OPTIX™ Applied Intelligence — The Only Real-time Quality Measurement for Finished Product

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OPTIX™ Applied Intelligence — The Only Real-time Quality Measurement for Finished Product

Improving Operator and Production Efficiency Via Artificial Intelligence (AI) and Machine Learning

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INTRODUCTION

What would the impact be to your mill if you had real-time finished quality measurements (i.e., STFI, Mullen, tensile, wet tear, etc.) versus a periodic lab test? What if operational recommendations could also be provided to machine operators in real time? With the help of artificial intelligence and machine learning, OPTIX™ Applied Intelligence is blazing a trail toward complete process visibility with an analytics platform that uncovers mill improvement opportunities not previously possible.

Mill owners and operators need to respond to market trends that are pushing the limits of machine operation. The growing trend in e-commerce has forced packaging companies to produce lightweight paper while maintaining or exceeding strength quality requirements and reducing costs through smarter fibre utilisation, chemical optimisation, energy reduction and more. At the same time, higher demands for packaging requires increased productivity and conscious resource management. Additionally, water scarcity and water quality concerns demand improved water management.

Big data is emerging as a solution to these challenges. With innovative instrumentation readily accessible, mills are collecting vast amounts of data that provide them with ever-increasing visibility into their processes. However, the current data analytic tools are mostly backward looking and have specific limitations in highly variable, continuous-process manufacturing like the paper industry. The typical mill has as many as 5,000 data historian tags that can be associated through highly complex, multidimensional variable relationships. Traditional tools simply cannot handle the computations required to evaluate this level of complexity and nonlinearity in real time. Even the most experienced machine operators can struggle to understand all of the interrelated dynamics impacting production and how to respond to process variability. Furthermore, by the year 2029, all baby boomers will be 65 years old or older, presenting a major challenge for manufacturers

