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Critical inline instrumentation integration aspects in dairy total solids and Brix concentration measurements in membrane filtration systems

Membrane filtration systems play a central role in whey separation, with the functionality largely dependent on the quality of the retentate and/or permeate.

Optical Refractive Index measurement technology is widely trusted in food and bioprocessing industries for precise Total Solids (TS) and Brix measurements. The inline refractometer monitors Total Solids (TS) and filter integrity in real-time, ensuring optimal process conditions. It provides an accurate and repeatable TS signal throughout the entire process sequence.

Inline refractometer in membrane filtration

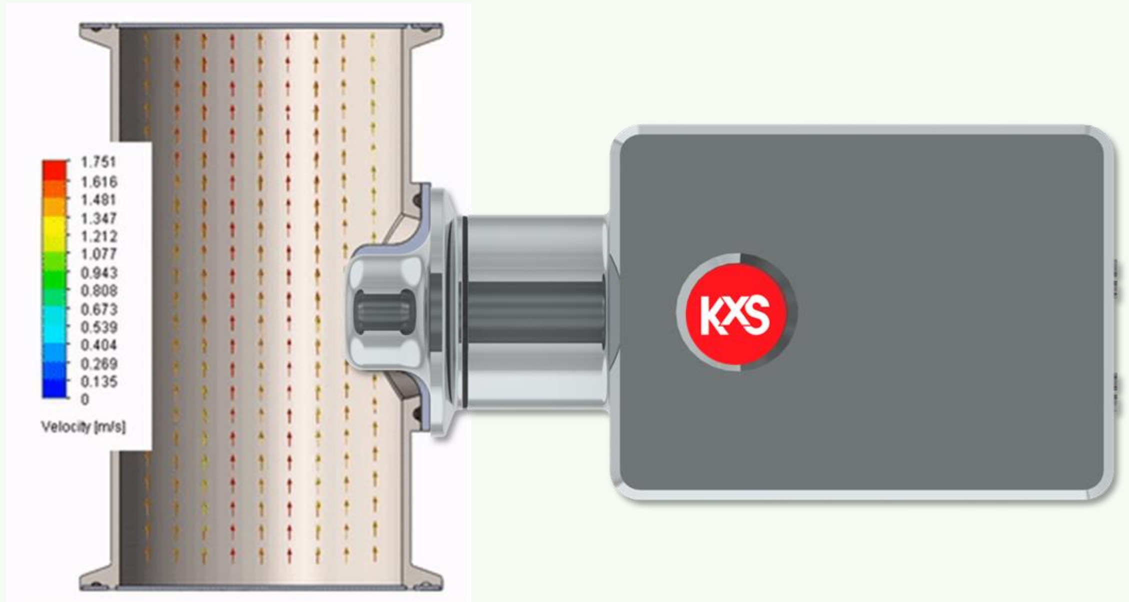
1 Best-Known Installation Method

Over the years, best known methods have emerged for integrating inline refractometer within membrane filtration systems. Computational fluid dynamics simulations have acted as a good tool in this development, providing valuable guidance to achieve successful integrations.

In 2020, best known installation method using straight pipe section was introduced, mitigating common issues of TS signal drift.

The novel refractometer housing's design positions the instrument measurement window in the best flow path, where the process flow is highest.

The new design is EHEDG certified for scalable pipe sizes (1…4") and pressure ratings typical of membrane systems.



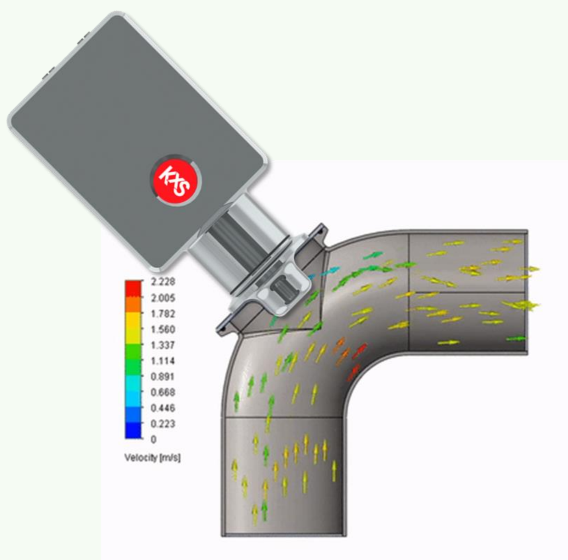
Straight pipe section installation

2 Problem Statement

Challenges with sensor Installation: Installation locations often face issues related to fluid flow and process liquid properties. Inadequate flow at the refractometer can lead to measurement errors.

Historical issues: Earlier recommendations for pipe bend installations have proven problematic, as low flow velocities at outer bends can cause scaling on the optical window, leading to drifting TS measurements.

