sonicwipe
taking care of the cleanness
by usePAT

#2

pH-probe applications

sonic**wipe** – accurate inline measurements through taking care of the pH-probe's cleanness

pH electrodes are among the most common of process analysis technologies and are used in many different industries and stages of production processes. This popularity is not least due to their easy way of handling and the variety of process parameters, which can be derived from the measurement values. Despite this versatile usability though, there are some important issues when working with pH-sensors, which need to be regarded. They for once are not a stable measurement system and have to be recalibrated from time to time due to internal drifts, related to leakage of the reference analyte. Furthermore, layers of organic, non-organic or mixed forms of both tend to grow on the pH-probe, diminishing the ions' ability to penetrate the sensors pH-sensitive glass-membrane at the tip. It then happens that this effect is commonly mistaken for a drift in measurement values due to internal reasons. The sensor is simply recalibrated as a counter measure or true values are estimated based on the falsified, measured ones.
Because production processes are often highly sensible and must not be interrupted, taking out the sensor for cleaning measures is not an option. Clean sensors are however essential in order to generate accurate in-line data in real-time, guaranteeing effective process control according to industry 4.0 and continuous production for e.g. The effect of these layer-formations on measurements of the process medium, is currently not properly considered or acknowledged. The goal therefore was to shed some light on this yet unknown degree of influence due to contamination on the sensors' membrane and hence on the gained process information.

The technology

Ultrasound waves are non-audible acoustic waves emitted at frequencies above human hearing and up to several gigahertz. If a transducer produces an ultrasound wave, it can be reflected by a second surface. The incoming and returning wave interact with each other, thus creating a quasi-standing wave. The standing wave field can exert force on particles, which have settled on the probes' sensitive areas.

sonic**wipe** is an add-on for various process analytical sensors, keeping them clean.
The technology is based on particle manipulations, as the ultrasound field depopulates particles form the sensing area, resulting in the removal of contaminations and layers. Thereby, the sound does not act on the window, but in the liquid and therefore treats the sensing area gently. The compact way of its construction makes sonic**wipe** applicable with a variety of sensors and enables multiple ways of implementation in tanks, as well as in pipes.

Aiding pH electrodes to sense what's really there

What lays beyond the films, covering the probes tip? Those formations hinder the probe from sensing the current status of the process medium. As layers mostly grow continuously in thickness, the border between measurement data gained from the medium, containing the genuine information, starts to overlap with the information gained from the contaminations. Overtime and as they grow thicker, they may even block information from the medium entirely. In any case, distinguishing and determining the sensors' status concerning its cleanness is very difficult. The following data shall help to provide an insight into the matter.
The common pH electrode is built with a pH-sensitive membrane from glass or ceramics and an internal reference analyte and electrode, against which the measuring medium is compared in terms of its electro-chemical potential.

