Non-invasive Level Measurement in Bright Beer Tanks

HYGIENICALLY BEYOND REPROACH | Bright beer tanks serve as a direct link between the lager cellar and the filling area and thus represent a particularly sensitive area of a brewery from the standpoint of hygiene. Knowing how much beer is available for packaging is also very important as is being able to establish how much beer is left in a buffer tank after filtration is finished. An ultrasound-based method of measurement as well as a combination management system for determining the volume can be of assistance here.

IN CONTRAST TO other systems on the market, the system described here has no contact with the product (non-invasive), does not need to be taken into consideration in the cleaning regimen, and reliably and fully automatically measures the contents of each bright beer tank connected to the system over the entire range of measurement with an accuracy of up to < 0.5 hl. The system can be retrofitted to fit any tank and meets all the needs and requirements of a modern, automated production facility.

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An accurate determination of the volume of beer available for packaging is obligatory for the smooth operation of a filling line. Increasingly, breweries are taking the approach of employing bright beer tanks as a buffer to moderate the impact of interruptions during filtration. For this reason, the brewery should have on line access to its available buffer capacity, if possible.

Common Practice

In many breweries, the contents and microbiological state of bright beer tanks are often still determined in a very rudimentary and microbiologically questionable manner. As an alternative to relying on the ability of the brewer to recall how much beer is left in the bright beer tanks, vertical fill level sight glasses are often installed to indicate how much remains in the tanks. An automated process or a way to monitor fill levels at any given time by means of visualization is unthinkable here. An inductive flowmeter (IDM) represents an alternative. An IDM keeps track of the volume that has entered and exited the tank. However, the accuracy of an IDM is negatively affected by rapid changes in volume or also by low volumetric flow rates, causing errors to rapidly

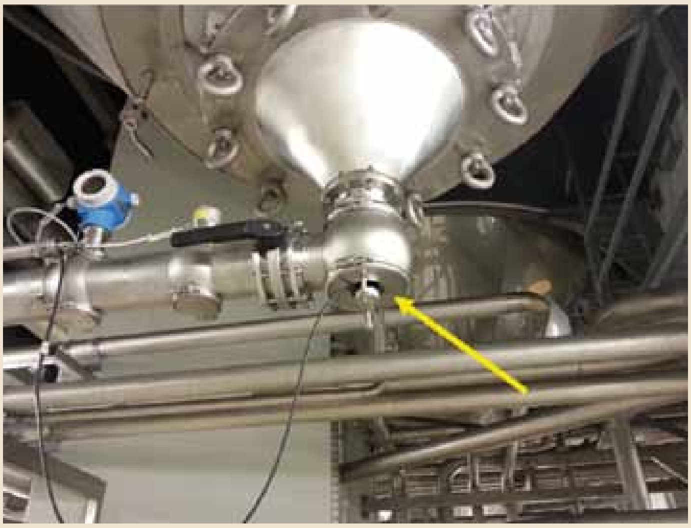

Fig. 1a Varivent cap/top with sensor

Fig. 1b The sensor is attached through adhesion directly onto the external surface of the tank bottom

increase in magnitude. Even a short-term outage results in unreliable measurements with regard to the contents of the tank. The majority of bright beer tanks on the market are equipped with devices for measuring the level of beer in the tank but these devices usually come into contact with the product and therefore require particular attention in terms of hygiene. Pressure transducers are most commonly used for measuring the level of beer in a tank. However, these often exhibit disadvantages, such as drift and insufficient accuracy, and they cannot easily be retrofitted. In the case of overhead ultrasonic systems, which are generally not positioned in the center of the tank dome, reflections from the cone may occur at lower fill levels. This may also contribute to less accurate measurements. Radar systems are affected by fittings in the tank and can deviate from their specified accuracy due to echo interference, especially at low fill levels. The systems described here are also only suitable for horizontal tanks in certain cases.

An ultrasonic measuring system is presented below, which does not measure the available headspace in the tank, but rather directly measures the medium in the tank. This technique is quite distinct from that employed in an overhead ultrasonic system. The sensor or the probe is attached in a non-invasive manner to the exterior of the tank. With cylindroconical tanks, this is best done mechanically, for example, by attaching the sensor to the Varivent cap/top of the Varivent housing (fig. 1a). For pressure tanks with a flat bottom, the probe is secured to the surface of the tank (fig. 1b).

There is no contact with the product. The system can be readily retrofitted to any tank without interrupting operations. The sensor enables the reliable determination of even small, residual volumes. The modular design makes the system inexpensive, allowing for cost-effective use in the brewery. It requires no maintenance or recalibration, and there are no costs associated with its usage.

