PROCSIM GmbH

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Digital Twin – heart of the new process control technology

The "Digital Twin driven control" of technological processes is a tool for discovering the existing **production capacities, harmonizing energy usage, increasing efficiency and driving equipment to its best possible performance.**

This technology far surpasses the current control approaches in the paper industry. It is incomparably faster, more accurate and more complex than the standard MPC technique. The control loops are "informed" about the state of the entire process and its dynamic development in the near future.

Digital Twin is a virtual copy of the real process. Every single process variable both measured as well as unmeasured has a "small digital twin" in this virtual process. Not only physical quantities such as temperature, flow, pressure are exactly controlled, but also **pointers to quality crucial occurrences** such as surface inhomogeneity, delamination, yellowing are simulated and through sophisticated control are eliminated.

Digital Twin is characterized by its versatile use. The multilateral applicability is wide and ranges from operator training tool, process design review, multivariable soft sensor, pool information on equipment wear for maintenance to the entire process control.

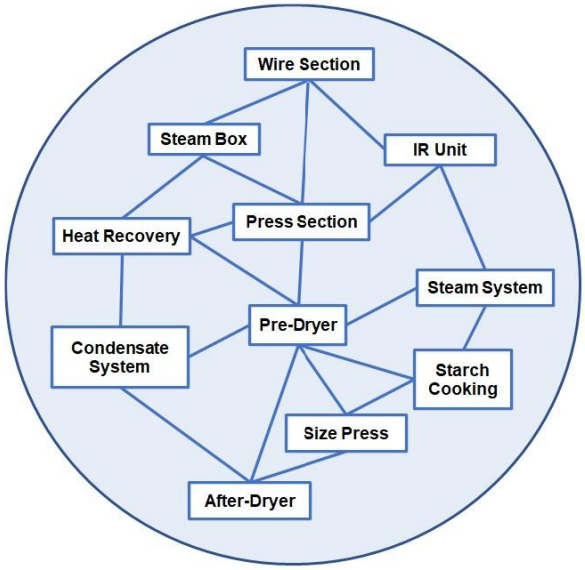
Digital Twin – simplified description

Essentially, it's about the application of well-known physical relationships during dewatering and drying. The entire papermaking process is broken down into elementary processes, which are then described mathematically and linked together again, creating virtual processes.

These are processes such as: dewatering in the press section, evaporation, heating of paper by conductive, convective and radiative heat transfer, air movement in the duct system and especially the properties of steam in the air and paper as enthalpy, entropy, pressure, temperature, evaporation heat and so on.

No less important are the equipment geometrical and technical parameters. These parameters are the limiting conditions for the system of equations representing the entire dewatering and drying process. **Nevertheless, this is not yet a Digital Twin!**

Only after validation does the model become a Digital Twin. **Validation involves calibrating the model parameters in order to achieve the same or very similar model results by comparing the measured values for all working points of the real machine**.



The high efficiency and precision of the drying process control is based on the mathematical linking of all individual processes running in parallel. In this way, every single control loop is "informed" about the reactions of other control loops and calculates control steps accordingly. A serious obstacle of current control techniques is the process dwelling time (sometimes minutes). To avoid overreaction the control loops must be even slower. This makes the control task inflexible and decreases its precision. **The Digital Twin eliminates this dwelling time practically to zero. Control steps lead directly to the target in the shortest possible time (technical and technological).**

Figure 1. Simplified example of the interconnection of the control loops. All control loops are immediately and continuously "informed" about the current status of the system and the control reactions are synchronized.

Digital Twin – Applications

Process control: Digital Twin simulates results of new target values long before they can be measured. **The simulated result is the window into the future.** A connected optimizer (AutomationX product) is a software that continuously searches for the best setpoints in order to minimize energy consumption. Within a few seconds, hundreds of operating points are simulated while maintaining (simulated) production and quality. The best one (according to the optimization criteria) is used for new process setpoints. **This technology has been proven to reduce energy consumption for the drying process by between 5 und 10%.**

Not only energy savings, but also quality is controlled using simulated process variables as soft sensors. For example: the simulated cylinder surface temperature is used as a control variable to avoid the formation of steam bubbles between paper and cylinder surface or partial lift off.

Soft sensors: Every single process variable (measured or not measured) has its own small digital twin in the model (process simulator). Over 1000 new high precision "soft sensors" (calculated values) even for difficult to measure process information can be used as a real measured value for process viewing or process control. A web dryness after the press section or cylinder surface temperature are examples of not measured but extremely important process information.

