Simulation à la carte

Model-based development boosts efficiency in the food service industry

You're sitting in your favorite restaurant and looking forward to your meal. Will it live up to your expectations? The answer depends on numerous factors, not least on the equipment that stores, prepares and dispenses your food. Manitowoc, a leading supplier of food service equipment, has decided to use model-based development and hardware-in-the-loop (HIL) testing to ensure the high quality of its products.

Tough Demands on Food Service Technology

Manufacturers of food service equipment face many challenges, some of the greatest being short development cycles, quick prototyping to show proof of concept to the customer, and aggressive delivery and reliability targets. Fast, consistent food preparation, perfected cooking processes and standardized, patented recipes require modern control software and sophisticated process control, including the precise execution of time-triggered events and states. For example, there are specific frying instructions for each

Typical application fields for Manitowoc products: cook, chill, prep/serve, ice.

Example of a touch panel for operating an oven from Merrychef, a Manitowoc brand.

kind of meat, defining the timing and temperatures for different phases of the frying process and also for hot holding if required. As in any other sector, some of the most important requirements in the food service industry are precision, energy efficiency and fail-safe functioning.

High-Tech Product Portfolio

Manitowoc is a leading manufacturer and vendor of professional food service equipment. The company's product range includes primary cooking equipment, refrigeration & ice machines, serving equipment and beverage dispensers. Manitowoc works incessantly to enhance its high-tech product portfolio with the help of electronic controls and extensive control software. For the systems to succeed in the kitchen, handling them has to be easy and problem-free.

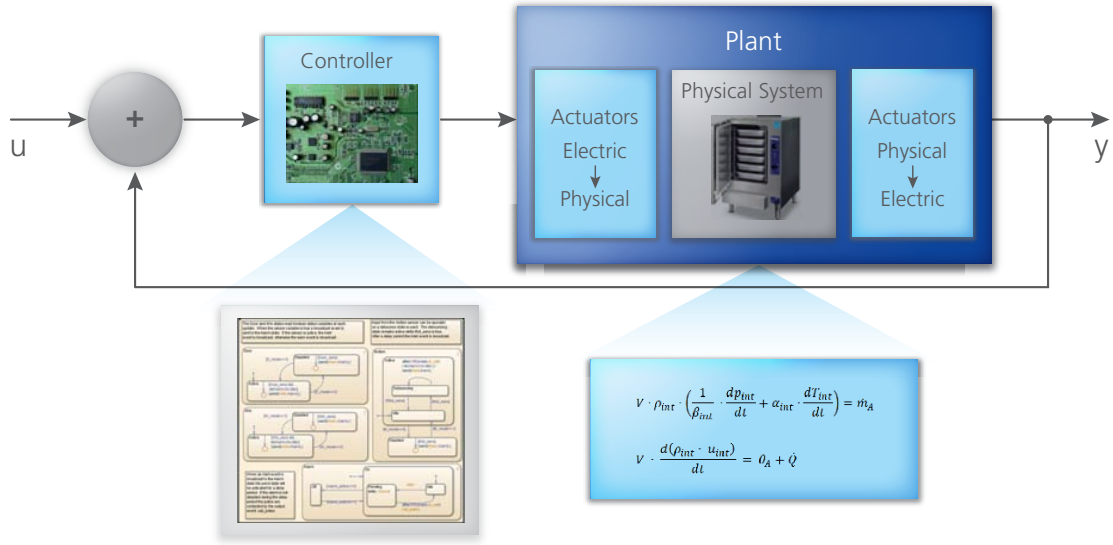
A Broad Range of Electrical Components

A variety of sensors and interfaces with touch panels, AC relays and coil drivers, motors and switches are just a few of the electrical devices in food service equipment. They all communicate more or less directly with sophisticated embedded electronic controls. The result is a complex electrical/electronic (E/E) system whose functionality has to be validated.

The Challenge of Software Quality

Food service equipment particularly requires software for the electronic control units and user inter-

The principle of hardware-in-the-loop (HIL) simulation: The equipment is represented by mathematical models. Actuators and sensors are also virtualized.



