# BINDER

## Rapid development of complex controls algorithms for environmental simulation chambers


speedgoat
real-time simulation and testing

BINDER

*BINDER shorten time to implement complex algorithms for climate chambers supporting cyclical temperature and alternating climate and temperature profile simulation by 80%.*

BINDER are the world's largest specialists in environmental simulation chambers for scientific and industrial laboratories. They aim to provide perfect simulation of biological, chemical and physical environmental influences for a variety of industries. The family owned company produces more than 22,000 units a year from their base in Tuttlingen, Germany.

## Rapid Control Prototyping

Previously the company used proportional-integral-derivative controller algorithms (PID) for their environmental chambers, but because of issues with nonlinearities and heavily coupled process variables, they needed to look for alternative, more effective controls approaches.

In order to develop the new algorithms quickly, BINDER realized that they needed to implement a Rapid Controller Prototyping (RCP) process, allowing them to run and test changed algorithms designed in Simulink on the controller hardware connected to climate chambers within seconds.


*The control panel of a BINDER environmental chamber*

## Physical modeling

The first challenge was to create a feasible model of an environmental simulation chamber. Physical modeling tools from MathWorks and Dymola from Dassault Systèmes were used to design a model of an environmental chamber.

The model was then validated using the Speedgoat Performance real-time target machine to log temperature readings from the real chamber, and compare them with the simulated results. The validation process was made easy by using a graphical comparison of simulated and measured results.

## Model Predictive Control

Once the chamber model had been validated the new control algorithms could be developed.

One of the algorithms chosen was model predictive control (MPC). This advanced algorithm uses a dynamic model to predict future system outputs, and can perform better than PID in systems with larger time delays or high-order dynamics.
After the algorithms were developed using the simulated chamber, they were then fine-tuned by running the controller model on a Performance real-time target machine from Speedgoat, controlling the real chamber.

Simulink Coder was used to automatically generate the code to run on the real-time target machine. The control relays for the chamber (heating, cooling, fan and compressor) were driven by the real-time target machine's digital outputs, and the chamber's resistance thermometers were measured using an external conditioning module fed into the analog inputs of the target machine.

The results from the simulation and measurement of the new algorithms were then compared with the previous algorithms.

## Achievements

Using model based control algorithms BINDER have achieved up to 30% better control performance. The tolerance range was reduced from 0.5°C to 0.1°C.

BINDER now have an effective process for quickly developing advanced control algorithms and tuning the controller parameters. Simulink models provide easy to understand documentation of the control algorithms

In the future the company is considering using MathWorks' Embedded Coder to easily transfer the control algorithms from Simulink model directly to the production target hardware.

## Speedgoat's value contribution

*"With our new rapid control prototyping process we can now complete trials of new control algorithms 80% faster than before" said Mr. Pfeiffer*

"Using automatic code generation results in fewer mistakes"

"Measurements can be easily recorded, and the results automatically compared in a few seconds"

"The simulation model and the simulation results can also be used for mechanical design improvements"

*Stephan Pfeiffer, Controls Engineer, BINDER*


*Running a new control algorithm on a Performance real-time target machine*


## BINDER GmbH

Tuttlingen, Germany

www.binder-world.com

**Speedgoat products used**

- Performance real-time target machine
- IO102 I/O module with analog and digital I/O
- External DIN-rail mountable temperature measurement modules, read by analog inputs of IO102

**MathWorks software used**

- MATLAB®
- Simulink®
- MATLAB Coder™
- Simulink Coder™
- Simulink Real-Time™

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