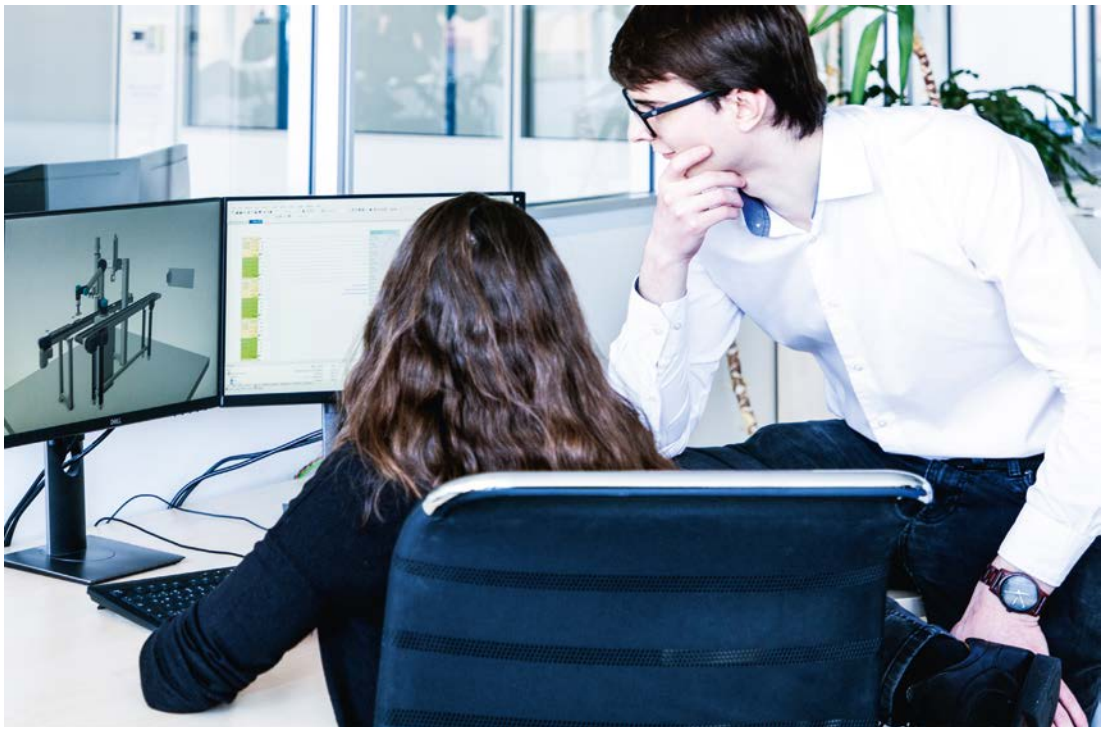
(Bild Sigmatek/123RF.com)

DANCE WITH THE DIGITAL TWIN

Build better machines faster with model-based design: Model-based design enables creation and simulation of a complete Digital Twin of a machine or system. Tests and optimization can be thereby performed, without having to wait for the actual hardware and mechanics. This helps to reduce development time, minimize the risk and eliminate reworking. It allows machine and system manufacturers to develop better machines faster and secure their market position.

by Ing. Peter Kemptner, x-technik



VIDEO

For machine builders model-based system development with the Digital Twin brings many significant benefits – such as minimizing risks during software creation and a shorter time-to-market. (All images unless otherwise stated: SIGMATEK)

Machine and equipment manufacturers are facing enormous and sometimes conflicting challenges. To survive in hard international competition, they must develop innovative machines and equipment with high efficiency and productivity. Their complexity is increasing, while the time for development and commissioning is continuously decreasing.

A Method Change in Machine Design

In the past, the mechanics were designed first, followed by the design and construction of the electrical technology and finally, the control programming. That has several disadvantages: The total duration is longer when the individual tasks are performed successively instead of being executable at the same time. Logical errors and misunderstandings often arise late in the overall design process. This makes their correction difficult and expensive.

Due to frequent delays in the previous development phases, programming is also often performed under enormous time pressure. Trouble, as is well known, always rolls downhill. In the process, programmers often have to guess the intentions behind the designs and compensate for inadequacies in the mechanics via software, which has very limited effectiveness.