Pipe bend: Not EHEDG approved, and least optimal flow profile for refractometer



T-piece: Not EHEDG approved, and not optimal flow profile for refractometer

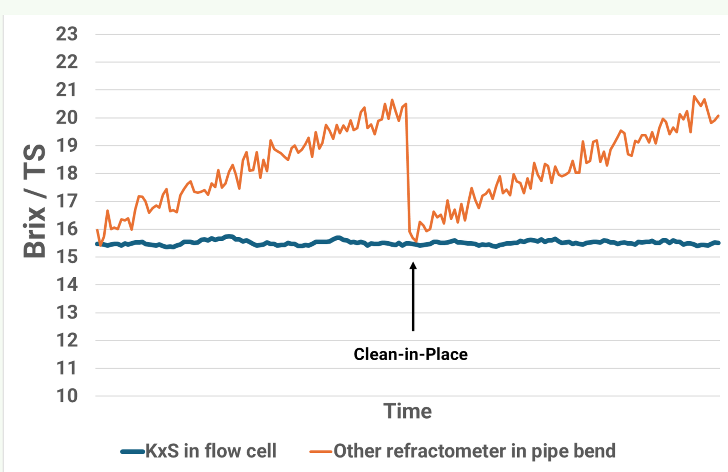
Varinline housing: EHEDG certified, but not optimal flow profile for refractometer in dairy applications

3 Results

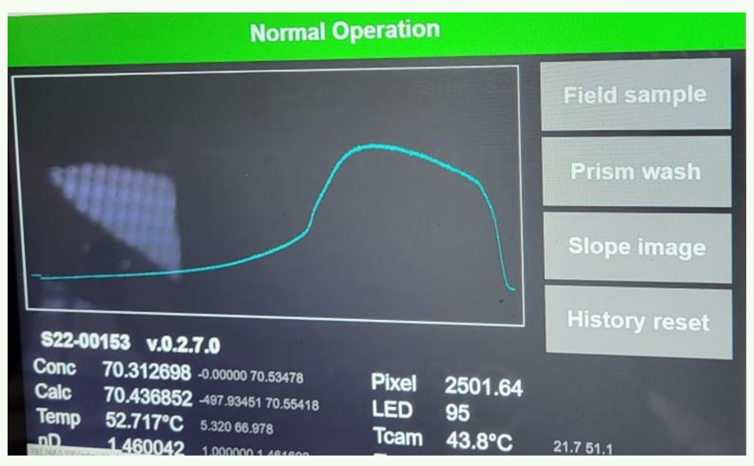
Case Study: A refractometer installed in a pipe bend showed drifting Brix/TS signals during early filtration stages.

Solution: Relocating the sensor to a new KxS specific housing in a straight pipe section stabilized TS/Brix measurements across multiple process sequences.

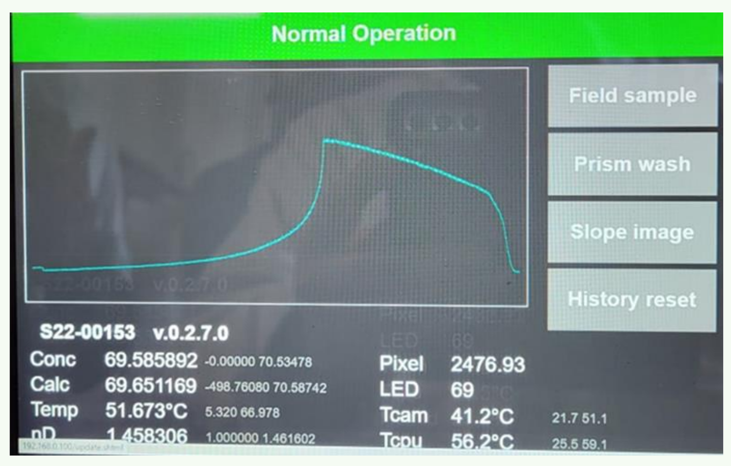
Inline refractometer comparison



Poor optical image with non-ideal installation method



Good optical image achieved with straight pipe section method



4 Lund University initiates a project for innovative cleaning protocols for sustainable and energy efficient process in the dairy industry

The overall project aims to develop models that can optimize costs and reduce the environmental impact of membrane cleaning. Initially membranes are fouled by milk or whey during ultra- and microfiltration. The performance of the filtration process will be studied before and after the cleaning of the membranes. This will be followed by characterization of the fouling on the membrane surfaces and inside the membranes by different scattering techniques.

Finally, the results are integrated in mathematical models to predict membrane fouling and cleaning considering different filtration scenarios. The models are used to develop and optimize new cleaning protocols with the goal of reducing the costs of cleaning by optimizing the use of chemicals and water.

The initial part of the project focuses on changes of membrane surfaces during fouling and cleaning and its effects on energy consumption. Ultra- and microfiltration of skim milk and whey will generate fouled membranes for analysis. The inline total solid refractometers from KxS will provide data for calculations of mass and energy balances to determine the effects of fouling/cleaning on filtration capacity and energy consumption.

The total solid refractometers will be used on the feed and permeate side of the filtration unit. The experiments will use a volume of about 20 L of feed operated in equilibrium mode. The permeate mass will be measured on a scale. The effects of fouling and cleaning on the filtration performance are expected to be captured by the refractometers and contribute to the filtration capacity and energy consumption evaluation.