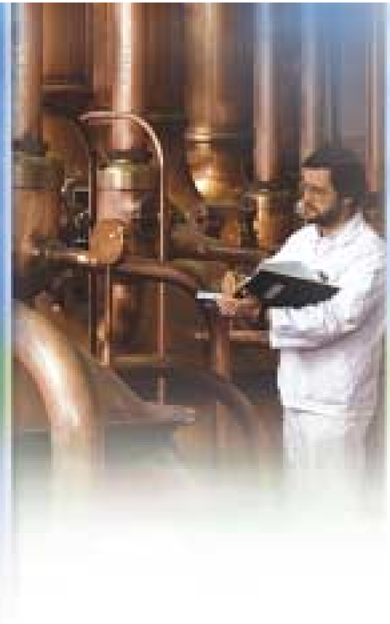
Dissolved oxygen
in Brewing Applications



Notes

DO measurement in the brewing process.

Process Analytics
Application

Background

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.

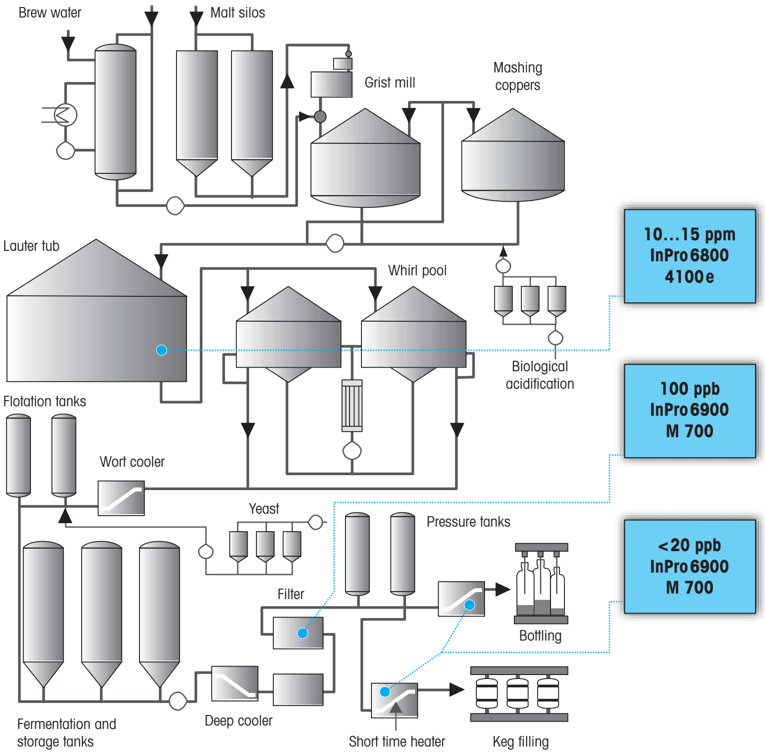


Figure 1:
Typical flowchart for the production of normal gravity beer.

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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 mash tub. 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 run into vats, 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 skimmed off or allowed to settle, and the beer is drawn off for cellaring.

Cellaring

The beer is aged 3 weeks to 3 months in storage vats, 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 three interests to control oxygen level:

- Many of the substances contained in beer are oxidized when exposed to air (oxygen). During hot process steps, such as boiling or pasteurization, oxidation is very rapid. Neglecting this eventuality can cause a noticeable change in taste, shelf life and clarity of the final beer.
- 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, and a monitoring means installed to detect leaks at any transfer points, such as pumps, filters, coolers and pipes.

Oxygen measurement during mashing and lautering

The performance and technological function of a lauter tun in the brew house is one of the most important steps in the brewing process with regard to efficiency, product quality, and capacity. Already at this early stage, oxygen uptake has a direct influence on turbidity and color as well as on the quality of bitterness. Measurements are generally made by a side-entry installation of the sensor (housing) in the wall of the lauter tun.

Typical process conditions:

Temperature	76…78 °C

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.

Typical process conditions:	
Temperature	4…14 °C
Oxygen concentration:	at start saturation then 0 ppm

Carbon dioxide recovery

The oxygen concentration in plant CO_2 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 sensor (housing) can be installed into the pipe at the top of the fermenter so that venting of the CO_2 can be switched off when a desired limit ($\leq$50 ppm oxygen) is reached, resulting in optimum recovery of CO_2 otherwise wasted to the atmosphere.

Water deaeration

Degassed water is used throughout the brewery to reduce oxygen levels in filters, tanks, and lines.

Typical process conditions:	
Temperature	10 °C
Oxygen concentration	10…50 ppb
Typical process conditions in the storage tank:	
Temperature	1…4 °C
Oxygen concentration	<100 ppb (young beer)

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	1…4 °C
Oxygen concentration	<50 ppb

The sensor (housing) is installed directly in the process line. The last and important measuring place is in the inlet tube to the filler.

METTLER TOLEDO Solutions

In-line measuring system for Wort/Fermentation

Transmitter O_2 4100 e

The O_2 4100e is a versatile and highly cost-effective transmitter for dissolved oxygen. The modern pictographic display facilitates operation of the instrument functions and monitoring of the measurement data.

O_2 sensor InPro6800

Dependable and precise in-line dissolved oxygen (DO) measurement systems fulfilling high sterility criteria in biotechnology, and sanitary requirements in the food and beverage industry

Transmitter M 700 S

The modular concept of the M 700 transmitter allows integration of up to three modules into one basic instrument. Double channel measurement reduces total costs per measuring loop typical for fermentation processes (pH/DO).

It has no communication limitations. Modules for PROFIBUS® PA and extended output modules fully integrate the M 700 into all control systems. Extended data storage is possible with the SMARTMEDIA™ card capability which allows transfer of your data to a personal computer.

Housing InFit 761-CIP

InFit 761-25CIP, the new state-of-the-art static housing for safe, quick and simple mounting of electrodes/sensors with Pg 13.5 thread for measurements in food and beverage applications.

In-line measuring system for filtration and filler lines

Sensor InPro 6900

This new line of dissolved oxygen sensors is specifically designed for reliable, in-line measurement in processes under hygienic conditions. With a detection limit of 1 ppb, the InPro 6900 sensors satisfy the most demanding measurement requirements.

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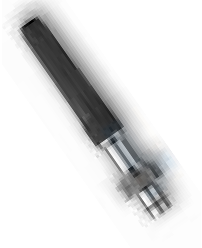
InFit 761-CIP/Varivent



InFit 761-25-CIP, the new state-of-the-art static housing for safe, quick and simple mounting of electrodes/sensors with Pg 13.5 thread for measurements in food and beverage applications.

On-line measuring system

Portable okygen analyzer InTap 4000 e

The InTap 4000 e 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.

With the help of a stat-of-the-art data logger with remote interface for data transfer to a PC. The InTap 4000 e can be used to locate any oxygen leakage along the production line.

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