Chris Jones compares the technical pros and cons of four types of non-contact displacement measurement technologies. Selecting the most appropriate technology for the application is what matters

Non-contact displacement sensors: a review

The use of non-contact displacement technologies in the field of precision measurement is rapidly growing. This is due to many factors, but the two main drivers are that customers need to measure much more accurately - to sub micron or even nanometer resolutions - and they need to measure against difficult surfaces or surfaces that cannot be touched during the measurement process. Examples include silicon, glass, plastics, miniature electronic components, medical components and even food-based surfaces.

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

In practice, besides eddy current and laser triangulation sensors, capacitive and confocal sensors are proving popular with customers. But 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 in hand.

A specialist in non-contact measurement, Micro-Epsilon offers a variety of precision sensor technologies, including eddy current, capacitive, confocal and laser triangulation. One of its services is to help customers choose the correct technology for their applications, including hybrid technologies if this is appropriate.

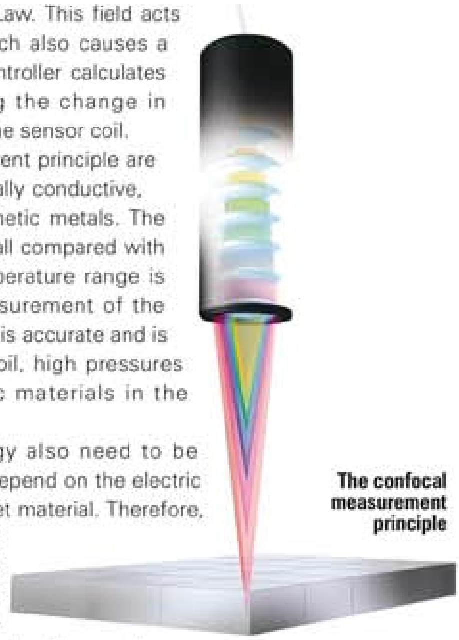
The eddy current principle

The eddy current measurement principle is an inductive measuring method based on the extraction of energy from an oscillating circuit. This energy is required for the induction of eddy currents in electrically conductive materials.

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

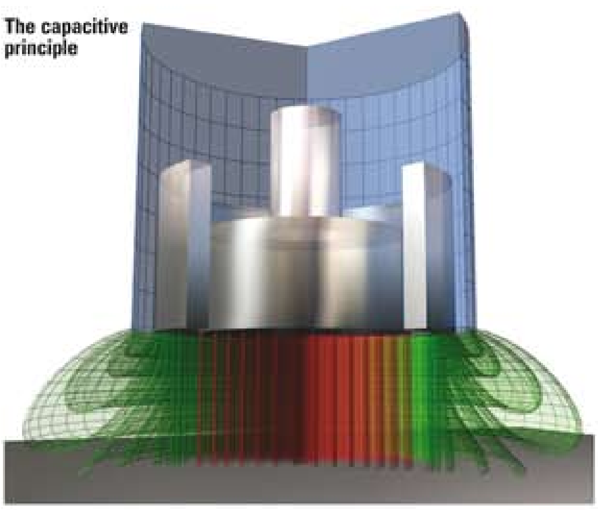
The advantages of the eddy current principle are that it can be used on all electrically conductive, ferromagnetic and non-ferromagnetic metals. The size of the sensor is relatively small compared with other technologies and the temperature range is high due to the resistance measurement of the sensor and cable. The technology is accurate and is immune to dirt, dust, humidity, oil, high pressures and the presence of dielectric materials in the measuring gap.

Restrictions of the technology also need to be considered. Output and linearity depend on the electric and magnetic features of the target material. Therefore, individual linearisation and calibration is necessary. Cable length has a maximum of 15m and the diameter of the sensor (and therefore the effective measuring diameter) increases as the measuring range increases.



The confocal measurement principle

> "It is....more important than ever to have a greater level of understanding of the strengths and limitations of each non-contact measurement principle"



The capacitive principle

The capacitive principle

With the capacitive principle, sensor and target operate like an ideal parallel plate capacitor. The two plate electrodes are formed by the sensor and the opposing target. 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 simultaneously generated in the amplifier electronics. After demodulation of both ac voltages, the difference is amplified to provide an analogue output signal.

Because the sensor is constructed like a guard ring capacitor, almost ideal linearity and sensitivity to metals is achieved. The technology also offers high temperature stability, as changes in the conductivity of the target have no effect on the measurement. Capacitive sensors can also detect electrically insulating materials.

However, the technology is sensitive to changes in the dielectric sensor gap and so is therefore only really suitable for clean, dry applications. Cable length is also relatively short due to the effect of the cable capacitance on the oscillating circuit tuning.

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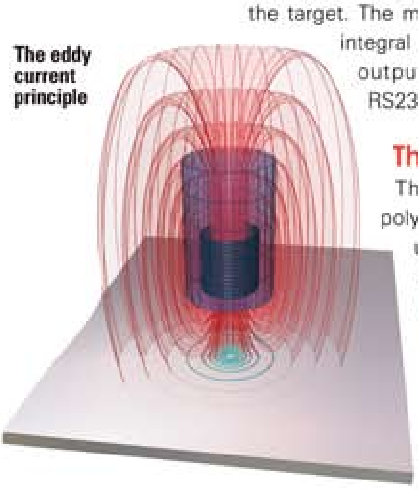
The laser triangulation principle

In the laser triangulation principle, a laser diode projects a visible point of light on the surface of the object being measured. The back scattered light reflected from this point is then projected onto a CCD 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 on the CCD array and analysed to output the exact position of the target. The measurements are processed digitally in the integral controller and then converted into a scaled output via analogue (I/U) and digital interface RS232, RS422 or USB.



The eddy current principle

The confocal principle

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

This light reflected from the target surface is then passed via a confocal aperture to the receiver, which detects and processes the spectral changes. This unique measuring principle enables displacements and distances to be measured very precisely.

The laser triangulation method

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

Confocal technology offers nanometre resolution and operates virtually independently 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, and white light is used instead of a laser.

Restrictions of the technology include the limited distance between the sensor and target and intolerance of dusty environments.

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