FOOD & BEVERAGE

Application Bulletin

IoT in Brewing

Introduction

Digitalization — based on the **Internet of Things (IoT)** — is omnipresent today. Whether in communication, smart home management, mobility, health care or dealing with authorities, IoT is our daily companion. In the business area, digitalization opens new possibilities for process optimization, improving occupational safety, for comprehensive resource savings, improved productivity and quality and the associated profitability as such.

The advantages of digitalization in processes and products are significant. Therefore, it is now time to establish digitalization in the field of beer filtration and stabilization and to use the associated possibilities of data analysis up to fully automated process optimization.

Data in the Brewery

A modern and automated brewery processes a large amount of data during operation, which often far exceeds our imagination and thus the possibility of data evaluation, use and optimization.

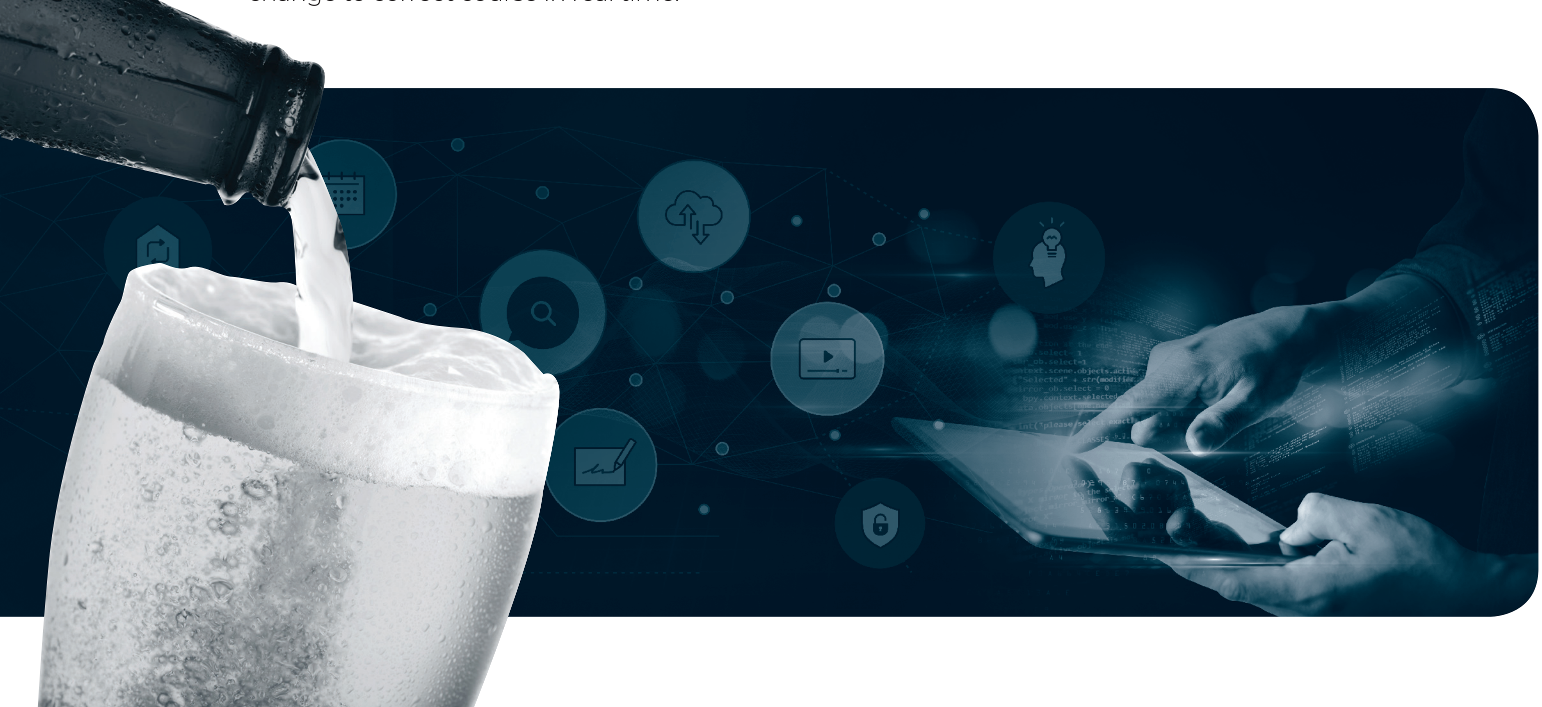
Depending on the equipment, an automated brewery with an annual production of 1.5 million hl generates—from the malt intake to the bright beer tank area without bottling—between 75,000 and 150,000 data sets, based on 2-3,000 physical sensors and measurement points which generate corresponding program sequences with the associated data.