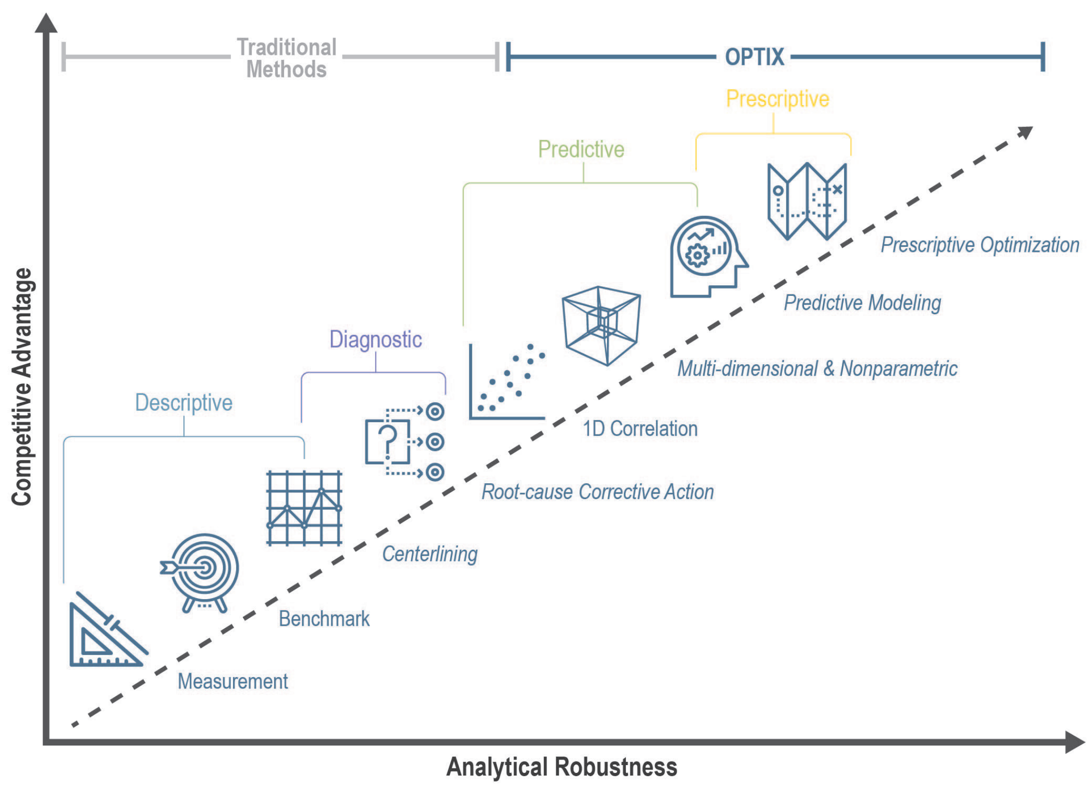

Figure 1. *Overview of data analytics evolution.*

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to anticipate an effective knowledge transfer to the younger generation.

So how does one utilise the current data streams to successfully achieve both corporate and customer-driven goals? Turning data collection into actionable insight is key to successfully exceeding expectations and reducing costs.

Predictive analytics supported by machine learning can provide real-time quality measures that remain robust and accurate in the face of changing machine conditions. These adaptive quality "soft sensors" allow for more informed, on-the-fly process changes, rapid change detection, and process control optimisation without requiring periodic model tuning.

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THE EVOLUTION OF DATA ANALYTICS

Analytics has been in use in the paper industry for decades and, as Figure 1 illustrates, has experienced a gradual evolution. In the early days, critical measurements of both quality and process variables were collected and used for improved machine control, customer specification setting, and benchmarking. This descriptive data collection then evolved into process centerlining, a statistical approach that analyzed where a process's key variables should be set for machine stability and improved product performance. When the process deviated from the ideal state, a more involved analysis task called root-cause corrective action (RCCA) was conducted to identify what caused the deviation. The goal of RCCA was to identify process improvement opportunities that reduced the chance of failure reoccurrence. However, this approach was diagnostic rather than proactive, meaning it relied on a failure to occur rather than preventing failure in the first place.

A newer generation of analytics emerged in which driving process and product optimisation relied on understanding how process variables influenced a machine's key quality and performance variables. The most basic understanding of these relationships was found by calculating simple correlations, where an important dependent variable was inspected against a single independent variable. This improved the insights an operator could achieve, but it still oversimplified the papermaking process, where the dependent variables of interest, such as quality parameters and production tonnage, are highly related to numerous variables within the process. Further, these multidimensional relationships required the use of nonlinear, multidimensional techniques to fully grasp the relationship between a dependent variable and many interrelated process variables.

The need to understand the true nature of these multidimensional relationships ushered in an era of more accurate predictive modelling, allowing for proactive process control of the dependent variables being predicted. Predictive analytics spread quickly across the paper industry and continues to be a valuable alternative to diagnostic analytics. Predictive analytics can provide insight on the impact a change in machine conditions will make on a critical dependent variable of interest.

Unfortunately, few of these descriptive, diagnostic and predictive analytics tools, though widespread in papermaking, have been successful in the predictive analytics space, and virtually no prescriptive analytics tools are available. Having a robust predictive model opens the door to the most advanced form of process control, which is prescriptive optimisation. Prescriptive analytics answers the question, "what can I do to achieve my desired dependent variable result?" While predictive analytics uses relevant information about the process and the critical dependent variable, prescriptive analytics provides insight on what process variables need to change and by how much to achieve the desired output. It takes paper machine control to new levels of accuracy, minimising materials and energy waste and maximising first quality production.

LIMITATIONS OF CURRENT STATIC PREDICTIVE MODELS

Predictive analytic products have been gradually introduced to the papermaking industry. While an array of predictive analytic tools can be purchased from a variety of sources, including chemical suppliers, software companies, and equipment suppliers, these products are developed for generic purposes and frequently lack papermaking focus.

