Whitepaper

SmartMill

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The SmartMill journey
A revolution in efficiency for the milling industry

We have reached a key moment in the development of the SmartMill. A journey that started less than a decade ago has led to technological advances that improve yield, product quality, cost efficiencies, traceability, and environmental impact. This Whitepaper explores today's advances and where the SmartMill journey is taking us.

Every journey requires a first step and a destination. Bühler's vision of the fully autonomous SmartMill was created less than ten years ago when the development of affordable and sophisticated sensor technology, an unprecedented growth in computer processing power, vast data storage capacities and lightning inter-connectivity led to a digital revolution in the food and milling industries. Suddenly, new processing power was available to analyze digital data generated in real time by sensors placed throughout the milling process. The question was, how to best utilize all this data?

For over a decade Bühler has been working with its customers to answer that question. The first step on this journey, was to set the foundation for digitalization and collect data from sensors to understand in granular detail what happens at each stage of the milling process. Once collected, this data was structured and visually presented on a dashboard using a laptop, phone, or tablet to provide transparency to operators and management, even when operating remotely.

Algorithms were then applied to the data to analyze the impact on yield and quality between plants and over time. This comparative analysis enabled a skilled mill operator to take decisions that improved plant and product performance. As Bühler is collecting more and more production data across the milling industry, it is now possible to go a step further and develop prototypes that predict production outcomes depending on variables like grain type and moisture content. These digital innovations can now make autonomous adjustments to production parameters to optimize individual milling steps in real time. Today these prototypes only cover certain parts of the milling process. Once autonomous processes are developed and combined to cover the whole production process from intake to bulk-load or packing, we will have reached our destination, the SmartMill.

A prerequisite for SmartMill is equipment able to make production data digitally available, one such example is the IGS Arrius.

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What is the SmartMill?

The modern automated mill has been with us for nearly half a century. Next came digitalization. The idea of storing digital data in the cloud, analyzing it with complex algorithms and feeding it back in a useful format to the miller or directly into the plant's automation processes. As the SmartMill evolved, it has brought digitalization and automation together in ever more sophisticated iterations. With each new digital solution, the industry gets closer to creating a mill that is fully autonomous, self-optimized and self-learning. The SmartMill is not just reactive, responding to errors and deviations in the production process, it is also proactive, anticipating operating conditions based on external factors such as the quality of the raw material or weather conditions. As we get closer to achieving the SmartMill vision, the skill set of the miller will be more varied and multifaceted as he or she makes data-driven decisions that impact efficiency and quality.

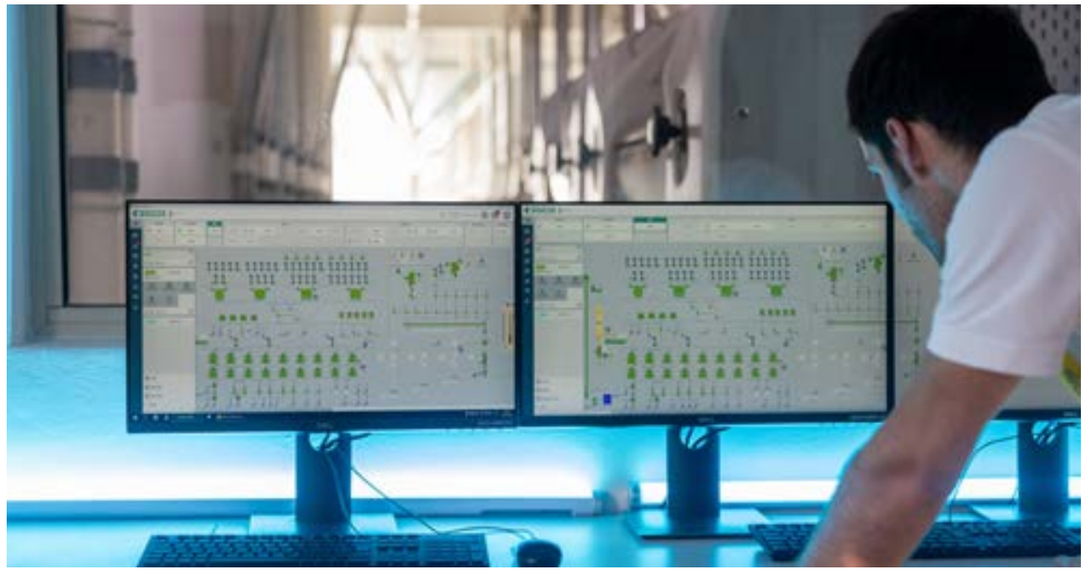
Why develop the SmartMill?

