Practical ways to influence response times (2)

The previous article "Calculating response time for different conditions" [Ref 1] discussed how we can use simplified mathematical models as a starting point to predict a specific sensor installation's response time. In this article we will look at a number of practical changes that can alter the temperature sensor's own influence on the response time.

First, it is important to state that a temperature sensor in an installation does not have a fixed response time. The response time varies along with many factors that can change during the measuring process. Flow velocity and medium composition are examples of things that can change rapidly, whilst deposits and dirt from the fluid often change more slowly. However, a temperature sensor can have a specific measured response time that is the result of its design and the specific conditions which prevailed during a specific test event. As we explained in the previous article, response time measures the heat transfer to the sensor in the probe tip. The difference in temperature is what causes this heat transfer. That is why a sensor which is in equilibrium with its surroundings – for instance when it is lying on a warehouse shelf – has no response time.

This assertion may seem strange, at least to electricians, who have been trained with regard to RC circuits to delay such things as relay switches. The time constant RC (resistance times capacitance) is only marginally affected by external conditions and is regarded as fixed.

How can we choose from among the many available sensor types and installation options in order to reduce a response time? Of the factors listed in [Ref 1] the following are the simplest to consider in terms of their practical aspects:

- 1. Reducing the mass
- 2. Improving the heat transfer from the medium to the sensor in the probe tip
- 3. Reducing the heat conduction in the sensor probe

Figure 1. The wire thermocouple has an extremely small mass with thin wires. However, its structural strength is very limited within flows. Figure 2a. A process sensor mounted in a conical thermowell with a reduced diameter tip. The measurement insert is Ø 3.0 mm and the hole in the thermowell's tip is Ø 3.1 mm. This sensor type is used, for example, in consumption meters for district heating systems.

away from the measuring position

- 4. Using insulated mounting devices on heat-transferring walls
- 5. Creating the best flow around the probe tip
- 1. Reducing the mass enables the amount of energy stored in the sensor to change more rapidly in response to the temperature of the fluid. Unfortunately, reduced mass usually also means reduced structural strength. See Figure 1.
- 2. Air gaps are effective obstacles to heat transfer. For a specific sensor design, the heat transfer to the Pt100 detector or to the measuring junction in the thermocouple tip can be improved by bridging the air gaps to the outer protective tube with heat conducting compound or metallic filling. This is particularly necessary at low temperatures. See examples in [Ref 2].

REDUCED TIP DIAMETER

An alternative method is reduced tips, which means that the probe tip is given smaller dimensions while the rest of the measuring probe is allowed to retain its mechanical strength. This procedure can also be applied to thermowells, see Figure 2a.

The tips of conical thermowells can be turned to the desired dimensions. For straight protective tubes or probes, you can reduce the tip by welding on a smaller tube, see Figure 2b. These measures must not be allowed to jeopardise structural strength.

In some situations it is not possible to avoid air gaps. At high temperatures, the presence of air gaps in a sensor is not necessarily a major disadvantage because at these temperatures, radiation begins to dominate the heat transfer process. At low temperatures, air gaps are more of a disadvantage because they worsen thermal conductivity, which dominates the heat transfer process at low temperatures. Accordingly, if we are using the same sensor to measure both high and low temperatures as part of the same process, we will get decent response times

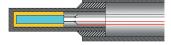


Figure 2b. A reduced diameter tip on a straight outer protective tube. In this situation, heat conducting compound in the form of a metal bushing or powder (yellow) can be used to give the Pt100 detector (blue) better thermal contact with the inner walls of the probe tip.

at high temperatures and considerably longer ones at low temperatures, for instance during the later stage of a cooling process.

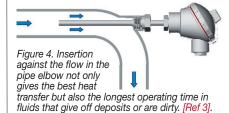
- 3. The cross-sectional area of wires, casings, protective tubes and thermowells influences the heat conduction out from the sensor. The material of these items is often some kind of steel alloy but these have very similar heat conductivity. Reducing this cross-sectional area really comes under the heading of reducing the mass, and it is seldom possible to replace steel with materials that have lower heat conductivity. It is therefore more effective to focus on improving the design of the probe tip (point 2 above).
- 4. A sensor must be mounted onto something such as a pipe wall. Threaded plugs and other types of connection devices increase the heat capacity of the sensor, which in extreme cases may need to be thermally insulated from the plug or pipe wall. In this situation, physical stresses such as pressure often place limitations on what can be done. See Figure 3.

5. In general, you can achieve the absolute best heat transfer in pipes by mounting the sensor counter flow in pipe elbows. These have the space for a long insertion depth and thereby a reduced heat exchange with the connection device. The efficient flow around the sensor also means that the sensor becomes almost self-cleaning from deposits and dirt emanating from the fluid.

See Figure 4. [Ref 3] 🝙



Figure 3. A thin sensor designed to have a short response time has this response time significantly lengthened due to the large threaded plug. The response time can be reduced if the thermal contact with the threaded plug can be insulated.



References: see: www.pentronic.se >>Pentronic News>>Technical Articles Archive (Fil Pentronic News 2010-2 page 4 (File 2) Pentronic News 2008-5 page 4 (File 3) Pentronic News 2008-1 page 4

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