State-of-the-art process control technology:
Siempelkamp's road to a self-optimizing production plant for wood-based materials with "Prod-IQ® Next"

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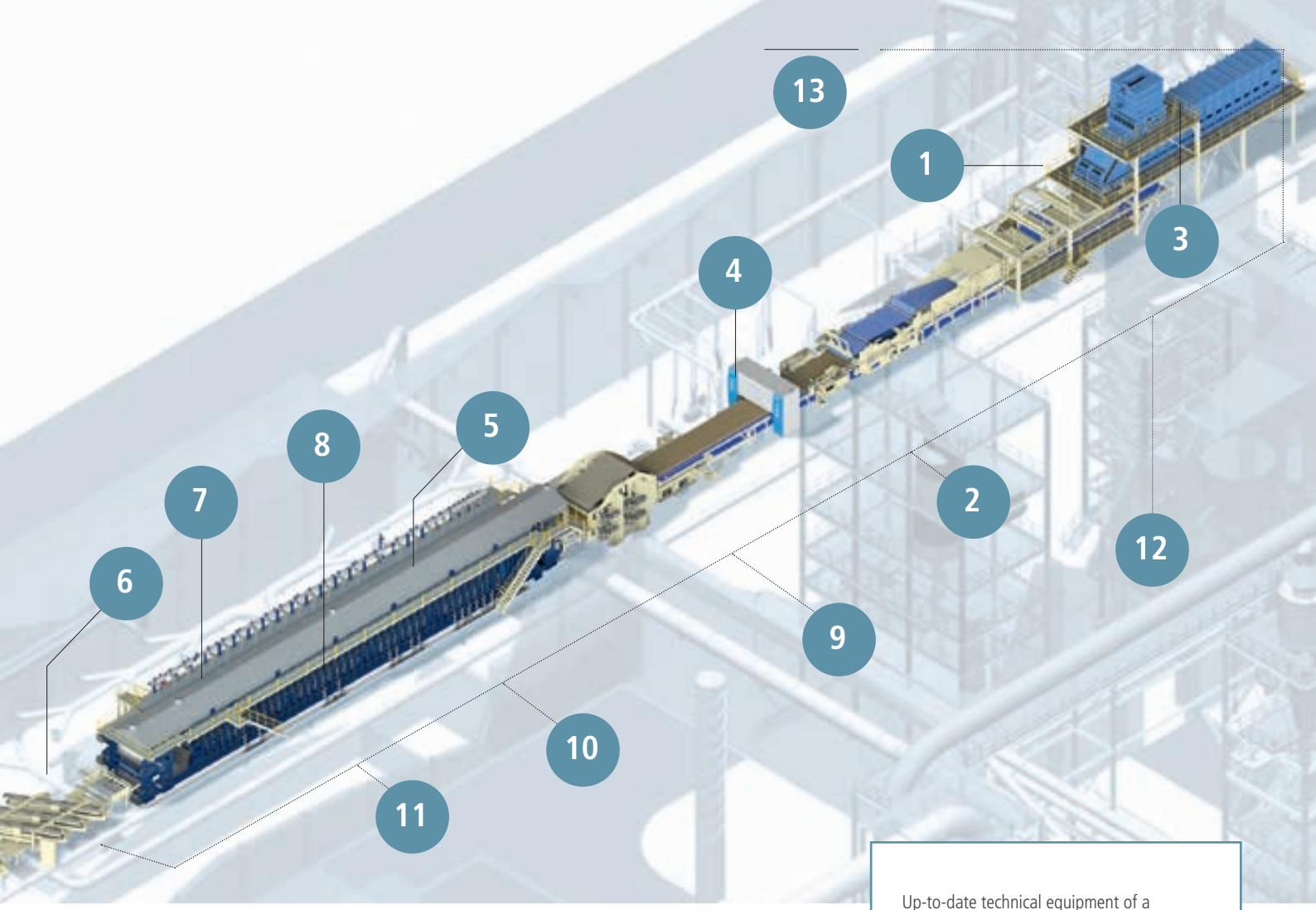
Intelligent production in the smart factory – opportunities for digital networking to increase product quality and resource-efficient use of material and energy have long been applied in the wood-based materials industry. In Siempelkamp's plants for wood-based materials all decisive factors for achieving the final product communicate and interact with one another. All interactions are traceable since each stacked board possesses a digital product memory along the entire value-added chain.