Maintenance: Immediately after the validation period, the actual equipment parameters as well as the equipment performance (e.g., felt dewatering parameters, heat exchanger efficiency and others) were the same (or very similar) to the model behavior. **The real parameters are getting worse over time while the model parameters stay unchanged.** Comparison of actual performance with model performance quantifies the extent and economically evaluates higher energy costs.

Upgrade review: Typically, a huge part of the capital investment is made during the early engineering period. In this early phase, the integrated model of the new equipment in the existing and proven simulator provides values that already include the upgrade or conversion. **This significantly reduces the risk for the investment.**

Operator training: The dynamic process simulator is a valuable tool that helps operators reduce errors in the control room, thus avoiding potential upsets or production downtimes. The operators learn the process and the complexity of the control task as if operating a real process, however risk free. **This speeds up the education and makes it extremely intensive**.

Drying curve: The drying curve online! Digital Twin simulates drying process in MD direction step by step. For example: the web temperature at the cylinder exit points is in many cases an important paper quality factor, anyhow impossible to measure online. The optimizer can control MD web temperature and calculate the steam pressure setpoint for each particular cylinder group accordingly (figure 2). It is an incomparable sophisticated approach to standard cylinder group cascade control.

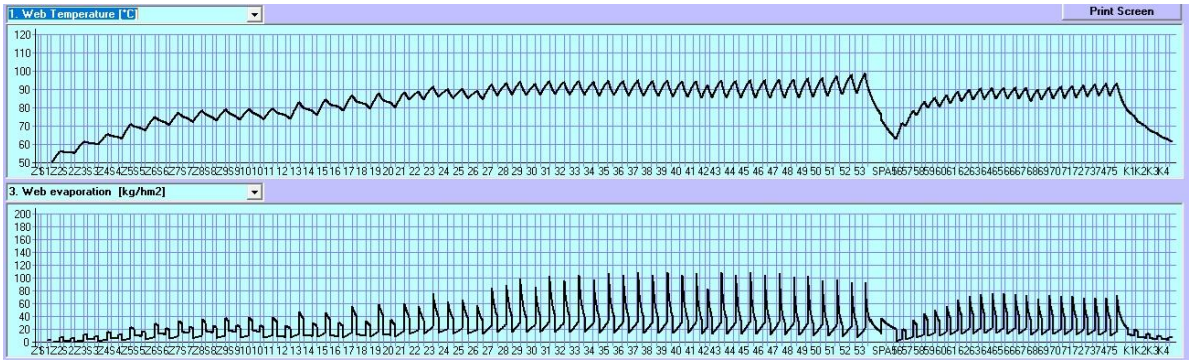


Figure 2. An example of the soft sensor's diverse possibilities. Online detailed drying curve for paper web temperature and evaporation rate in a multi cylinder paper machine.