Simply put, predictive models are developed using historical tag data to infer a mathematically driven outcome once the new tag data is calculated by the model. A successful predictive model employs the correct techniques by considering the type of data and the true relationships between the response and the predictors to make accurate predictions. Static predictive models ultimately fail when the variables influencing the predictive model constantly change. Machine runnability, grade mix, fibre availability, chemistry usage, water characteristics, seasonal changes, operating crew and upstream operations are among the many sources of variability in paper manufacturing. While some of these sources of variability may be directly captured in the predictive model, most are not. Without regular tuning, today's predictive models quickly become irrelevant in highly variable applications such as papermaking. While manually tuning of predictive models is an option, the process is time-consuming, costly, inefficient, and requires a subject matter expert.

Current predictive models have a number of disadvantages. For example:

- They require full-time dedication of mill resources for development, monitoring, and interpretation.
- They are expensive to develop.
- They have a lengthy implementation process.
- They are not developed specifically for the papermaking market.
- They are not supported by an onsite representative.
- They require manual tuning.
- They focus primarily on asset protection and preventative maintenance.

While each product offering presents a unique method for applying advanced analytics in the papermaking process, all lack the ability to provide predictions of key quality measures that remain robust and accurate in a continuous, time-stamped manufacturing environment.

THE SOLENIS SOLUTION

OPTIX Applied Intelligence is a unique adaptive analytics platform built with the latest artificial intelligence (AI) and machine learning capabilities available today. OPTIX was developed

