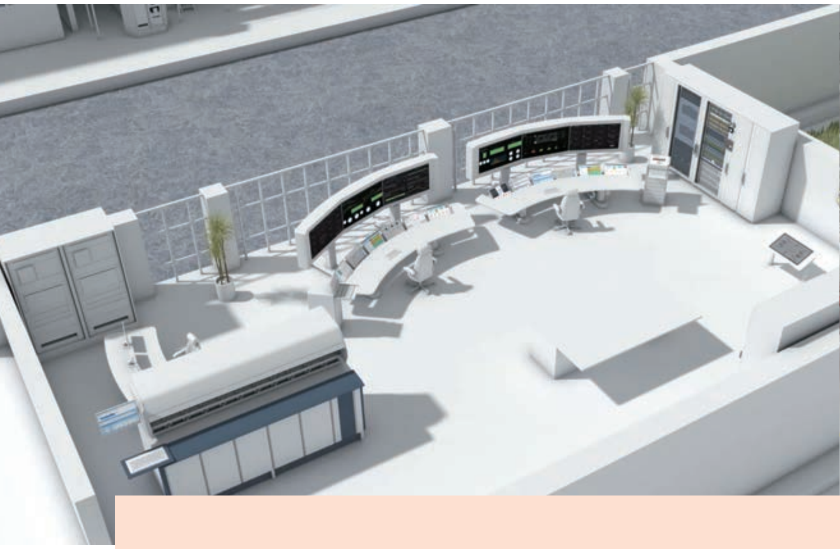

Hard data, soft sensors and process expertise: a recipe for Industry 4.0 success

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For pulp and paper manufacturers, a robust data strategy backed with sector expertise maximizes the benefits of Industry 4.0 technologies, such as the latest machine learning-based soft sensors. Donald Stanley, ChangYuan Liu and John Schroeder of ABB, explain.

Industry 4.0 technologies are transforming the pulp and paper industry, empowering manufacturers to achieve previously unseen levels of efficiency and output. This change is being fueled by data, which lies at the center of strategies to provide reproduceable, robust and sustainable results.

However, data is almost irrelevant unless it can be gathered and validated in a meaningful way: thus, data collection and conditioning – an unglamorous, time-consuming task – is vital if we are to extract valuable insights from our data with minimal false positives. Taking an approach to data acquisition and cleansing that also leverages industry expertise ensures that our models and advanced data-driven applications are accurate and therefore useful.

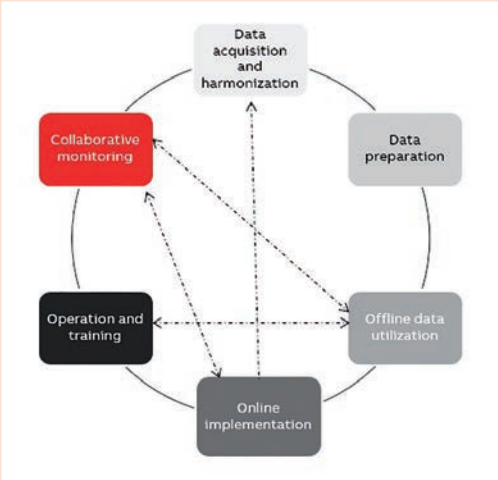
In this article, we discuss creating a data strategy that systematically combines Industry 4.0 technologies and data analysis with sector-specific competencies, particularly as it relates to the newest advances in soft sensors. Building these applications based on machine learning has been talked about for years, but only now do we have the data techniques that enable these to be deployed as reliable, sustainable tools—especially when continuous monitoring of data-empowered systems is used to mitigate the risk of performance degradation.

Following a strategy that equalizes the importance of domain know-how with data acquisition and validation ensures the best results are achieved. This also reduces production costs by minimizing raw material usage, increasing throughputs by improving equipment reliability, or raising quality by stabilizing processes and automation performance.

