THE CERAMIC PRODUCT FOR PRESSURE MEASUREMENT

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***Abstract*:** The significant advances in materials science in recent decades have not only brought us silicon wafers, PTFE coating and heat shields for the space shuttle, but have also perfected the industrial ceramic.

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1. INTRODUCTION

The hard - wearing properties of the ceramic are key to both its everyday and instrumental application. Industrial ceramics also have excellent thermal properties, are light and strong, easily molded and have extremely good dimensional stability. All such properties help ensure long-term stability.

Their chemical properties are also excellent: technical ceramics are practically immune to chemical attack. They can be used in aggressive gases and liquids, or in searing heat, for much longer than other materials. So it is surprise that they are also to be found in pressure transmitters operating in the toughest environments, such as those found in a pulp and paper plant.

2. CERAMIC SENSORS

Pressure transmitters using ceramics sensors were introduced to the market by Endress - Hauser about ten years ago. After initial maker skepticism, most vendors now include ceramic sensors is 96-100 per cent pure alumina (Al_2O_3) (see figure 1).

The 96 per cent alumina is a polycrystalline, isotropic material with a surface roughness of less than 0.6 mm. In comparison, metal diaphragms have on average a surface roughness of 0.6 – 0.8 mm. Silica (SiO_2) makes up the remaining 4 per cent of material.

The 100 per cent ceramic is a pure, single crystal sapphire with anisotropic structure. Both are resistant to chemicals such as concentrated acids and alkalis, as well as to thermal shock, mechanical overload and vacuum.

Since a ceramic's cohesive energy is roughly ten times greater than that for a metal, its behaviors differs under overload conditions. Whereas a metal will suffer plastic deformation, leading to a shift in zero, the ceramic still operates in its elastic range.

The greater strength of the ceramic also means that the threshold for the onset of deformation in metals is lower than the fracture strength of the ceramic. Under similar overload conditions, therefore, the ceramic performs better.

3. SENSOR CONSTRUCTION

The pressure sensor comprises a body, diaphragm, electrodes and active soldering ring that bond the body and diaphragm together (see Figure 2). At atmospheric pressure the body and diaphragm are about 0.002″ apart.

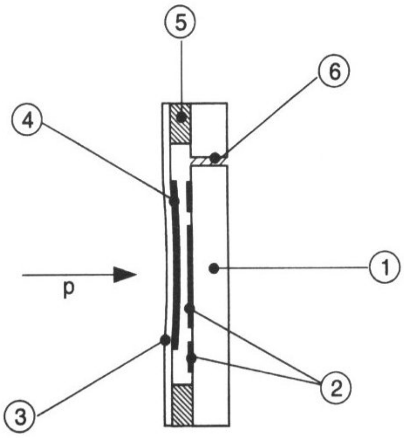

Figure 1. Ceramic pressure sensor:
1 - Ceramic body; 2 – Tantalum electrodes; 3 – Ceramic diaphragm; 4 – Common tantalum electrode; 5 – Bonded spacer; 6 – Capillary for Gauge pressure sensor

Two annular tantalum electrodes are spluttered on the 0.2″ thick bodies. A third tantalum electrode is spluttered on the inner face of the diaphragm.

When the pressure increases, the diaphragm is deflected towards the body, causing a change in the capacitance measured between the inner body and diaphragm electrodes.

Since the outer body electrode is located very close to the joint between the body and diaphragm, where there is practically no movement in the diaphragm, it outputs a constant capacitance signal which is used as reference

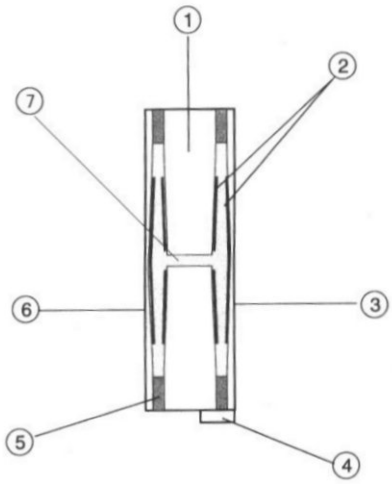

Figure 2. Ceramic dp sensor:
1 - Ceramic body; 2 - Tantalum electrodes; 3,6 – Ceramic Diaphragm; 4 – Temperature sensor; 5 – Bonded spacer;

7 – Capillary connecting two halves of sensor.