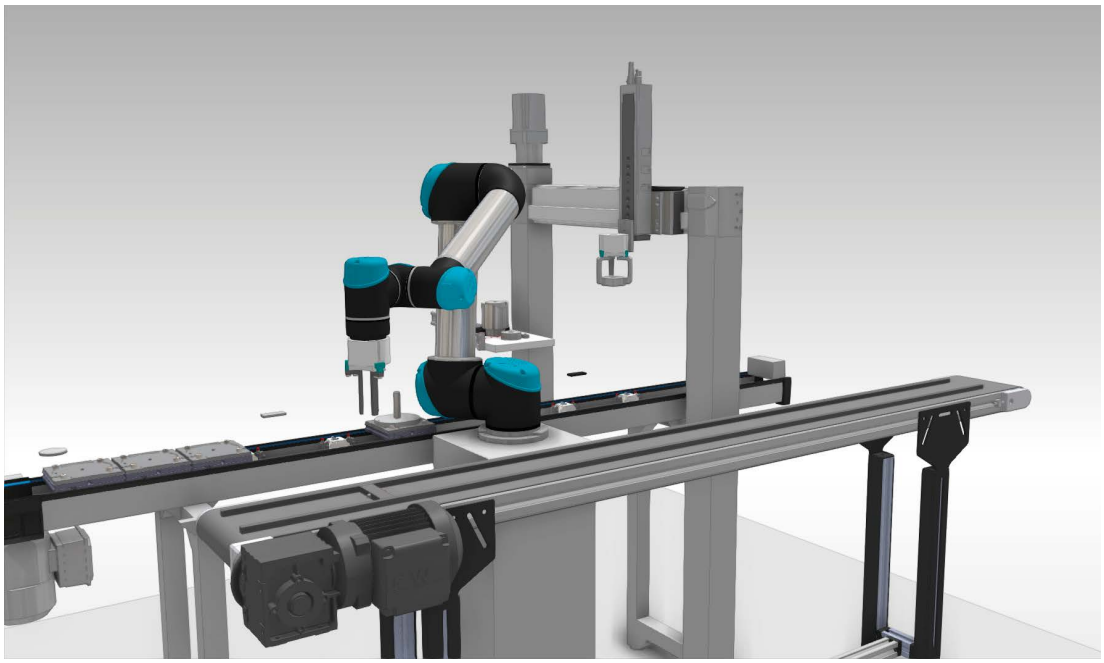
The key to success under these conditions is model-based design. Thereby, the Digital Twin of the machine or system is first designed and simulated. “This term is unfortunately used for many different things, so it's worth taking a look at the nature of the Digital Twin”, says Franz Aschl, Technology Management at the automation systems provider SIGMATEK. “This is not just the 3D-model of a machine or system, it also includes the various aspects of its function.”

Acceleration with Parallelism

This function model is nothing more than a more elaborately formulated requirement profile of the machine and system. Combined with the 3D-models of the mechanics, a complete Digital Twin can be created for the physics-based 3D-simulation using software products. >>

> The number of hours for actual development work remains about the same. Through the ability to work in parallel, instead of consecutively, the overall development time is shortened considerably.

Franz Aschl, Management Technology at Sigmatek GmbH & Co KG



In model-based design, the Digital Twin of the machine or system is first designed and simulated using software products for physics-based 3D-simulation. This allows comprehensive testing and optimization before completion of the mechanics and hardware. (Image: machineering)

This forms a valid basis for detailed software development, electrical planning and construction.

An essential advantage of model-based design using the Digital Twin is the option to parallelize, thereby accelerating development. Contrary to the previously common design process, the development in the various disciplines can – and must – begin at the same time, with the respective specialists contributing their part to the Digital Twin.

The Digital Twin helps to overcome the language barrier between the various technical disciplines. Via the plastic 3D-representation, it is easier for developers to coordinate their activities with one another, as well as consider the requirements and needs of the other special areas.

“Experience shows that the number of hours for software development remains about the same, some effort is shifted from programming into the early phase of creating the Digital Twin”, explains Franz Aschl. “Through the ability to work in parallel, instead of consecutively, the overall development time is shortened considerably.”

