Virtual commissioning for industrial machines

Simulation of a robot plant in automotive manufacturing (Source: Adobe Stock, Machineering)

The Iphysics tool from Machineering enables virtual simulation of a machine on the physical and software levels. For example, CANopen-based communication between integrated drives and higher-level control can be simulated as well. Especially in the planning and development phase, this helps to save costs and time.

A lot of medium-sized companies either do not or only occasionally use virtual commissioning in engineering, the reason being that it is difficult to quantify the benefits of these technologies. On closer inspection, it becomes apparent that cost and time savings are possible in different project-phase areas.

Iphysics from Machineering provides users a tool for implementing virtual commissioning. Especially the connection of devices such as controllers, drives (also implementing CANopen interfaces) as well as various kinematics from different manufacturers make the system implementation more intuitive, safe, and fast. Using virtual commissioning, problems and possible improvements can be identified early in the development process and can thus often be avoided. Expensive repairs of the actual machine and subsequent customer complaints are therefore reduced. Engineers have more time for their actual tasks if they do not have to deal with time-consuming amendments, sometimes at the customer's site.

What is virtual commissioning

Virtual commissioning is part of a modern machine development process. It includes testing and changing of construction data, planning data, and control software in advance using a virtual system. After a successful virtual commissioning, and once changes and optimizations are carried out virtually, the transfer to a real machine can begin. Therefore, errors are recognized and can be eliminated in the early development phases. This happens before the errors could lead to additional expenditure in terms of costs and time.

A physics-based 3D simulation serves as the basis for virtual commissioning, which simulates the real behavior of the machine as a virtual model, ideally in real time. In this way, the entire system, individual machines, or certain machine elements can be presented. This enables to visualize, in particular, the interplay between the individual machines and more complex collaborations with, for example, robots or material flows. ▷

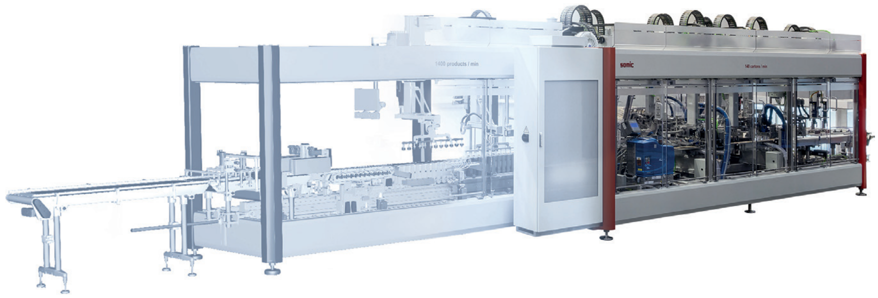

Figure 1: Simulation model of a complete packaging machine (Source: Somic Verpackungsmaschinen, Machineering)

From today's perspective, virtual commissioning considers all the challenges that arise during the development, such as changing customer requirements or changes in construction. Even technologies that are not yet fully developed, supplier bottlenecks or the lack of communication between those involved in the development, can be recognized and avoided at an early stage. This eliminates time-consuming changes at the end of the development process. Problems on the real machine that could not have been foreseen beforehand, can be avoided. Furthermore, projects that cannot be implemented can be stopped early and then adapted according to given possibilities.

The software component of machines is steadily increasing these days. With the help of virtual commissioning, it is possible to represent the interaction of mechanics, electronics, and software at any point in the development process. Thus, companies can counteract the increasing cost pressure, reduce material waste during machine start-up, and avoid production interruptions due to inadequately tested software.

Commissioning through simulation

Virtual commissioning can be carried out with the help of simulation. The simulation software should be at the center of the development as a cross-departmental platform to verify the current state of development at all times and check for feasibility with other areas. Hereby, the mechanical, electrical, and software departments use the same models simultaneously, which they work on in their native development environment, furthering the development together and immediately able to test the interaction using the simulation. This way, the current state of development in mechatronics development is tested in an interdisciplinary and continuous manner during the earliest phases of the process.