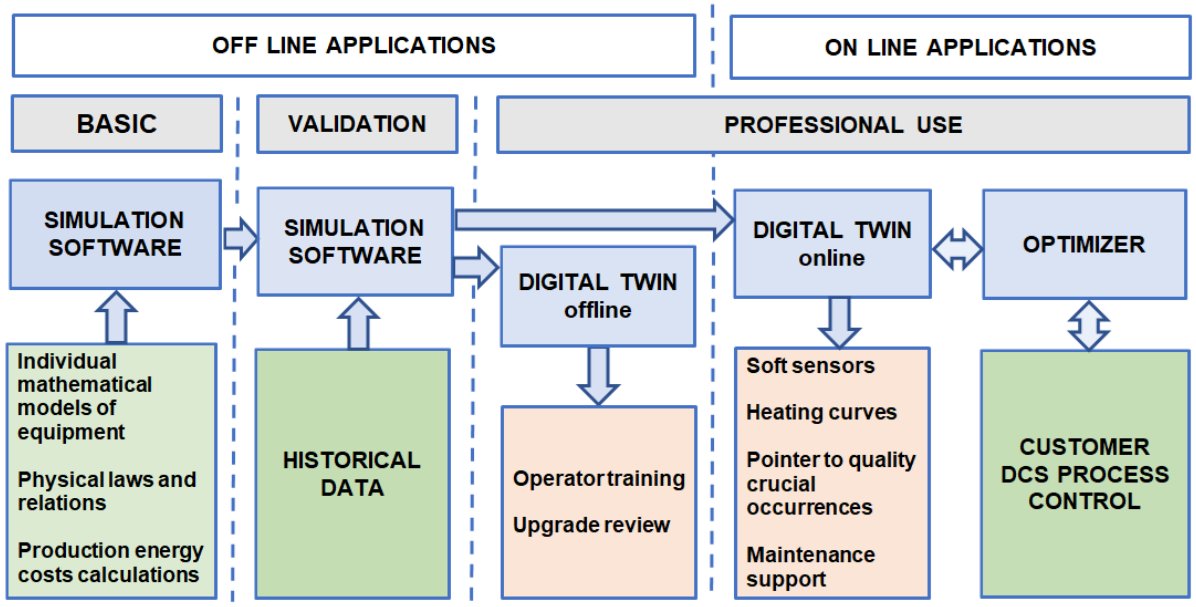


Figure 3. Structure of applications

Digital Twin – Development

The development of the Digital Twin software for the control of technological processes is a continual process. Not only Digital Twin but also the optimizing software is continuously adapted to the new criteria such as frequent changes in energy prices. The following areas are permanently analyzed and the results are included into the digital twin software solutions:

- Energy reduction in individual processes of paper drying
- Effect of wear on energy costs (Dewatering efficiency, Heat recuperation)
- Energy costs evaluation in real time absolute and relative to production
- Evaluation of CO2 emissions in real time
- Impact of changes in raw material on dewatering and consequently energy consumption for drying.
- Exploring the limits of safe drying to increase production while maintaining consistent quality

Developed process simulations

- Paper machine for all paper and board grades
- Coating machine for all types of drying equipment and coating layers
- Pulp drying machine
- Batch digester house
- Steam network for papermills
- Yankee machine – MG and Tissue grades

The optimization software controls the real and virtual process with exactly the same setpoints. The control strategy is based on the search for the best setpoints in the Digital Twin and subsequently their application in the real process. **This control technology not only reduces energy consumption, but more importantly, ensures that the devices perform at their best.**

Digital Twin – Solution potentials

- **Energy reduction up to 10 %**
- **Production increase by 2%**
- **Development of solutions for quality disturbing occurrences**
- **Secure review and fine-tune machine upgrades**
- **Payback less than 1 year**

Digital Twin – References

Recent implementations demonstrate substantial savings:

- **Smurfit Kappa PM9, UK**: Over **7% energy reduction** focused on hoods and condensate control and paper drying process.
- **Weig Karton KM6, Germany**: Over **5% energy savings** in coating and pre-dryer sections.

Awarding

- first prize for sustainability by CPI in England 2022,
- first prize for the best project by VNP in Netherlands 2023
- second prize Constantinus by WKÖ in Austria 2023.

Publications

- Mondi Frantschach, Regelungstechnisches Novum, Papier aus Österreich, p. 45, 3/2012.
- M. Schneeberger, P. Leuk, Optimierung durch ein Simulationsmodell, Papier aus Östereich, p.34-35, 3/2013.
- M. Schneeberger, P. Leuk, U. Hirn, W. Bauer & P. Fisera, A Simulation model to optimize the energy consumption, IPW Science & Technology, p.45-47, 4-5 2014.
- P. Fisera, A.R.Voigt, Possibilities of reducing energy consumption at papermaking process, Paper Technology, p. 34-37, September 2015
- P.Fisera, E. Bargfrieder, Upgrading Paper Machines with virtual Technology, Japan Tappi Journal, p. 66-69, April 2016.
- Mondi Stambolijski EAD, Virtuelle Batch Kocherei setzt neue Maßstäbe, Wochenblatt für Papierfabrikation, p. 384-387, Juni 2016.
- P.Fisera, R.Klug, Clasical MPC powered by Physical Simulation is the way into the industry 4.0, Paper Technology International, p.20-23, Autumn 2016.
- P.Fisera, T.Björnberg, Digitalisation brings transparency into the drying of coated paper, Paper Technology International, p.34-35, Summer 2017.
- B.R. Read, P. Fisera; Advantages and limits of current control Technology, Paper Technology International, p.22-24, Autumn 2018.
- B.R. Read, P. Fisera, Do you really want to forego £1 million and do nothing against your high operating costs, Paper Technology International, p.22-23, Spring 2019.
- T.Klemz, P.Fisera, IR Dryer as a Tool in the Press Section, Paper Technology International, p.16-21, Spring 2020.
- AutomationX, CF Procsim, Simulationsgestürtzte Steuerung des Trocknungsprozesses, Wochenblatt für Papierfabrikation, p.45-49, 8/2024
- B.R. Read, P. Fisera, Up to 8% Reduction in Steam Consumption in the drying process of paper machines through “Simulation Aided Control, Paper Technology International, p.14-17, Spring 2025.