IDEAS Digital Twin in Process Industries

IMPROVING PULP M WITH DIGITAL TWIN

Since the 1980s, thanks to advances in computation technologies, computer-based simulation of processes using first principle models has become a well-known and widely used engineering tool for various industries. As our understanding of processes has increased, their representative models have become more realistic and sophisticated. The resulting improvement in accuracy has made simulation a fundamental predictive and diagnostic tool in process industries.

Accurate simulation can reduce engineering and construction costs, optimize process design, and improve operation performance by decreasing operation costs and increasing efficiency. In fact, simulation technology has become so advanced that it is now possible to simulate the interrelated processes of an entire pulp mill and connect these in real time to the mill's physical operation. These sophisticated first-principles based models are referred to as "Digital Twins."

DEFINING THE DIGITAL TWIN

The term Digital Twin was first introduced by NASA [1] in 2010 and quickly adopted by other industries. There is no official definition of Digital Twin as it relates to process industries; however, there are three important characteristics that are common across most descriptions of the term. Firstly, the simulation must be core to the functionality of the process. Secondly, the simulated process must follow the entire life cycle of the plant. And lastly, the simulation must be directly linked to the operation. Together, these three aspects create an intricate pairing between process and simulation – a Digital Twin.

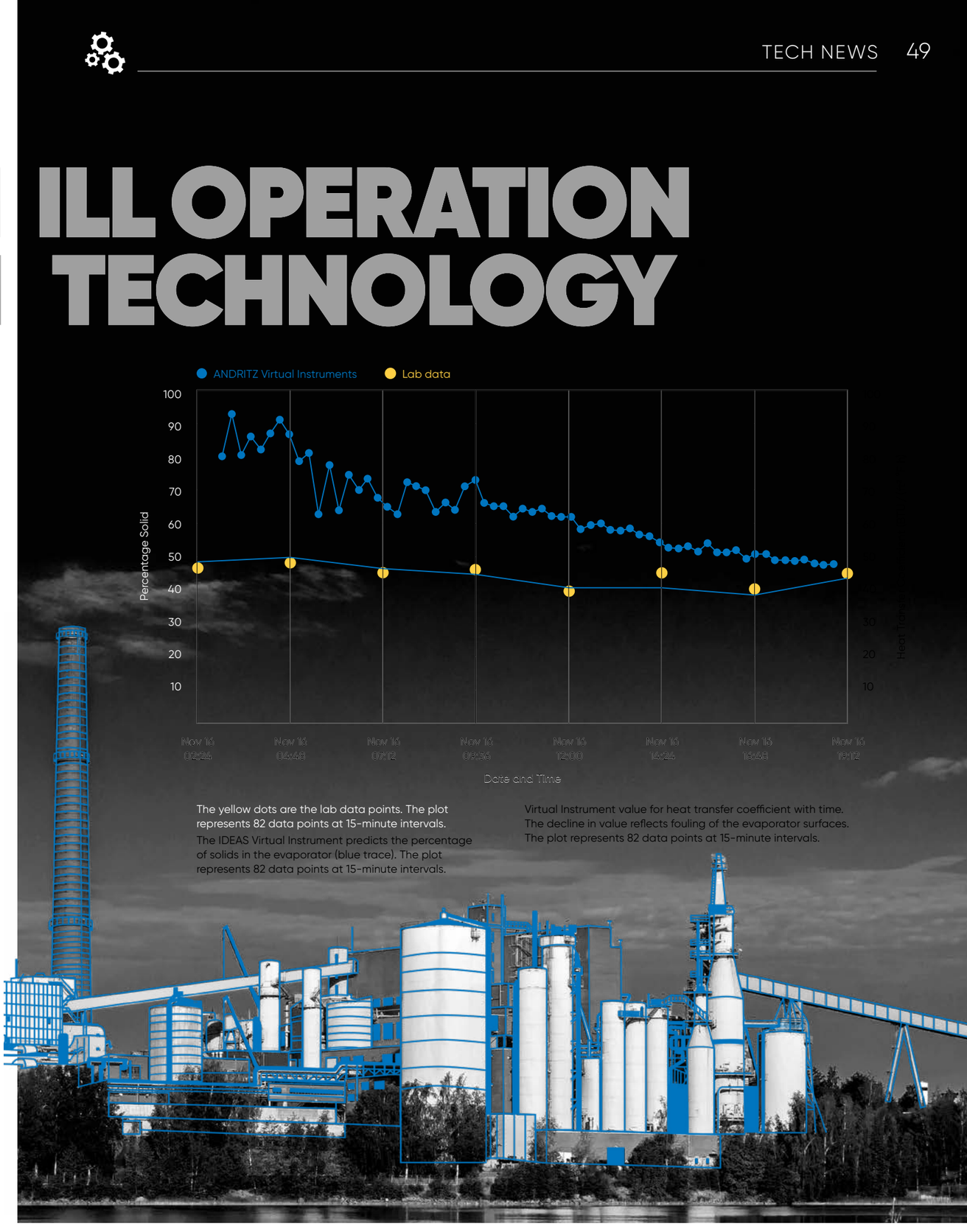
According to the industry research and trend analysis group Gartner, the concept of a Digital Twin is considered to be one of the most important disruptive technologies of 2018 [2]. As the internet and information technologies have been integrated into industrial operations, a new industry era known as Industry 4.0 (or the Industrial Internet of Things) has emerged. Digital Twins are a fundamental aspect of cyber-physical systems, which are one of the basic pillars of Industry 4.0, closely integrated with artificial intelligence and advanced analytics.