The primary reason is efficiency. Anyone working in the milling industry knows what a competitive market it is. Competition means tight margins that require optimum efficiency. Each new digital solution must achieve the highest rate of automation while providing the greatest extraction yield at the lowest cost with little or no deviation from optimal quality. The aim of the SmartMill is to achieve this using the minimum amount of energy and creating the smallest environmental footprint.

A mill is an inter-dependent process operating in real time requiring constant adjustment. For example, what happens when the grain is being cleaned impacts the milling quality later in the process. The speed and accuracy of these adjustments are how optimization is best achieved. The advantage of the autonomous mill is that it reacts faster than a human and is informed by a more precise and complete data set that relates to the whole production process rather than just one aspect. "In many validation trials, results have shown that our data models perform better than the average mill and sometimes beat the performance of the top-performing assets in the field as the optimization can run 24/7" explains Alexis Noël, Digital Program Manager Bühler Milling Solutions.

The development of the SmartMill is also driven by the global climate change crisis. A third of all food goes to waste [Ref 1] while, according to the UN Environment Program, between 8 percent and 10 percent of global greenhouse gas emissions are associated with food that is not consumed [Ref 2]. The more waste that can be cut from the production process and the less resources we use, the lower the cost base and the smaller the industry's environmental footprint.

The third reason for the development of the SmartMill is an industry-wide shortage of skilled millers. Milling has historically been an experience driven industry with generations of millers learning the trade from others. As with other manufacturing sectors young people are less attracted to working in the often-challenging environment of the traditional mill leaving a skills shortfall. The SmartMill is bridging that skills gap and is providing a more attractive workplace for our next generation of millers.



Providing transparency by collecting, structuring and presenting data visually is the first level of SmartMill.

The evolution of the SmartMill

When thinking of the evolution of the SmartMill it is useful to equate it to the three key car technologies that have led to the development of the driverless car. For the automobile industry the journey started over 60 years ago with the introduction of cruise control, one of the first driver assisted functions developed to make driving easier and safer. This later transitioned into more sophisticated semi-automated systems like lane assistance, capable of analyzing driver behavior. Next came greater automation like the autopilot function, enabling vehicles to take over the driving in controlled settings like motorways. Each technological advance has taken the car industry closer to the development of the fully autonomous vehicle capable of taking control of the whole driving experience once the passenger has set the desired destination.

The SmartMill is evolving in a similar way. Less than a decade ago Bühler started to develop the digitally connected mill, providing the miller with visualized production data in real time. In recent years this evolved into a mill that monitors production parameters and provides actionable insights to improve yield, quality, and energy efficiency. Today, we have reached the third stage in our journey with the development of the semi-autonomous mill. Not only can it provide ever-more sophisticated actionable insights, but it can self-regulate some processes without human intervention. The final part of our SmartMill journey will be the fully autonomous, self-optimized mill requiring minimal human input. Like a passenger setting their destination in the driverless car, the miller will set the parameters of the required end-product, and the mill will do the rest by adapting and adjusting its production parameters through a process of continual learning to maximize efficiency.

The four levels of the SmartMill

Level 1: Connect

Connectivity and data readiness are the foundation of the SmartMill. Once production data is digitalized it offers transparency and it also provides a historic record of production parameters that can be fed into an Internet of Things gateway for analysis to help optimize production. Connect is the foundation of SmartMill, unlocking exponential benefits in Levels 2 and 3. Customers are encouraged to invest in Level 1 early in the process to access these benefits.

