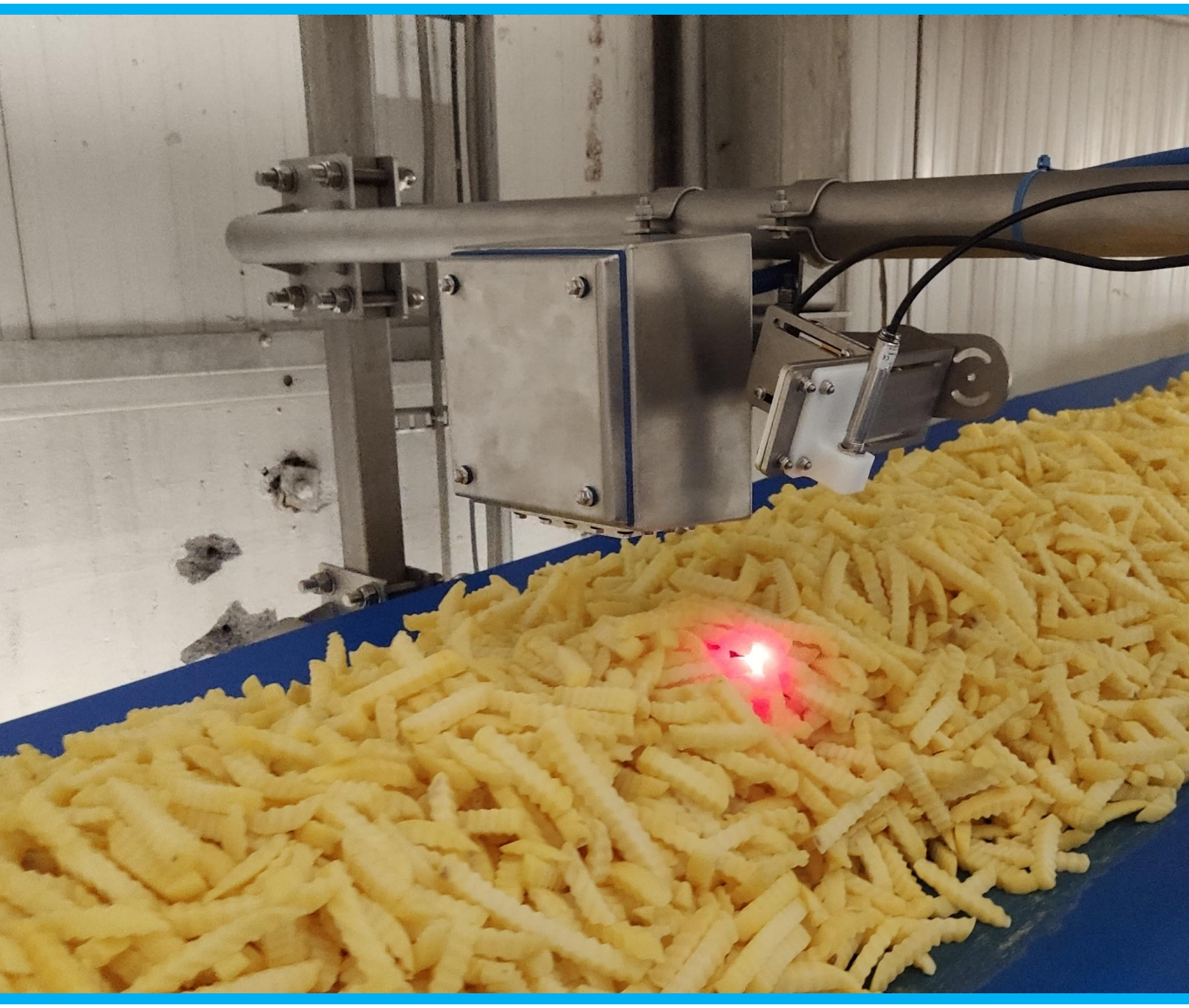
AQUANTIS

Inline Measurement Solutions



MICROFREEZE®

Inline freezing monitoring

INLINE FREEZING MONITORING

Why the need for inline freezing sensors?