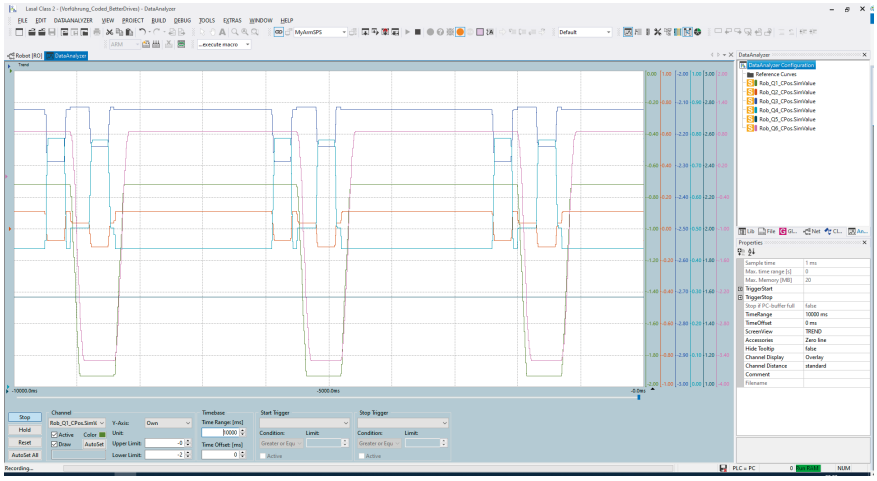
Safely Achieve the Development Result

The fact that waiting for the availability of real mechanics and hardware before configuring and testing is unnecessary, helps to significantly accelerate development. Not only developers from all disciplines but also production and even customers can be involved at a very early stage. For example, misunderstandings in the requirements definition can be uncovered not in the prototype phase, but at a time when corrections can still be made with little effort and without great delay.

As a further essential step towards developing better machines more quickly, model-based design with the Digital Twin also provides the option of virtual commissioning. The Digital Twin thereby replaces the real machine or system. This is initially completely simulated as a computer model with "software in the loop". In the next steps, the programs are transferred to the real control hardware, which controls the simulated kinematics as "hardware in the loop" including increasingly more and more real components. This provides the option to include a large part of the time response in the testing in addition to the machine logic.

> In software development, the artistry is usually not in programming normal processes, but in coping with unexpected special situations. All possible error conditions can be simulated and tested on the Digital Twin, right up to a sudden power failure.

Daniel Schachl, Software Engineer at Sigmatek



In the diagnostic tool of the LASAL design environment, the axis positions (e.g. of the robot) can be precisely tracked and deviations detected.

Many deficiencies and problems can therefore be detected and eliminated already in the developer's office, which with traditional methods, are only found during commissioning of the real machine or system. This often first happens at the customer site. Virtual commissioning can be performed in the office environment, as well as collaboration between employees working at different locations. This in itself can greatly reduce the expensive presence of programmers with equipment at the installation site. This brings us closer to the goal of "Plug & Produce", i.e. machines and systems that are immediately productive from the moment they are switched on and begin to pay for themselves.

Full Integration into the Engineering Tool

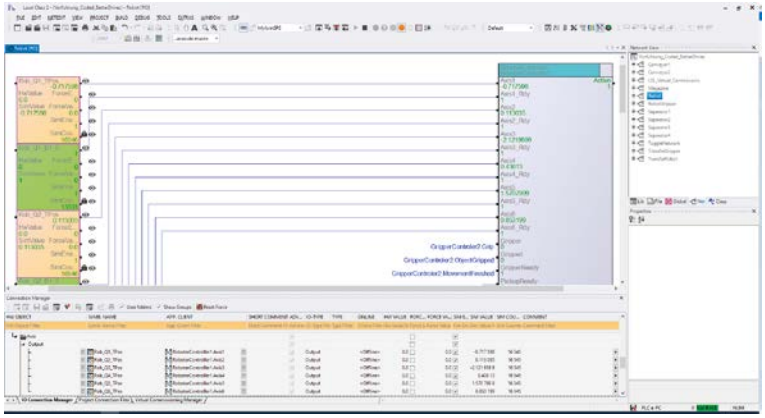
As a manufacturer of control and automation systems, Sigmatek sees its task in enabling machine builders and automation specialists to develop and manufacture future-oriented, modular and flexible machines and equipment simply, quickly and economically. That also includes the standardization and automation of software development.

To support model-based design and virtual commissioning, the Salzburg manufacturer modified its LASAL software design environment. In the process, all outward-facing I/O object classes have been significantly extended. These advanced I/Os no longer need real connections at their "outer" end but can operate in various modes with predefined or simulated values, or values created in the Digital Twin.