Beverage dispenser, Frymaster Cobra Fryer and Convotherm Oven-P4: These products are tested on the dSPACE Simulator.

faces that regulate their internal processes, for example, in heating elements and valves. And if there are any problems or errors in the user interface, there is a risk they will impact negatively on food preparation, giving restaurant guests an unpleasant culinary experience.
A high-quality user interface module is therefore essential. Maintaining consistently high software quality across such a wide product portfolio is a major challenge for Manitowoc. This is where development approaches used in other industries such as the automobile and commercial vehicle sector can help, as the food service sector is confronted with similar tasks.
Suitable methods and processes are crucial, together with a tool chain that ensures efficient software development.

Model-Based Development Methods

As food service equipment grows ever more complex, the manual methods used up to now no longer suffice to develop and validate its functionality. So Manitowoc took the bold step of becoming the first manufacturer in the food service equipment industry to adopt model-based testing. The aim is to redefine how products are developed in order to achieve a significant competitive advantage.
With this objective in mind, Manitowoc contacted dSPACE, who partnered us in introducing model-based development. The following requirements were defined:

- Develop generic models for Manitowoc's broad product portfolio
- Reuse the test system across all the strategic controller platforms
- Develop generic test cases and harmonize our tool chain across all of our operating companies
- Simulate the physical behavior of loads and test with the controllers which are still under development
- Develop stress test cases to simulate the failures found in field tests and validate the diagnostic codes

Why HIL Simulation?

When Manitowoc's engineers compared the company's requirements with dSPACE's products and services, it became clear that hardware-in-the-loop (HIL) systems from dSPACE can play a major role in fulfilling the quality standards. For the first time ever, HIL simulation enabled the developers to virtualize the real environment such as the heating elements. This means important electronics tests can be performed

"To switch to using model-based development, we needed a hardware test platform that supports future extensions. dSPACE's reconfigurable and extensible platforms were perfect for integrating all our requirements."

Pedro Zayas, Senior Engineer,
responsible for Hardware-in-the-Loop Tests and
Rapid Control Prototyping at Manitowoc Foodservice

"Testing food service equipment requires systems like the dSPACE Simulator with its enormous flexibility in handling different types of signals and communication protocols."

Jake Blake, System Engineer, responsible for Hardware-in-the-Loop Tests and Automation at Manitowoc Foodservice

