Active Compensation of the Temperature Sensor with Diaphragm Seal Systems

Pressure measurement with diaphragm seals

Diaphragm seals are frequently used in the process industry for pressure measurements to protect the measuring device against aggressive media or – for example in the pharmaceutical industry – to create a gap-free process connection. The process is separated from the measuring device by means of a thin metal diaphragm. A pressure transmission fluid behind the diaphragm transmits the process pressure to the actual pressure sensor.

A solution can be found for almost any pressure measurement task using diaphragm seal systems.

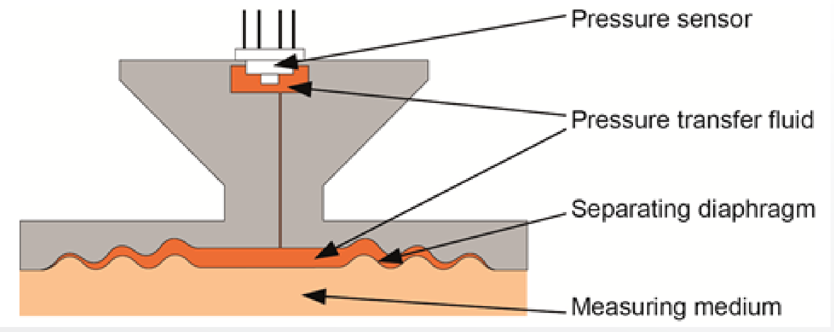

Fig. 1 Diaphragm seal principle

Measurement errors caused by the influence of the process temperature

A drawback is that the diaphragm seal is not completely non-reactive. A measurement error caused by the influence of the process temperature can occur depending on the design. The pressure transmission fluid expands as a result of the process heat and deflects the separating diaphragm. This generates a restoring force depending on the rigidity of the latter, which is received as an error in the pressure measurement.

The magnitude of the restoring force is crucially dependent on the thickness, diameter¬ and contours of the diaphragm. The diaphragm must have a certain minimum thickness because of the mechanical resistance required. Optimised diaphragm contours are therefore typically used to reduce the rigidity. The limits of what is feasible are quickly reached especially with small diaphragm seals. It is therefore necessary to use an appropriately sized diaphragm seal for critical pressure measurements to ensure that the error caused by process temperature changes remains acceptable.

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Large diaphragm seals are not only more expensive to manufacture, but also often present a problem with the process connection. The spatial conditions generally do not allow the installation of large diaphragm seals especially in small, compact systems that are frequently encountered in the pharmaceutical industry.

Approach: Compensation in a temperature chamber

There are several approaches to reducing diaphragm seal errors. One approach is the temperature compensation of the entire pressure measurement system including diaphragm seals. The temperature of the entire pressure measurement system is adjusted in a temperature chamber and the errors that occur are stored in correction tables. The system electronics can thus remove these errors.

It should however be noted that the temperature must be measured to apply the right correction factors. Solely the temperature of the pressure sensor is usually available to the system electronics. This is continuously measured to compensate the temperature error of the sensor itself.

However, the temperature of the pressure transmission fluid behind the separating diaphragm can differ substantially from the sensor temperature because the pressure sensor is positioned considerably further away from the process (see Fig. 1). Consequently, only a proportion of the temperature error is avoided using this method.

The correction can only be performed as quickly as the pressure sensor is heated. However, significant delays occur because of the distance to the process, meaning that the compensation is also delayed during fluctuations in the process temperature.

Approach: Active correction using the sensor temperature

The sensor temperature is used for active compensation in a further approach. The fixed relationship between the pressure sensor and diaphragm seal temperature can be assumed with constant marginal conditions because of their physical connections. This means that it is possible to approximate the temperature in the diaphragm seal from the sensor temperature. The temperature error can thus be fully compensated in theory with this process.

However, constant conditions can rarely be assumed in a real process. Just a change in the ambient temperature will lead to an inaccurate compensation. A conservative correction factor is therefore usually selected, reducing the errors but not completely eliminating them.