There are some major differences between a traditional simulation solution and a Digital Twin. In addition to being connected to an operational plant in real time, a true Digital Twin must run concurrent to the plant's operation, receive operation data in real time, process this data, and then generate valuable results in a timely manner. From a technical perspective, the combination of three components enables a true Digital Twin of processes to be formed: High-fidelity models, real-time connectivity to the operation being simulated, and a robust simulation environment.

THE MODELS MATTER MOST

High-fidelity models are at the heart of any Digital Twin solution. The term "fidelity" corresponds to how realistically the

ILL OPERATION TECHNOLOGY



The yellow dots are the lab data points. The plot represents 82 data points at 15-minute intervals.

The IDEAS Virtual Instrument predicts the percentage of solids in the evaporator (blue trace). The plot represents 82 data points at 15-minute intervals.

Virtual Instrument value for heat transfer coefficient with time. The decline in value reflects fouling of the evaporator surfaces. The plot represents 82 data points at 15-minute intervals.

models represent the process. Once high-fidelity models are built, they can be used for different applications within the Digital Twin structure.

ANDRITZ provides a true Digital Twin solution for the pulp and paper industry using IDEAS simulation software and its unique execution platform. A unique feature of IDEAS is its ability to combine continuous processes with discrete events (human characteristics and interventions). This enables IDEAS to simulate pulp and paper processes spanning the entire life cycle of a mill – from feasibility studies, engineering, construction and commissioning to operation and online optimization – and then combine each individual process unit into a single, interconnected high-fidelity model.

ANDRITZ ensures the high fidelity of IDEAS models by combining the process, mechanical/physical, and control/logic aspects of a mill. Building a true representation of the entire mill operation requires consideration of information obtained from process descriptions and calculations, P&IDs, physical layout drawings, equipment characteristics and data sheets, material-balance equations, chemical reactions, and lab test data as well as discrete events. The control system behavior and logic are integrated, as is operation data when available to further tune the models.

Once the modeling process is complete, the simulated, or virtual, mill behaves in the same way as the actual mill, providing realistic dynamic process responses. This simulation is then tied into the ANDRITZ execution and communication platform, which is connected to the mill's control and monitoring systems. Through the ANDRITZ execution platform, the virtual mill can be accessed and used by ANDRITZ's Digital Twin applications (also developed using IDEAS software) for a variety of purposes at different stages of the project life-cycle.

BENEFITS OF DIGITAL TWIN TECHNOLOGY

Digital Twin applications have a wide range of uses. During the early stages of a project, Digital Twin applications can analyze the pros and cons of various design scenarios, eliminate design mistakes, identify potential bottlenecks and early engineering flaws, and inform necessary equipment specifications. Operator training simulators similar to flight simulators can be built using the digital replica of the mill. Later in the life cycle, applications can be used to measure the conditions and/or physical characteristics of a process and provide virtual measurements where real-world measurements are impossible and real-time plant-wide optimization becomes possible. Digital Twin technology can also be used to simulate the future operation of a mill, providing insights that can be used to conduct maintenance, manage inventory, guard against process failures, and minimize the impact of major events such as shutdowns.

For example, one of ANDRITZ's Digital Twin applications, called the IDEAS Designer, can be used to automatically run the virtual mill through thousands of what-if design and equipment scenarios in order to optimize the circuit design and determine the most competitive net present value (NPV). Another, the IDEAS Instructor, allows operators to train using the virtual rather than real plant environment. And the IDEAS Guardian application connects to the mill's real-time operation, allowing numerous what-if scenarios to be run rapidly alongside the mill's operation using real-time data. The results provided can be applied for condition monitoring and optimized decision-making.

USING DIGITAL TWINS IN REAL TIME

Connecting the Digital Twin applications to real-time operations is what truly unlocks the full potential of the ANDRITZ Digital Twin solution. Consider the evaporation process in a pulp mill (Figure 1). The virtual model of the pulp mill is connected to the mill's real-time operation. The IDEAS Guardian application uses this replica to detect any undesired conditions such as fouling and scaling, and is also used to take virtual measurements that are not accessible in the real world using conventional instrumentation.