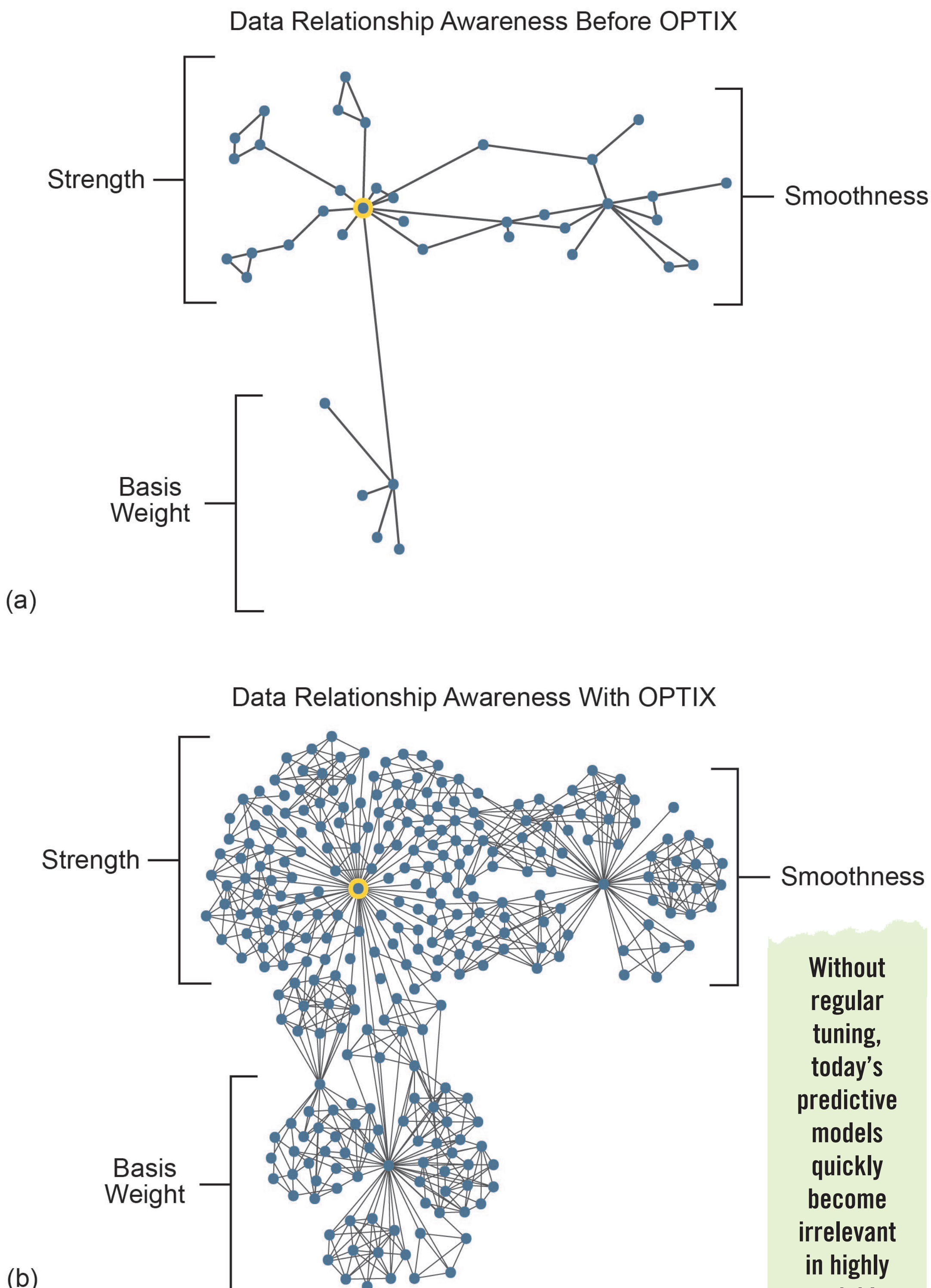

Figure 2. *(a) Comprehensible relationships between strength, basis weight, and smoothness; (b) Causal network showing multidimensional relationships between strength, basis weight, smoothness, and numerous other predictors.*

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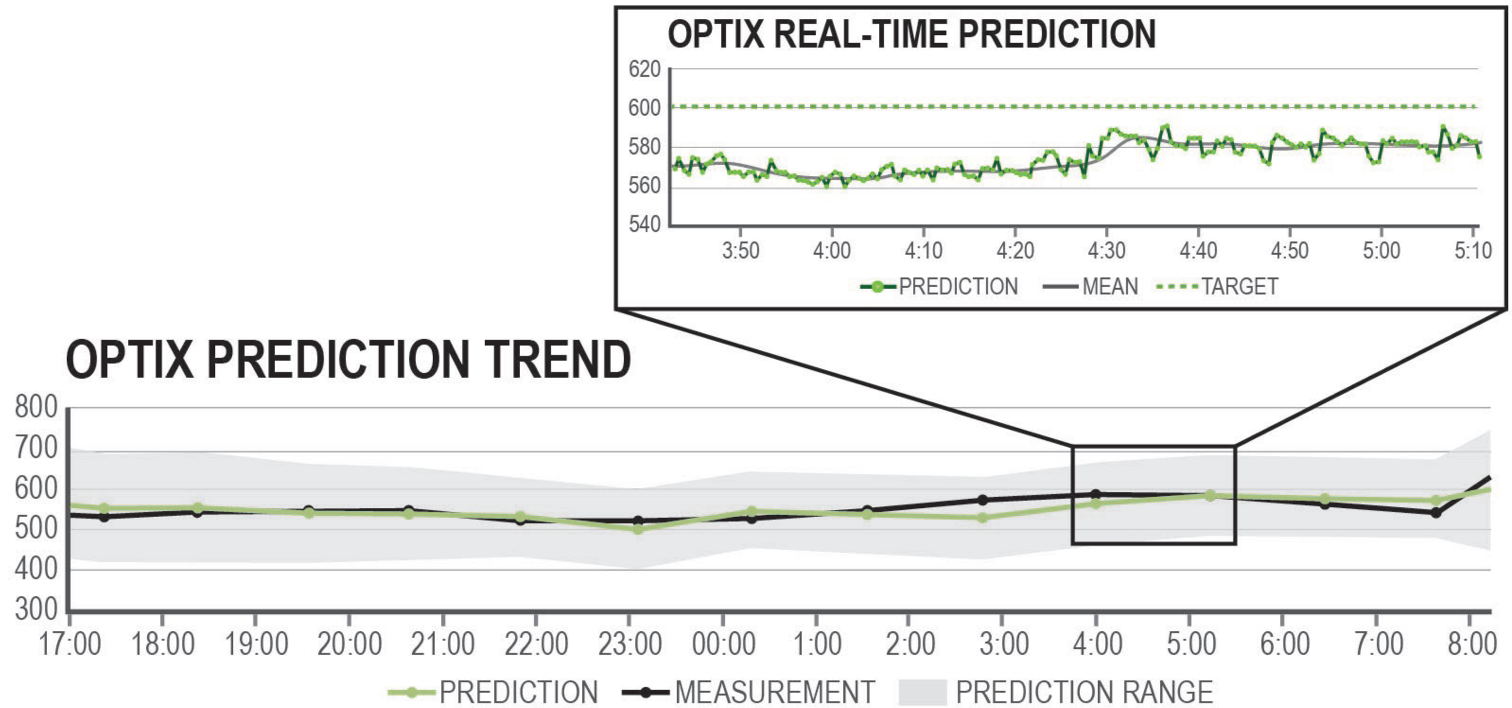