DATA STRATEGY IN PRACTICE

Putting a proper data strategy in place is crucial to the overall success of digitalization. When considering the optimization of papermaking, the following key areas need to be considered:

1. Data acquisition and harmonization
2. Data preparation and validation
3. Offline data utilization
4. Online implementation of data-driven solutions
5. Operational integration and training
6. Collaborative monitoring and continuous enhancement



1. Key tasks in implementation of data-driven solutions.

STEPS 1 AND 2: ACQUIRE, HARMONIZE, PREPARE AND VALIDATE YOUR DATA

The first two steps in such a data strategy ensure that data is collected and prepared to be usable in data-driven process optimization. In the pulp and paper industry, this data comes from a wide variety of sources (distributed control systems, quality control systems, manufacturing executions systems, other databases and historians): the challenge is to bring this data together in a usable way.

Some key considerations include identifying and locating the variables of interest, which requires a high level of industry experience to provide context and insight into the process and operations. In addition, the time synchronization of data sources is crucial: even a few seconds difference between the clocks of two data sources can distort the data and impact the validity of any subsequent analytics.

Also important is understanding the impact of sampling and compression; ideally, data should be sourced as closely as possible to its 'real' or 'raw' form. For real-time data-driven operations, data must be aggregated from its various sources into a harmonized repository for analysis, preferably using a flexible time-series database capable of subscribing to OPC data and bringing data over from other databases or historians.

While there are many more considerations for cleaning and filtering, knowing how to sort data for use is crucial. Different data sorting schemes must be applied, depending on what type of machine learning, data mining or modelling a user is trying to create, while taking into account that machine conditions, different grades and transition periods result in different operating characteristics. Multivariate analysis techniques should be used to further validate collected data and identify the dominant contribution data sets, which is crucial to the efficiency of subsequent modelling.

Once the process data has been collected, prepared and validated appropriately, it is possible to structure data-driven applications to extract insight – which leads us to consider the use of data and specifically to the creation of soft sensors.

STEPS 3 AND 4: PUTTING YOUR OFFLINE DATA TO WORK FOR ONLINE SOFT SENSOR APPLICATIONS

The insights extracted from collected data are most often presented through the creation of models (step 3) that illustrate how selected process variables interact with other variables. These models could be soft measurements of unmeasurable process variables or product properties, complex models of process behavior for process control solutions, and/or calculations of process performance indices that help monitor the health of a process. To illustrate the idea, we will focus on soft sensors, the types of models that are based on machine learning and that produce inferred calculations of physical measurements.

A soft sensor uses various process variables to infer or estimate a process variable or product quality measurement that cannot be measured in real-time or by a physical sensor.

So, what is a soft sensor? A soft sensor uses various process variables to infer or estimate a process variable or product quality measurement that cannot be measured in real-time or by a physical sensor. They are an addition to laboratory measurements, which provide valuable insight into the final properties of a reel at end of production, but not during production, when actions can still be taken to affect the end result. In the world of papermaking, soft sensors can be applied to many different properties including: sheet quality, sheet strength, sheet weight, kappa value in pulping processes, and wet-end ash calculations.

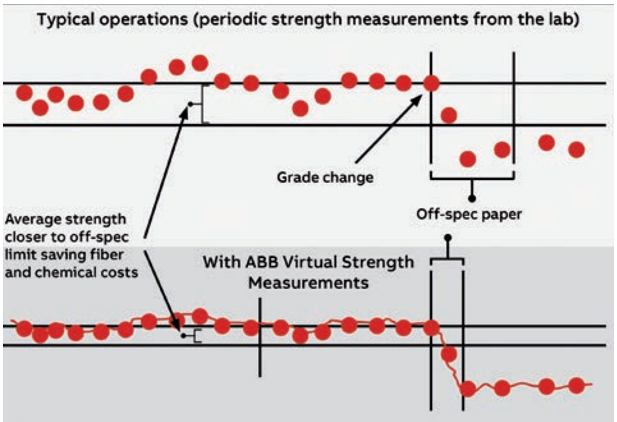
Building soft sensor models requires a significant investment in time and effort before they can be used online in the manufacturing process. Historical process and product quality data – the foundational inputs for soft sensor development – are usually stored in different databases.