Operational evaporation data on pressure, temperature, and flow are the inputs in real time, and IDEAS Guardian outputs virtual instrument information to the operator screens, including heat transfer coefficients and predicted evaporator percentage solids (see Figure 2), Temperature Rise, Boiling Point Rise per effect, heat and mass balance, and production levels.

The IDEAS Guardian uses this virtual instrument data to enable operators to continuously analyze fouling of heat transfer surfaces, guiding them by providing the optimal cleaning frequency. In the case of a physical instrument failure, the IDEAS Guardian can be set to automatically input values from that instrument's virtual twin into the control system, bypassing the need for manual input and thereby eliminating any disruption of operation.

CONCLUSION

You could compare the concept and function of the ANDRITZ Digital Twin architecture to that of a smartphone. The IDEAS simulation software and first-principle model are like the phone itself and its hardware, systems, and circuitry. The ANDRITZ execution platform is like the operating system, the iOS or Android, that allows the phone's functionality to be accessed as well as connected to other systems and devices. The Digital Twin applications are the mobile "apps". Through the operating system, the "apps" draw on specific functions, connections, and data to either perform a specific task or generate a specific result.

The trajectory of the pulp and paper industry continues towards Industry 4.0 as more and more mills integrate new and cutting-edge technologies into their operations. Digital Twin technology can greatly enhance the efficiency, cost-effectiveness, productivity, and profitability of pulp mill operations, and industry-leading systems, like IDEAS, that combine high-fidelity models with real-time connectivity and an advanced operating platform, are poised to take those operations to the next level.

IDEAS Digital Twin has many other applications for the engineering, commissioning, and operation. For further information, please visit www.andritz.com/metris.

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[1] M. Shafto, M. Conroy, R. Doyle, E. Glaessgen, C. Kemp, J. LeMoigne, and L. Wang, "Draft modeling, simulation, information technology & processing roadmap," Technology Area, vol. 11, 2010.

[2] https://www.gartner.com/doc/3865406/top-strategic-technology-trends

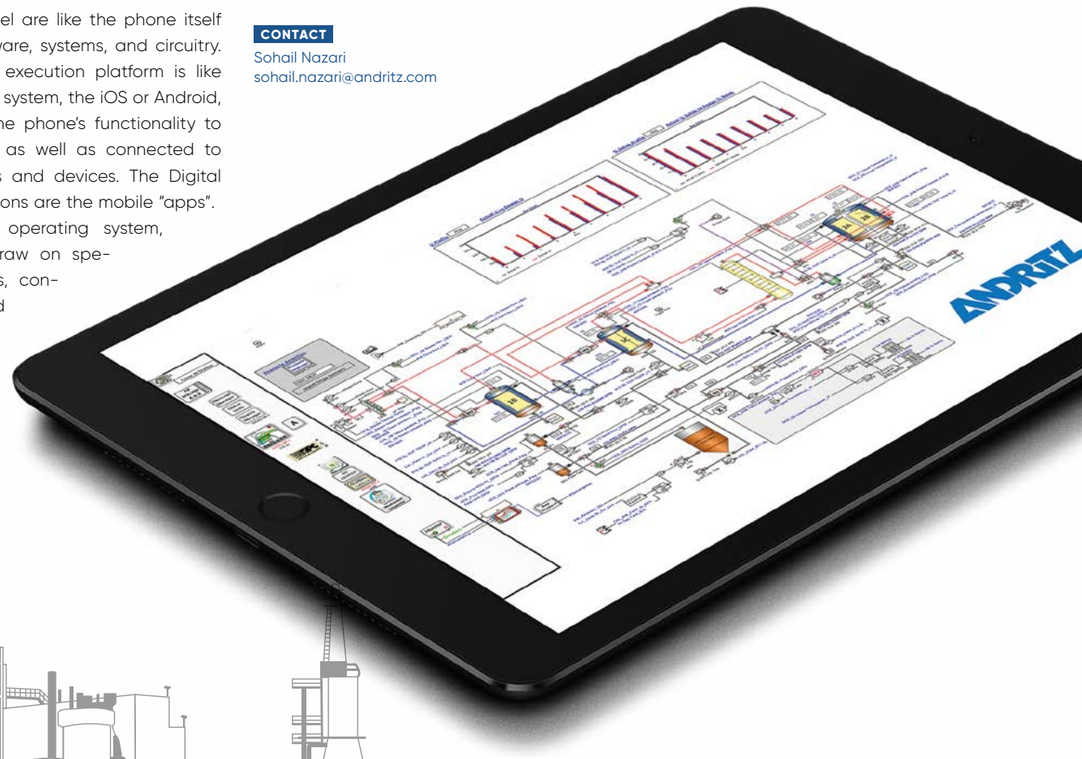

Figure 1: The Digital Twin - IDEAS model of a pulp mill's evaporation process