Control and record

Modern machine design makes great use of sensors to control and record performance. Bob Dobson offers a quick refresher on the basics, concentrating on the most popular.

Most sensors are now available with communications ability, so that they can be connected to a control network and work in concert with the many other parts of a machine and its control system. The control network's central computer can be set up to record a sensor's reading at intervals to provide the basic data from which sophisticated operational and production analyses can be developed.

The main functions of sensors are to measure physical states – pressure, temperature,and so forth – movements of either parts of their host machine, or throughput of objects. A profusion of sensors is available to meet the many different requirements of engineers.

Photo-electric

Many different types of sensor are classified as photo-electric, with subtle distinctions between how they work and where they are used. Essentially they are presence detectors, able to say whether something is in position or not. As such they are typically used for counting objects as they pass along a conveyor belt, to measure production rates, or to detect the entry of a work piece into a particular zone of a machine and thus initiate a sequence of actions to be performed on the workpiece.

Their principle of operation is that an emitter transmits a constant light signal or beam and this is detected by a receiver. An object passing through the beam path blocks the signal from being received, so causing the sensor to switch and either change state or count interruptions. In subtle variations, photoelectric switches can be tuned to specific colour – light frequencies – to 'see' transparent or semi-transparent objects, or to have time delays, suiting them to many different tasks.

Photo-electric switches can be physically configured in different ways. For instance emitter and receiver can be separate bodies, which must be individually mounted and aligned; or they can be side by side in the same housing, in which case a separate reflector plate has to be mounted opposite the sensor to bounce the signal from one back to the other.

Typically photo-electrics use a high frequency pulsating beam of light which is effectively a unique signature within its working environment. This virtually eliminates false readings caused by changes in ambient light. However, in applications where a really fast response is required it is necessary to use unmodulated light, which is slightly more susceptible to false readings.

Optical sensors have many advantages, making them particularly popular with machine builders. Generally, if installed properly and used correctly, they are robust and reliable and, as non-contact devices are not subject to wear or risk of damaging items to be sensed.

They can also have a very long detection range; many industrial photo-electrics can reliably detect at 25 metres or more, while variations used in security applications may have a range several multiples of this. Any material can be detected by a photoswitch – even those that are highly transparent, such as high quality glass, will absorb a proportion of the light signal.

Photo-electrics are ideal for high speed production environments because of their instantaneous response. They are also reliable and easy to install and maintain, with usually a quick wipe down of the lens the only maintenance required.

One of the drawbacks of photo-electrics is that selection of the right type for each application can seem a bit daunting. However, it is straightforward; they are classified by their physical structure, by the frequency of the light beam, by the sensing mode and by the output circuitry.

Proximity

Proximity sensors operate in a manner similar to photo-electric, in that they can detect the presence or approach of a target object without contact. They are better suited to some working conditions than photo-electric, typically being robust enough for harsh environment installation, although their signal resolution may in some circumstances be less precise.

The operating principle is that rather than a light beam they emit an electromagnetic field which is disturbed when approached by a metal object. The degree of disruption is measured electronically to give an indication of the object's distance from the sensor, although such sensors are often used in a simple present/absent mode rather than to determine actual location.

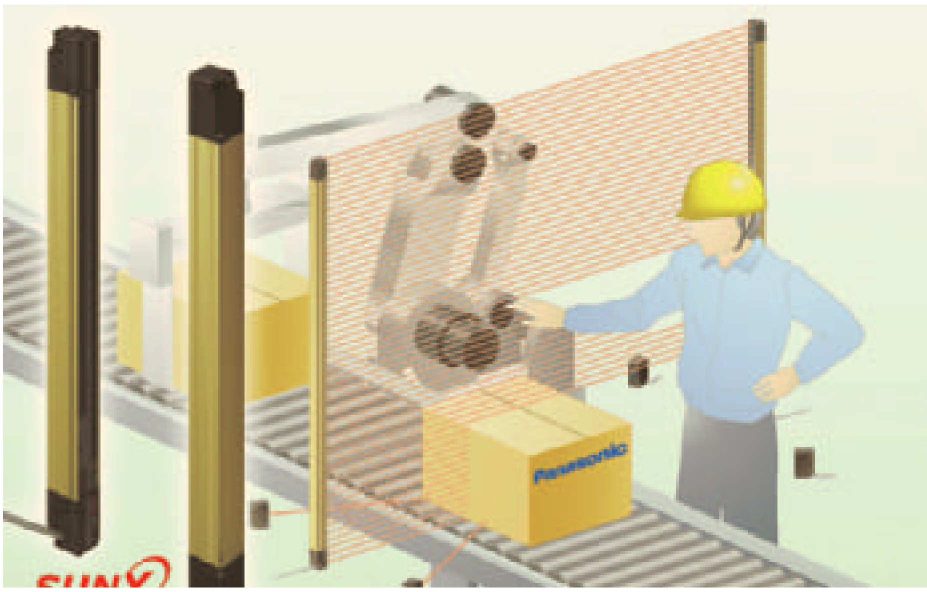
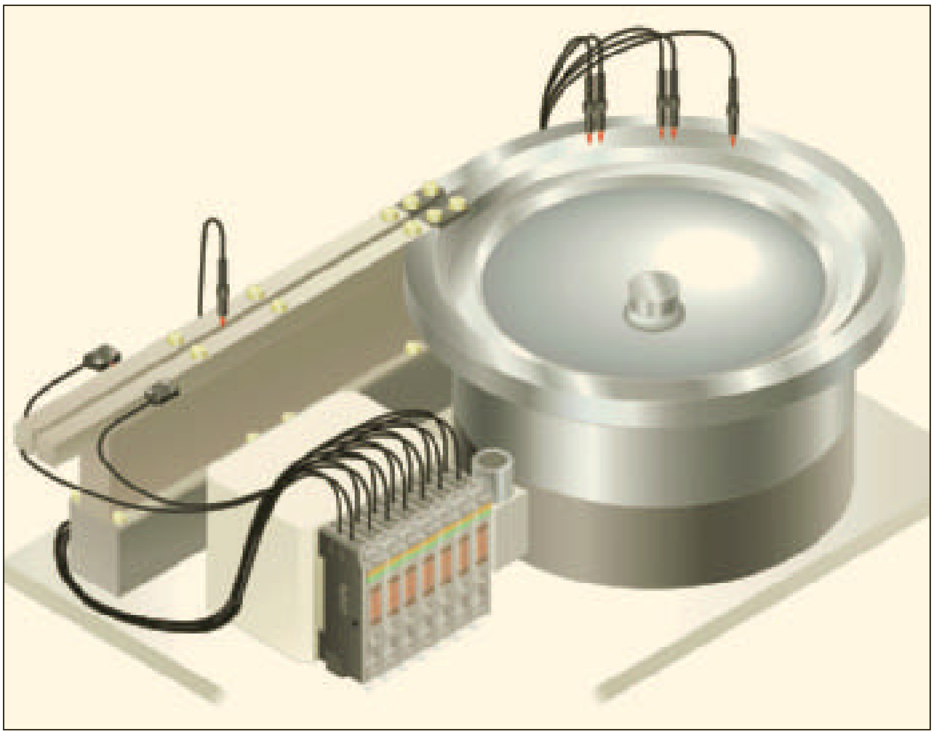


