Keep in touch with non-contact sensing

Choosing non-contact displacement sensors can be confusing. Chris Jones, managing director of Micro-Epsilon (UK), outlines the key characteristics of four leading technologies and offers advice on selecting the most appropriate for an application.

The use of non-contact displacement technologies for precision measurements is growing rapidly. Two of the main drivers are that users need to make measurements with increasing accuracy – to sub-micron or even nanometer resolutions – and they need to be able to measure against difficult surfaces or surfaces that cannot be touched during the measurement process – such as silicon, glass, plastics, electronic and medical components, and even food-based surfaces.

This rapid growth has pushed the development of new technologies, and also the adaptation of existing technologies to meet the new measurement requirements and to improve accuracies and resolutions. It is more important than ever to understand the strengths and limitations of each non-contact measurement principle when selecting a sensor technology for a particular measurement task.

Non-contact displacement sensors come in a wide variety of shapes, sizes and measurement principles. The key is selecting the most appropriate sensing technology for the application.

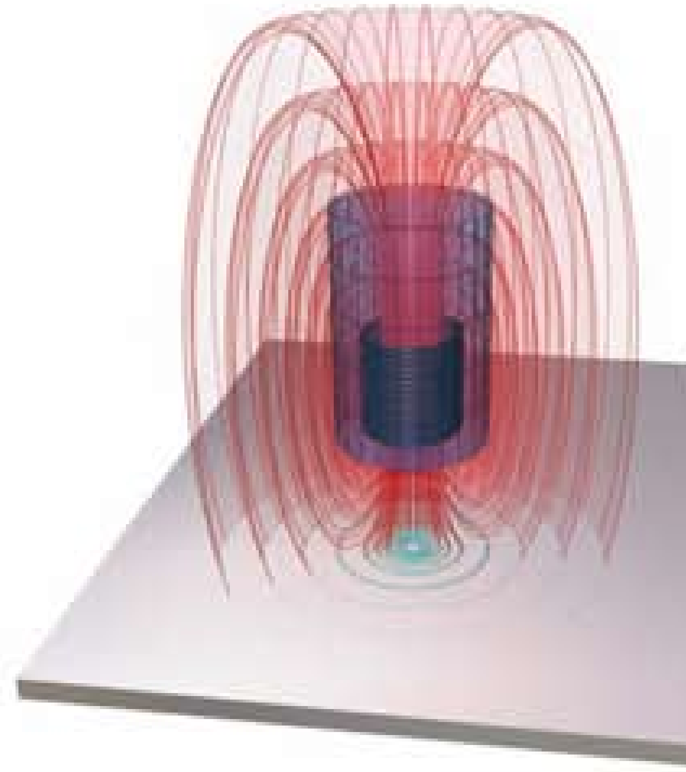
> Eddy current sensors

Eddy current measurement is an inductive method based on the extraction of energy from an oscillating circuit. This energy is required to induce eddy currents in electrically conductive materials.

A coil is supplied with an alternating current, causing a magnetic field to form around the coil. If an electrically conducting object is placed in this field, eddy currents are induced, forming an electromagnetic field in accordance with Faraday's Induction Law. This field acts against the field of the coil, causing a change in the impedance of the coil. A controller calculates the impedance by evaluating the change in amplitude and phase position of the sensor coil.

Eddy current sensing can be used for all electrically conductive, ferromagnetic and non-ferromagnetic metals. The sensors are relatively small compared to other technologies and their operating temperature range is wide. The high-accuracy technology is immune from the effects of dirt, dust, humidity, oil, high pressures and dielectric materials in the measuring gap.

But eddy current sensors also have limitations. Their output and linearity depend on the electric and magnetic features of the target material. Individual linearisation and calibration is therefore necessary. The maximum cable length is 15m and the diameter of the sensor (and thus the effective measuring diameter) increases as the measuring range increases.



