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PLUG & WORK IN 3D – NEW WAYS IN RAPID PROFESSIONAL COMMISSIONING*

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Abstract
With the proven “Plug & Work” concept developed by SMS Siemag, automation systems are tested and optimized in the test field in a near-reality environment before being shipped and commissioned at a customer’s site. The process and production simulations provide scenes showing the specific mechanical equipment, the drive systems and the technology of the corresponding customer plant. Beside the technological simulation of the plant and the IO-simulation with the automation system, the production simulation is one of the three important parts of the Plug & Work simulation environment. It serves two important additional purposes: the 3D visualization of the entire customer plant on the one hand and the mapping of the logistic procedures in the plant on the other. In order to provide a close-to-reality visualization of the plant, the original design data of the individual customer plant are used for creating the visualization and prepared using an appropriate export filter. In this way, it is ensured that production sequences can be optimized in advance together with the customer, so that each customer can be trained on his own future plant.
Keywords: Simulation; Quick return on invest; Fault-free equipment; Short commissioning times; 3D.

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1 ADVANCED TECHNOLOGY TO SHORTEN COMMISSIONING TIME

Instead of starting the test series for the electrical and automation systems and the operator training courses only upon completion and installation of the mechanical equipment, the Plug & Work concept means to bring forward these activities and carry them out simultaneously with the construction work in a so called test field (Figure 1).

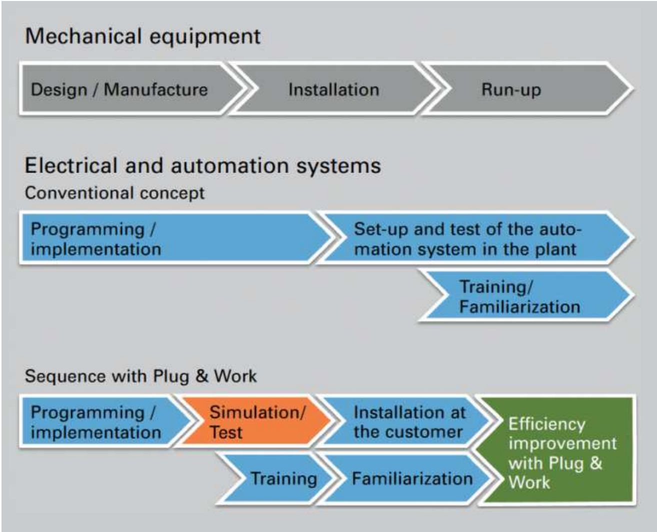

Figure 1: Efficiency improvement with Plug & Work.

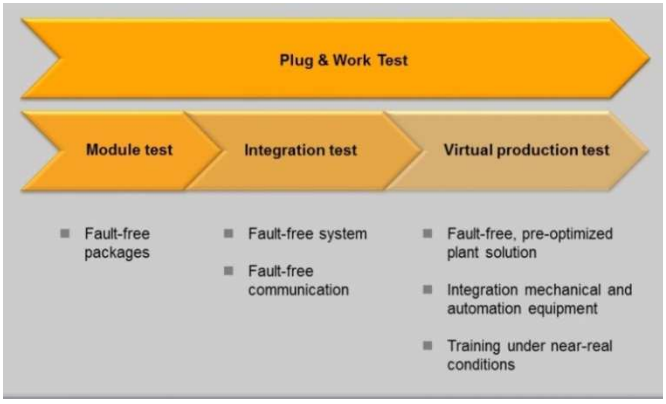

Figure 2: Different parts of the Plug & Work Test.

For Plug & Work, the entire automation system of the plant to be tested is installed in the test field and connected to the simulation system. The Plug&Work Test itself is divided into three separate phases (Figure 2):

A. Module test
   In the module test phase, individual modules of the overall plant are tested on a stand-alone basis. This includes IO checks, manual movement tests and the automatic sequences of the module. When this phase has been completed, the module is ready for operation.
B. Integration test
   In the second phase of the Plug&Work test, the individual pretested modules are combined to form an overall plant, enabling the production sequence of the overall plant to be displayed. The essential aspect in this phase is to test any

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communication taking place between the modules themselves and with the higher-level process control systems.

C. Virtual production test
Before the actual commissioning, the virtual production test makes sure that the entire automation system of the plant masters the production sequences without any errors. Likewise, the automation and electrical systems are perfectly coordinated with the mechanical systems, and the customers' operating personnel are trained under near-real conditions.

In respect of different plant types and equipment items, the length of the three different phases may vary from test to test. The transition from one phase to the next may also be fluid under some circumstances.