Data falls into 3 main sets: process control; process adjustment and supervision; and process analysis and optimization. Process control represents 60-80% of the data and includes background data like valve position, pump orientation, proximity switch signals. Process adjustment and supervision represents 20-40% of collected data including pressure, temperature, pH and turbidity.

Process analysis and optimization, depending on the operation and control concept, represents < 1% of the process control data.

Today the evaluation of this data is manual or semi-automated, based on data shown in the HMI or pulled from the PLC via USB stick or modem for further evaluation either manually or by using a Microsoft Excel file or similar software.

This is time-consuming, has a certain degree of imprecision and is usually retrospective, which means that when the evaluation takes place, the process is already complete and the production batch is processed further. There is no change to correct course in real time.

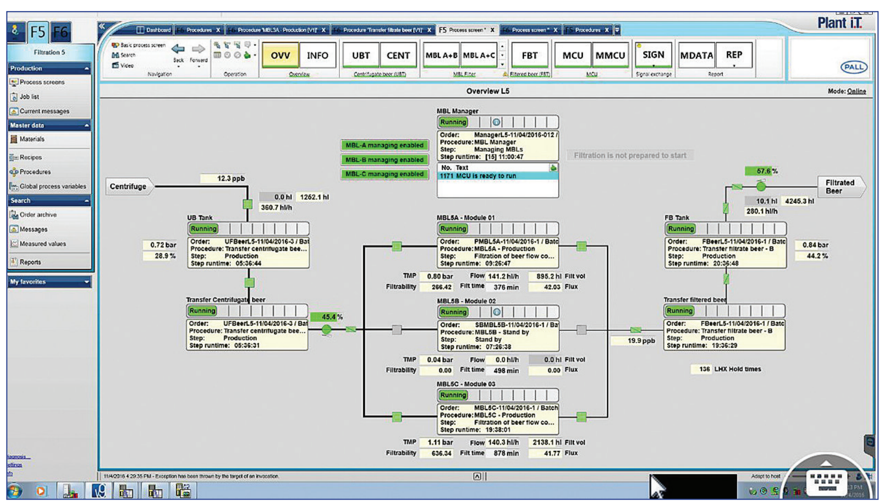


With the use of SCADA systems, data recordings and evaluations can be created and carried out more comprehensively and effectively. However, the challenge continues to be the timely analysis combined with a direct reaction to process flows and the associated process optimization. Access to SCADA data and their timely evaluation outside the control room is also an often challenging and complex task, which is by no means in used within the scope of technical possibilities. Important data and insights remain unused.

The amount of data that is available and how it is processed and evaluated is shown using a small beer filter system as an example.

The Pall PROFi Craft 12 is a system for beer clarification using crossflow filtration in the performance range of 60 - 120 hl/h. The system is fully automated, has a small CIP integrated and is supplied prefabricated on a frame. The installation and commissioning take place in a few days.

As a stand-alone system, this small PROFi Craft provides 274 different data points and signals that can be read and evaluated every second or every 10 seconds, whatever the suitable time interval would be to have optimized control and steering capabilities for the machine The control has a data memory of 8 MB (*e.g.,* Siemens PLC 317-2 PN) with an optional extension to several GB on an external data storage at the HMI or an external data storage system. The standard data storage corresponds to the data volume over a period of approximately 6 months. The operator has the option of reading out the data via an interface or a modem. Though rarely requested, a memory extension or an automated reading is possible if required. After the data memory has reached the maximum capacity, the controller automatically overwrites the oldest data. Besides reading the data, direct monitoring on the control panel (HMI) is the main use of the data. Only the current status can be recorded here, an interpretation or trend analysis is not possible or only possible with a great deal of effort.



This simple example shows the limitations of data processing in systems without a SCADA basis:

- Only indirect access to records
- Manual data analysis
- Time-limited data documentation
- No real-time analysis

In real life, the breweries are using the data seldomly. A lot of time, effort and manpower is necessary to generate meaningful analysis combined with process improvements. Without leveraging IoT, analysis and process improvements are typically not realized as additional value for the brewery. Thus, the system operates on settings established at commissioning, and the process is never optimized further based on data collected. What does this mean in money: A brewery with a yearly production of 200,000 hl and specific filter cost (OPEX) of 0.3 dollars/hl spent 60,000 dollar for dollar for filtration. An optimization of the process based on a data analysis can save between 10-30%, representing a yearly value of $6,000-$18,000 which corresponds with a payback of < 1 year.