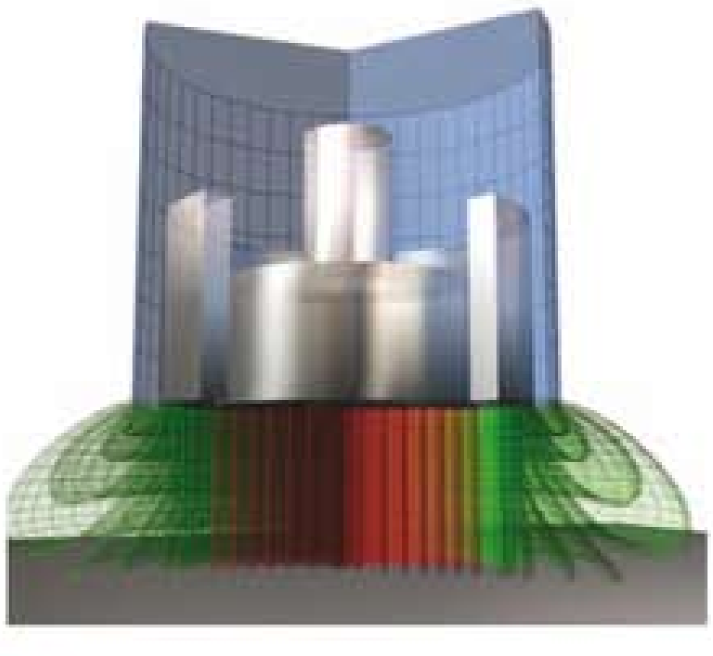
Eddy current sensors are suitable for metallic targets

> Capacitive sensors

In capacitive sensors, the sensor and target operate like the electrodes in a parallel-plate capacitor. If an AC current with constant frequency flows through the sensor capacitor, the amplitude of the AC voltage on the sensor is proportional to the distance between the capacitor electrodes. An adjustable compensating voltage is generated simultaneously in the amplifier. After both AC voltages have been demodulated, the difference is amplified and output as an analogue signal.

Because these sensors are constructed like guard ring capacitors, they achieve almost ideal linearity and sensitivity to metals. The technology also offers high temperature stability, because changes in the conductivity of the target have no effect on the measurement. Capacitive sensors can also measure insulators.

However, the technology is sensitive to changes in the dielectric sensor gap and so is therefore best suited to clean, dry applications. Cable lengths are also relatively short because of the effect of the cable capacitance on the oscillating circuit tuning.



Capacitive sensors achieve almost ideal linearity

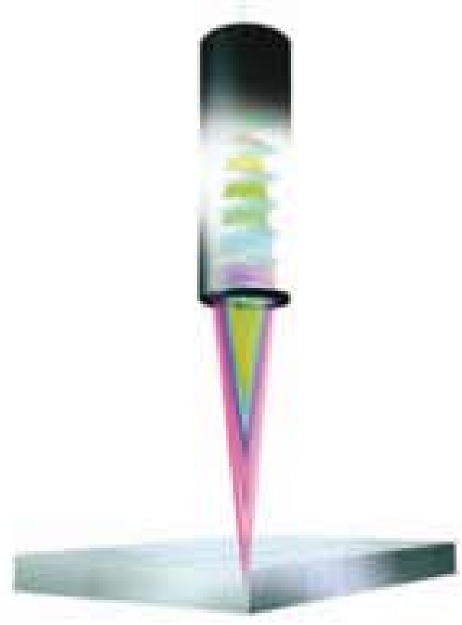
> Laser triangulation

In laser triangulation sensors, a laser diode projects a visible point of light onto the surface of the object being measured. The back-scattered light reflected from this point is projected onto a CCD light-sensing array by a high-quality optical lens system.

If the target changes position with respect to the sensor, the movement of the reflected light is projected onto the CCD array and this is analysed to determine the exact position of the target. The measurements are processed digitally by an integrated controller and then converted into a scaled output via analogue or digital interfaces.

> The confocal principle

Confocal sensors work by focussing >>>



Confocal sensors offer nanometre resolution

>>> polychromatic white light onto a target surface using a multi-lens optical system. The lenses are arranged so that the white light is dispersed into a monochromatic light by controlled chromatic deviation. A certain deviation is assigned to each wavelength by factory calibration. Only the wavelength that is focussed exactly on the target surface or material is used for the measurement.

The light reflected from the target surface passes via a confocal aperture to a receiver, which detects and processes the spectral changes. The technology can measure displacements and distances extremely precisely.