Timescale: In 2015 Bühler started to develop its first versions of Bühler Insights and Mercury MES solutions at the point when cloud and sensor technology was first available.

Key Bühler solutions needed to achieve Level 1:

- Bühler Insights
- Mercury MES
- Equipment like Arrius, Moisture control unit, Optical Sorters, Weighing and Dosing solutions
- Sensors like NIR Multi Online Analyzer

Level 2: Monitor

Next, the ability to provide actionable production insights with decisions based on empirical evidence rather than instinct and experience. The gathered data is assembled in comprehensive visualizations and analyses and as more historical production data is stored digitally different yield and quality outcomes could be compared depending on production parameters. This allows to highlight the parameters that need to be adjusted to best optimize efficiency and quality, depending on variables such as a raw material characteristics or differing energy efficiencies.

The second level involves applying algorithms to analyze and monitor the collected data.

Level 2 also enables the monitoring of each machine's performance throughout the production process and how machine parameters are interrelated. By looking at key performance indicators for each machine and process, algorithms can analyze performance trends and then make recommendations on energy usage, maintenance scheduling and how best to optimize machine performance to achieve the highest quality and most efficient end-product. For example, the Error and Downtime Analysis is a service that interprets and records machine incidents that cause production losses and recognizes patterns and trends. The Energy Management System keeps a close watch on energy consumption with every part of the process monitored and inefficiencies flagged up. Data sent to the cloud interprets both the problem and the solution.

Timescale: The first version of a level 2 mill was developed in 2021 with Level 2 functionality now operating across an estimated 80 Bühler production lines.

Key Bühler solutions needed to achieve Level 2:

- Error and Downtime Analysis
- Machine Condition Monitoring
- Overall Equipment Effectiveness
- Temperature and Vibration Management
- Energy Management System
- Quality Management System

These services are underpinned by new developments in Bühler Insights and Mercury MES.

Level 3: Assist

Today we have reached Level 3 on our journey to the SmartMill where human intervention is now reduced thanks to the plant's ability to self-optimize some of its key production processes. Bühler has now developed new prototypes that predict the behavior of the mill and make adjustments of individual processes in real time (see below).

Timescale: Level 3 has arrived and is currently in prototype on a handful of sites. Customers who wish to start their own SmartMill journey are invited to contact us to join the Bühler partner program for the Level 3 SmartMill.

Key Bühler solutions needed to achieve Level 3:

- Color Loop
- Grinding Gap Optimization (in prototype stage)
- Flour Moisture Optimization (in prototype stage)

Again, these services are underpinned by new developments in Bühler Insights and Mercury MES.

Level 4: Self-Optimizing

Level 4 will require minimal human intervention apart from setting the product characteristics required. The mill optimizes quality while running at greatest efficiency. Through intelligent learning it will continuously adapt its own production parameters based on variables like raw material characteristics or weather conditions.

The miller decides the type of end-product required while the mill achieves the desired quality in the most cost-efficient way. The analogy with the driverless car is the ability to set your destination and then allowing the vehicle to get you there in the safest, fastest, and most efficient way possible.

Timescale: Level 4 is currently at the vision stage.

The Assist level reduces human intervention through individual real-time, self-optimizing production processes.

New Level 3 prototypes

The difference between Level 2 and Level 3 solutions is that the mill can autonomously adjust some production parameters to maintain quality and efficiency at speed.

The number of these new self-optimizing functions will increase in the coming years until the mill is fully autonomous and running with minimal human input (Level 4).

“We now have our first Level 3 prototypes working in the industry and we are seeing a huge value change between these Level 2 and Level 3,” explains Noël. “We have used closed loops before, for example with flour ash content, where a sensor informs a specific machine to amend its production parameters.