These values can be further improved if the data is used in a second step for self-optimization of the system. The filter system is always operated in the optimal process status through continuous data analysis and the associated constant process adjustment. By using algorithms for process control, the filter system learns, independently of the operator, under which conditions the longest filter service life, the lowest water and energy consumption and the maximum filter utilization are achieved.

This digital filter solution was developed by Pall in crossflow systems for wine clarification in 2019 and has since been installed successfully to 33 + wineries.

By using the "Pall Optimizer", the winery achieves savings of between 20 and 38%, which allows for a quick amortization of the digital solution. Compared to wine, beer filtration is much more complex which increases the demands on the algorithms. At the same time, the higher complexity opens the possibilities of a much broader spectrum for process optimization and thus, for cost optimization.

In larger installations, a SCADA system is often used at the process control level. These monitor and visualize the entire installation and thus make a significant contribution to planning, quality assurance and documentation. Accessing and evaluating the data is much easier, more convenient and, to a large extent, freely configurable. The disadvantage of the SCADA systems is that the data is not, or only partially, processed within the IT structure.

By combining SCADA data with appropriate evaluations and analysis tools, a maximum benefit of the information can be achieved for the brewery. This is realized by implementing an IoT-based digital extension.

IoT systems organize the secure data transfer from the SCADA system to the cloud. Once the system is handed over, the customer needs to actively grant acces to Pall if this is desired.

The Pall IoT approach utilizes the latest security protocols on the market and is constantly updated to assure maximum security.

The data analysis is evaluated as defined and configured to meet the requirements of the brewery and subsequently forwarded to a display device (*e.g.* tablet, mobile phone or laptops of specified users).

With this IoT-based extension of data management in real time, a significant gap in the information management of process data is closed. Different levels and hierarchies in the brewery always have access to defined data in an edited format defined by the user.

Typical examples are:

- Specific consumption data such as water, cleaning agents, electricity, membranes
- Performance data such as degree of utilization, efficiency and downtime
- Quality data such as original extract, haze, etc.
- Alarm data and messages
- Documentation and service data

In addition to current data, trends, historical reviews, brand related influences, raw material effects and many other aspects can be analyzed with the IoT tool.

An additional feature is the comparison with other installations within the brewery group and with the industry average if desired.

Another feature is the direct online availability of all system-specific documentation and training documents, spare parts lists, service reports, operating instructions, safety instructions and acceptance reports.

Alarm messages can be displayed directly on the various display devices, reducing response time in the event of a production problem. This function can be switched on or off by each individual user, selectively.

As already seen above, IoT contributes directly to plant optimization and process/product assurance. This is shown again for various aspects in the following examples:

Example 1:

- Brewery with 800,000 hl annual output
- Fully automated filtration and stabilization system and partially automated periphery as fermentation, maturation, and bright tank area
- Plant capacity 250 hl/h
- Largely automated including SCADA system
- Central control in the brewhouse with HMIs on the corresponding systems
- 3-shift operation
    - Day shift 2 employees in the cold area including filtration
    - Late and night shift 1 employee each in the cold area

Situation:

During the late shift, the swing panel thread and nut connection was not tightened correctly with supply tank change. This draws air into the beer pipework and raises oxygen levels in the unfiltered beer to 0.8 ppm, well above the maximum allowable level of 0.05 ppm. The SCADA system displays the oxygen reading on the control room screen and on the HMI at the filter system as an alert (flashing value). The following scenarios are representative of the incident described above:

1. The responsible employee in the cold area is busy with preparatory work for the tank CIP and only occasionally pays attention to the filter display. After noticing the out of spec oxygen level, they acknowledge it to complete the work that has started. After that, they go into the prescribed break and fixes the problem afterwards.