A Description of the Measurement System

A probe is attached to the external surface at the bottom of the tank, which emits an ultrasonic signal into the tank (fig. 2). At the phase interface between the liquid and gaseous states, the signal is reflected back

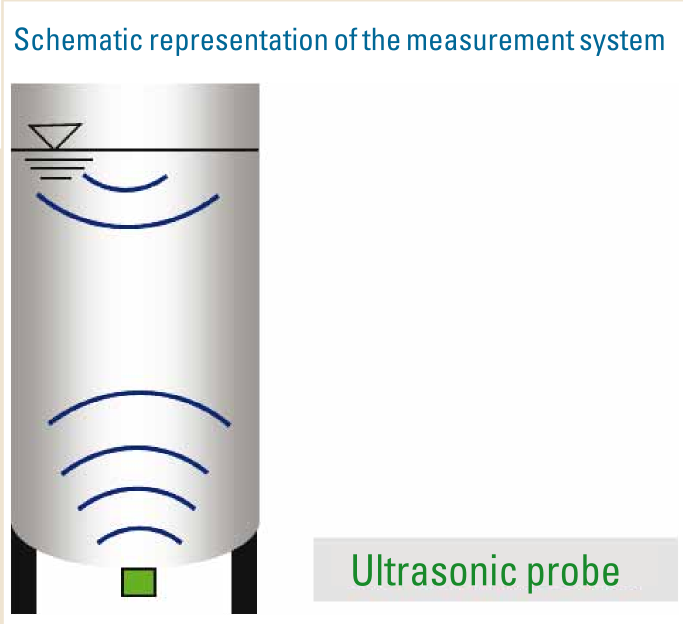

Fig. 2
Principle of operation of the ultrasound system

towards and thus detected by the sensor. Based on the time elapsed between sending and receiving the signal, the fill level of the liquid can be determined. The velocity of the ultrasound signal in the liquid must be known. Since tank geometries can be stored in the analysis unit (e.g. whether the tank is cylindroconical or horizontal or has a dished bottom), the exact volume can be displayed. The expensive and costly physical measurement of the tank capacity thus do not need to be carried out, unless no information regarding tank geometry is available.

Depending on the geometry of the tank, an accuracy of less than one hl is possible (fig. 3). The speed of the ultrasonic signal depends on the temperature and the density of the medium. For example, the signal travels at 1484 m/s in water at 20 °C, while its velocity is only 1407 m/s in water at 0 °C. The speed of sound at 20 °C in non-alcoholic beer compared to strong beer differs by about 85 m/s. In practice, this means that the accuracy of the measurement can be further increased by taking specific parameters into account, which can be stored in the system, such as the particular type of beer (density) and the temperature. Measurements are not affected by foam and the like.

Modular Design

The system is modular in structure and can be expanded as needed. Up to four tanks can be monitored by a single analysis unit. These are connected via a modbus and either directly connected to the process control system (PCS) or alternatively linked to any bus system via a master box, which can

Fig. 3 Measurement while emptying a bright beer tank (max. volume 400 hl), measurement accuracy: < 0.5 hl