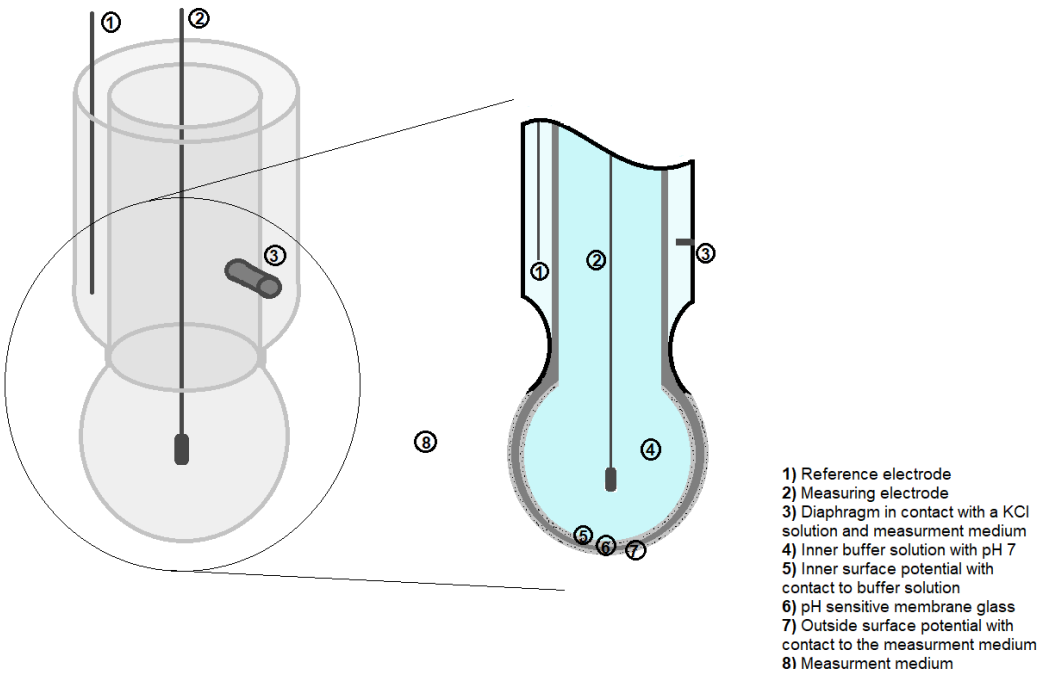

Figure 1: Scheme of a pH-electrode

Have you ever experienced fouling on your pH-probe?

Once dipped into to the process medium, ions of the latter penetrate the semipermeable barrier at the probe's tip. When a film blocks their way to the membrane's surface, the effectively measured pH values do not properly represent the actual values of the process medium. sonic**wipe** is therefore used to remove layers from the tip in order to gain the correct medium data by exerting an ultrasound field on the pH-probe tip.
For the sake of demonstration, two types of contaminations were used: a sugar/fruit layer and a sugar/fat layer were applied to the probe's tip. The pH-value of the medium was kept steady with a buffer-solution.

Upon contact with the contamination, the pH-value of the latter is measured and the one of the medium becomes no longer ascertainable. As the layer is gradually removed by the ultrasound, the pH-value slowly converges back to the actual one, indicating once more a clean probe tip.