It took 3.5 hours from the start of the disruption to its elimination. During this time, 875 hl of beer with a significantly increased oxygen content was filtered and made available in the bright beer tank for bottling. What were the potential next steps?

a. Before filling, the laboratory measures the oxygen levels in the pressure tank and determines the high oxygen levels. After discussion with the management, the contaminated beer is returned to the fermenting cellar and distributed to several fermentation tanks before yeast dosage to reduce the oxygen levels again through fermentation: Estimated effort $3,000 — no impact on taste or loss of quality in the bottled beer.

b. The oxidized beer is directly bottled (2,062 crates each 20 bottles with 0.5 l); Due to the flash pasteurization, there is a clear influence on the taste stability; the EAP value and the T400 value are significantly reduced, the aldehyde values including furfural are significantly increase. Colloidal stability (forcing test 0/60) decreases by 20%. Customers complains around off flavors — paper taste after 4 weeks.

2. The installed IoT system recognizes the fault as soon as it occurs and sends an alarm message with a time stamp to the employee's mobile phone, the QA manager, and notes the fault in the alarm register. The employee in the cold area reacts immediately as the system reminds constantly; operator puts the system into standby mode and checks the entire pipe route for possible causes. After 1 hour the problem is solved and the filter system is back in full operation. Before packaging the batch, the laboratory team measures the oxygen content in the affected bright beer tanks and releases them based on the minimal increase within an acceptable range. Estimated effort $400 — no impairment of taste or loss of quality in the bottled beer, no customer complaints.

The same scenario applies for other quality factors such as haze, color, °Plato, CO_2, etc.

Example 2:

- Brewery with 5,000,000 hl annual output
- Fully automated production
- Plant capacity 2 x 600 hl/h
- Central control room to operate the entire brewery, distance to filter room 8 min walk
- 3-shift operation
- Number of brands produced = 4, main brand represents 75%

Situation:

With the same initial conditions, the — not identical — filter lines show different specific throughput results. The performance of the filter lines varies from not noticeable to significant differences in filter capacities. Selective investigations and analyzes based on the data and process curves read out by the SCADA system did not reveal any causal relationships. Due to the physical distance between the central control room and the filter systems, it was difficult to track direct effects on the filter itself as a function of process and program adjustments.
In addition, two different platforms are used for process control, which made direct comparison even more difficult. Since the differences represented a significant financial value, the brewery decided to assign a qualified employee to analyze the process over a longer period.

Analysis period: 18 months

Personnel requirements: 1 full-time employee/process engineer

Cost: $185,000

Execution:

- Creation of an on-site SCADA workplace beside the filter line
- Adaptation of the SCADA data programming to the brewery-specific situation in order to achieve simplified manageability and thus improved comparability of the data
- Detailed analysis of the relevant process data including peripheral influencing variables
- Step-by-step implementation of the findings from the data analysis
- Adjustment of the cleaning effectiveness to a comparable level for the installed lines, based on the analysis of the cleaning times, detergent consumption, and cleaning processes
- Adaptation of the upstream process steps (fermentation/storage cellar) for smoothing out the solid loads to the centrifuges
- Optimization of the centrifuge efficiency to achieve a more constant solids content at the respective filter inlet
- Improvement in the control and handling of the filter inserts and thus an optimized inventory management
- Overall cost reduction of 15-20 % depending on beer type and volume

This example shows that system optimization based on SCADA data can become very complex and usually requires the data to be adapted to the individual situation. In addition to the adjustment, the time required for the analysis is considerable.

By using an IoT system, the relevant data for a process check and optimization are individually configured, the evaluation is carried out directly at a workstation and the effectiveness of adjustments is tracked promptly.

Summary

The IoT Platform/Phase 1 developed by Pall provides breweries with easy and secure access to production-related data at various communication levels. The availability of freely configurable process information allows a timely, specific analysis and corresponding adjustment and optimization. This results in a quick reaction and optimization of the processes combined with an improved cost, consumption and quality structure. Even if during phase 1 of the IoT project a direct ROI can only be calculated to a limited extent in advance, the manageable effort and low costs for implementation and use are very quickly offset by process optimization and data transparency. Phase 2 covers machine-based learning and self-optimization and is based on the data analysis established during phase 1.

Based on practical values with already installed Pall crossflow systems, significant savings in energy and media consumption combined with longer filtration cycles can be expected.

About Pall

Pall Corporation provides critical filtration, separation and purification solutions to meet the demanding needs of a broad spectrum of life sciences and industrial customers around the globe.

Across 80 locations and 10,000 people worldwide, we are unified by a singular drive: to solve our customers' biggest fluid management challenges. And in doing so advance health, safety and environmentally responsible technologies.

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