Figure 3. *Prediction trend: Green points indicate predictions, the grey band defines the prediction confidence interval, and black points indicate actual lab values.*

to provide a comprehensive digital service for the mill of the future. It incorporates Solenis' customer- and quality-first philosophy, which means it can accommodate every mill's unique processes. Using process data, physical paper measurements of the critical quality parameters and papermaking process knowledge, Solenis applies robust data science techniques to turn complex, multidimensional relationships into an accurate, real-time, adaptive "soft sensor." Unlike other data analytic tools, OPTIX does not require data interpretation and simply provides an actionable solution. The resulting real-time predictive and prescriptive analytics enable a step change improvement in mill optimisation not previously feasible.

HOW OPTIX WORKS

Solenis carefully evaluates mill process data using sophisticated data collection, cleaning and mining techniques. Advanced data mining practices, such as multiple regression and causal networks, reveal multidimensional relationships between the response and predictors that are not easily identified any other way. Figure 2 illustrates the relationships comprehensible by the human mind compared to the complex relationships that actually exist and can be identified using OPTIX. Solenis employs a proprietary screening methodology that allows OPTIX to focus on the most important tags needed to drive the machine-learning, predictive platform.

For the first time, papermakers can have a real-time, machine-direction quality profile for the entire length of the reel.

The predictive model provides a real-time, mathematically driven measurement for paper quality metrics that cannot be delivered using any other method. The traditional method of laboratory testing key quality parameters only provides a quality measurement every reel turn-up or less frequently. As Figure 3 shows, real-time predictions from OPTIX provide high-frequency data every 15 to 30 seconds. For the first time, papermakers can have a real-time, machine-direction quality profile for the entire length of the reel.

Because of the ever-changing environment of the papermaking process, it is crucial to continually update predictive analytics platforms. Predictive models incorporating machine learning adapt to changes in the process by learning from observations and interactions. This information drives shifts in the predictive model aimed at maintaining prediction accuracy. This level of machine learning is built into the platform, which is why OPTIX measurements remain robust and accurate in the face of changing machine conditions. Figure 4 shows how a static predictive model

