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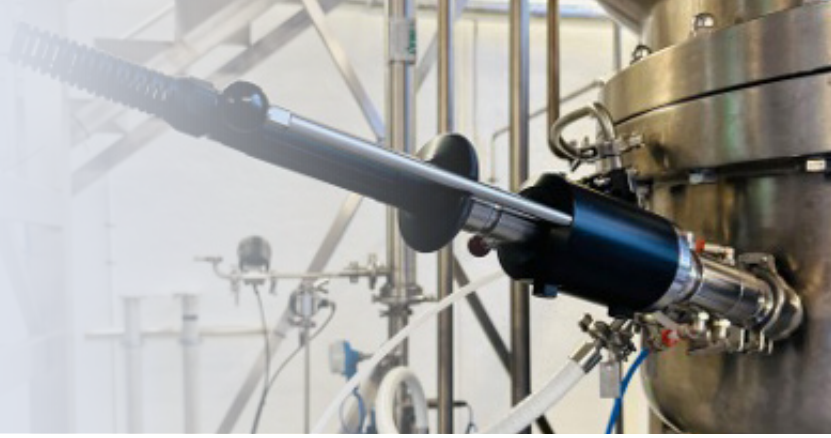

Dissolved Hydrogen Monitoring in Gas Fermentation Using a Retractable Sensor Solution

A case study from NORCE demonstrating in situ hydrogen monitoring under sterile, pilot-scale bioprocess conditions

The application note is based on the research and report by:

Opsahl et al., NORCE Research

The application note is written by:

Petersen et al., Unisense

Introduction

Hydrogen-based fermentation is gaining increasing attention as part of the development of the corresponding technology and the interest in hydrogen utilization. During gas-based fermentation, microbial cultures consume gaseous feeds and produce beneficial products, such as chemicals, organic solvents, or fuel.

The gaseous feed often consists of H_2, CO_2, or CH_4 and to obtain optimal bioprocess monitoring, the feed gas concentrations need to be measured. Despite this importance, reliable in situ monitoring of dissolved hydrogen in closed, sterile bioreactors remains challenging, particularly under industrially relevant conditions.

A major limitation of commercially available hydrogen sensors is their limited tolerance to elevated temperatures during in situ sterilization, typically performed at 121°C.

The Industrial Biotechnology Group at NORCE Norwegian Research Centre contacted Unisense with the request of a dissolved hydrogen sensor suitable for bioprocess monitoring in a pilot-scale gas fermentation setup. While Unisense hydrogen sensors are specialized for operation up to 60°C, a collaborative solution was developed that enabled in situ sterilization without compromising the sensor performance.

Figure 1: H_2 sensor in a 12 mm OD stainless steel tube with PG13.5 thread

Sensor design and setup

To enable integration of a hydrogen sensor in a fermenter with in situ sterilization, a retractable sensor concept was selected. NORCE provided a commercially available retractable sensor housing from Mettler-Toledo International Inc. This setup would allow the sensor to be withdrawn from the reactor during sterilization and reinserted under sterile conditions once operating temperatures were reached.

Based on the mechanical constraints of the retractable housing, Unisense designed and manufactured a hydrogen sensor with a 12 mm outer diameter stainless steel shaft and a PG13.5 thread, thereby providing mechanical robustness while matching the retractable housing dimensions (Figure 1). With this design, the sensor would be able to withstand operating temperatures of 60°C with 10 bar(g) pure hydrogen and sterilization at 121°C.

Figure 2: Unisense H_2 sensor mounted in retractable housing on 150 L fermenter

Results and conclusion

The retractable hydrogen sensor was installed in a 150 L pilot-scale bioreactor at NORCE and integrated with the bioprocess control system (Figure 2). Initial tests were conducted in water, followed by operation under pressurized hydrogen conditions. The sensor showed stable and linear response to increasing hydrogen levels (Figure 3) with no leakage observed.

Subsequently, the sensor was used for continuous hydrogen monitoring during an active hydrogen gas fermentation process at 60°C. Reliable sensor signals were obtained during more than a week of operation, which demonstrates how the hydrogen sensor performs reliably under real bioprocess conditions (Figure 4).

This case demonstrates how a retractable sensor concept can overcome temperature limitations associated with in situ sterilization, while monitoring hydrogen levels in fermentation processes. Following the development of this sensor customization, the 12 mm stainless steel hydrogen sensor with PG13.5 thread has since become a standard Unisense product and it has been used in multiple process monitoring setups.

For more information on sensors for reactor systems, please visit https://unisense.com/ or contact sales@unisense.com

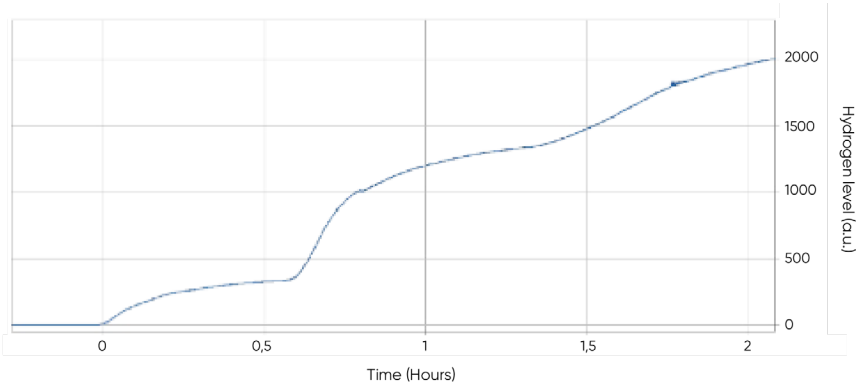

Figure 3: Initial test: Increasing hydrogen levels with no leakage

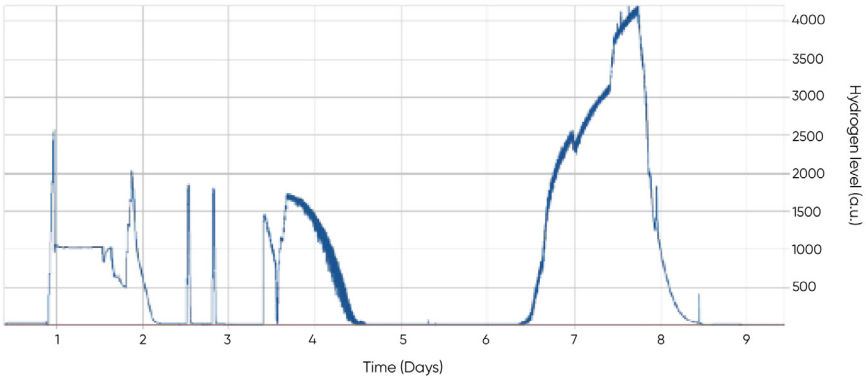

Figure 4: Continuous monitoring under real bioprocess conditions

Suggested products

- H_2-ST-12-REACTOR
- H_2 UniAmp
- uSense Log

Acknowledgements

The work highlighted in this application note was supervised by Eystein Opsahl (Engineer Industrial Biotechnology) at NORCE Research with SFI Industrial Biotechnology as the funding body: https://sfi-ib.com/

The application note is based on the following internal report by Eystein Opsahl from NORCE Research: https://hdl.handle.net/11250/5368055

The pictured sensor in the retractable body in Figure 2 originated from LinkedIn and is used in this application note with permission from Eystein Opsahl: https://www.linkedin.com/posts/hydrogenfermentation-bioprocessing-industrialbiotech-ugcPost-7381384629238251520-v2B-

Version: May 2026