The delayed reaction of the sensor temperature to process temperature changes also leads to significant variations in the event of temperature fluctuations with this approach.

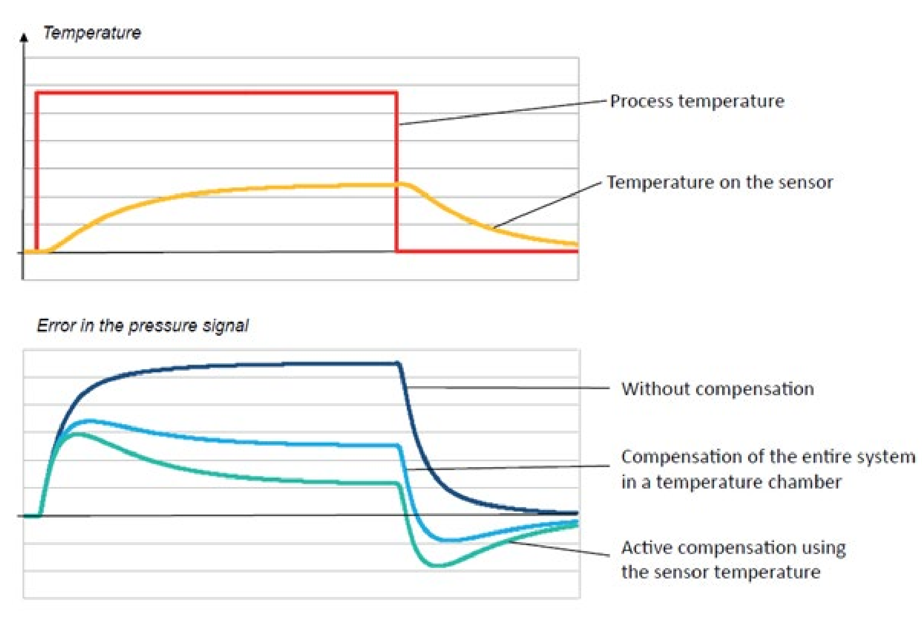

Fig. 2 Schematic comparison of the existing temperature compensation process

Approach: Active correction using the sensor and diaphragm seal temperature

LABOM has developed and implemented a further compensation process to eliminate the disadvantages of the existing processes. The temperature of the pressure trans¬mission fluid is recorded with an additional temperature sensor with the ATC technology (ATC = Active Temperature Compensation). This sensor (a Pt100 element) is positioned as close as possible to the separating diaphragm. The sensor thus records the temperature of the liquid behind the separating diaphragm with good accuracy.

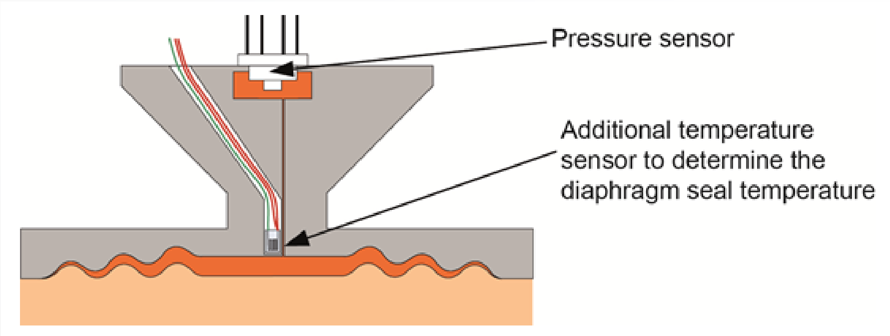

Fig. 3 Positioning of the additional temperature sensor in the diaphragm seal

The great advantage of the additional temperature measurement is its significantly faster response time compared to the pressure sensor temperature. The additional sensor records changes in the process temperature much faster. The resulting measurement errors can therefore also be mathematically corrected much faster.

The method is much more robust against changes in the ambient conditions because the temperatures of the significant amounts of fluid in the system (behind the diaphragm and in front of the sensor) are known. The correction can therefore be set so that the measuring error is fully compensated in a stationary state.

