USER STORY

Plug Power Accelerates Fuel Cell Control Development

To meet their objective of putting future power generation to work, Plug Power Inc. designs and develops onsite energy systems based on fuel cells. They use MathWorks tools to enhance product performance, reduce costs, and improve manufacturing and integration processes.

"These systems need to be reliable and efficient," explains Rebecca Dinan, controls engineer for Plug Power. "We accomplish this by using MathWorks tools to rapidly develop and simulate our control algorithms before trying them on a system."

THE CHALLENGE

To create a reliable and cost-effective product while shortening time to market, Plug Power must accurately model fuel cell systems and rapidly test new or improved algorithms before implementing them on hardware.

For optimal performance, the power generation module (including the fuel cells) and reformate processing module are run within strict temperature ranges, creating further control design challenges. As Dinan explains, "A change in electric power demand creates a huge disturbance on the system. We need to automate the control of the entire system."

These automated control algorithms must provide the same level of performance with less input, enabling the company to lower costs by reducing the number of sensors in the control system.

Plug Power fuel cell system.

THE SOLUTION

Plug Power uses MATLAB® and Simulink® to develop and test algorithms, simulate components and systems, and streamline the development process from idea to implementation.

In a recent project, Dinan developed a control algorithm to maintain a consistent catalyst temperature by manipulating an air blower. She first moved the blower manually in the lab to determine how the blower affects temperature in the real world.

Dinan then used MATLAB to analyze the data and perform system identification. "I fed the data in and used MATLAB to determine all open-loop transfer function parameters, such as gain, time delay, and the time constant," explains Dinan.

Using these parameters, she quickly developed a model incorporating a proportional integral derivative (PID) controller in Simulink. "The PID controller is given a setpoint and uses the air blower to regulate the temperature to setpoint—somewhat like cruise control in your car," Dinan explains. "I used a PID block in Simulink to accomplish this. It's simple and right there for me to use."

THE CHALLENGE

To shorten time to market and reduce operational costs in fuel cell control development

THE SOLUTION

Use MathWorks tools to model systems and rapidly test new algorithms through simulation

THE RESULTS

- Shorter development time
- Increased process efficiency
- Reduced operating expenses

> *We don't have time to investigate our algorithms with C or C++. Fortunately, MATLAB lets us test out our ideas with just a few lines of code. It saves a lot of time, and moves us toward our goal of creating a commercially viable onsite energy system.*
>
> Rebecca Dinan, Plug Power

When the dynamics of the system require a more complex strategy, Dinan tunes a model predictive controller with the Control System Toolbox and the Neural Network Toolbox.

The Neural Network Toolbox enabled Dinan to also create a model that predicts the power demand placed on the fuel cell system. The model is based on a large volume of historical electric load data.

"The Neural Network Toolbox allowed for fast data analysis, model creation, and validation," says Dinan.

Using a single line of MATLAB code, Dinan then created three-dimensional plots to analyze various aspects of the system, such as the signal-to-noise ratio.

After making adjustments to the controls, Dinan forwarded the pretested algorithms to the embedded software engineers for easy implementation.

A GUI developed with MATLAB will enable Plug Power to further accelerate control system development by simulating the effects of blower positioning.

Another group at Plug Power is accelerating control design by using Simulink to create a complete model of a next-generation fuel cell system. They are currently validating their Simulink system models with the physical system.

THE RESULTS

- **Shorter development time.** Using MathWorks tools, Plug Power reduced algorithm development time by weeks. "With MATLAB, it took me less than a week to develop a pattern recognition algorithm and obtain the desired results. In C++, it would have taken more than a month to code all the matrix math to accomplish the same thing," says Dinan.
- **Increased process efficiency.** MathWorks tools enable controls engineers to design and validate control algorithms quickly. "When I develop an algorithm in MATLAB, I am more confident that it will work in the system and that I will not have to go back to the software developers with a change later on," Dinan reports.
- **Reduced operating expenses.** Dinan notes, "MathWorks tools help us save operation expenses and reduce aging on system components. We can simulate our ideas, find errors or inefficiencies, and correct them before testing the algorithm on the system. In other words, MathWorks tools help us take preventative action." Plug Power has also reduced the number of parts, including sensors, in their next-generation system by 50%.

To learn more about Plug Power, visit **www.plugpower.com**

APPLICATION AREAS

- Control design
- Data analysis
- Industrial equipment and machinery
- Utilities and energy

PRODUCTS USED

- MATLAB
- Simulink
- Control System Toolbox
- Neural Network Toolbox

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