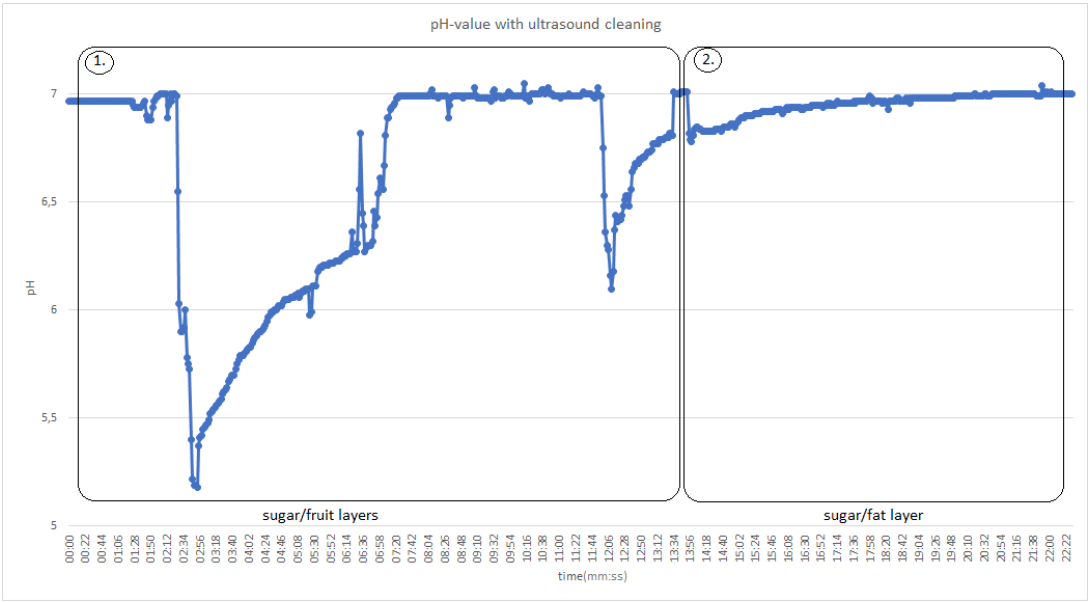

*Figure 2: pH value at continuous radiation of the pH-electrode with ultrasound by sonic**wipe** and alternating application of dirt layers (1. twice sugar/fruit and 2. sugar/fat), which are removed due to the ultrasound forces. During the pH-steady phases, the medium is measured at the ultrasound also being turned on – the measured pH value is not influenced by the ultrasound and remains steady until the contaminations are applied on the probes tip and the data adapts to the change.*

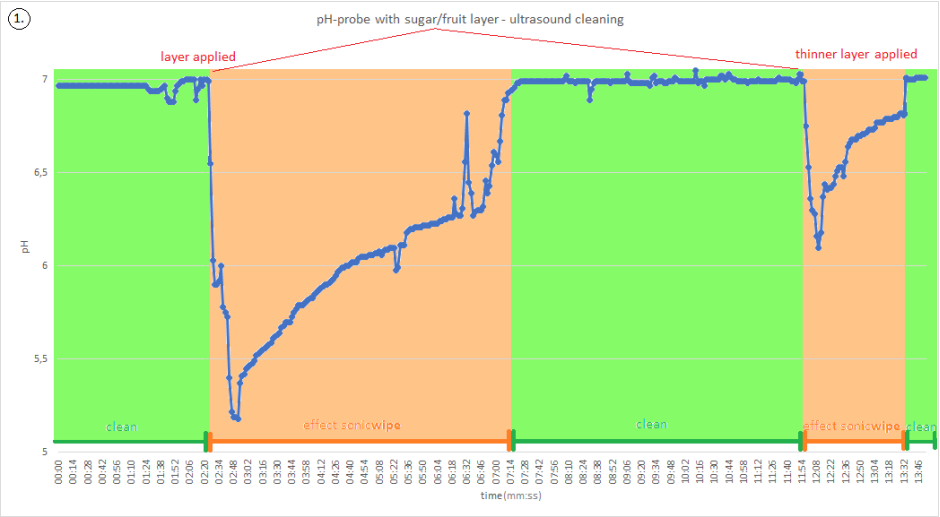

*Figure 3: Application of sugar/fruit mixture- contaminations on the pH-probe's tip and cleaning effect of the ultrasound field, radiated by sonic**wipe.** For the second contamination, a thinner layer was applied.*

The prominent signal variation near the end of the first cleaning process is likely caused by layer patches, which became detached during cleaning, but reattached shortly afterwards, before being finally dragged off completely.
The duration of the cleaning process strongly correlates with the layer thickness. The second application of contamination yields a faster cleaning process, which is caused due to a thinner layer thickness. Hence, when used in an actual production process, the growth of a layer is prevented due to a regular ultrasound cleaning interval. Furthermore, the ultrasound was turned on faster than the first time - the pH value did not yet have the time to reach a stable value before the cleaning process was started.