The electronic signal is a function of $\frac{C_p - C_r}{C_p}$

where:
C_p is the capacitance measured at the inner electrode;
C_r is the capacitance measured at the outer electrode;

The absolute pressure sensor is made by evacuating the space between the body and diaphragm to $1x10^{-8}$″. The sensor is completely dry, thus eliminating any undesirable degassing effects from fill fluids when measuring in the vacuum range. For the gauge pressure version, a small hole the transmitter electronics housing. If the diaphragm is overloaded it simply sets back on the sensor body, avoiding any mechanical damage.

Figure 2 shows the construction of the pressure sensor. Here there are two sets of capacitance electrodes. The two sides of the transmitter are connected together by a capillary in the body. An oil fill fluid transfers the pressure from one side to another.
The electronic signal is a function of: $\frac{1}{C1} - \frac{1}{C2}$ where C1 and C2 are the capacitance measured at each side of the sensor.

Since the two sides are connected, it is possible to build a self-monitoring cell. As the temperature increases, the volume of the fill fluid increases and the capacitance of the sensor changes as a function of $\frac{1}{C1} - \frac{1}{C2}$.

As the expansion coefficient of the fill fluid is known, this gives an indirect measurement of temperature. By comparing this temperature an independent measurement of the sensor temperature, it is possible to detect whether the sensor is operating correctly.

For pressure and dp sensor, the effects of temperature, humidity and density fluctuations in the surrounding atmosphere are compensated electronically.

4. CERABAR AND DELTABAR TRANSMITTERS

In the Cerabar / Deltabar S family, sensor, housings, electronics, displays and process connections can be interchanged, as long as it is not used in a hazardous area. Here the requirement for 100 % testing and correct identification is a restriction, but large companies with the appropriate authorizations and facility may exchange ex-devices too. By stoking only the electronics and sensor, most of the failures occurring in practice can be quickly dealt with.

Two housings are available: one with a top reading display and one with a separate connection compartment and side reading display. The optimum angle for reading can be set after the transmitter has been wired up.

Electronics with 4-20 mA/ HART and PROFIBUS-PA outputs allow continuous measurement. A limit switch version offers electronics for all standard output signal. The transmitters can be calibrated either at the test bench or via the display or communication interface.

The transmitters can be supplied with all standard process connections.

5. APPLICATIONS

A Canadian cardboard plant produces about 110 000 tones of liner board annually, much from recycled paper and cardboard, which reaches the pulper baled and bound with metal wire.

During the pulping process the metal wire, rocks and other debris are removed. A pneumatic dp transmitter feeding to a P to I converter was used measure the level in the pulper. Both the transmitter and converter needed regular maintenance and calibration, and the metal diaphragm of a standard electronic transmitter was damaged by the debris and wire.
Therefore, the company installed a flush-mounted Deltabar transmitter with ceramic pressure sensor, which has significantly reduced maintenance time and cost. In operation for over two years, it has only needed minor corrections.

New applications have since been found for the deltabar in the pulp reservoir, head box level, white water level and chemical product level using the same transmitter.

Optimum process control relies on accurate measurement of its variables. In pulp and paper manufacturing, the majority of flow and level measurements are made by differential pressure transmitters.

The tough plant conditions, however, take their toll on the transmitters and many last only a few weeks. By using ceramic sensors, the lifetime of such critical measuring point can be greatly increased, with the additional benefit of greater accuracy and saving in cost.

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