Modern control room of a forming and press line with ContiRoll®

The advantage for the operator of the self-optimizing plant: The operator only specifies the production order, everything else is handled by the plant itself. If, for example, 1,000 5,500 mm x 2,240 mm E1 panels with a thickness of 16 mm are to be produced with standard strength properties (bending strength and transverse tensile strength, swelling values), these specifications alone are sufficient to start the production of the batch. Everything else is taken care of by the plant; production changeovers are performed automatically. After precise completion of the production batch, guaranteed by online quality control, the system prompts a fully-automated sequential product changeover to the next product. At any time the process control system "Prod-IQ® Next" guarantees cost-effective, quality-assured production operation with as little use of material and energy as possible while, at the same time, maintaining high production speeds.

The status quo in wood-based material production

The development objective of each Siempelkamp plant for wood-based materials is the highly efficient production of particleboard, fiberboard, OSB, and LVL. The development takes place according to the process requirements for operational safety and strives for the possibility to produce the widest possible material thickness spectrum with high quality – while offering maximum ease of operation and highly economic use of resources. Through in-house developments and in-house production of all plant components, such as the complete hydraulics, Siempelkamp is able to equip all components with cutting-edge measurement and control technology and to visualize, collect, and document all process steps. This provides the plant operator a highly precise tool which can quickly and reliably analyze the current process settings and the currently produced product quality in the ongoing production process. The operator is supported



Up-to-date technical equipment of a forming and press line

1. Recipe management
2. Control system
3. Filling control
4. Weight-per-unitarea gauge
5. Pressure/position control and heater control
6. SicoScan
7. Thickness measurement feedback
8. ContiRoll Ecodrive
9. Prod-IQ
10. DAHMOS
11. SPC
12. Energy management
13. Digital plant likeness

by the process data trending system (Dahmos) which allows a comparison of the collected raw material and process data. With this information the experienced operator can manually intervene in the production process at any time, if necessary.

Status quo of the sequential product changeover and Prod-IQ®

After precise completion of a batch the product changeover takes place automatically during the ongoing production process in modern Siempelkamp wood-based material plants by means of the "sequential product changeover"-module and in most cases without opening the reject nose. The process parameters of all involved components from the blending system to the matformer station, from the forming line to the press with its downstream measuring components, to the cooling and stacking line adjust sequentially to the new process conditions triggered by the material flow, that is, when the new material reaches this section of the plant. The data necessary for the respective optimal settings are stored in a recipe database.

Siempelkamp's current process control system Prod-IQ® represents the information link between the management and the system operation levels. The data exchange with the production plant takes place via the connection to an ERP system. Prod-IQ® passes production orders from, for example, the SAP system to the plant and, in turn, submits the current production and consumption reports of the plant back to the ERP system. More comprehensive and detailed support of the plant management takes place via flexible production, raw material, and energy consumption reports (MS Excel files) which are automatically generated by specialized Prod-IQ® modules. With the Prod-IQ.quality module (formerly SPOC), process-related quality analyses can be generated which go far beyond a comparison by means of stored, historical process data.

Prod-IQ.quality recognizes board-type related, statistically relevant connections between raw material*, process**, as well as laboratory data*** and thus significantly simplifies their systematic analysis and documentation.

Operators have been using Prod-IQ.quality as a proven online board quality control system in more than 20 Siempelkamp wood-based material production plants worldwide. The self-learning system analyzes data records from laboratory samples, in other words, the associated raw material and process data, and presents the resulting board quality in a mathematical-statistical format. From the results constructive conclusions about the forecasted tensile strength, bending strength, surface soundness or thickness swelling, and raw density of the produced boards can be derived ("quality forecasting").

For this, the development histories of the boards, their raw material and process data along the material flow, are combined with archived laboratory data and evaluated by generating a statistical process model. As experience has shown, 30 to 100 laboratory samples are needed for a board quality model. The selection of process parameters and data sets needed for a precise process model is prepared by the person in charge of the product together with the Prod-IQ.quality recommendations.

With the help of this statistical model, the quality of the board at the moment it leaves the press can be calculated since all statistically significant raw material and process data are available. This quality calculation confirms with amazing precision the actual board quality, for example, strength values are calculated with 94 – 97 % accuracy and board raw densities with an accuracy of 99 %. At any time, the operator can determine, via a graphical visualization of the quality, if the current board quality meets the requirements or if optimization potential through a manual adjustment exists. In this way, material savings of up to 2.5 % and speed increases of up to 6 % can be realized in modern Siempelkamp plants.