Food safety, minimal operating costs and sustainability are key challenges for food processors. Increasing energy costs are forcing food producers to increase their product prices. However, there is a lot of room to improve the efficiency of these freezing processes. The MICROFREEZE® offers a sustainable solution to reduce these costs while maintaining the highest food safety and quality standards.

Figure 1: MICROFREEZE® monitoring French Fries.

MICROFREEZE®

The MICROFREEZE® is the first inline freezing sensor to monitor and optimize freezing and defrosting processes in **real time**. The sensor measures the fraction of water within **layered** products (e.g., French fries) that is crystallized into ice. This fraction is expressed as the level-of-frozenness (LOF). By measuring through the product and non-metallic packaging material, the sensor provides insights about the core of the layered products. This information is used to provide real-time feedback to the freezing and defrosting units.

The installation of the MICROFREEZE® translates into an **increased production capacity** and **reduced energy costs** without affecting the freezing quality. The MICROFREEZE® is specifically designed to measure the LOF of layered products such as French fries, vegetables, etc.

Figure 2: MICROFREEZE® with transmitter, receiver and computing unit.

BENEFITS OF INLINE MEASURING

Conventional measurements: offline

Evaluating freezing processes is typically achieved by at-line or offline temperature measurements. A quality control manager collects samples from the production line and places a temperature probe in or between products. It takes 15-30 minutes before the equilibrium temperature is reached. Based on the obtained readings, the freezer settings are adjusted. This quality control approach is time consuming, prone to manual errors, and energy inefficient.

MICROFREEZE®: inline monitoring

By continuously monitoring the freezing state of the food products, you can follow up the freezing processes in **real-time.** Inline measurements no longer require sampling and sample preparation of the processed food products. Removing this intermediate step saves time, energy costs and eliminates manual errors. This system allows to minimize process variations and immediately adjust the freezer's settings. This significantly increases the efficiency of the freezer.