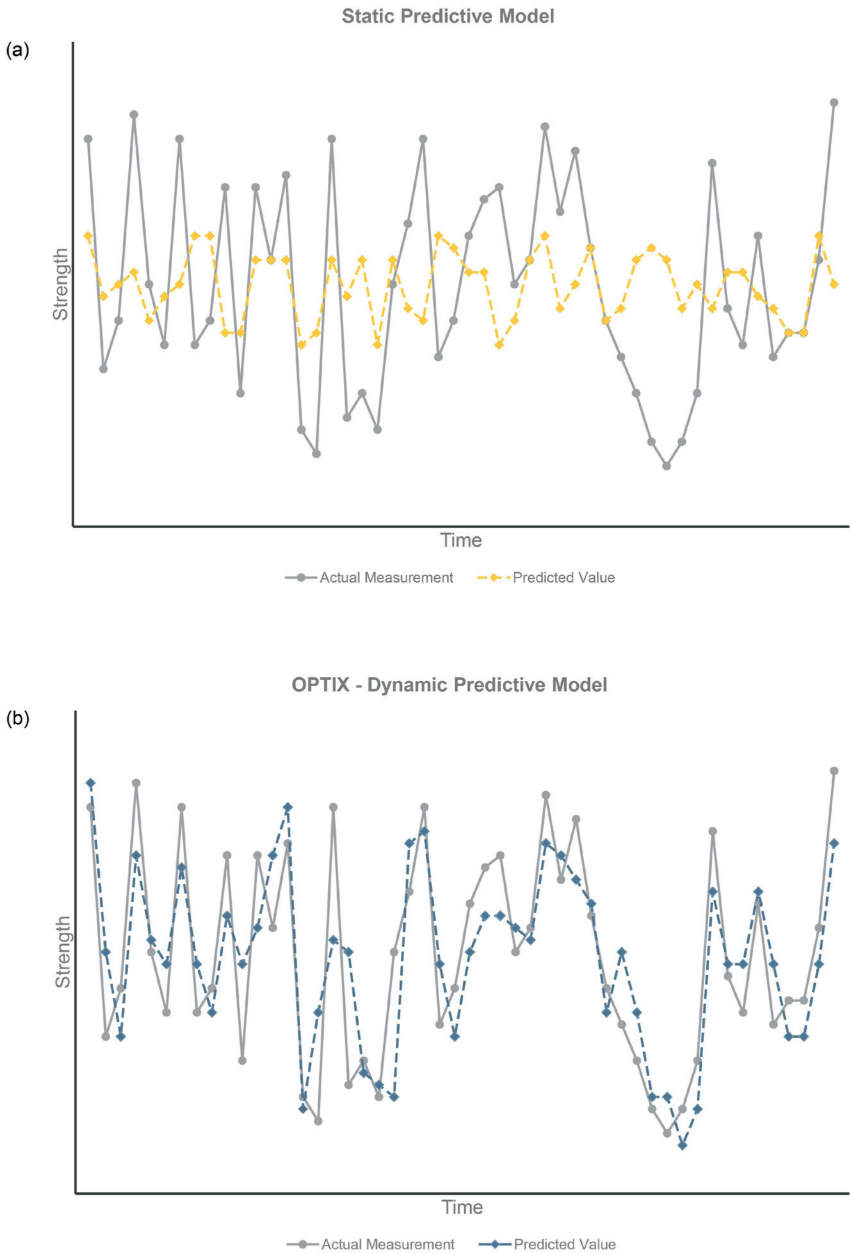

Figure 4. *(a) Predictive model using poor prediction techniques that oversimplify the process; (b) Predictive model with the same data utilising OPTIX, which is capable of handling paper machine process data.*

can lose prediction accuracy over time, whereas the machine learning algorithms built into OPTIX constantly tune predictive models and preserve prediction accuracy in real time. Each OPTIX model is supported with a self-diagnostic prediction accuracy monitor, which calculates the difference between the prediction and actual value of the quality measurement.

Upon successful implementation of the predictive model, deep learning and advanced data analytic methods are used to develop a prescriptive recommendation engine. OPTIX prescribes real-time actionable insights for optimising the manufacturing process. Operators can use data-driven recommendations to maintain manufacturing conditions or target optimised machine efficiency.

SIGNIFICANT RETURN ON INVESTMENT

Implementation of OPTIX provides solutions that cannot be obtained any other way and enables value-creating opportunities not previously available. These opportunities are illustrated in Figure 5 and detailed on the right.

Reduced error. OPTIX real-time predictions have inherently less error than lab measurements. When the prediction is used in place of the lab measurements to make quality control decisions, the system variability decreases because the testing error is no longer transferred into the process.

Reduced variability. Using the real-time predictions generated by OPTIX, operators can make optimal adjustments to key process variables to positively influence the key quality parameter. By avoiding typical reactions to overfeed basis weight and/or chemistry or to reduce speed, overall variability is reduced.

Improved quality consistency. Real-time monitoring of product quality allows for informed decision-making. Reduced process variability and early adverse event detection reduce the risk of product downgrade and ultimately improve quality.

