Online Bath Monitoring

Continuous Measurement of the Concentration and Degree of Contamination

In cleaning, rinsing, coating or treatment baths, inline measurement of the bath concentration is essential in order to ensure product quality and to minimise the consumption of resources. Robert Bosch GmbH has therefore equipped the cleaning baths at two of its production plants with a measuring system for continuous bath monitoring.

The need for industrial component cleanliness and optimum surface treatment is becoming increasingly important at companies from various sectors of industry. To meet these requirements, cleaning baths, degreasing cascades, rinsing baths and coating processes are monitored online along the entire process chain.

Spray or immersion baths are used to remove contamination or to apply anti-corrosion coatings. To monitor the process, these baths are equipped with analytical measuring systems that determine the concentration of the cleaning agent or anti-corrosion agent inline. In addition, the degree of contamination can be analysed directly in the bath in order to ensure efficient bath maintenance.

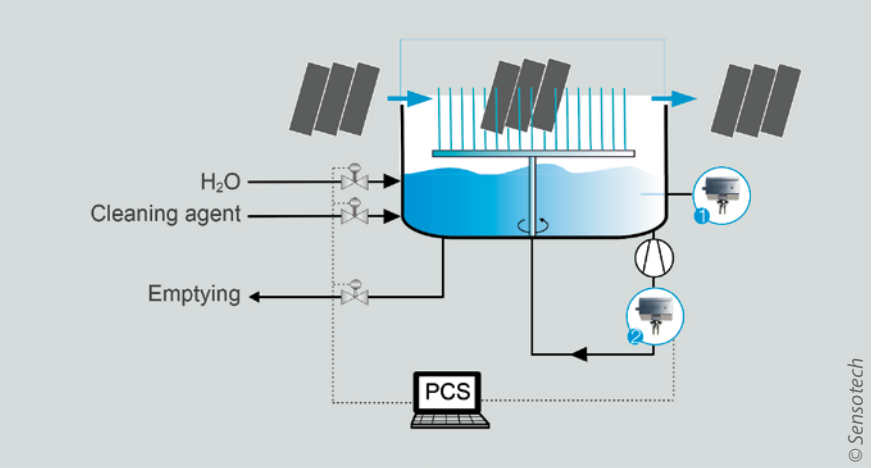
Time-consuming discontinuous processes such as titration are being replaced by modern inline processes that make the measured data available continuously and in real time. This significantly reduces the need for sampling and laboratory analyses.

Process example – cleaning PCBs

A vitally important step in PCB production is the cleaning process to remove residues of flux, resin or soldering paste. PCBs need to be cleaned reliably, as otherwise electrical failures or component corrosion might occur. In order to ensure the maximum lifetime of the products, the concentration of the cleaning bath is continuously monitored directly in the process.

The cleaning process for PCBs includes a bath for dissolving contamination and one or more aqueous rinsing baths to remove the cleaning agent. Single-chamber, multi-chamber or continuous flow systems are used. The online measuring system is integrated into the cleaning plant in order to measure the concentration of the cleaning agent in both the cleaning bath and the rinsing bath. If the concentration decreases in the cleaning bath, cleaning agent can be added immediately.

In the PCB rinsing process, on the other hand, the concentration of cleaning agent in the bath increases. The measuring system indicates when the rinsing bath needs to be changed, thus avoiding carryover or too frequent bath changes. As an example, Figure 1 shows a spray cleaning bath with integrated measuring points.



Measuring point	Installation	Measuring task
1, 2	Pipe, bath	Monitoring the concentration of cleaning agent or the degree of contamination

Figure 1: In order to meter the precise concentration of cleaning agent and to control bath changes efficiently, a sensor is installed either in the pipe or in the bath.

Application of measuring technology at Bosch

The Automotive Electronics Division of Robert Bosch GmbH develops, produces and sells microelectronic products for automotive and non-automotive applications. The product range extends from semiconductor components and electronic control units (ECUs) to non-automotive applications such as MEMS sensors for consumer electronics or eBike systems.

Both at its German plant at the headquarters in Reutlingen and its

Figure 2: The measuring system monitors the concentration of the cleaning agent or the degree of contamination directly in the bath and makes the measured values available online.

Hungarian plant in Hatvan, the company produces electronic modules that are used especially for electric power steering systems in vehicles. As these are copper-coated high-end modules that carry high currents, Bosch places the greatest possible emphasis on comprehensive quality management during the component production process. For that reason, the cleaning plants in Reutlingen and Hatvan were equipped with a LiquiSonic measuring system from SensoTech.

The production lines are in a cleanroom and include, among other things, ultrasonic and spray cleaning baths. The measuring systems were integrated in close consultation between SensoTech and the respective plant suppliers.

The LiquiSonic sensors measure the concentration of the aqueous cleaning agent inline and detect when the levels are above or below the limits, thus ensuring that the concentration is always at an optimum with regard to performance and resources. Figure 2 shows a LiquiSonic system consisting of one or more sensors and a controller.