2 INTERDISCIPLINARY KNOW-HOW AS BASIS OF SIMULATION MODELS

Realistic real-time plant simulations are the core of Plug & Work. In order to develop and set up such simulations, mathematical models alone are not enough. In-depth technological and empirical knowledge of the processes to be introduced into the simulations is just as important.
The simulation basically consists of three components (Figure 3):

- IO simulation
- Technological simulation (dynamic simulation)
- Visualization (production simulation)

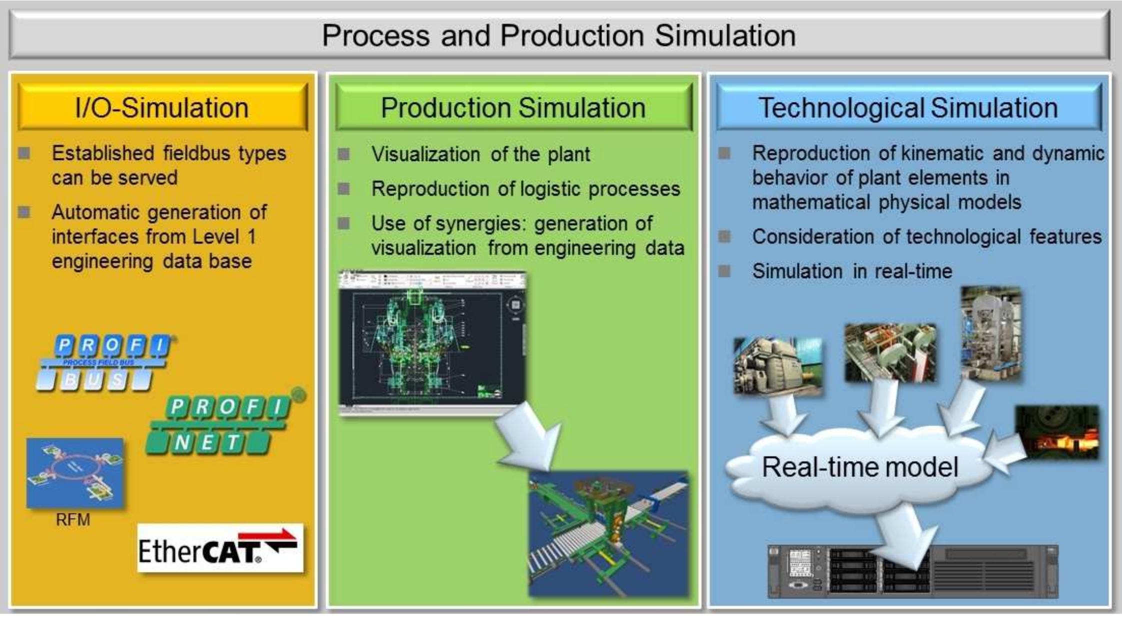

Figure 3: Basic components

3 IO SIMULATION

One target of the simulation is to ensure that the automation systems do not "notice" whether they communicate with the actually existing peripheral devices or with the simulation system. That is why the field bus systems used are mapped by means of an IO simulation.
In order to obtain information e.g. on the structure of a Profibus strand with all its peripheral devices, the simulation features an automated import of the hardware export by the respective master system and reproduction of each single Profibus

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strand with all its peripheral devices. The behavior of the simulated strand then corresponds to the behavior of the original strand. The master system now detects all configured slaves and can communicate with them.
Furthermore, actually existing bus subscribers, such as control desks, can be integrated as well. In this case, the corresponding signals will not be controlled by the simulation system.

4 TECHNOLOGICAL SIMULATION (DYNAMIC SIMULATION)

The technological continuous processes are modeled with their pertaining differential equations using Matlab/Simulink. In order to simulate the real plant behavior regarding dynamics as authentically as possible, characteristic valve curves, moments of inertia, millstand modulus, etc. of the real plant are considered. Common model calculation time here amounts to approx. 50 mysec. In the following, modeling is shown using the example of a rolling mill.
Dynamic modeling of millstands
A millstand consists of many internal parts (HGC, rolls, bending systems, balancing systems, etc.) interacting among each other and with the mill housing and whose interdependencies among each other have to be considered within a mathematical model.
In mathematical modeling of a millstand special attention is paid to the simulation of dynamics, to the coupling of the individual internal parts and to design-dependent mechanical limitations (Figure 4).