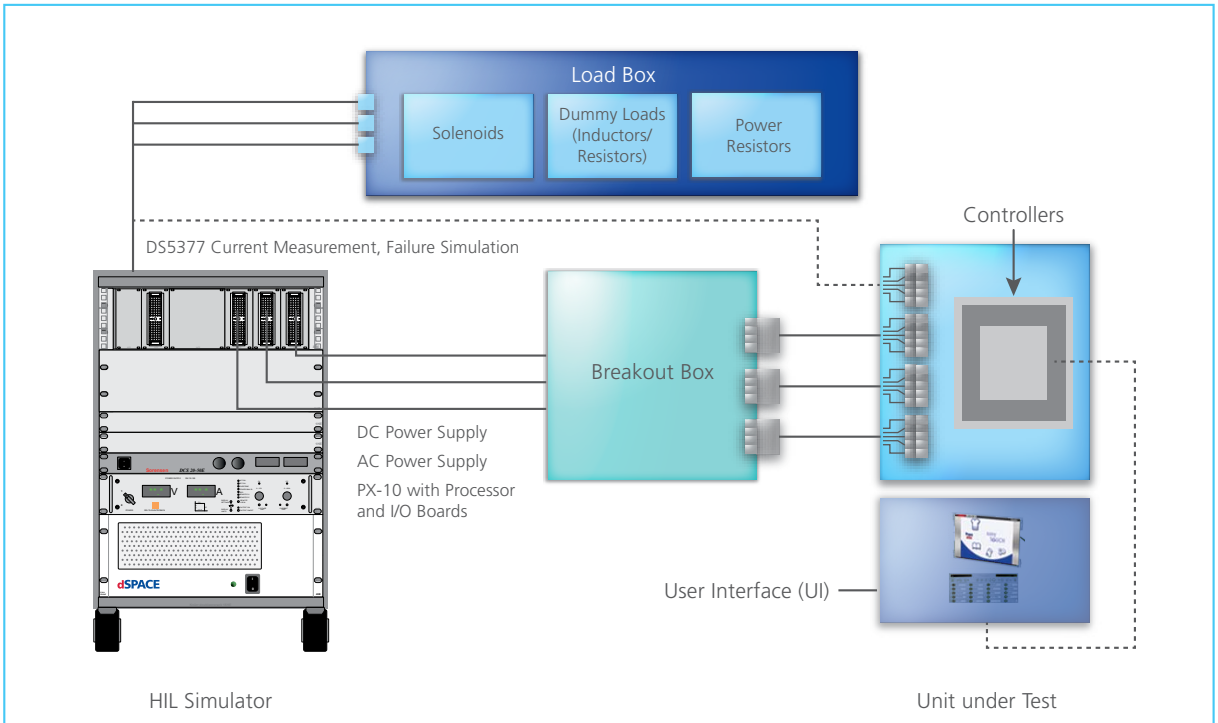
much earlier in the software development process, even before the actual heating element is available to developers. It is anticipated that this will lead to a lower failure rate in everyday use, higher product reliability, and greater customer satisfaction. It was therefore decided to use a dSPACE Simulator. In terms of development methods, it provides the ideal conditions for a strictly model-based approach to all development issues. The system was first used in development projects for ovens, fryers and a drink dispenser.

Concept of the HIL Test System

Manitowoc needed a flexible HIL system for hardware tests which meets the I/O and load requirements of the entire product range – from ovens, grills, fryers, and smoothie machines to drink dispensers and refrigeration systems. The different I/O and interface boards in dSPACE's versatile product portfolio provided excellent solutions for the resulting mix of I/O and interface boards.

For Manitowoc it was important to continue using an internally developed test automation platform (TAP) as the central entity for auto-

Test bench concept: HIL simulator (left), break-out box (center) and the unit under test (UUT) with its user interface (right). The substitute loads for performance tests are housed externally in a load enclosure.



mated product testing. dSPACE offered a simulator API that provided a generic architecture for this, allowing developers to integrate the HIL simulator seamlessly into the TAP. Manitowoc's global company structure means that test developers all over the world work together, and now they can access the generic dSPACE test bench architecture to test different products. The entire test system is housed in a movable rack. The controllers under test are connected via a break-out box. Substitute loads are available for integrating power stages into the tests if required.

The Simulator Goes Live

The HIL simulator was put into operation in Manitowoc's development labs and completely integrated into the existing test automation platform. The system appeared very mature and has convenient handling options. The simulator definitely meets the requirements to run systematic tests, analyze targeted errors, and use regression testing to verify whether the errors were successfully remedied.
In the meantime, practical experience has been gained in three development projects and the approach can be compared with previous test methods.
The results exceeded expectations: Testing time was reduced by 80%, yet engineers achieved several times the test coverage – even though they are far from using the simulator's full potential.
Tools such as the Stimulus Editor and the Failure Insertion Unit (FIU) already brought numerous improvements.

How Testing Benefits

When creating and executing tests, testers have the following decisive advantages over the previous approach:

- Time savings: Test execution takes only a fraction of the time it needed previously, helping to meet the requirement for short product development cycles.
- Time-synchronous testing: Time-critical tests are easy to implement and monitor.
- Easy regression testing: Repeated test runs and software updates can be performed quickly and at lower cost.

These advantages put developers in the happy position of being able to perform more comprehensive and more targeted testing.
And because this can even be done in a fraction of the time, there is new potential for extending the scope of tests and expanding the test architecture and processes.