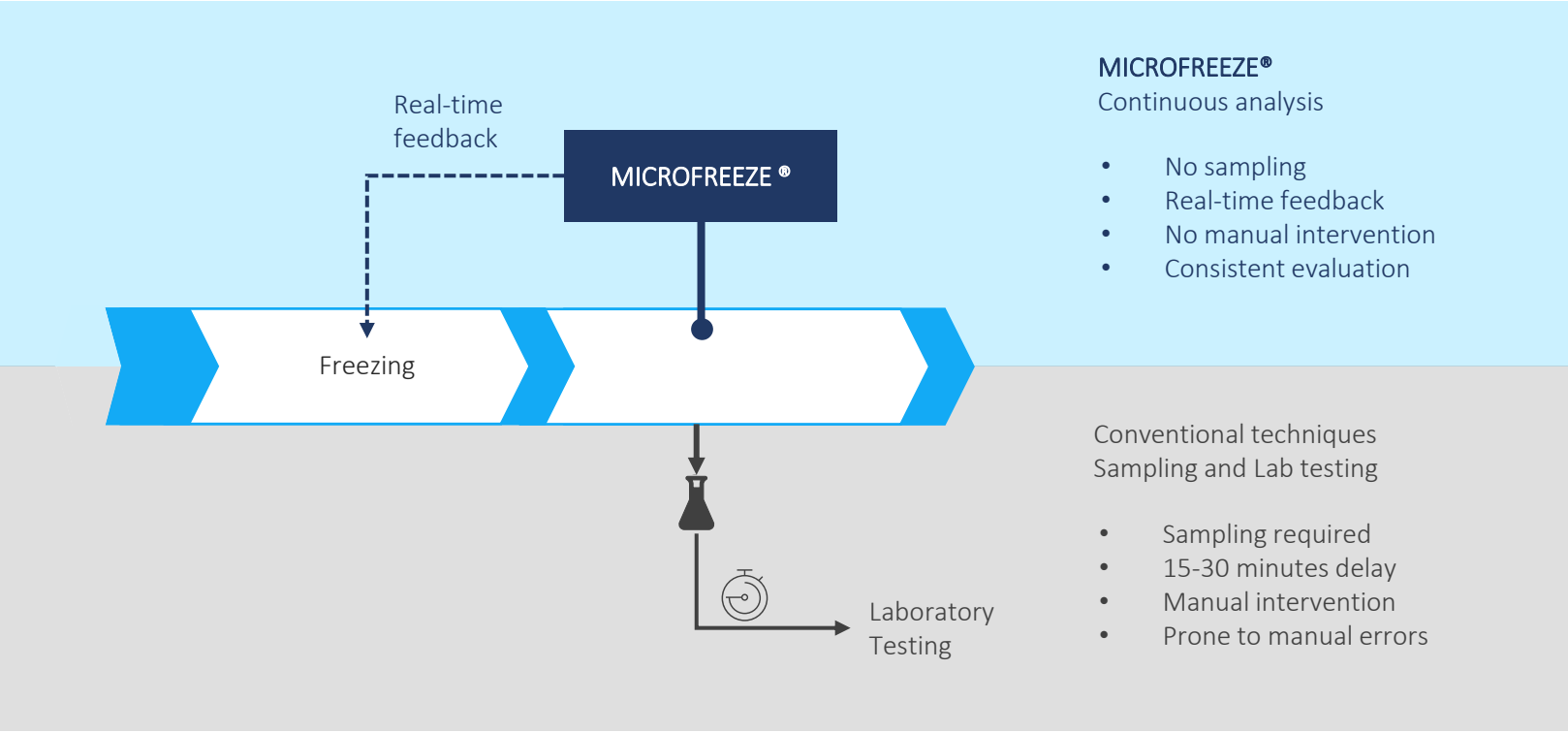


Figure 3: Benefits of the Aquantis sensors over the conventional techniques to monitor LOF.

Lower your energy consumption

The MICROFREEZE® allows to continuously adjust the freezer parameters lowering the average energy cost with 10 to 15%.

Increase your production capacity

The MICROFREEZE® can be used to optimize the retention times of the product in the freezer allowing to freeze more product within the same timeframe.

Continuous and consistent quality control

The current delay of ± 15-30 minutes between the manual measurements and changing the freezer's settings is replaced by real-time data.

BENEFITS OVER CONVENTIONAL METHODS

Temperature vs. Level-of-Frozenness

Temperature is an unreliable indicator to evaluate if a product is frozen. Once the temperature drops below the freezing point, the water starts to crystallize. During this crystallization process, the ice fraction grows over time, while the temperature remains rather constant (latent heat region).

Aquantis introduced the use of level-of-frozenness (LOF) instead of temperature in order to determine to which extent a product is frozen. The MICROFREEZE® clearly distinguishes the liquid from crystallized water fractions in food products. This makes it more reliable to determine if your product is properly frozen.