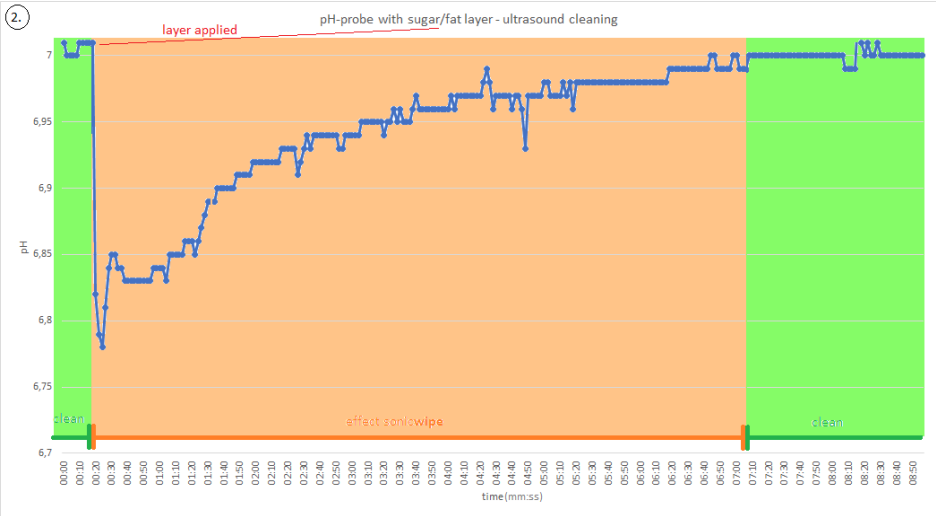

*Figure 4: Application of sugar/fat mixture- contamination on the pH-probe's tip and cleaning effect of the ultrasound field, radiated by sonic**wipe***

In the case of the sugar/fat contamination, a different cleaning behavior was noticed. It took longer for the ultrasound to wipe off the layer, especially near to the end of the cleaning process, where the probe remained to be “almost clean” until being finally freed from contamination. This is likely due to the layer’s fatty ingredients and their more adhesive nature.

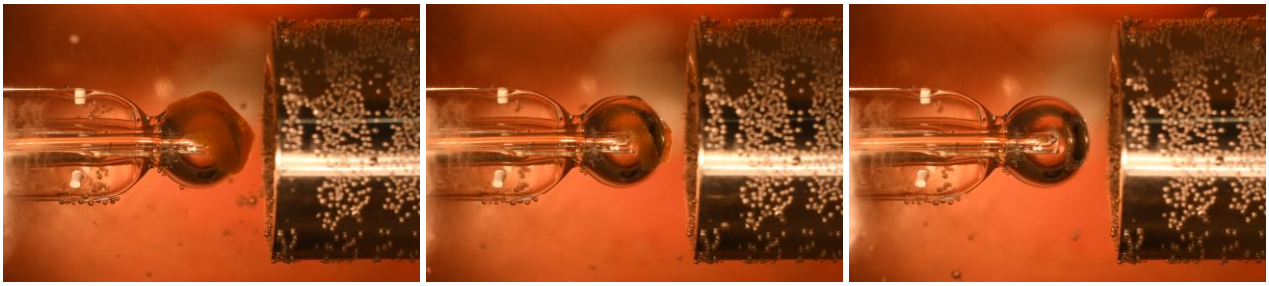

Figure 5: ultrasound cleaning effect: removing a contamination from the pH-probe’s tip

Comparison to process without ultrasound cleaning

For the record, sugary depositions will dissolve on their own after some time in watery solutions, so one might argue why anyone might need a cleaning mechanism then in that case. To better explain the cleaning effect of the ultrasound, the data was compared to the case where no ultrasound was applied to the probe tip, letting the contamination come off on its own. The comparison reveals the gain of using ultrasound for cleaning, for it speeds up the cleaning-process significantly.
On the other hand, the situation is different for contaminations, which don't come off by themselves, like oily filmy, biofilms and generally fouling. In these cases, the ultrasound proved to be very effective in case studies with other sensors.
When comparing the data curves, one can observe that using sonic**wipe** restores the pH value to its original a lot faster (arrows), indicating that the probe is clean and will deliver the correct measurement data. This is especially valid for the case of the sugar/fat layer.