Adverse event detection. Prediction trending can be used to identify adverse events in the manufacturing process. OPTIX predictions offer insight during process upsets. Additionally, mills can take advantage of the relationships recognized by OPTIX to

Operators can use data-driven recommendations to maintain manufacturing conditions or target optimised machine efficiency.

OPTIX Applied Intelligence is the most comprehensive predictive and prescriptive analytics tool available for the paper industry

Figure 5. *Savings opportunities afforded through the implementation of OPTIX.*

identify manufacturing anomalies and clues for root cause analysis.

Increased production volume. Optimising basis weight allows for reduced drying time and increased line speeds.

Learning and training opportunities. Visualising process relationships previously difficult to identify offers significant learning opportunities. OPTIX allows operators to shift perspective and focus on real-time and future quality measures by accessing the secure, cloud-based interface. Operators can use the configurable OPTIX dashboard (Figure 6) via a custom URL.

CONCLUSION

OPTIX Applied Intelligence is the most comprehensive predictive and prescriptive analytics tool available for the paper industry. By utilising machine-learning, the platform remains accurate and robust in continuous process manufacturing. The real-time, actionable quality measures generated by the soft sensors allow operators to optimise paper production and reduce costs.

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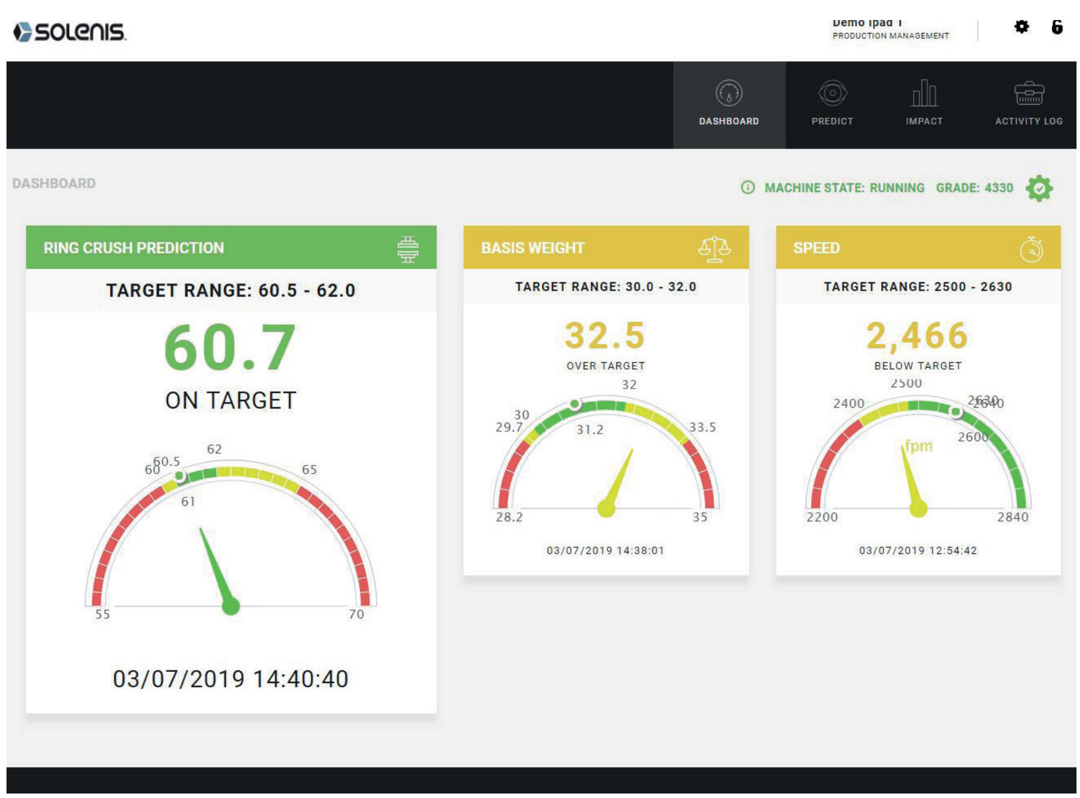

Figure 6. *The OPTIX dashboard displaying real-time readings of key process and quality variables.*