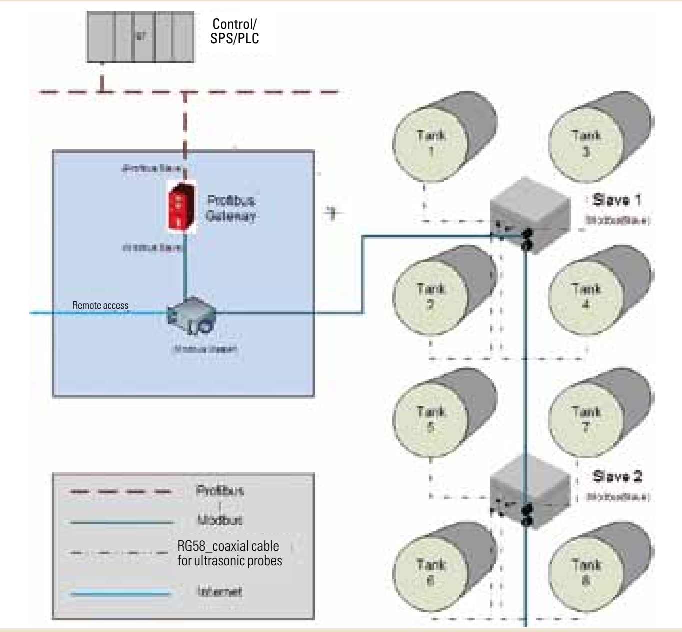

Fig. 4
A possible layout of the ultrasound system for eight tanks

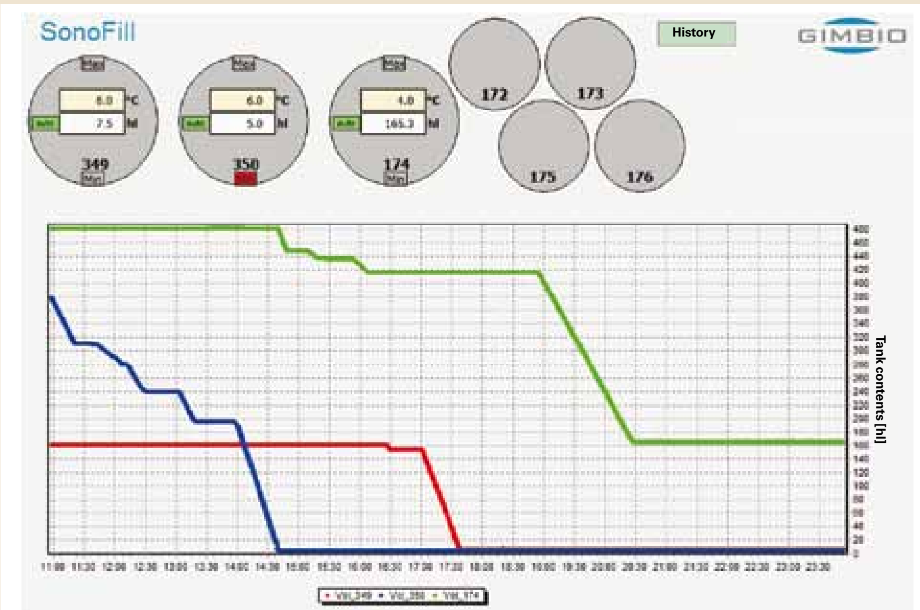

Fig. 5 Visualization of the tank contents

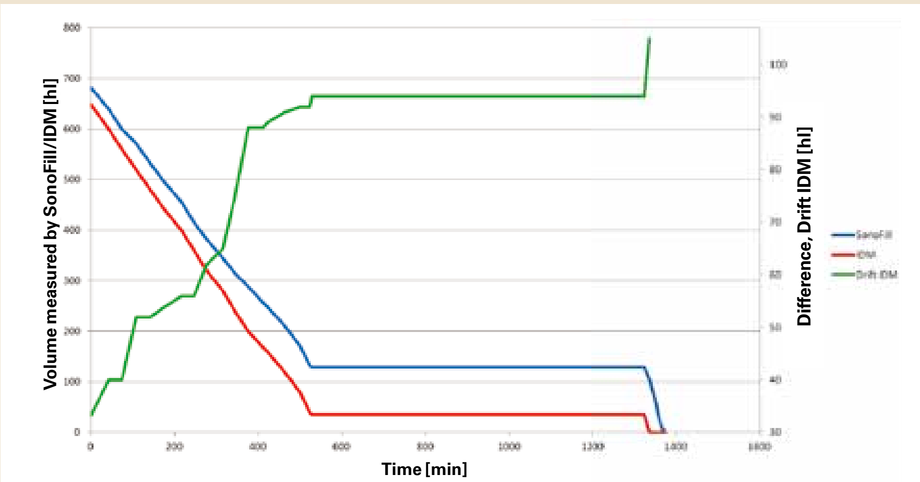

Fig. 6 Discrepancy due to drift with an inductive flowmeter

also serve as a means for visualization or for performing remote diagnostics (fig. 4). Of course, transmission with 4 ... 20 mA is possible.

Instead of connecting the analysis unit to the PCS, the level indicator can be displayed on a screen in the bright beer tank cellar. Regardless of the arrangement, effective management of tank volumes is possible at any time. Figure 5 shows a typical SonoFill measurement process for three horizontal tanks. Over a period of two months in a brewery, SonoFill was compared with the existing tank level measurement system using IDM, favored by the brewery, for three vertical bright beer tanks, one with a capacity of 1920 hl and two at 820 hl each. The IDM measurement was fairly accurate while the tanks were being filled at a constant volumetric flow rate (1 to 6 hl). However, the IDM was found to be inaccurate when measuring the residual volumes of beer in the tanks, especially when the tanks are being emptied in a stepwise manner (when filling kegs). This is illustrated in figure 6.

As depicted, while the tank was being emptied, an initial discrepancy of 33 hl, caused by drift in the IDM measurement, increased to more than 100 hl, compared to SonoFill. The measurement with the IDM system indicated that the tank was empty when in fact there was still 105 hl remaining in the tank. The ultrasonic measuring system proved to be accurate and drift-free in determining the volumes of the tanks at an accuracy of less than one hl, both while filling and emptying the tanks.

Summary

The ultrasound-based SonoFill measurement system facilitates accurate determination of the volume of beer in a bright beer tank. The time required for setting up filling lines can thus be scheduled more precisely. The probe can be installed non-invasively without difficulty on the bottom, external surface of the tank without disrupting production operations or requiring tank fittings, circumventing any potential issues with hygiene. Regardless of whether the tank in question is cylindroconical or horizontal, with input of the respective geometry of the tank, the ultrasonic measurement system can determine the volume reliably and drift-free, thus permitting more efficient management of the tank contents. ■