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Multiposition sensor monitoring in yeast fermentation processes for the analysis of gradients in the liquid phase

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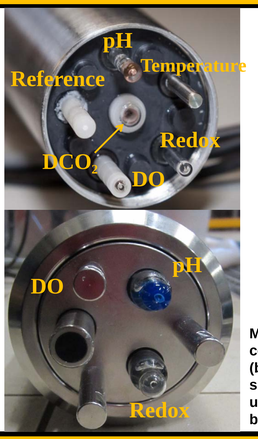
Motivation

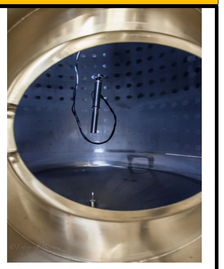
- In industrial scale bioreactors, gradients of key process parameters appear, leading to a heterogenic liquid phase that have an influence on process stability. The appearance of these gradients needs to be investigated specifically for each plant and process.
- Inhomogeneities likely influence the physiology and vitality of microorganisms, and thus their metabolic activity. The knowledge about gradients leads to an optimal positioning of sensors and an optimal choice of time points for sampling.
- The investigation of gradients in the core of the liquid phase demands for the development and application of a flexible sensor concept. This is applied in two industrial fermentation processes: beer production and biogas

Concept & Equipment

- Mobile housing units are equipped with different sensors for multiposition measurement. The movement is realized by a fishing rope
- (Micro-)electrodes are combined in a multiparameter unit and optimized for long-time data acquisition in corresponding environments.
- Data from multi-electrode-units are transferred via cable and acquired by LabVIEW and Python.

Dip units
A: for micro-sensors (Kurt-Schwabe-Institut Meinsberg e.V.)
B: for commercially available sensors (Exner Process Equipment)





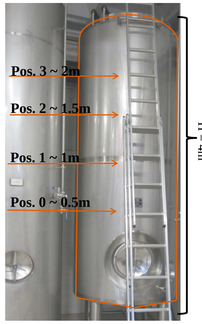
Application of multiposition sensors in semi-industrial scale (30hL)

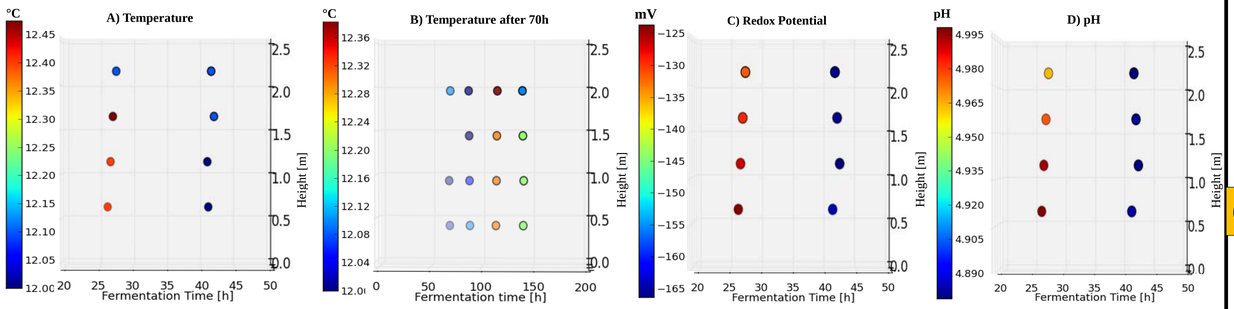
Microsensors (top) and commercially available sensors (bottom) integrated in submergible sensor housing units (diameter: top: 45mm, bottom: 76mm)

Results

The tank was filled with 15 hL wort the first day and the yeast was pitched. The 2nd brew of 15 hL was added after 24h from the tank bottom. Graphs A, B, D show the time points 2h and 18h after the 2nd filling. Differences up to 0.4 K at the temperature (A), 8 mV at the redox potential (C), and 0.04 pH-units (D) are estimated at different heights 2h after the 2nd filling. Therefore a certain formation of layers is detectable. After 42h the tank is nearly homogenized for all displayed parameters. However, after additional 30h inhomogeneities in temperature (up to 0.1 K) can be observed again, especially at the end of the fermentation (B). This leads to differences in yeast activity and metabolic activity. Hence, the production and degradation of substances is influenced, which is also affecting the beer quality.

Application of the multiparameter sensor units in a scale of 30 hL in validation experiments





Conclusion and Outlook

- The (micro-)sensor technique allows to study the impact of inhomogeneities for improved process control and optimization.
- Based on the plant-specific understanding of the importance of gradients, a plant can be monitored directly at the spot, where critical concentrations appear at first.
- By a customized control, the operational flexibility of the plant is increased, the risk of process failures is reduced. However, more data of industrial scale plants is needed to implement suitable monitoring and control strategies.

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