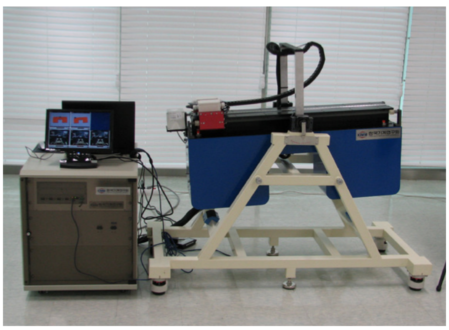
KIMM Develops Prototype Maglev-Based Antirolling System for Mobile Harbors



KIMM's prototype maglev-based antirolling system for mobile harbors.

The Challenge

Build a prototype antirolling system for stabilizing mobile harbors

The Solution

Use Model-Based Design to design and simulate the controller, prototype hardware, and generate real-time control code

The Results

- Development time reduced by 70%
- $20,000 or more in potential prototyping costs saved
- Confidence in design performance increased

Korea is investigating the feasibility of mobile harbors: platforms that enable the unloading of container ships near cities that do not have deep-water ports. The challenge is to stabilize the platform in ocean waves so that containers can be unloaded safely and quickly.

Researchers at the Korea Institute of Machinery and Materials (KIMM) developed a small-scale prototype of an antirolling system to evaluate the feasibility of using maglev and active mass driver (AMD) technology to stabilize mobile harbors. The system slides a mass side to side to counteract the force of the waves. Researchers designed and implemented the prototype's controller using Model-Based Design.

"Using Model-Based Design, we optimized the design and accurately predicted how it would perform," says Cheol Hoon Park, senior researcher at KIMM. "After simulating the controller model, we moved directly to hardware implementation, confident that we had the best design."

The Challenge

KIMM researchers needed to evaluate the antirolling system for a catamaran-based mobile harbor platform. The system required two complementary controllers. The first manages the gap between the magnets and the rail in the maglev subsystem, taking input from a gap sensor and sending control signals to the maglev current driver. The second positions the mass, taking input from tilt and mass position sensors and sending control signals to a linear drive motor.

KIMM projects typically take one to three years, but the antirolling system had to be completed in just three months. "With the aggressive schedule, we had time for only one prototype, so the design had to be right the first time," says Park. "Also, there was no time to integrate disparate modeling and simulation tools for the controller and the physical system."

The Solution

KIMM used MATLAB®, Simulink®, and several other products to design, simulate, and implement real-time controllers for the antirolling system and demonstrate a working prototype.

Park converted a SolidWorks assembly of the mobile harbor platform into a SimMechanics™ model comprising a one-meter-wide cross-section of a scaled-down version of the catamaran. Park used SimMechanics to model the AMD system.

Simulations of the AMD system model enabled Park to determine how much mass would be needed to counteract the catamaran's motion.

Park developed Simulink models of the maglev and AMD controllers. He then performed closed-loop simulations using the catamaran model to verify the functionality of the control algorithms.

Using Simulink Design Optimization™ and Optimization Toolbox™, Park tuned design parameters, including the speed of the AMD and the size of the linear motor, to improve system performance.

> *"We completed the prototype in just three months with Model-Based Design. We saved months of development time by using an integrated environment to model the controller and the physical system, simulate them together, generate code, and create a real-time hardware prototype that worked flawlessly."*
>
> —Cheol Hoon Park, Korea Institute of Machinery and Materials

"Simulations in Simulink and SimMechanics showed that the mass didn't need to move as quickly as I had thought, so I revised the specification for the linear motor," says Park.

Park used a simulation of the optimized design to show managers and stakeholders at KIMM how the system would perform before it was implemented in hardware.

He used Simulink Coder™ to generate C code from the Simulink controller models. He executed the code in real time using xPC Target™, which ran on a PC/104 computer with an I/O board providing the analog-to-digital and digital-to-analog interface to the prototype catamaran hardware.

Initial experiments showed that the controller for the AMD worked flawlessly. The controller for the maglev required minor adjustments to the gain. After this tuning was complete, the prototype controller successfully stabilized the 118 kg catamaran cross-section using a 4.1 kg mass in about 5 seconds.

Experiments with the prototype showed that it would be difficult to generate enough power to drive the mass required on the planned mobile harbor. However, KIMM researchers also learned that the stabilizing technology worked, opening opportunities to commercialize it for smaller vessels, such as yachts and cranes, and for bipedal walking robots.

The Results

Development time reduced by 70%. "Without Model-Based Design it would have taken 10 months or more to develop the controller and hardware prototype," says Park. "By simulating and optimizing the system and generating code from the controller model, we completed the project in less than three months."

$20,000 or more in potential prototyping costs saved. "Typically, significant modifications to the prototype are needed during development," notes Park. "For this project, the performance of the actual hardware matched the simulation results from our Simulink model of the maglev system, so we did not need to modify our test system. Eliminating multiple prototypes saves time and—when the prototype costs $20,000 to $30,000, as it did for this project—reduces costs significantly."

Confidence in design performance increased. "The results of the simulation were within about 10% of the actual performance of the system," says Park. "This level of accuracy was impressive, and it gives us a great deal of confidence that our designs, once verified in Simulink, will work as intended."

Industry

- Industrial automation and machinery

Application Areas

- System design and simulation
- Physical modeling
- Rapid prototyping
- Control systems

Products Used

- MATLAB®
- Simulink®
- Optimization Toolbox™
- SimMechanics™
- Simulink Coder™
- Simulink Design Optimization™
- xPC Target™

Learn More About KIMM

www.kimm.re.kr/english/index.php

MathWorks®
Accelerating the pace of engineering and science

mathworks.com

91942v00 06/11