Technical Report

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

CIP and SIP cleaning cycles include tremendous 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 your food safety in the production?

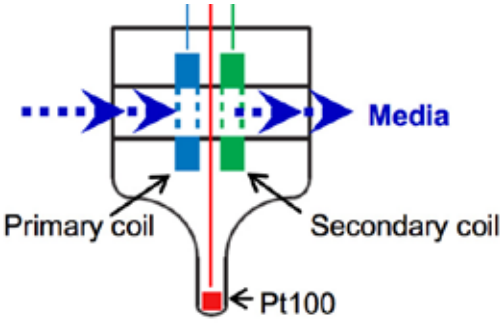
Since we know that heat kills bacteria or at least improves the cleaning result there is temperature involved which influences the environment and the equipment. This influence caused by temperature stresses the materials over time. Usually the lifetime is an indicator for the robustness of the equipment in use. The processor has two pains: on the one side he wants to be sure, that the production equipment is clean and sterilized to assure food safety, on the other he wants to avoid costs and time for cleaning, he is trying 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. This way is problematic, because the thermal stress imposed on the equipment in the end reduces its life cycle.

Learning from the past

Since 1990 Baumer focused in hygienic processes and sensor applications and had an impact 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 food processors affected the sensor portfolio of today. The results are sensors with great robustness to withstand harsh processes with long life cycle and high performance. Nowadays where machines and equipment becoming more and more intelligent and flexible and expand their functionality, the cost per unit increases. Therefore the need of cost effective sensors with outstanding performance are becoming more required.

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 in order to have the maximum cleaning effect. Another application is to detect different media during media separation in order to collect already used liquids which can be used again and not be wastefully discarded. Therefore this sensor has to work with the inductive principle in order to detect high concentrations. This principle gives the sensor a very specific design which can be seen in picture 1. The sensor has a hole in the tip to induce a magnetic field into the liquid and thereby measures the conductivity of it. The sensor tip must be isolated and cannot be manufactured completely out of metal. For this isolation the most commonly used material is a special plastic, called PEEK. This PEEK plastic is certified to be used in contact with food and withstand high temperatures at the same time. Picture 2 shows a conductivity sensor with inductive measuring principle. It is not an all-met-



Picture 1: Schematic presentation of the inductive measuring principle

Picture 2

al sensor tip and you may wonder why two materials are involved.

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 it is possible to see the conductivity of drinking water and the behavior within temperature changings. These changings are different depending on the liquid measured. Not only the conductivity is different at the same temperature, also the deviation due to temperature changes varies for different media. Table 4 shows approximately conductivity values of media being used in the food & beverage industry at 20 °C.

Importance of temperature compensation

Considering all these aspects measuring the true value during the process of CIP is 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. To always ensure the true conductivity value it is a must to compensate the actual measurement by the temperature. As you can see in picture 2 the temperature tip is made of metal. Metal is a great conductor of heat allowing for a very fast temperature measurement, but this sensor has an area where metal joins PEEK. Baumer has focused on this metal/PEEK connection for many years and found that this can cause food safety issues within production.

Challenging temperature swings during cleaning cycles

The more cleaning the more temperature cycling

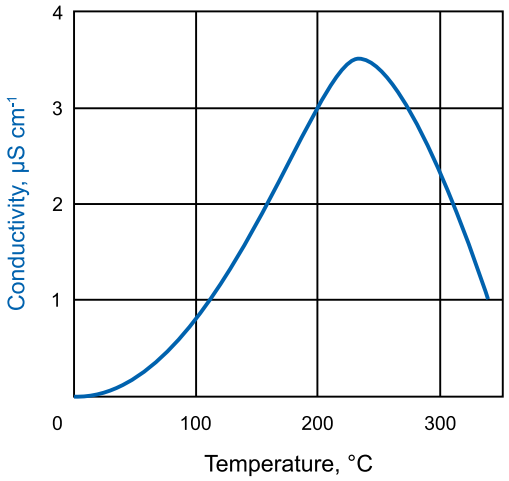


Diagram 3

will occur. This thermal cycling creates stress on this metal/PEEK connection. The thermal expansion rates of metal and PEEK are very different creating stress at this connection. The coefficient of linear expansion of PEEK between 23 and 150 °C is around 50 × $^{10\text{-}6}$K, stainless steel's coefficient is around 16 × $^{10\text{-}6}$K this is a factor of 3.1 and results in movement between the two materials and a tight hygienic connection cannot be realized. During these temperature cycles this connection is being stressed many times and is just a matter of time, when cracking or leakage will occur and as a result of cracking there will be a gap where bacteria can

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

grow due to the impossible cleanability. Baumer has focused on two solutions in order to avoid this problem in the future. The most obvious solution to tighten a connection with two materials is to use a sealing ring, a gasket. The gasket balances the different expansions and assures a tight connection. Under hygienic aspects a gasket has to be exchanged on a regular time. Under these requirements, an exchange would drastically increase the maintenance efforts during production. The other solution was to avoid the issue of using 2 different materials all together. If the materials have the same thermal coefficient of linear expansion, there will be no stress to avoid.

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 hole of 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. In addition to this visibility, all products welded are also checked for tightness with a helium-leak test.

On top of this, this sensor comes like many other sensors from Baumer with an EHEDG certificate. Even during the EHEDG test, which every product must follow, the result of cleanability was outstanding: "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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