Both diffuse and spectral surfaces can be measured using the confocal principle. With transparent materials such as glass, a one-sided thickness measurement can be accomplished along with the distance measurement. Because the emitter and receiver are arranged in one axis, shadowing is avoided.

Confocal technology offers nanometre resolution and is almost independent of the target material. A very small, constant spot is achieved and the technology offers one-sided thickness measurement of transparent materials. Miniature radial and axial versions of the technology are available for measuring drilled or bored holes. White light is used instead of a laser.

Restrictions of the confocal technology include the limited distance between the sensor and target. In addition, the beam requires a clean environment.

As a specialist in non-contact measurement, Micro-Epsilon offers users a choice between eddy current, capacitive, confocal and laser triangulation technologies. D&C

At its site in Ashford, Kent, Premier Foods produces a variety of ready-meals and soups including the Batchelors, Pasta'n'sauce, Oxo and Vesta brands.

The site includes many feed hoppers to supply the machines that fill the products into sachets and other containers at speeds of up to 600 containers per minute. The hoppers incorporate a variety of agitators and vibrators to assist the flow of the powders.

One machine, in particular, packages 160 sachets of Batchelors Cup a Soup every minute to help cater for the UK's consumption of more than 250 million mugs of Cup a Soup every year.

The machine has to handle a variety of flavours and consistencies of the powder product. There are variations in moisture levels, particle sizes, and stickiness (because some of the ingredients contain small amounts of natural oils).

To ensure that flow and mixing occur evenly as the sachets are filled, the hoppers incorporate a small rotating agitator and use probes to sense the level of the product. Premier Foods experienced reliability problems with the level switches it was using on these hoppers, especially when products were changed.

The company has now fitted vibrating fork sensors with remote electronics housings and quick release, hygienic fittings that allow the sensors to be removed and cleaned easily and quickly between product changes. The sensors are robust enough to work reliably even next to the agitators inside the hoppers. Because they can mount from any orientation, they also have an advantage over proximity-based detectors, which need polymer windows in the vessel. If these windows crack or chip, the tiny shards of plastic are almost impossible to detect.

The new level switches, supplied by Vega, combine mechanical detection – using the damping of a vibrating element – with the reliability of solid-state electronics. The vibration frequency is monitored to detect any damage, product build-up or device failure. The vibration technology is claimed to be easy to set up compared to capacitive techniques, and to be more reliable than rotating paddle devices.

In a typical application for colour sensors, two sensors work together to check bottle labels against cap colours, thus verifying that the right product is in the bottle.

How colour sensors can help to raise product quality

Unlike vision sensors – which are designed to detect patterns, to verify contours, or to locate edges – full-colour photoelectric sensors are aimed at a specific spot on the target to verify that the right product or the desired attribute is present. They can therefore operate at update rates of as short as 1ms – much faster than the typical 20ms update time required by vision sensors.

Full-colour sensors can help to ensure that the right steps happen in a production process – also known as "error proofing." Not only can they match colours and reflectivity values precisely, but they can also identify and exclude, or include, colour matches on dissimilar as well as similar surfaces. Their ability to identify reflectivity also allows them to be used to identify invisible markers on products, making them ideal for error proofing on packing lines.

Most full-colour sensors contain a white light emitter and three separate receivers – one each for red, green and blue light. The white light is reflected off of the target and returns to the sensor. The three receivers are tuned to look for specific wavelengths of light and to record the components of the reflected light and their intensity. The sensor then compares these values with user–specified settings to determine the necessary action.

Programmable tolerance settings in the sensor make it possible to control closely the match of the target to the programmed value. This capability is important when sorting or matching objects with similar colours. The more precise the required match, the tighter the colour tolerance level is set.

Full-colour sensors are suitable for a wide variety of applications. For example, packers use them to sort products and to verify contents on high-speed lines. Companies assembling products with multiple coloured pieces use the sensors to ensure quality.

In one particular application, an automotive carpet manufacturer is using colour sensors to match carpets to vinyl heel pads. The colour variations between these two dissimilar surfaces may be indistinguishable to the naked eye. Using colour sensors to perform these checks ensures quality and can save the OEM costly rejection of an entire lot of carpets by the car manufacturer as a result of colour production errors.

This article was supplied by Balluff.