The difference is that at Level 3 we are talking about much more complex loops where we have multiple process inputs reacting in unison to amend production parameters to maintain the desired end-product quality, which is something completely new.” The two newest Level 3 self-optimizing prototypes currently in development are Grinding Gap Optimization and Flour Moisture Optimization.

Grinding Gap Optimization

Probably the most iconic task for any miller is the adjusting of the grinding gap in any milling operation. It is a time-consuming process impacting extraction yield, energy consumption and quality that requires experience and know-how. The traditional miller uses temperature and the feel of the grain to adjust the grinding gap on a sequence of roller stands, a job carried out intermittently among many other tasks. The Grinding Gap Optimization solution monitors each roller stand 24 hours a day and analyzes data such as yield values, final product quality, roll temperatures, and energy usage throughout the whole milling process. The system then recommends roller adjustments to the plant operator, depending on where the roller stand is in the milling sequence. It then informs the operator of the result of that adjustment and how it has impacted end-product quality or energy usage. Grinding Gap Optimization is currently on trial with a handful of Bühler customers. Once enough data has been collected both historically and across a range of different mills, Bühler will have sufficient data and proven reliability to adjust the grinding gap autonomously in any condition.

Flour Moisture Optimization

Getting the water balance right in milling is increasingly challenging as weather patterns become more erratic. How much water to add or extract is currently a fine balance requiring skilled judgement. The Bühler Flour Moisture Optimization solution automates that decision process by using algorithms to analyze real time data feeds. In addition to data on the water content within the raw material the algorithms assess the ambient moisture level in the mill, current weather conditions, forecasted weather changes and then look at the optimum water content used in past recipes. The Flour Moisture Optimization then suggests to the plant operator what adjustments are needed to improve productivity. This solution is currently being trialed by selected Bühler customers. Once the dataset becomes large enough, the water balance adjustments will be done autonomously by the Flour Moisture Optimization.

Through continuous monitoring and analysis, the Grinding Gap Optimization recommends adjustments to optimize product quality and energy usage in the milling process.

Why should I join Bühler on the SmartMill journey?

Every new digital development is designed to improve your mill’s efficiency. Each iteration of the SmartMill uses automation to achieve the best extraction yield at the lowest cost at optimal quality and with a minimal environmental footprint.

Some of our customers have been on our journey towards the SmartMill with us from the very beginning, others have adopted elements of it and others are yet to join us. Whether a customer chooses to develop their plant functionality in stages by adopting each of the different Level technologies over time or transition to level 3 functionality in one leap depends on their own business requirements. Over the past decade Bühler has received feedback on how different digital processes benefit customers and how they can be adapted to better achieve customer goals. However, while today all our Level 2 and already several Level 3 solutions are available for sale, we continue to develop, prototype and trial future features together with Bühler customers. “We call them prototypes because they are solutions that will be soon released onto the market once performance and reliability are proven to be at the highest level,” explains Alexis Noël.

Conclusion

Imagine a world where a fully autonomous mill is seamlessly integrated into your operations, self-evolving through continuous real-time data collection, and analytical reflection on every aspect of production, from machine efficiencies to the nuances of process optimization. The SmartMill is not a product that you can buy today. It is a vision of the future of the milling industry. It is also a journey, in which the endpoint is the fully autonomous mill.

Bühler stands at the forefront of carving the way towards this transformation, charting four key levels in the evolution of the SmartMill. And each step we take is another stride towards the pinnacle of our journey.

Picture your operations infused with intelligence, where insights become decision-making power. Join us on this captivating journey to shape the industry’s future. Together, we will not just reach for the next level in milling – we will set it.

Do you want to be part of shaping the industry’s future? Are you ready to start the journey towards your SmartMill? Contact us: **milling@buhlergroup.com**

Alexis Noël
Digital Program Manager

References

1 https://www.carbonbrief.org/in-depth-qa-what-food-waste-means-for-climate-change/#:~:text=According%20to%20the%20UN%2C%20food,2022%2C%20according%20to%20the%20FAO

2 https://www.unep.org/resources/report/unep-food-waste-index-report-2021

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