"With this ground-breaking technology, our reliability tests have the same quality standard as the automotive and aerospace industries. Model-based development is opening up a new era for the food service industry. It would not have been possible to introduce model-based design tools and short development cycles without a committed partner like dSPACE."

Vikram Verma, Manitowoc



From left to right: System Engineer Jake Blake uses dSPACE ControlDesk to configure the Convotherm HIL test bench.
Pedro Zayas and Vikram Verma check the signals on the Convotherm HIL test bench.
Monitoring the signals for oven control with ControlDesk.
Jake Blake, Pedro Zayas, Vikram Verma, Paul Touchette. (from left to right)

"The dSPACE tool chain enabled us to implement our strategic visions for electronic control systems by using model-based development and hardware-in-the-loop simulation."

Paul Touchette, Director of Engineering, Manitowoc Foodservices, Center of Advanced Electronic Control

Results and Conclusion

Consolidated results and experience from the three completed development projects performed with model-based development and HIL testing are now available. Moreover, the equipment has passed the acid test of real-world use in professional kitchens. The results can be summed up as follows:

Greater competitive advantage and higher reliability:

By using the HIL system, Manitowoc was able to test the electronic control units much faster than we had been with any manual test, and even improved test coverage. This cut the time to market and further reduced the failure rate in the kitchen.

Cost savings:

Instead of writing product-specific tests, test teams now employ dSPACE hardware to create adaptive platforms that can be used across as many different Manitowoc products as possible.
The quick, efficient tests halved the cost of testing. The HIL systems also greatly reduce guarantee costs,

The Manitowoc Group

Manitowoc was founded in the lakeshore community of Manitowoc (Lake Michigan), Wisconsin, as a shipbuilding and ship-repair company. Since that time, the company has grown and diversified, entering the lattice-boom crane business in the mid-1920s and branching into commercial refrigeration equipment in the late 1940s.
Today, the company is comprised of two segments – cranes and food service equipment. Manitowoc is one of the world's largest manufacturers of commercial food service equipment, with a portfolio covering cooking, refrigerating, prepping, ice making, dispensing, holding, merchandising, and warewashing. Its products have been awarded numerous prizes for quality and energy efficiency. These are some of its brands:
Cleveland Range, Convotherm, Dean, Delfield, Frymaster, Garland Commercial Ranges, Lincoln Impingers, Merco, Merrychef, Moorwood Vulcan, Delfield, Harford, Kolpak, Kysor Panel Systems, Manitowoc Ice, Manitowoc Beverage Systems, McCall.

Manitowoc
BUILD SOMETHING REAL

because far fewer faults occur in daily use.

Pioneering role:
Manitowoc is playing a pioneering role in using HIL systems to develop food service equipment. The systems can be extended, and functions can be added by integrating the hardware components of other vendors. This opens up completely new possibilities.

Synergy effects:
At the lowest development level, automated regression testing can be used not only for food service equipment, but also in Manitowoc's other business field, the development of cranes. This is the perfect scenario for achieving synergies in Manitowoc's research and development processes. ■

Vikram Verma,
Manitowoc

Video:
Manitowoc products in action in Munich's famous Hofbräuhaus.
http://www.youtube.com/watch?v=4JtQvPhS9jQ&sns=em

Summary

Manufacturers of food service equipment are increasingly using embedded control electronics and multi-option graphical user interfaces, and developing extensive software for them. The US-based global company Manitowoc is using model-based development and hardware-in-the-loop (HIL) simulation to make development and testing more efficient. Manitowoc worked with dSPACE to create a completely model-based development approach to developing food service equipment. New processes and tool chains are boosting both efficiency and software quality. Testing has particularly benefited, from early testing (frontloading) and increased test depth providing significant improvements compared with the previous manual methods. Manitowoc is using the dSPACE Simulator to reduce time to market and improve the reliability of the food service equipment.

Vikram Verma
Vikram Verma is Engineering Manager and Lead Architect for HIL Testing, Rapid Control Prototyping and Model-Based Design at Manitowoc Foodservice, in New Port Richey, FL, USA.