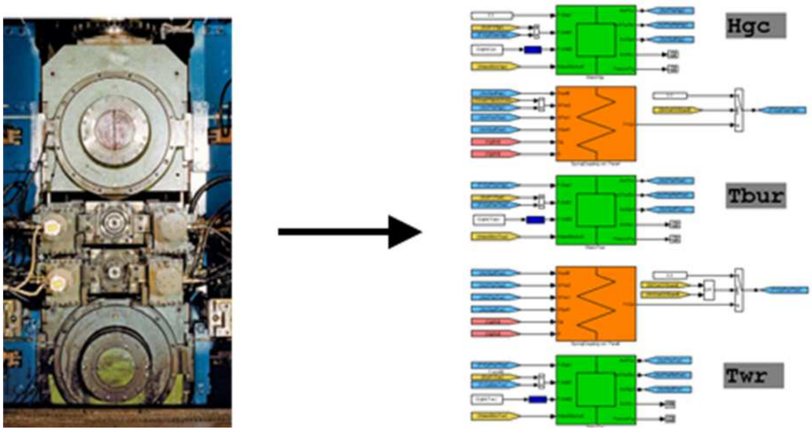

Figure 4: Modeling – from the real system to the mathematical-physical model.

In addition to the dynamic processes, the Plug & Work test also maps the technological processes, such as thickness reduction and flatness of the rolled stock, using appropriate models.
In order to verify the correctness of the models created, their behavior is compared to real plant data. The following illustrations show examples of the correspondence between a real and a simulated step response of a hydraulic adjustment system (Figure 5 and 6). In both cases, the same automation software is used.

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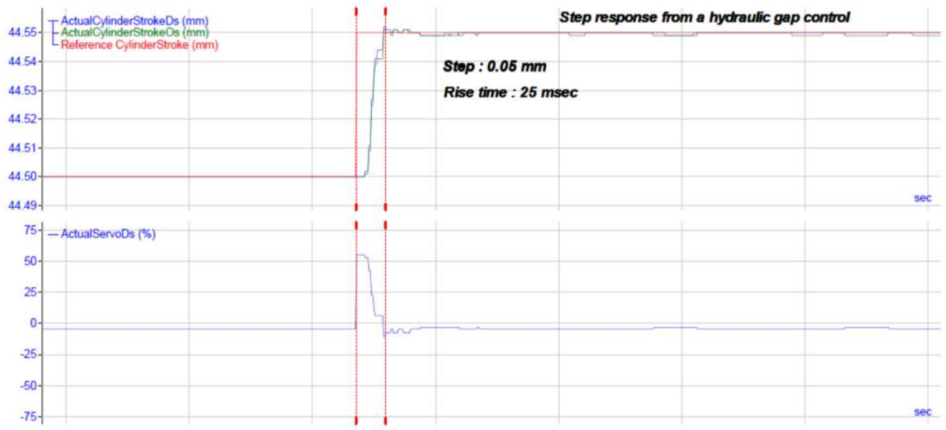

Figure 5: A step response of a hydraulic gap control (from a real plant).