To create soft sensors, various exporting tools and techniques (examined in steps 1 and 2) are needed to extract and synchronize this data. Step 3 is the physical creation of the model using the insightful information extracted from the data. When done correctly – and within the context of a proper data strategy – soft sensors bring the value of real-time measurements to variables that were previously only measured periodically.

To make the most of soft sensors, they need to be integrated with controls systems by leveraging application programming interfaces (APIs), which provide connectivity, device management, software management, and data handling for various data-driven solutions. APIs are the backbone of online digital solutions, allowing data to flow seamlessly through control systems, edge devices, cloud platforms, and online data-driven analytics solutions. This means the output of such analytics solutions – of which soft sensors are one – can be made available to control systems for monitoring and/or control applications, completing step 4.

For example, soft sensors that provide measurements of sheet quality can stand in for traditional sheet measurements during start-up, sheet breaks, or while scanners are temporarily offline for service. With this additional insight, papermakers are given complete visibility of the process status and have full access to process controls to achieve smoother transitions, faster sheet break recovery, and better overall process conditions.

An example would be the online prediction of sheet strength – a measurement that is only available in the laboratory. This type of soft sensor application – such as ABB's Strength Virtual Measurement—allows operators to maintain strength properties much closer to their lower limits with measurements that are considerably



An online strength calculation provides more frequent measurement to keep strength properties closer to their lower limits, helping to reduce raw material usage and maintain quality more consistently.

more frequent than those tested in the laboratory at the end of the reel. Mills gain valuable insight that can help reduce raw material consumption, increase machine speed, and complete grade changes faster. The key to creating this valuable insight is constructing a predictive model for the soft sensor application that leverages process knowledge and expertise.

Online models used to predict paper properties can only be as accurate as their architect's knowledge of the individual process. In the case of selecting input variables to consider for modelling against the strength of the paper, you need a deep understanding of the process conditions that contribute to and affect the final product's strength. These include more generalized inputs, such as weight, refining, and fiber orientation, as well as inputs that are specifically detailed to the individual process, such as the initial furnish blends and other pulp characteristics.

STEPS 5 AND 6: MAKING INDUSTRY 4.0 GAINS STICK

Spending all this time and effort on data collection and validation, model building, soft sensor development and online connectivity is worth nothing, however, unless improvement gains can be sustained. And this brings the final two elements of a proper data strategy into play.

The first task is to bring those that will use the system onboard through a people-focused and inclusive implementation approach. Operators, engineers and supervisors all have valuable insight into their process and what avenues exist for improvement. They should be brought into any solution's development at an early stage, and through implementation and commissioning. This allows the project to benefit from both their expertise and buy-in, maximizing chances for success. As an example, process operators should be included in the design of the user interfaces and displays to ensure they are informative and intuitive.

The final element of a successful digital strategy looks beyond final installation and commissioning to ensure its long-term use to its users. The lifecycle of digitalization solutions is all too often one of initial benefit, followed by slow degradation, until they are turned off. To break this cycle, a system of collaborative monitoring and continuous improvement must be put in place.

CONCLUSION

The benefits of Industry 4.0 solutions are potentially enormous but depend on the implementation of a solid data strategy as outlined above. In particular, soft sensors can play an important role in allowing infrequent or even unknown variables to be predicted and used to optimize performance. As their benefits become more widely known in the industry, their use is likely to expand to the point where paper mills have multiple paper properties that are calculated using soft sensors.

As with all digital solutions, however, soft sensors are just tools. To achieve the most value from a digital solution requires not just the technology but an implementation partner with a deep-level understanding of the process, such as that found in the decades of experience ABB's had serving pulp and paper mills. Building an industry-expertise-backed data strategy that follows a proven process will provide lasting value and, more importantly, the trust a business needs to act on the insights digital technologies unlock.