Photo-electric: *Muting function of Sunx SF4AH light curtains from Panasonic allow operator intervention into the process under controlled conditions*



Fibre optics: *A number of Panasonic FX302 sensors used to detect items at various stages in a bowl feeder*

Colour mark sensor: *Sunx LX100 from Panasonic detects colours or registration marks*

There are also versions that rely on magnetism or electrostatic discharge rather than electromagnetism.

Proximity sensors are often used in place of limit switches, which need physical contact with the object to operate, thus making them susceptible to wear and damage.

Typically they are used in severe working conditions and are constructed to IP67 or a similar standard so are resistant to water, oil, dust, dirt and other environmental problems. They generally prove to be precise, particularly when two or more fast moving targets are to be detected. Disadvantages include that they only work with metal objects and their detection range is very small.

Pressure sensors

Some machine control systems require the measurement of pressure of a liquid or gas. There are two common types of pressure sensors: mechanical, which rely on a diaphragm or other deflection type mechanism, and electronic, which use a diffused semiconductor transducer. Not surprisingly, mechanical is generally giving way to electronic.

Generally the pressure sensor selected has to be matched to the fluid with which it is to operate and one should check whether they are measuring gauge (absolute) or differential pressure.

Additionally pressure can be measured using a strain gauge principle similar to a load cell, as described below

Linear displacement

A linear voltage displacement transducer (LVDT) comprises three coils, a primary and two secondaries, and a slidable magnetic core. Current is transferred from the primary coil to the secondaries via the core. When the core is in its central position the secondaries receive equal current, giving a zero differential and therefore zero readout. But moving the core in one direction or the other will favour a particular coil and the growing differential is proportional to linear displacement.

The phase of the output (compared with the excitation phase) enables the electronics to know in which half of the coil the armature lies and therefore whether it is a displacement to the left or right.

The strength of the LVDT sensor's principle is that there is no electrical contact across the transducer position sensing element which for the user of the sensor means clean data, infinite resolution and a very long life.

Magnetostrictive

A magnetostrictive transducer comprises a sensor element, a signal converter and a position magnet. The signal converter applies an electrical pulse to the sensor element and simultaneously starts a timer.

The magnetic field generated around the sensing element by the electrical pulse interacts with the field of the position magnet and produces a mechanical pulse.

The mechanical pulse travels back down the sensing element where a sensor in the signal converter detects it and stops the timer.

As the speed of the mechanical pulse is constant, the time taken for the pulse to reach the sensor can be used to measure the position of the magnet accurately. Typically the mechanical pulse travels at a speed of 2800 metres/sec and the cycle process is repeated 1000 times a second.

Load cells

Load cells are based on strain gauges and comprise a long length of conductor arranged in a zigzag pattern or comb on a membrane. When subjected to load the conductor is stretched and its electrical resistance increases. Strain gauges are mounted in the same direction as the strain and often in fours to form a full 'Wheatstone Bridge'.

Torque

Strain gauges can also be used to measure the torque in a rotating shaft. Most torque sensors need slip rings to connect the sensing head attached to the rotating shaft to the static control electronics, but non-contact versions are also available.

They use Wheatstone Bridges as described above, so small that they use piezo levels of power, glued to the shaft. Rotation of the shaft causes the combs of the gauges to deform and thus change electroresitivity.

Because the power levels are so small they can be both measured and powered via a radio frequency link rather than hard wiring through slip rings.

This non-contact technology has been pioneered in the UK and has reached a level of mature development such that it is now finding users around the world. ■

For further information on PPMA members able to supply sensing devices consult the PPMA machinery finder service, tel: 020 8773 8111, or visit www.ppma.co.uk