pressure (also know as the overload pressure) is restricted to 1.2x the rated pressure. Today, this technology has limited use above 1,500PSI due to the availability of low cost strain gauge technologies with much better performance and longevity.

In cyclic environments, the proof pressure rating must be reduced to the same as the operating pressure range to avoid failure of the O-ring seal. Since this design does not incorporate a hermetic seal, these sensors are not suitable for operation in ammonia, hydrogen, oil and gas production, hydraulics, oxygen service and many other critical mild to harsh applications. The O-ring can be specified in a range of materials to deter against specific media attack that can cause system failure in certain abusive environments.

Metal foil strain gauges tend to be large so are normally put on to a beam or a diaphragm prior to welding to a pressure port; and although thin film sensors are smaller, they also need to be welded to a pressure port. In both cases, the welds need to be deep enough so that they do not fail under normal and overload conditions specially operating above 2,500PSI (170Bar). Under high cyclic and pressure conditions, where the pressure pulsations can vary by 50% of the pressure sensor range, the sensor package design must incorporate a mechanism to make sure that the weld is under compression to avoid sensor failure.

Figure 5 shows a thin film piezoresistive sensing element welded to a pressure port. Since both metal foil and thin film technologies have low outputs at high operating strains (typically 1,000 microstrain), the diaphragm material must be carefully selected so there is enough room for over pressure without sacrificing shift in sensor performance. Common diaphragm materials used in metal foil and thin film sensors tend to be 15-5PH, 17-4PH and 17-7PH high strength stainless steels with yield strengths up to 190,000PSI and low thermal coefficient of expansion. The pressure ports must be of the same material as the diaphragm to avoid any separation of the welds under thermal conditions.

Sensors employing semiconductor strain gauge technology can be broken into two categories – oil filled sensors employing a thin isolation diaphragm and ion implantation technology, and the emerging diffusion bonded bulk silicon Krystal Bond Technology. Oil filled piezoresistive sensors mainly employ a small silicon chip with ion implanted strain gauges, isolated by means of a thin metallic membrane (typical thicknesses between 0.001 and 0.0015" depending upon the pressure range). This design is not suitable for high cyclic environments as the thin

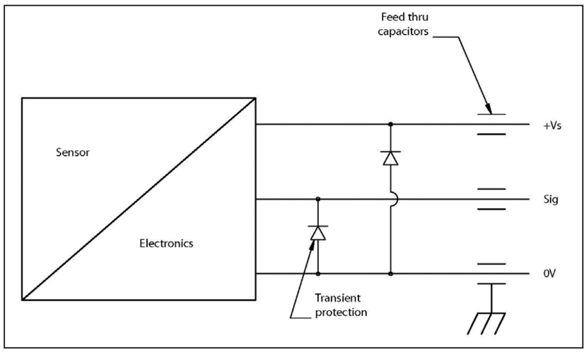

Figure 5

welded diaphragm will fatigue and lead to sensor failure. With pressure and temperature increases, the silicone oil will become compressible, leading to a shift in the sensor calibration and eventual failure due to deformation of diaphragm.

With bulk semiconductor strain gauge technology, the gauges are directly mounted onto a machined sensing element, where the diaphragm and pressure port are machined in the same process, eliminating the problems associated with welds, oil filled cavities and internal O-rings. The use of a direct inorganic diffusion process allows semiconductor gauges to be placed precisely on a metallic diaphragm, efficiently and accurately on the side of the diaphragm that is not exposed to the media. The hermetic design is suitable for high cyclic environments associated with hydraulic pumps and motors. The high Gauge Factor, along with low operating strain, allows the diaphragm to be thick, offering excellent proof and burst pressures.

Transient protection

Hydraulic systems tend to generate rapid, high frequency pressure spikes and transients that may last from a few microseconds to hundreds of milliseconds. Rapid opening and closing of valves and solenoids generate these transients. The amplitude of these fast moving transients can be up to 20 times the rated pressure of a system and will destroy electronic pressure sensors unless they are protected using snubbers and restrictors. These protection devices can be installed as an integral part of the sensor or as a stand-alone device.

While protecting the sensor from damaging fast moving transients, the devices can (depending on the design) dampen the response time of the sensor. For system optimisation such as response time and snubbing, the length, (L) and diameter (D) must be carefully selected. In an ideal condition, the snubber must be able to snub all signals that are between 100 and 150% of applied pressure to maintain fast through-put, but remains dependent upon the type of sensing technology and packaging.

EMI/RFI protection

In mobile hydraulic applications, electrical pollution in the form of fast electrical transients, Electro Static Discharge (ESD) and Electro Magnetic Interference/Radio Frequency Interference (EMI/RFI) must be contained for system stability.

Examples of this interference include communications equipment, switching power supplies, welding equipment, and electric motors. The sensor package must not generate or be influenced by unwanted external electrical signals from 100kHz to 2GHz. It must also be able to withstand radiated and conducted susceptibility and operated within its published specs in critical applications such as mobile cranes, scissor jacks, forklifts and many others.

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The tide is turning towards energy generation

As a manufacturer of hydrokinetic turbines designed to generate energy from the motion of the sea, Tidal Energy (TEL) decided to test its prototypes under real world conditions in the open sea. It found, however, that to calculate the power produced, it would need to measure the rotational speed of the turbine shaft – a straightforward process – but also the torque being transmitted by it, which was more of a challenge.

The RWT410/420 series of TorqSense rotary torque sensors from Sensor Technology, which use a sensing technology that depends on surface acoustic wave (SAW) transducers, met the demands of the application. Available in three body sizes and six shaft sizes, these cover torque measurements from 1Nm to 13,000Nm and, as they operate at radio frequencies, it is easy to couple signals to them wirelessly. As a result, TorqSense sensors with SAW transducer technology can be used on rotating shafts, and can provide data continuously without the need for brushes and slip rings.

In addition to accurately measuring shaft torque, the sensors, which have a robust sealed construction, also measure rotational speed and, by combining these two measured values internally, they can produce an output that directly indicates shaft power.

In the TEL application, the RWT410/420 sensor is used in conjunction with Sensor Technology's TorqView software package. This runs on a laptop PC that is taken on board the boat when the scale-model hydrokinetic turbines are being tested, and provides a direct real-time readout of the power produced by the turbine. The software also logs data from the sensor so that this can be analysed further after the test has been completed.

According to David Baird of TEL, the sensor has provide invaluable. He said: "It's easy to use, it's reliable, and it consistently delivers accurate results that are playing a key role in helping us to refine the design of our hydrokinetic turbines."

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