To use the simulation software as a cross-departmental platform, it is necessary that the simulation has a stable bi-directional interface to the inventor. This is implemented in the simulation software Iphysics whereby changes on the simulated model are also immediately available in the CAD (computer-aided design) system, thus eliminating the need to change the model redundantly. By connecting ▷

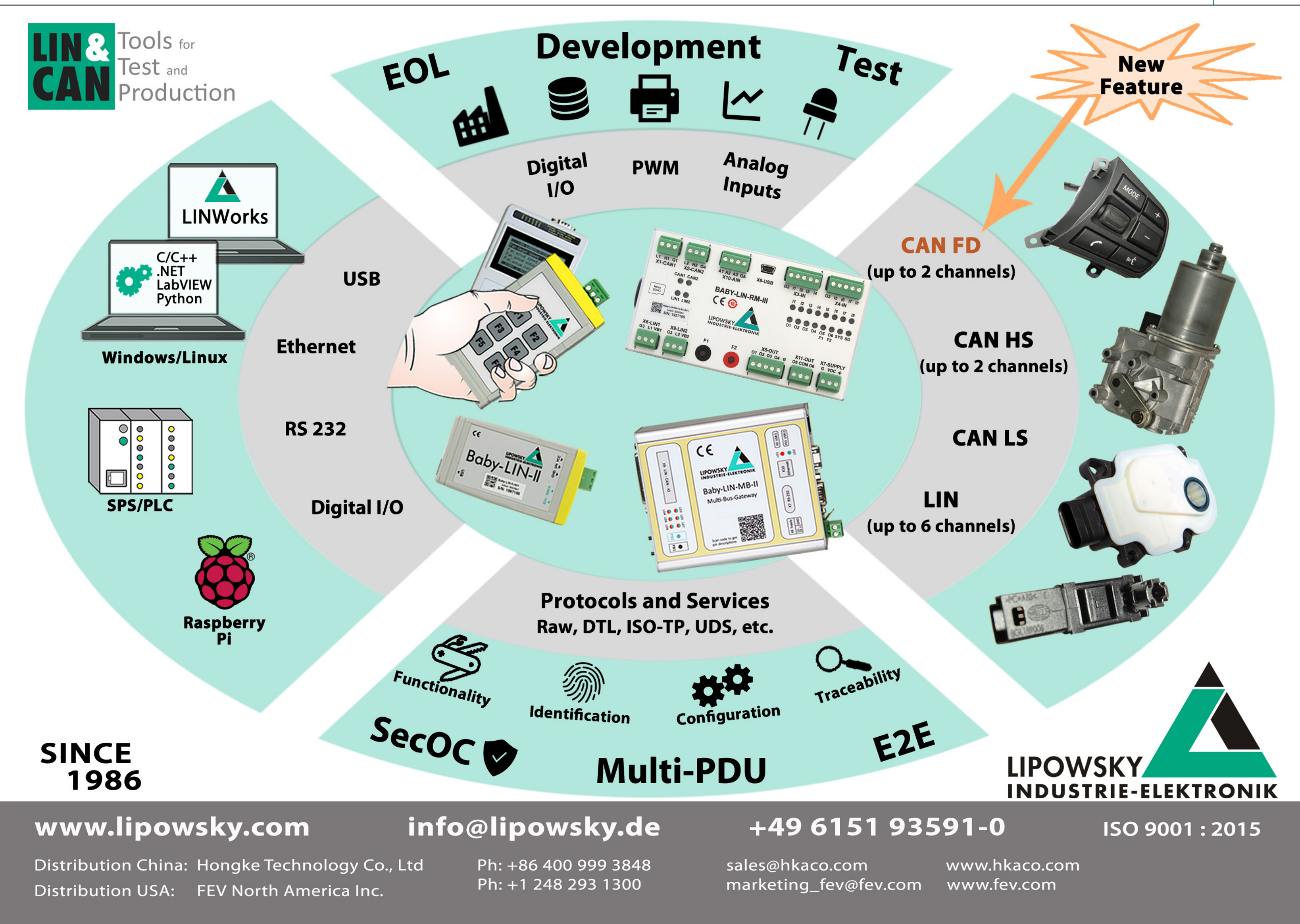

Figure 2: Coboworx pelletizing cell and panel with the digital twin of the plant (Source: Coboworx, Machineering)

various control devices, drives, and robot kinematics, these can already be tested during virtual commissioning under real conditions and, if necessary, adapted.

CiA 402 drive operation modes available in library

The Iphysics tool supports software libraries for simulation of drives' real-time behavior inside of machines in the design phase. Recently, Machineering has extended the library with drive functionalities according to the CANopen device profile for drives and motion control (CiA 402). CiA 402 (IEC 61800-7-201/-301) specifies several operation modes and according application parameters for frequency inverters, servo-controllers, and stepper motors. The tool supports the common operation modes for positioning, velocity control, homing, as well as the cyclic synchronous position mode. The implemented homing mode includes homing methods with limit and homing switches. Thus, simulation of a pre-defined CANopen-based communication between drives (moving machine parts) and higher-level control is possible. In the future, it is planned to implement further operation modes such as the touch-probe functionality.