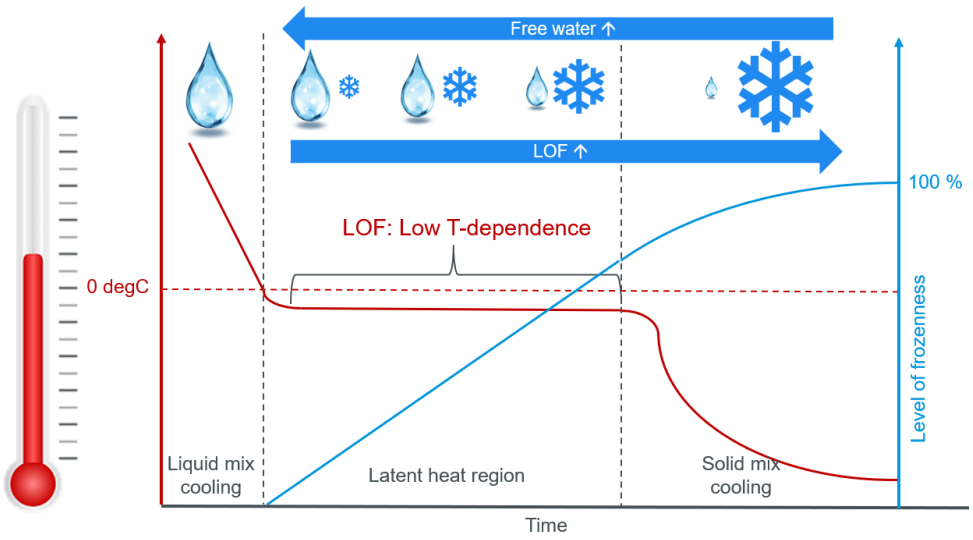


Figure 5: Comparison between temperature and Level-of-Frozenness (LOF) measurements. The water droplet and ice crystals represent the ratio of fresh over frozen water. The red and blue line represent the temperature and LOF, respectively.

MICROFREEZE®: Core measurements

The MICROFREEZE® is based on microwave technology. The microwaves travel from the transmitter (Tx) to the receiver (Rx) **through** the product evaluating a large volume of products.

These **volumetric measurements** averages variations of individual products within the layer providing reliable measurements. Based on received signal the level-of-frozenness (LOF) is calculated.

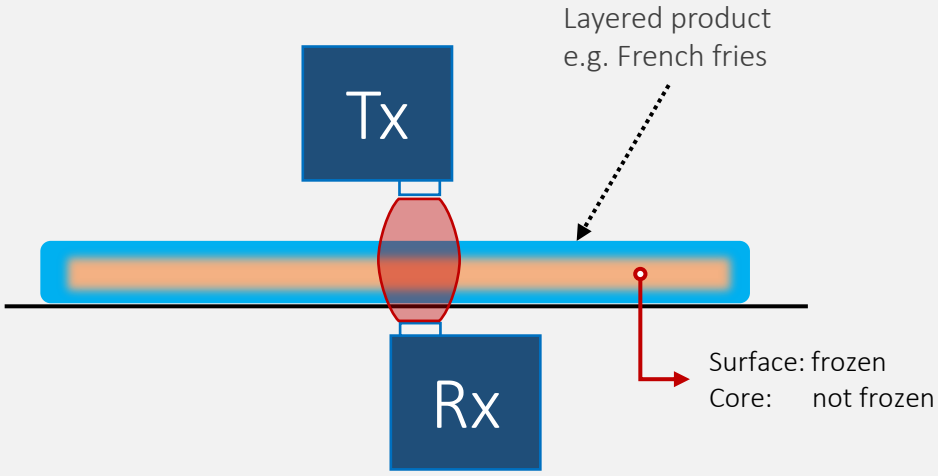


Figure 5: Cross section of layered products on the conveyor belt scanned by the MICROFREEZE®.

FINANCIAL GAIN OF THE MICROFREEZE®

Energy as the main cost of the freezer

When considering an investment in an industrial freezer with a 20 - 30-year lifespan, only 25% of the total costs represent the capital investment. The maintenance costs are estimated to be around 20%. However, more than half of the total costs are energy related. Reducing energy costs becomes essential to stay competitive and to meet the safety and quality standards. This reduction in energy costs can be realized using the MICROFREEZE®.

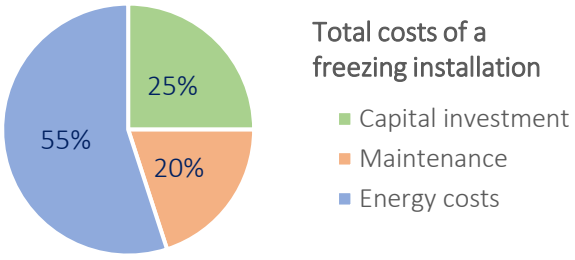


Figure 7: Cost distribution of an industrial freezing installation.