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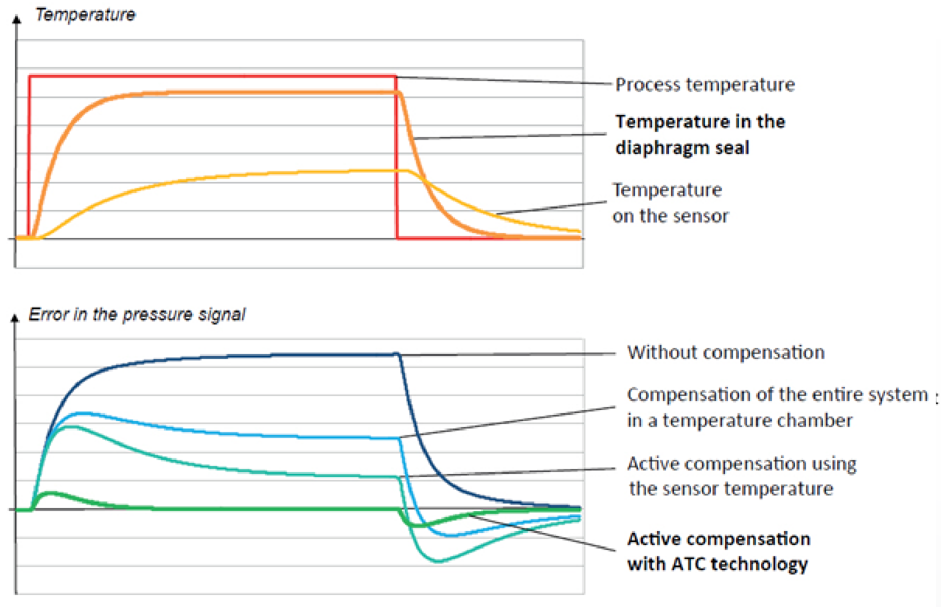

Fig. 4 Comparison of ATC technology and other compensation processes

The influencing factors on the temperature stability of the pressure signal are thus limited to the manufacturing tolerances of the diaphragm seal and the achievable precision when filling the diaphragm seal. Studies have shown that errors can be reduced by 80-90% with small diaphragm seals in a stationary state.

The individual measurement of the pressure measurement system is also possible for a very exact measurement. The correction factors can thus be set specifically for the measuring system.

The example of a real measurement with individual correction factors shows the potential of ATC technology. A level measurement was simulated with a temperature-controlled water tank. The correction factors were determined for a very small diaphragm seal (3/4“ clamp) and then a temperature ramp was run.

The temperature error was almost completely eliminated in its stationary state. There were minimal deviations from the nominal value during the heating and cooling phases.

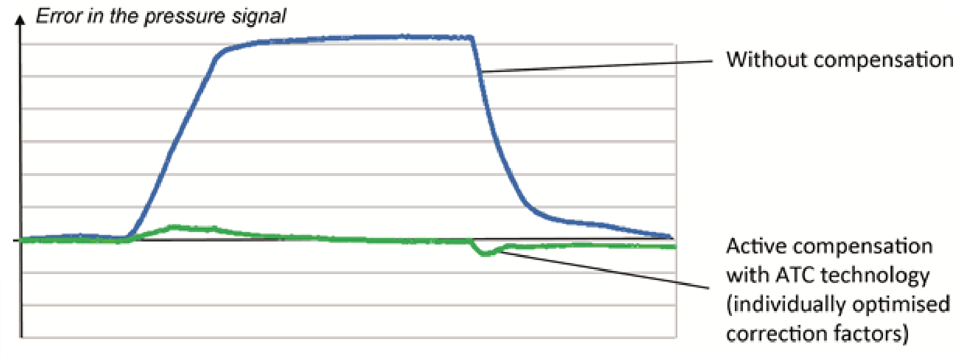

Fig. 5 Test measurement, comparison uncompensated with ATC compensation

Summary

LABOM has made a quantum leap in the temperature stability of diaphragm seal systems with the ATC technology. High-precision pressure measurements can thus be carried out together with the high accuracy of the pressure measuring device.

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