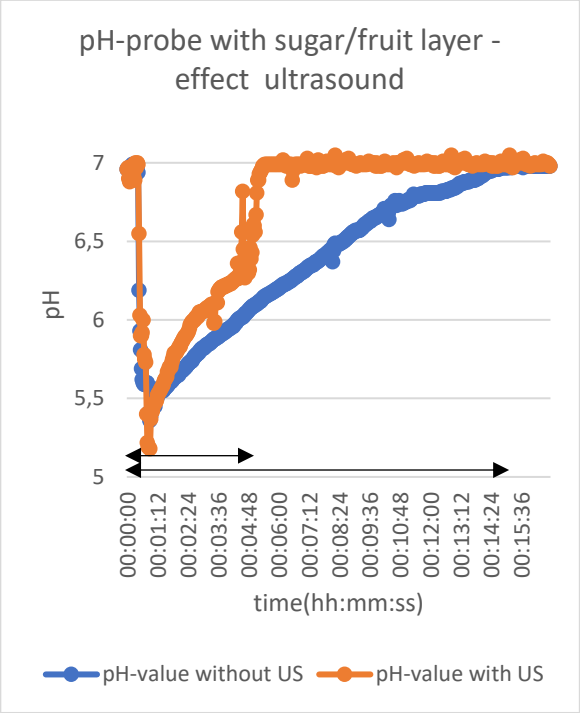

Figure 6: Comparison of sugar/fruit layer on the probe tip with and without ultrasound – time to cleanness (arrows)

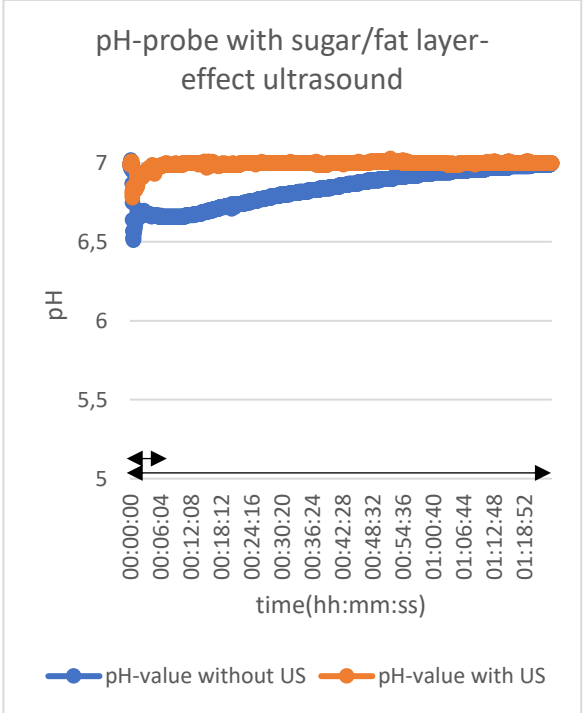

Figure 7: Comparison of sugar/fat layer on the probe tip with and without ultrasound – time to cleanness (arrows)

Ever tried ultrasound before?

It helps to obtain reliable data from a production process due to the elimination of measurement-influencing contaminations from the pH-probe.
The measured pH values of the medium are not influenced by the ultrasound. This indicates that it has no obvious or immediate effects on the membrane and its ion-selectivity, i.e. the ability to channel ions through its barrier.
Once the layers have been removed, the initial pH-value of the medium is once again regained and steady. The probe is clean.
Furthermore, the pH-probe's measured values had reached their original value, hence showing cleanness even before the probe was visibly clean to the eye, indicating to be sufficiently clean. The ultrasound field thereby acts on the entire probe tip and shaft (fig.8).
The technology poses a promising method for determining the influence and the degree of contaminations, which affect the sensors' measurement data.

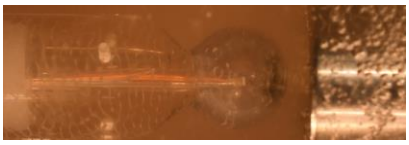

Figure 8: Making the ultrasound field visible with the help of suspended particles: their pattern on the pH-probe reassembles the cleaning force's active area and indicates the range of the cleaning effect

Want to know more?

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