Prod-IQ.quality today: immediate production optimization without laboratory results – Prod-IQ® Next: Siempelkamp's road to the self-optimizing wood-based material plant

The development goals for Siempelkamp's process control technology arise from prevalent customer needs and the desire to manufacture, under all predominating production conditions, a high-quality product resource-efficiently – automatically and self-controlled. "Prod-IQ® Next" is the higher-level control circuit which adjusts the production plant cost-efficiently and at the same time ensures the desired board properties – without necessary operator intervention. "Model-based Predictive process Control" (MPC) is the control concept behind it for which a time-discreet, dynamic model of the process to be controlled is used in order to calculate its future behavior depending on the input signals (raw material and process data). This allows the calculation of the optimal input signals, in terms of a power function, which will result in optimal output signals (board properties).

Model-based predictive process Control (MPC) for Siempelkamp plants

How does the self-optimizing Siempelkamp plant work? The dynamic process model is the core of the "Prod-IQ® Next" control circuit. For it, a combination of the statistical modellings (Prod-IQ.quality) and the physical/rheological simulation of the behavior of the material mat during the press process takes place whose usable result is primarily the raw density profile of the board, but also simulated press data such as pressures or distances. To completely simulate the production process, the statistical process modelling is combined with the physical/rheological simulation of the press process to a hybrid model. The physical/rheological simulation supplies the statistical process model with press data which is used to calculate the board quality.

From the "Virtual Hot Press" simulation (VHP) to Prod-IQ.profile:

The core development from Prod-IQ.quality to the hybrid model is the physical/rheological simulation of the press process. Together with Professor Dr. Thömen and his team from the Berne University of Applied Sciences in Biel, Siempelkamp uses the "Virtual Hot Press" (VHP) software for the simulation. VHP was developed and linked with Prod-IQ® during a very productive cooperation between the Berne University of Applied Sciences and Siempelkamp. The software is now suitable for industrial use (module Prod-IQ.profile). During comprehensive tests at two MDF manufacturers, the precise calculations of raw density profiles, based on mat properties and press parameters measured online, could be confirmed. The basis of it is a newly developed calibration algorithm which determines the properties of

MORE THAN
20 x
WORLDWIDE

The Prod-IQ.quality can already be used as an online board quality control system in Siempelkamp's wood-based material plants.

* Raw material data = automatically collected properties of wood, resin, and other chemicals in the production process, for example, densities, quantities, moisture content.

** Process data = automatically collected data from process machines, for example, speeds, pressures, distances, temperatures.

*** Laboratory data = product properties determined in the laboratory, for example, tensile strength, bending strength, thickness swelling, raw density

the material used in the plant with the help of two different raw density profiles measured in the laboratory in such a manner that the calculated raw density profiles agree with those measured in the laboratory. Thus, both components of the hybrid process model are available. Currently, additional industrial trials are taking place to further test Prod-IQ.profile. The benefits of hybrid modelling: With hybrid models process scenarios can be simulated and process parameters, which ensure the desired product quality within necessary safety margins thus allowing cost-optimized production, can be systematically determined. In this way for example the resin factors and the mat weight are reduced, the press speeds increased, and the energy consumption optimized.

Siempelkamp's next steps towards self-optimizing wood-based materials production

Plant operators that are already using the sequential product changeover and Prod-IQ. quality are already equipped with the foundation for a self-optimizing plant with "Prod-IQ® Next" and have optimum production. Combining both individual modules, Prod-IQ.quality and Prod-IQ.profile, to the hybrid process model and developing the cost-optimizing function as "model-based predictive process control" are Siempelkamp's logical last steps towards the self-optimizing wood-based material production plant which runs at the optimum – resource-efficiently under all process conditions, fully automated, and quality controlled. After the trials regarding the calibration of Prod-IQ.profile are completed, Siempelkamp will initially install this module in MDF plants and thus provide customers the opportunity to use "Prod-IQ® Next" for the technological safeguarding of their product quality and minimizing of their production costs.

Left: Online board quality monitoring and optimization with Prod-IQ.quality
red = online quality trending, calculated every 10 seconds
green = necessary safety margin to maintain the required quality safely
blue = minimum quality level that has to be safely maintained

Right: Raw material and process data visualization of the fiber spreading