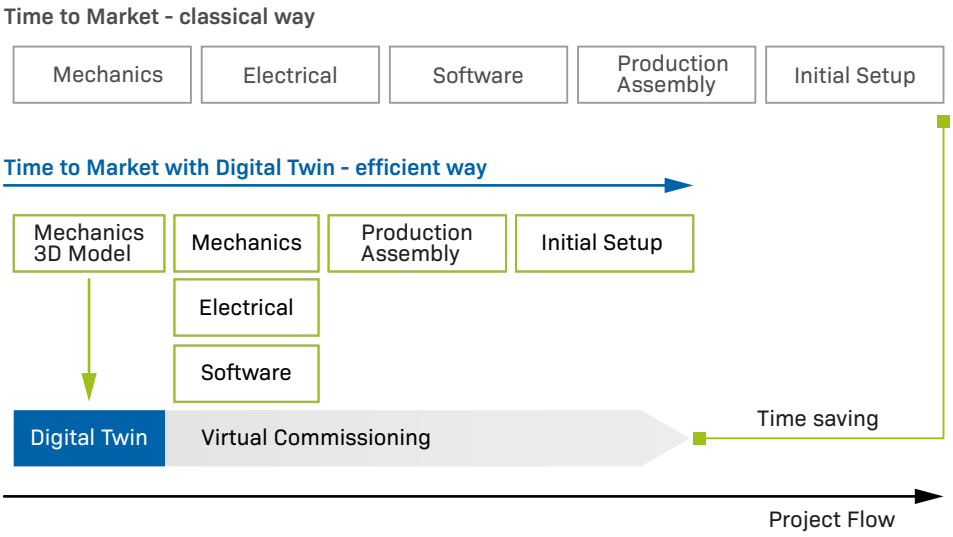
Switching between these operating modes is done class by class or all at once for the entire project by setting a parameter in the Virtual Commissioning Manager. “Without leaving the design environment, software developers can first test their programs in the simulation and later test and optimize them in the Digital Twin, as well as perform virtual commissioning”, explains Daniel Schachl, software developer at SIGMATEK. „Also, to commission programs on the real machine, they simply have to change the appropriate parameters.”

Object Orientation Makes it Possible

In this further development of LASAL, Sigmatek’s use of object-oriented programming for over 20 years turned out to be an advantage. This made it quite easy to adapt base technology to integrate with the physics-based 3D-simulation software. Most of the effort went into testing for full interoperability. After all, the system must continue to function with many specialized I/Os, the overall drive- and safety technology, to name just a few areas. iPhysics from the Munich-based software manufacturer machineering GmbH & Co. KG was the first such system to be integrated. Through the easily modifiable object classes in LASAL, Sigmatek can very quickly generate the option to use other, similar systems if required. >>



To support model-based design and virtual commissioning, SIGMATEK modified its LASAL software design environment by expanding all outward-facing I/O object classes.



Model-based development with the Digital Twin of a machine or system helps to minimize development risk, eliminate reworking and shorten the overall engineering time.

Reduce Development Risk

For machine builders, reverting the development sequence to model-based system development with the Digital Twin brings many significant benefits. The most important is certainly minimizing the development risk.

Since the software is the description of the machine function, it can serve as a starting point and reference for everything else. The basic function can already be programmed during the quoting phase. Coordinating this with the customer helps to avoid miscommunication, discrepancies in expectations and misunderstandings.

The design and physical configuration of sensors and actuators can already be defined without the actual hardware and/or mechanics. Checking large parts of the time response, even before a prototype is built, saves an enormous amount of time and provides greater certainty in component design.

Virtual commissioning allows problems to be solved and machine programs optimized in advance. A pretested, error-free program is available for commissioning the physical mechanics with its actual inertial response. This significantly reduces the time software engineers have to spend on the "construction site". If many optimizations have already been made in the Digital Twin, a large part of the reworking often previously required, is also eliminated.

In serial machine construction, the ability to prepare a construction kit from pretested, proven modules is an advantage. Creating the Digital Twin for deviating options only, simplifies and accelerates the development of variations significantly. In addition, the Digital Twin of the machine can already be used with real HMI devices to train operators and maintenance personnel.

It Doesn't End with Commissioning

The quality of the software can also be significantly increased using model-based design on the Digital Twin. „In software development, the artistry is usually not in programming normal processes, but in coping with unexpected special situations," Schachl knows. „All possible error conditions can be simulated and tested on the Digital Twin, right up to a sudden power failure." In a real prototype, this often generates rejects or not uncommonly, even the destruction of the machine.

Since it involves only a modification to several object classes, working with LASAL in combination with physical simulation software is easy to learn. Parameters such as runtimes, switching times and motor curves for example, can be provided by individually created object classes. However, they can also be entered in iPhysics or returned from real measurement values. Using scripts, different situations can be easily reproduced in the simulation software.

The application possibilities of the Digital Twin, however, are far from exhausted with commissioning. This can run during operation to detect deviations and take the appropriate actions. The error tolerance as well as the lifespan of the machine is therefore increased and predictive maintenance is enabled. "Using the Digital Twin for model-based design in machine and equipment building clearly has potential," concludes Schachl. „By integrating with LASAL, SIGMATEK control users have a significant head start on their journey through digital transformation."

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