Excess freezing

The installation of the MICROFREEZE® on various industrial freezers has shown that most systems excessively freeze the products. Typical refrigerant evaporation temperatures of -33°C or lower are used leading to a LOF of 100%. Increasing the evaporation temperature to -30°C, did not alter the LOF measurements indicating the products are well frozen. Further increases depend on the product since French fries cut-sizes of 13x13 mm^2 require more energy to freeze compared to 7x7 mm^2. The MICROFREEZE® can reduce these costs with an **average of 10-20%**.

The potential savings depend on the application and equipment. Considering a 10 ton/h freezer with a power of 900 kW for French fries. Assuming a 3% savings in electricity per degree evaporation temperature, an increase of 3°C (e.g., -33 °C to -30°C) translates in a 62 000 EUR cost reduction a year. In most cases, the evaporation temperature can be increase more than 3°C (Table 1). This a pure electricity profit, not even considering the gain in production capacity.

Reducing the retention time

Another parameter which can be used to optimize the freezing processes is the residence time (time of the product in the freezer). Tests with the MICROFREEZE® installed after a spiral freezing, showed a significant reduction in retention time. For a production line with French fries on a 10 ton/h line with a -33°C evaporation temperature, the retention time was reduced from 11 to 8 min while maintaining the freezing quality. This translates in a **27% increase in production capacity** for the same energy consumption.

Evaporation temperature	ΔT = +3°C	ΔT = +5°C	ΔT = +7°C
Electricity savings per unit Evaporation temperature	3%/°C	3%/°C	3%/°C
Relative electricity savings	9%	15%	21%
Annual savings electricity costs*	62 354 EUR	103 923 EUR	145 492 EUR

Table 1: Annual savings for a 10 ton/h line (900 kW) using the MICROFREEZE®.
* Based on the average electricity prices EU 2021S1 (Eurostat)

WEB INTERFACE AND NETWORK COMMUNICATION

The web interface is used to visualize the processed data and manage the device settings for the different type of products.

The software supports Modbus TCP/IP communication to integrate the data in the used SCADA systems. Other communication protocols can be foreseen.

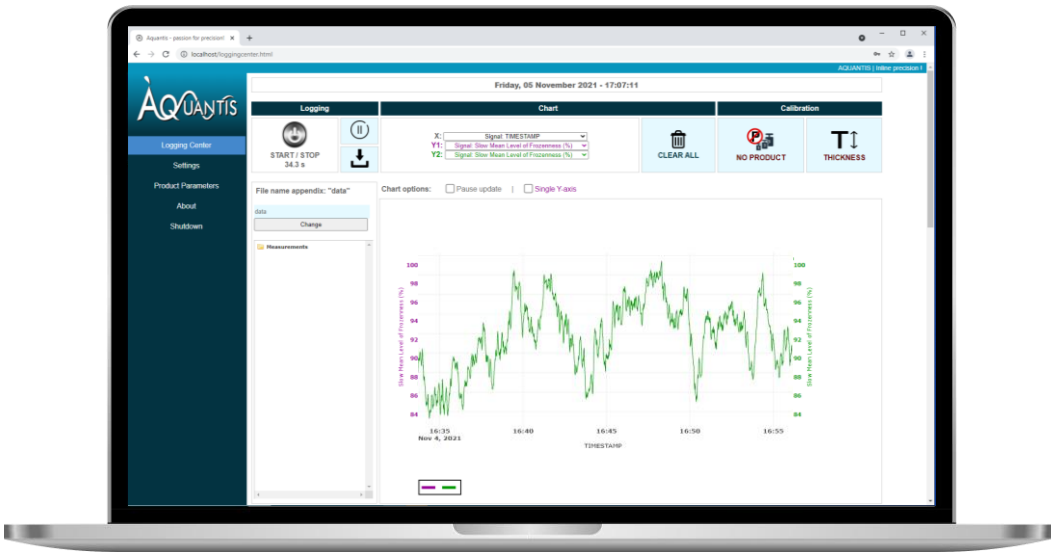


Figure 4: The web interface of the MICROFREEZE®.

