Dissolved Oxygen in Milk and Dairy Products

Relevant for: Dairy Industry

Dissolved oxygen (DO) in dairy products is a critical quality parameter and must be monitored. DO reduces suitability for consumption, shelf life and affects the major quality parameters of dairy such as nutritive value, color and taste. During pasteurization DO has to be removed from the milk to improve process performance and to secure consistent quality of the final product.

To assure your product contains the target DO content, Anton Paar’s inline oxygen sensor Oxy 5100 can be easily implemented directly into your production line. Customers benefit from an accurate and reliable DO monitoring for a wide range of concentrations.

1 Milk pasteurization process

The milk pasteurization process is a series of process steps which transform non-sterile raw milk into a sterile product. On arrival at the dairy the milk will contain an equilibrium amount of DO ~ 8 ppm and finely dispersed air as a result of transportation. During the processing and in the final package the DO content should be lower. Deaerators are used to remove dispersed air and reduce the oxygen (O$_2$) content to the target value (0 – 3 ppm). Typically this is done before the temperature treatment to improve efficiency of heating and to minimize oxidation rate during the high temperature processing. Deaeration also prevents foaming, maintains constant filling and reduces fouling, development of stale flavor and loss of O$_2$-sensitive ingredients (vitamin C and B9).

2 Application of Oxy 5100

To assure the goal of deaeration has been accomplished the concentration of DO must be measured. The Oxy 5100 easily detects any deviations from the target DO value. This allows adjustments of deaeration to correct the production process (e.g. by increasing vacuum when the measured values are too high). The sensor should be installed after the deaerator at the pressure side of the pump (Figure 1).

Installing the sensor prior to packaging enables the last check of the DO values before the product is filled into its final package.

Tip: O$_2$-sensitive ingredients like vitamin C are often added to dairies. Precise control of the DO content reduces the amount of the vitamin addition. The rule of thumb to consider: 1 ppm DO reduces the vitamin C content by ~ 12 mg/L.

Dairy products to be measured

The Oxy 5100 is feasible DO monitoring in

- any kind of milk,
- flavored milk drinks and milk smoothies and
- sour milk products (i.e. soured milk, kefir, yoghurt, cream yoghurt, buttermilk).

Lab and process working together

Results of the process measurement (Oxy 5100) show a good agreement with the lab reference (OxyQC Wide Range). This enables precise real-time control of the DO content in milk during production. Figure 2 illustrates the correlation of process and lab data obtained for pasteurized milk (3.5% fat) for a wide range of DO concentrations.

![Figure 1: Installation recommendation of Oxy 5100](image)

![Figure 2: DO content measured in pasteurized milk](image)
Sudden changes (Figure 2) of the DO concentration result from the harsh concentration adjustments in the test system.

3 Measurement Setup

The Oxy 5100 performs measurements of DO in a wide range of DO concentrations (0 – 24 ppm). The sensor can be additionally equipped with Anton Paar’s evaluation units and data acquisition software. Robust and hygienic design and easy installation make Oxy 5100 (Figure 3) a minimum maintenance device.

The sensor consists of a luminescent dye (O$_2$-sensitive layer) which is in direct contact with the measured fluid (sample). The measurement setup of the sensor is shown in Figure 4.

A light-emitting diode (LED) of suitable wavelength sheds light on the O$_2$-sensitive luminophore which is excited by absorbing light. A part of this absorbed light is released by emitting fluorescent light at a higher wavelength. In the presence of O$_2$ as the quencher molecule, a fluorescence phase-shift between excitation of the luminophore and fluorescence emission occurs. The sensor detects this fluorescence quenching, and the resulting phase shift is a direct measure of the DO content.

### Specifications of the Oxy 5100

<table>
<thead>
<tr>
<th>Trace Sensor</th>
<th>Wide Range Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring range</td>
<td>0 … 2000 ppb</td>
</tr>
<tr>
<td>Accuracy at 20°C two point adjusted ¹</td>
<td>±1 ppb or 3 %</td>
</tr>
<tr>
<td>Sample temperature</td>
<td>-5 … 65 °C, non-freezing</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-5 … 50°C</td>
</tr>
<tr>
<td>Line pressure</td>
<td>max. 12 bar rel. (174 psi rel.)</td>
</tr>
<tr>
<td>Max. temperature (CIP/SIP)</td>
<td>99 °C</td>
</tr>
<tr>
<td>Measuring interval</td>
<td>1 - 60 s</td>
</tr>
<tr>
<td>Process connection</td>
<td>VARIVENT® Type N</td>
</tr>
<tr>
<td>Certifications</td>
<td>EHEDG Type EL Class I</td>
</tr>
</tbody>
</table>

¹ the larger value is valid

4 Benefits

The reliable and accurate Oxy 5100 enables to

- eliminate manual grab sampling and avoid sampling errors,
- detect any irregularities in DO content and control the deaeration in real-time,
- optimize energy efficiency of dairy processing and reduce operating costs,
- reduce raw material input of O$_2$-sensitive ingredients and
- extend shelf life of dairy products.

5 Other Anton Paar Sensors in the pasteurized milk production

### Process instrumentation

**L-Dens 7400 equipped with mPDS 5:**

Inline monitoring of density, and (with skim milk adjustment) fat, corrected lactometer reading (CLR), solids-non-fat (SNF), total solids (TS).

### Laboratory instrumentation

**OxyQC and OxyQC Wide Range:**

Determination of DO content (in a lab or at-line)

**DMA™ 4100/4500/5000 M:**

Determination of density and (with predetermined fat content) CLR, SNF, TS and fat content

**DMA™ 35, DMA™ 501, DMA™ 1001:**

Determination of density

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