Concentration monitoring and continuous bath maintenance

The measuring points are used for monitoring the bath concentration and for continuous maintenance of the bath. Monitoring the concentration of the initial cleaning mixture, water is mixed with the concentrated cleaning agent in a container. The mixture is pumped through a pipe to the ultrasonic or spray cleaning bath. The electronic circuits are now cleaned. After a while, carryover of the cleaning agent into the next bath and evaporation of the cleaning agent result in a change in concentration in the bath.

In order to be able to add the precise quantities of cleaning agent or water required, the concentration of cleaning agent in the bath liquid must be continuously monitored. For this purpose, LiquiSonic sensors are installed in a DN 15 pipe in each cleaning system. Measurement requires neither a bypass nor stilling pipes. Standard DIN flanges were used to connect the sensor into the process. Alternatively, other versions such as Tri-Clamp or ANSI are also available for use according to customer specifications. Figure 3 shows a LiquiSonic sensor installed in the circuit of an ultrasonic cleaning plant. The sensors carry out measurements in the concentration range between 20 vol% and 40 vol% at process temperatures of between 20 °C and 60 °C. “It is important that we have precise and stable measured values,” said Dr. Jens Klein, Process Planner at Robert Bosch in Reutlingen. “The online measuring system from SensoTech helps us to meet our cleanliness and quality requirements. By using continuous bath monitoring, we can ensure the cleanliness quality of our products and we also have an efficient use of cleaning agents, water and energy. That not only reduces our costs but also protects the environment.”

Figure 3: The immersion-type sensor is installed in a pipe of the cleaning plant at Robert Bosch and continuously measures the concentration of the cleaning agent.

Inline measurement and online analysis

To measure the concentration, LiquiSonic uses the principle of absolute sonic velocity measurement. This makes the sensors particularly robust and they are able to provide stable values even in the presence of gas bubbles or in bath fluids that tend to form deposits.

The measuring principle is based on runtime measurement, in which an ultrasonic sound signal is transmitted from one side of the sensor probe to the other. The distance and time are used to calculate the sound velocity. The ultrasonic signal is transmitted several times per second, which means that the measured data are recorded and updated extremely quickly. As the sonic velocity depends not only on the concentration but also on the temperature, two Pt1000 temperature sensors are also integrated into the sensor. So the concentration is measured on the basis of the sonic velocity and the temperature. The measuring accuracy is 0.1 vol%. The correct operation of the sensors can be quickly checked by a system test in water.

Fast overview of the process

The mathematical model used for calculating the concentration is stored in the LiquiSonic controller. The system is supplied as standard as a Plug&Play unit, which means that the controller shows the current concentration on the display as soon as it is switched on. Clear trend displays provide a fast overview of the process.

The measured data are stored in the memory of the controller, and at Bosch are transmitted to the PLC via 4 to 20 mA signals. This enables the system to automatically add controlled quantities of cleaning agent and to indicate when the bath needs to be changed. Alternatively, the controller can be integrated into the process control system (PCS) via digital outputs, serial interfaces, Ethernet or a fieldbus such as Profibus DP.

The measured data that are stored can be read out online via the process control system or via a PC. The SonicWork software from SensoTech offers the possibility to comprehensively analyse the data, to illustrate them in diagrams and to document them in logs. "Another practical feature is remote-controlled communication between the units. Whenever we require support from SensoTech, we simply connect our controller to a modem," said Dr. Jens Klein.

Measuring systems for different cleaning agents

The sensors at the Bosch plants in Reutlingen and Hatvan are made entirely of stainless steel DIN 1.4571. For use in chemically aggressive bath solutions, corrosion-resistant sensor materials, such as Hastelloy or Tantal, or coatings of Halar or PFA are also possible. A typical example of such an application is a pickling bath, in which Halar-coated LiquiSonic sensors are used for measuring the acid concentration.

The cleaning agent used at Bosch belongs to the group of aqueous cleaners. As these do not have a flash point, the cleaning systems and the sensors do not have to comply with explosion-protection requirements. The opposite applies to anhydrous cleaning agents. For that reason, LiquiSonic sensors with ATEX and IECEx certification, Zone 0 to 2, are available for use in potentially explosive atmospheres.

The sensors can be easily integrated into any system. They are installed preferably in circulation pipes downstream of the pump or directly in the bath. The sensors can also be installed in small systems or pipes with small nominal dimensions, as flow adapters are available and the sensor electronics can be accommodated in a separate housing. Figure 4 shows a LiquiSonic sensor with a separate electronics housing made of stainless steel and with IP 68 level of protection. A LiquiSonic controller can control up to four sensors. This results in lower costs in the case of several measuring points.

Figure 4: As an option, the sensor electronics are located in a separate stainless steel housing, thus allowing the sensor to be installed even if space is limited.