INTEGRATED PROCESS CONTROL

The Moisture-Sense is a part of the Aquantis inline sensor series for the food industry. While the Moisture-Sense provides the moisture level, the MICROFREEZE® monitors how much of the water is frozen indicating the quality of the freezing process.

The collected data after every production step can be consulted via the Aquantis web interface or a SCADA system. Combining multiple inline sensors after drying, frying and freezing processes provides a powerful tool to steer and coordinate the different production steps to maximize efficiency.

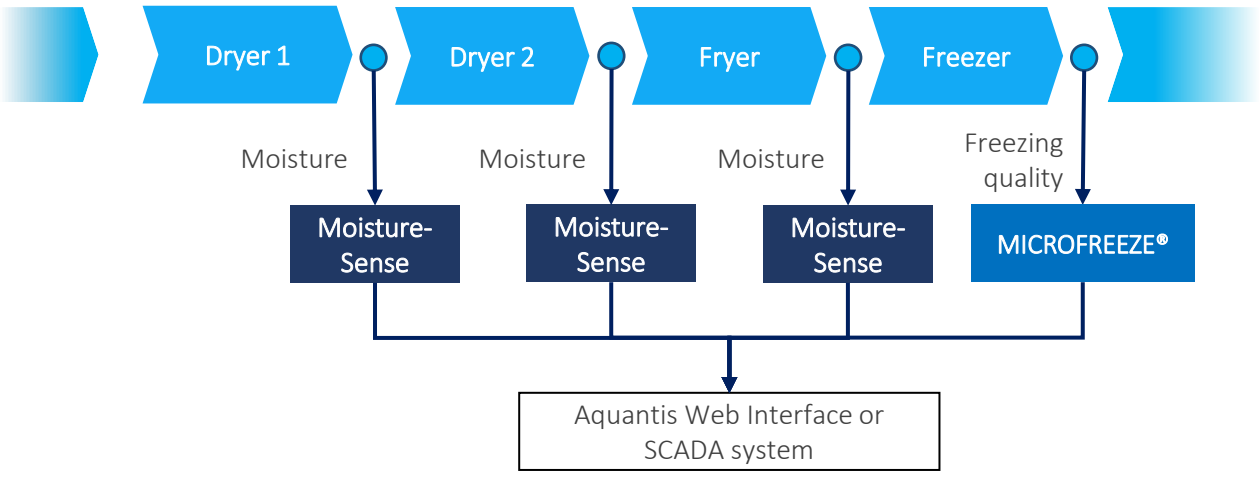


Figure 6: Aquantis inline sensors at different production steps of French Fries.

MAIN FEATURES

Our inline technology has various benefits compared to conventional methods:

- **High penetration:** The transmitted electromagnetic waves penetrate through the products. This guarantees that both the surface and the core of the products are measured
- **Non-stop LOF readout:** The sensor performs 500 measurements/sec on a 24/7 basis. This gives non-stop, real time measurement results.
- **Representative measurement:** The volumetric measurements averages variations of individual products within the layer providing representative measurements. Based on received signal the level-of-frozenness (LOF) is calculated.
- **Non-destructive measurements:** The power of the used electromagnetic waves are very low and consequently do not affect measured product in any matter.

