Technical Report

Ensuring food safety by mastering thermal stress without cracking and leakage.

CIP and SIP cleaning cycles include frequent temperature swings. During the cleaning process temperature swings between ice water of about 0 °C up to a sterilization step at high temperature of about 150 °C can occur. This is a temperature difference of up to 150 kelvin. All components installed in the production process must withstand these high temperatures. In addition fast changing temperature from hot to cold and vise versa stresses materials. What are the effects of fast temperature swings and how can this influence food safety in your production?

Since knowing that heat kills bacteria or at least improves the cleaning result, temperature has been involved in the process causing long-term stress to the environment, the equipment and material. Usually lifetime is an indicator for the robustness of the equipment in use. The operator is facing two pains: on the one side he must ensure food safety by clean and sterilized equipment, on the other he has to eliminate cost and time for cleaning to increase production efficiency. This pushes him into the situation, where the cleaning cycle is becoming shorter and there are more temperature changes in shorter times in order to reduce time or costs. The thermal stress imposed on the equipment is problematic because in the end it will cut down on service life.

Learning from the past

Since 1990 Baumer has been focusing in hygienic process and sensor applications and elaborating on solutions for the food & beverage and pharma industry, where sanitary requirements are essential. This long term focus and the partnership to machine manufacturers and the food processing industry has shaped the present-day sensor portfolio. The result are ultra-reliable and high performant sensors that withstand harsh process environments at yet maximum service life. Machines and installations becoming more and more intelligent, multi-functional and flexible in use entail higher batch costs. Consequently, there is an evergrowing demand for cost-efficient sensors with outstanding performance.

Powerful and robust measuring principle

Together with leading companies from the food industry, Baumer started a new development of a conductivity sensor. Conductivity measurement is being used to measure the concentration of acid and caustic achieve the maximum cleaning effect. Another application is media detection and separation to collect already used liquids for another cycle instead of disposing and wasting them. In doing so, the sensor operates on the inductive principle in order to detect high concentrations. The very specific sensor design which can be seen in figure 1 originates in the sensor's operating principle. The fluid loop in the channel bore of the sensor tip acts as a coupler between two toroid core coils. The sensor tip must be isolated and cannot be fully made from metal. For this isolation the most commonly used material is a special plastic, called PEEK. PEEK is certified for food contact and at the same time endures high temperatures. Picture 2 shows a conductivity sensor with inductive measuring principle. It is not an all-metal sensor tip and you may wonder why two materials are involved.

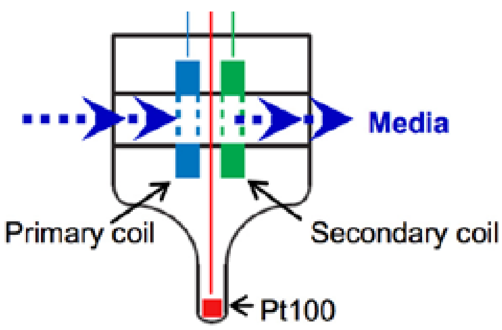

Figure 1: Schematic presentation of the inductive measuring principle

Picture 2

Correlation of conductivity and temperature

The answer comes with the behavior of conductivity, as it is dependent on temperature. That means when the temperature rises the conductivity of the liquid increases, when the temperature drops, the conductivity decreases. In diagram 3 you can see the conductivity of drinking water and the behavior within temperature swings which depend on the measured liquid. Not only the conductivity is different at the same temperature, also the deviation due to temperature changes varies for different media. Table 4 shows approximate conductivity values of media used in the food & beverage industry at 20 °C.

Temperature depending on conductivity

Measuring the true value in a CIP process under all these aspects is really challenging. The solution is to measure the temperature inside the sensor tip, close to the measurement of the conductivity. The metal front end of the sensor is the temperature probe. Obtaining a comparable conductivity value requires compensation of temperature-dependent influence in the measuring operation. As seen in picture 2, the sensor tip is made of metal. Metal has excellent heat conducting properties allowing for fast temperature measurements, but the the sensor tip is also made of PEEK. For many years, Baumer has been focusing on PEEK research and found out it may impair food safety in production.

Challenging temperature swings in cleaning cycles

More cleaning entails more temperature cycles causing stress to the metal/PEEK material bond due to the very different individual thermal expansion rates. The coefficient of linear expansion of PEEK between 23 and 150 °C is around 50 ppm/K, while the stainless steel coefficient is approx. 16 ppm/K which is a factor of 3.1. The thermal expension between the two materials does not enable a tight, hygienic bonding. Stress by temperature cycles make cracking and leakage just a matter of time. Cracks cause gaps that will be omitted in the cleaning process and allow bacteria to grow. Baumer has focused on two solutions in order to avoid this problem in the future. The most obvious solution to tighten a bond between two materials is to use a sealing ring, a gasket. The gasket balances the different expansions and assures a tight connection. Gaskets however must be regularly exchanged under hygiene aspects which would drastically increase maintenance efforts. An alter-

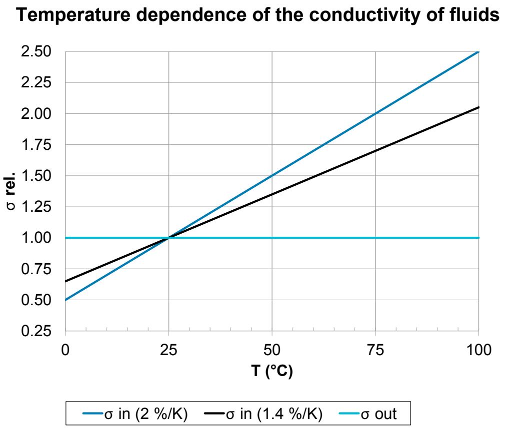

Diagram 3

Conductivity in different media:

Conductivity			Media group	Media
55	nS/cm		Water	Ultra-pure water
1	µS/cm			Pure water
10	µS/cm			Process water
100	µS/cm		Food	Drinking water
				Beer
1	mS/cm			Milk
				Orange juice
10	mS/cm	AFIx		Apple juice
100	mS/cm	Range	Process	Phosphoric acid
				Hydrochloric acid
1000	mS/cm			Sodium hydroxide

Table 4

Picture 5: Robust and hygienic one piece design

native approach would be eliminating the issue by using materials of the same thermal coefficient in linear expansion.

Solution one piece design

The new conductivity sensor *CombiLyz* comes in a one piece design, with both the sensor tip and the temperature element being completely made of PEEK. Since the thermal transmission of metal is faster than that of PEEK, Baumer developed a new tip (Picture 5). The result was a temperature compensation time t 90 of 15 s. This one piece design provides a unique value on the market. To implement this one piece design into production, Baumer benefits from the experience of ultrasonic hygienic welding. Ultrasonic welding has developed further over many years and this technique is used in manufacturing the *CombiLyz* sensor tip. A side effect can be found around the channel bore in the sensor tip. A dark thin line is the evidence of this welding procedure. The dark line indicates that the welding was done ensuring that there are no gaps. Besides this visible proof, all welded products are checked upon leakage in a helium leak test.

On top of this, this sensor comes like many other sensors from Baumer with an EHEDG certificate. Even the EHEDG test which every product must undergo proved outstanding results in cleanability: "The in-place cleanability test method has proven that this sensor made of peek and the process connection of the Varivent ball housing (GEA Tuchenhagen) is easy to clean. The tests were done with the short version of the sensor. There were no problem in cleaning the product contact surfaces and the joints. The cleanability was better than the reference pipe" (EHEDG Hygienic Design Evaluation Report no. 474TUM2015).

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