Oxygen Measurements in the Brewing Process

Brewing is the process of making beer, ale, and similar cereal beverages that are fermented but not distilled. The raw materials of these beverages are water, hops, and barley, supplemented by corn, rice, or sugar.

Background

Malting

Barley is first steeped in cold water for 45 to 72 hours, the water being drained off about once a day. The barley is then placed in slowly revolving drums or in shallow tanks equipped with plows. As the wet grain is stirred and aerated, it begins to germinate. This process produces several enzymes in the grain, the most important being malt diastase, which has the property of changing starch into sugar. Germination is allowed for about 6 days; the sprouted barley, now called malt, is finally kiln-dried. Kilning checks germination and produces substances that give an aromatic flavor to the beer. By varying the heat, the malt can be toasted from light tan to dark brown; the color of the beer is partially determined by the color of the malt.
Mashing
Brewing is begun by crushing the malted grain between iron rollers. The grist is then mixed with warm water in large tubs until it forms a mash of porridge-like consistency; next the supplementary grains are added. If raw grain is used, it must first undergo boiling; when cereals, such as cornflakes, are used as malt adjuncts, however, precooking is not required. The temperature of the mash is then raised in steps from 38 °C (100 °F) to 77 °C (170 °F), with time allowed at each step for the various enzymes to act. The finished mash is allowed to rest for a short time during which the spent malt settles to the bottom of the lauter tun. There it forms a filter bed through which the liquor, now called wort, is drawn off. Hot water is run through the residue to rinse out, or sparge, the remaining wort from the spent grain.

Cooking
The wort is drawn off into copper kettles in which it is boiled with hops. Next, the hops are screened out, and the wort is passed through a cooler and flows into tanks, where fermentation takes place.

Fermentation
Fermentation is started by adding pure yeast culture. This culture has been reserved from a previous brewing of the same kind of beer. Bottom-fermenting yeast (which settles to the bottom) is used for lager beer, and top-fermenting yeast (which rises to the top) is generally used for ale. Fermentation continues for a number of days, depending on the beer brewed. The yeast is then allowed to settle, and the beer is drawn off for cellaring.

Cellaring
The beer is aged 3 weeks to 3 months in storage tanks, in which it clarifies and its flavor develops. Often, when it is fully matured, a small amount of fresh wort or sugar is added, and the beer is placed in pressure tanks for final fermentation to produce the carbon dioxide gas that gives the characteristic head, or foam. Finally, the beer is usually pasteurized and filtered and is then sealed in pitch-lined kegs or packaged in individual bottles or cans.

Process
The brewer has two major interests to control oxygen level:
– Propagation of the yeast at the start of the fermentation requires the presence of oxygen.
– After fermentation, care must be taken throughout the process to minimize air pick-up, therefore O₂ measuring systems are installed to detect leaks at any transfer points, such as pumps, filters, coolers and pipes.

Fermentation
Oxygen is an essential constituent of fermentation; any excess or deficiency is detrimental to the gravity, clarity, color and taste of the final beer. The effects of oxygen are partly biological, because of its implication in yeast metabolism, and partly chemical due to its reactions with the many sensitive organic substances of which beer is composed.

Carbon dioxide recovery (gas phase measurement)
The oxygen concentration in plant CO₂ can significantly affect the dissolved oxygen level in the final beer. Measurement and control of oxygen are therefore required to maintain a quality product without unnecessarily wasting large amounts of carbon dioxide. The measurement system can be installed directly into the pipe at the inlet of the CO₂ recovery plant so that venting of the CO₂ can be switched off when a desired limit is reached, resulting in optimum recovery of CO₂ otherwise wasted to the atmosphere. A second installation point is in the outlet of the CO₂ recovery plant after the vaporizer to control the quality of the purified CO₂ gas. In both cases no special gas conditioning is necessary.
Water deaeration
Degassed water is used throughout the brewery to reduce oxygen levels in filters, tanks, and lines.

Typical process conditions:
- Temperature: 10 °C (50 °F)
- Oxygen concentration: 10 … 20 ppb

Transfer points, filler
Transfer points such as filters, coolers, pumps and before the filler are the most important measuring points to detect air leaks.

Typical process conditions:
- Temperature: 0 … 4 °C (32 … 39 °F)
- Oxygen concentration: < 50 ppb

METTLER TOLEDO Solutions

■ In-line measuring system for Fermentation (1) / Wort Aeration (2)

Transmitter M400
The transmitter series features advanced digital ISM (Intelligent Sensor Management) technology. Consequently maintenance intervals can be optimized and unscheduled plant downtime is reduced. The mixed-mode input functionality also allows the input of an analog sensor for highest user flexibility.

O₂ sensor InPro 6850i
This amperometric sensor is characterized by its design for quick maintenance. The ISM functionality “Plug & Measure” guarantees quick start-up and sensor replacement. Advanced diagnostic features lead to more process safety because the user is informed by a maintenance request prior to a critical loss of measurement performance. Of course, sanitary requirements in the food and beverage industry are fulfilled by the EHEDG compliant hygienic design.

Housing InFit 761e
InFit 761e series housing are stationary housings for 12 mm sensors with a Pg 13.5 threaded collar. Among others the housing is also available with GEA Tuchenhagen Varineline® or Alfa Laval Tri-Clamp® process connections.

■ In-line measuring system for CO₂ recovery (3)

O₂ sensor InPro 6950i
This sensor convinces with its low detection limit (5 Vol ppm) and easy maintenance features. Thanks to the amperometric measuring principle costly gas pre-conditioning becomes needlessly.

Transmitter M700S
The modular concept of the M700 transmitter allows integration of up to three modules into one basic instrument. Double channel measurement reduces total costs per measuring loop. Input for process pressure compensation completes the offer for gas phase applications. Modules for PROFIBUS® PA and extended output modules fully integrate the M 700 into all control systems.

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In-line measuring system for filtration (4), water deaeration (5) and filler lines (6)

Optical O₂ sensor InPro 6970i
This new line of dissolved oxygen sensors is specifically designed for highly demanding applications in the beverage industry. The groundbreaking fluorescence quenching technology eliminates the need for electrolyte handling and sensor pre-polarization. Consequently, times for start-up and maintenance are reduced to a minimum.

O₂ sensor InPro 6900i
Ease of maintenance and a low detection limit of 3 ppb in CO₂ containing liquids are the main characteristics of this sensor line based on the well-established amperometric measuring principle.

Transmitter M 400
The ISM technology is available for optical and amperometric O₂ sensors with this transmitter. Real-time status information from the sensor is translated into true predictive maintenance tools. The Dynamic Lifetime Indicator (DLI) tells the user when sensor consumables must be replaced, the Adaptive Calibration Timer (ACT) monitors the time to next calibration.

Off-line measuring system
Portable oxygen analyzer InTap 4000e
The InTap 4000e is an off-line dissolved oxygen measuring system. It measures the actual amount of dissolved oxygen in beer, mineral waters, soft drinks, wine, etc. at any individual stage of production as during filtration, filling or subsequent storage of the final product. It is equipped with a data logger with an interface for data transfer to a PC. The InTap 4000e can be used to locate any oxygen leakage along the production line – also in storage and bright beer tanks.

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