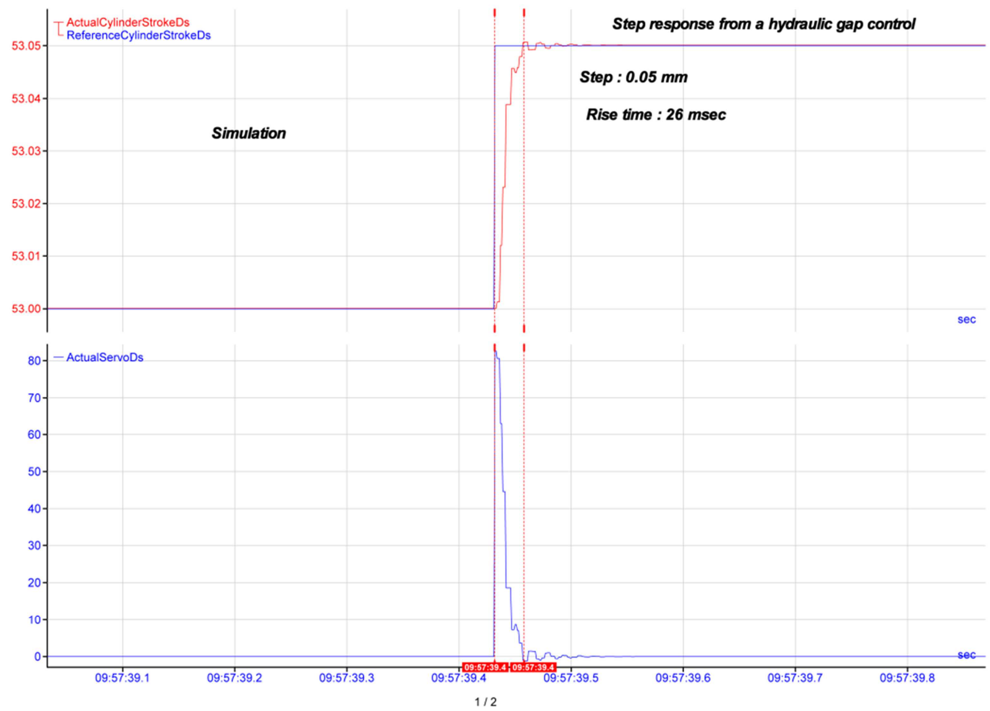

Figure 6: A step response of a hydraulic gap control (with simulation).

5 VISUALIZATION (PRODUCTION SIMULATION)

In addition to the IO simulation and the dynamic simulation, the production simulation is another important part of the Plug & Work simulation environment. The latest step in the future-oriented development of process and production simulations is entering the 3D world. This is achieved by simplifying 3D design data available of the customer plant and required for the production process in an automated procedure and feeding these simplified data directly into the simulation models. The next step of Plug & Work makes use of well-known, established techniques from an entirely different IT branch, namely computer games. This economically quite relevant segment has brought about tools capable of visualizing complex scenes in 3D and processes as well as fundamental physical relations. Such tools can be directly integrated into the systems for real-time simulation of production plants (Figure 7).

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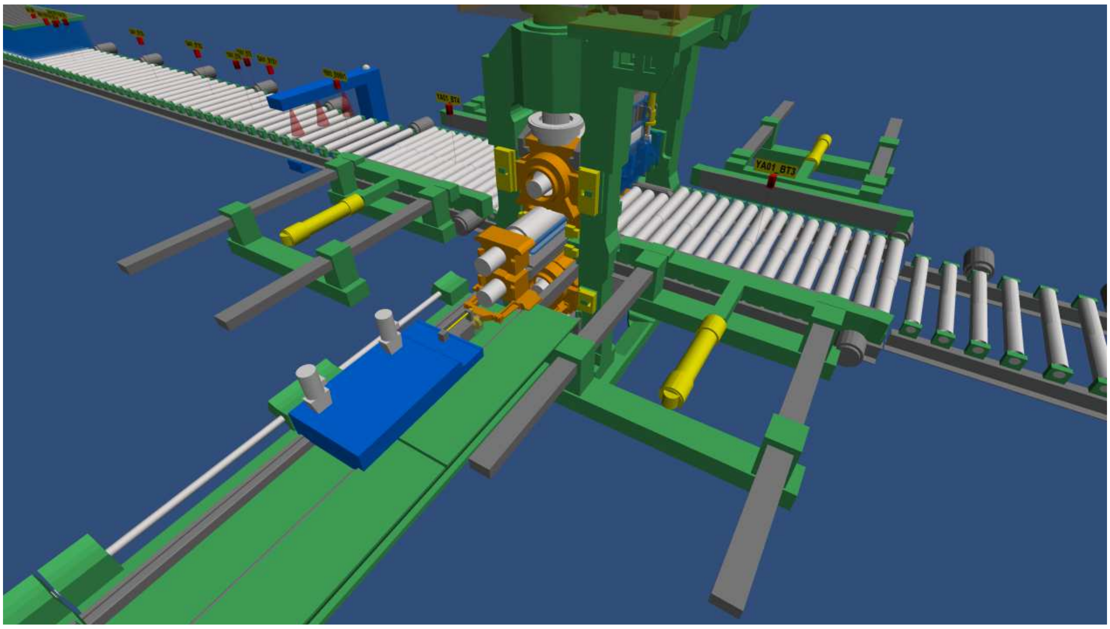

Figure 7: 3D visualization. During virtual test operation, the operating staff can familiarize themselves with the features of new plants.

6 CONCLUSION

Plug & Work ensures faultless equipment, short commissioning times and a quicker return on invest (ROI). More benefits are well-trained operating personnel right from the start of production as well as high product quality and good plant availability from the very beginning.
This new approach of 3D visualization simplifies and shortens the simulation process by taking advantage of the existing synergies. Moreover, it provides the process and production simulation systems with the necessary information to generate models that can go further into detail and have a broader functional scope, resulting in a markedly enhanced quality of the tests. Another advantage of 3D visualization in integration tests is that complex individual functions can now be illustrated in a clearer and easier-to-comprehend way. 3D is not a gimmick, but a solution that helps plant operators– in steel and aluminum production alike – understand the full range of functions and possibilities of their plants in less time.