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Thermowells with Improved Response Time

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Summary:

Thermowells are used in various processes as in the Oil & Gas Industry, Life Science Industry or Food & Beverage production to provide a mechanical robust test point for temperature measurement. They enable high immersion length and easier replacement of thermometers. Due to their design, state of the art thermowells decrease the thermal response time of the thermometers. This can be improved significantly by using thermowells with a thermally optimised design. They provide a quicker indication of the process temperature and a more reproducible measurement.

Keywords: industrial thermometer, thermowell, response time, thermal contact, air gap

Background, Motivation and Objective

Thermowells are used in processes, where the thermometer insert may not get in contact with the process medium or when high process temperatures or pressures require a robust design of the test point.

The geometry and dimensions of thermowells can be very different resulting from the requirements of the individual temperature measuring point in the application (see Fig. 1). Hence, length, inner and outer diameter as well as the design of the process connection vary. The thermowells are mostly manufactured of different grades of stainless steel.

Fig. 1. Examples of thermowell designs.

Since a thermowell adds an additional thermal mass and thermal capacity to the system, the response time of the sensor signal is reduced significantly. The magnitude depends on the dimensions and the material of the thermowell.

To quantify this effect, an investigation of the dynamic properties of thermometer inserts and combinations of inserts and thermowells was performed. The tests were done according to the standard IEC 60751 [1]. It confirmed that the response time of a thermometer strongly depends on the inner design of the thermometer inserts [2]. For well-designed inserts (thermometer) of 6 mm outer diameter one can reach response times t0.9 .of about 2 s. This is about 80% below the response time of standard inserts (see Fig. 2).

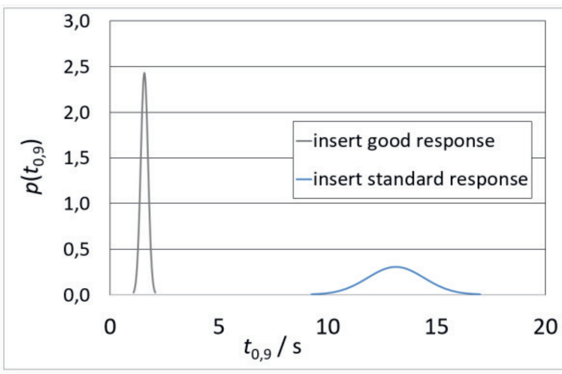

Fig. 2. Graph of distribution of thermal response time $t_{0.9}$ of two different thermometer inserts. $t_{0.9}$ is the time at which the indicated value of a thermometer reaches 90 % of its final value after a step like thermal excitation in water bath with v=0,2 m/s. Both thermometer inserts have an outer diameter of 6mm.

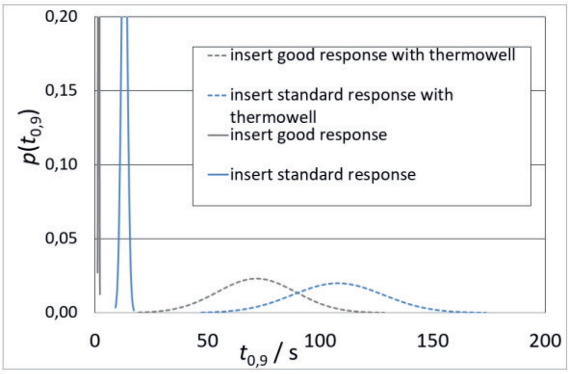

Fig. 3. Graph of distribution of thermal response time $t_{0.9}$.The two thermometer inserts shown in Fig. 1. are additionally measured with standard thermowell with an outer diameter of 11mm.

But, the investigation further revealed that response times of combinations of thermometer and thermowell are much slower than they are for bare inserts (see Fig. 3). They roughly increase by an order of magnitude. Furthermore, the propagation of the response time broadens. This shows that the response is stochastically influenced by dimensional tolerances of the specimen.

Optimisation and Results

The gap between the outer surface of the thermometer insert and the inner surface of the cylindrical thermowell has the biggest influence on the dynamic behavior. This is regardless of the process specific influences or individual application specific thermowell designs.

That is why a thermowell with a new inner design was developed. Here, a solid but flexible gap filler material is used to minimise the air gap. The material equalises dimensional tolerances and improves the thermal contact (see Fig. 4).

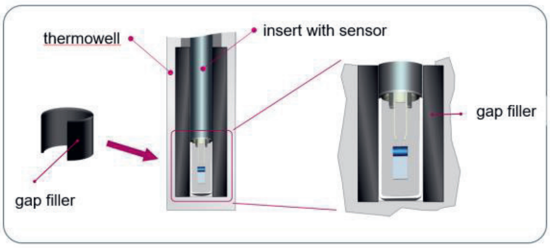

Fig. 4. Improvement of thermal contact by introduction of a gap filler

With this, the response time of thermowell and insert can be reduced drastically (see Fig. 5). Furthermore, the reproducibility of the dynamical behavior is improved, since the distribution of the response time becomes more narrow.

The remaining difference to the response time distribution of the bare inserts is due to the thermal mass and thermal conductive properties of the thermowell.

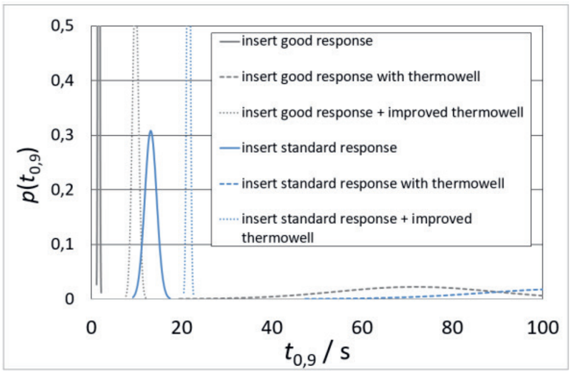

Fig. 5. Graph of distribution of thermal response time $t_{0.9}$. Here, Fig. 3 is expanded by the measured distribution of the thermometer response time with improved thermowells.

A further reduction of the response time could only be theoretically achieved by reduction of the wall thickness of the thermowell or by using of different material. Due to safety reasons this is not practically for the most applications.

References

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