. The reformer temperature and fuel flow used in the experiments sweeps the entire operating range of the reformer. The output of the four ANFIS models are:

- $\theta_{\text{CO}}$ — The carbon monoxide mass flow
- $\theta_{\text{H2},\text{fuel}}$ — The methanol slip mass flow
- $\theta_{\text{H2}}$ — The hydrogen mass flow
- $\theta_{\text{CO2}}$ — The carbon dioxide mass flow

Figure 3 shows the inputs used in the experiments as well as the measured CO mass flow and that predicted by the ANFIS model.

The data from the experiments is very noisy but the ANFIS training handles the noise well and the output of the ANFIS system follows the mean value of the test data.

The temperature controller $G_{\text{CC}}$ is a PI controller, with the output saturated at $250$ [A] for the analyzed system. The system is used as a battery charger and the fuel cell current can therefore be different desirable over a long time period. A fuel flow controller is therefore implemented as an outer control loop, which changes the fuel flow to make the correction current go to zero. Figure 5 shows the reformer temperature, fuel cell stoichiometry and correction current during a step change in the reformer temperature.

The temperature controller $G_{\text{CC}}$ consists of only an integral part, is therefore implemented as an outer control loop, which changes the fuel flow to make the correction current go to zero. Figure 6 shows the same temperature step, but with dynamic correction current saturation. The rise time is slower, but the stoichiometry is kept above 1.2 as desired.

The fuel flow controller slowly adjusts the pump flow until the desired output current is achieved with the smallest possible fuel flow for the system. This is the case when the correction current is equal to zero.

Future Work

Future work will include implementing and testing the CCTC method. The controller will include the developed ANFIS model to be used as a hydrogen mass flow predictor. The future test setup will be based on the mobile battery charger, H3-350, manufactured by Serenergy®. The battery charger, seen in Figure 7, has an integrated fuel processing unit and accepts external control of the system.