Potential of virtual commissioning

Practice has proved that using of virtual commissioning can have positive effects on productivity, quality, and the time-saving factors. It can also help to reduce invisible waste in the processes. With regard to productivity, early safeguarding of machine concepts and machine behavior reduce the risk for both human and machine. Due to improved communication and early knowledge, the coordination effort and the effort for troubleshooting can be reduced. As different program variants can be run, the optimal program can be developed early in the process. Productivity is also increased because of greater employee satisfaction, as they can focus on their actual tasks. With the help of virtual commissioning and the digital twin that is being created in parallel with the development, training for customers is possible on the virtual machine. Conversion to new products can also be tested in advance and implemented quickly during operation.

Companies can also benefit from a reduction in quality costs, as machine elements with the software to be installed have already been tested at an early stage. Thus, the company is able to deliver sophisticated machines to the customer. The customer will not have to deal with subsequent rework, corrections, and modifications. During the developmental phase, individual steps can be coordinated with the customer and approvals as well as identified problems can be discussed using the digital twin. Solutions that were virtually tested in advance can thus be transferred to the actual machine.

A shortening of the overall development time as well as the associated adherence to delivery dates speak to the use of virtual commissioning. Due to the parallel engineering in particular, the PLC (programmable logic controller) programming, for example, is adequately adapted, which results in the throughput time being shortened by 70 %. The time for troubleshooting and rectification of potential errors is also significantly reduced. Employees are able to spend less time at the customer's site, as many issues can be clarified in advance. Thus, they are able to focus on new projects sooner.

Practical example

In a practical example, an inventory was carried out at an exemplary machine manufacturer. Process indicators such as throughput times, complaint and error rates, KPIs (key performance indicators) for ongoing projects, and personnel costs were determined. A customer-specific concept with a set of rules for the use of simulations was then developed, showing how virtual commissioning can be optimally anchored and implemented within the company.

One year after the project start, these key figures were determined once again and the savings achieved were quantified. Around two-thirds of these savings can be ▷

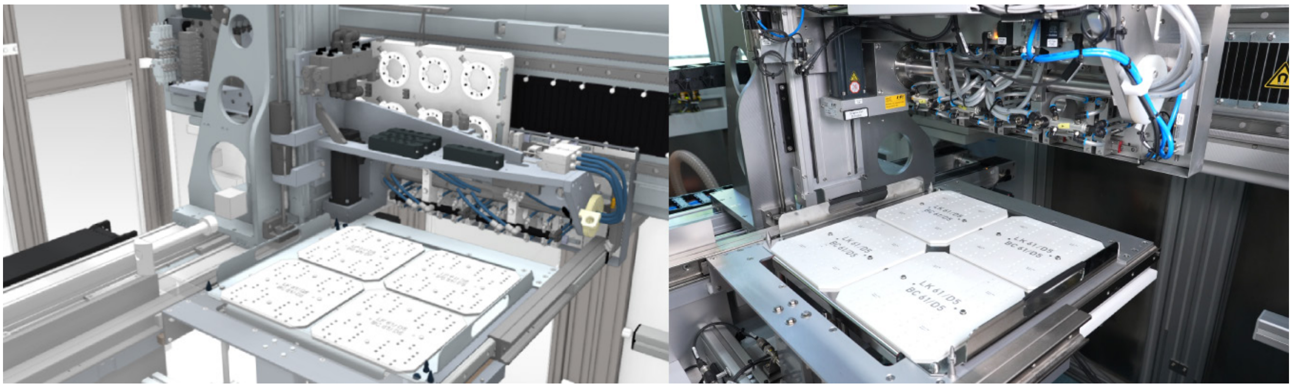

Figure 3: Plastic injection molding machine for pharmaceutical disposables and its digital twin (Source: MI Micro, Otto Männer, Machineering)

Figure 4: AR (augmented reality) application from Iphysics for hall planning (Source: Adobe Stock, Machineering)

attributed to the increase in employee productivity, mainly generated by the early validation of concepts and the avoidance of unnecessary activities such as trouble shooting. 26% of the savings were achieved by improving quality and measuring the reduction in quality costs through the decrease in customer complaints and error messages. 8% were due to the savings based on the increased adherence to delivery dates and the reduction of contractual penalties. The practice has also shown that the potential of virtual commissioning can only be fully exploited if it is deeply implemented in the processes. ◀

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