TECHNICAL SPECIFICATIONS

Item	MICROFREEZE®
Sensing Technology	Microwave technology
Measuring range LOF	60 - 100% *
Measuring precision	±1% *
Sampling rate	500 Hz
Field frequency	ISM frequency band
Transmitted power	~1 dBm (~1.25 mW)
Housing	Food-grade Stainless steel AISI 304 - Hygienic design
IP class	IP66
Dimensions transmitter unit (W x H x D)	177 mm x 187 mm x 178 mm
Dimensions receiver unit (W x H x D)	177 mm x 187 mm x 178 mm
Dimensions computing unit (W x H x D)	390 mm x 794 mm x 268 mm
Operational temperature range	-40 °C to 40 °C
Data connection	Ethernet RJ45 plug
Power input	AC Single Phase 100-240V~ 0.5A 50-60 Hz
Industrial interface	Modbus TCP/IP server
User interface	Web-based user interface

Table 2: Technical specifications of the MICROFREEZE®.
* Less than 1 % is also possible depending on product and measurement conditions

FURTHER CUSTOMIZATION IS ALSO POSSIBLE

Aquantis also provides **customized sensor solutions** tailored to the individual needs of a customer. Further customizations of the MICROFREEZE® are possible to fit the application-dependent needs. The same technology can be used to measure the **defrosting** of different products such as meat blocks, fish etc. To ensure our technological solutions fulfill your needs, each of your requirements will be evaluated by conducting a series of studies.

If the outcome is satisfactory, the technical specifications for the inline solution will be determined in collaboration with the customer. On-site validation will be conducted to prove technological benefits. The final step includes the delivery of the **inline customized solution** which is integrated in the production process.

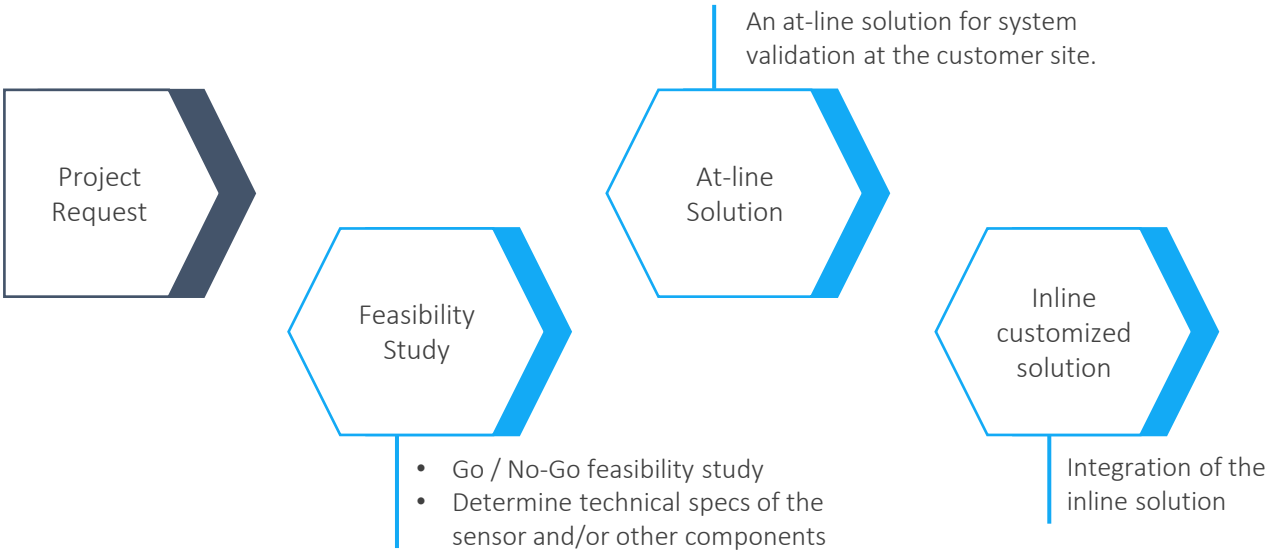


Figure 9: Project-based approach for inline customized solutions.

Contact Us

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