Intelligent Integration

As well as the miniaturisation and increasing functionality of non-contact displacement sensors based on electromagnetic measuring principles, smooth process integration is also a decisive factor in highly automated industrial production environments. Integrated sensors control the quality not only of the finished product but also the optimisation of production processes.

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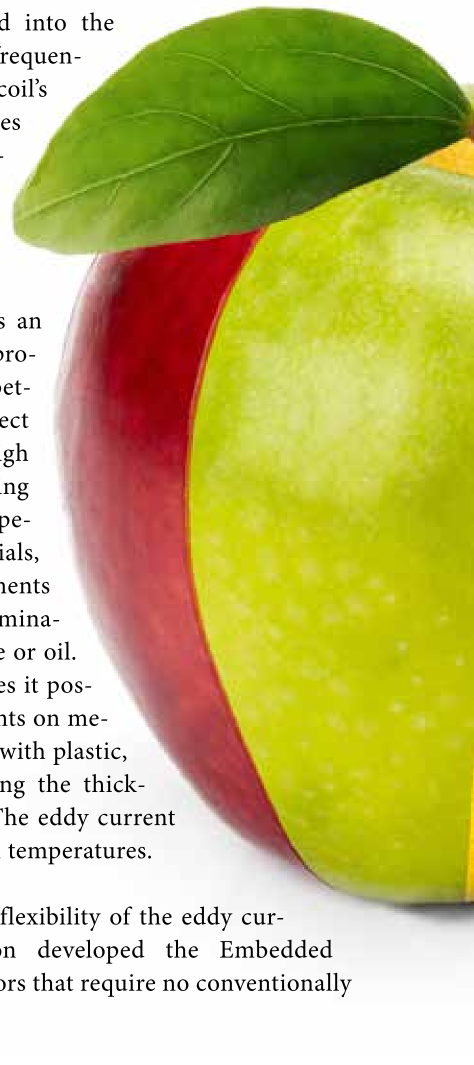
In addition to tactile (gauging) sensors, non-contact metrology is now also used to measure displacement, deformation, stretching, distances, position and other geometrical shapes and sizes. Depending on the measuring principle, non-contact sensors offer decisive advantages for increasingly fast, automated production and control processes. These sensors often measure faster, more accurately and reliably than tactile sensors. The measurement data is normally available in real time in order to automatically regulate and control the production. Quality control is not only carried out on finished products but metrology can also supervise and optimise production processes. The aim is to improve product quality, reduce rejects to a minimum and to lower total production costs.

But what does the user understand by the term "sensor integration"? On the one hand, it relates to physical integration. Can the sensor withstand dirty, oily environments surrounded by extreme temperature fluctuations and vibration? Can the size and shape of the sensor be adapted to the respective installation conditions? On the other hand, it refers to data integration: "Intelligent" sensors with integrated controller processing sensor data and transmitting them to a control system. Interfaces for real time data output such as Ethernet and EtherCAT contribute towards the optimisation of data integration into the process/data flow of the machine. In this article, we will take a closer look at a whole range of different sensors: from traditional electromagnetic sensors such as eddy current and capacitive systems, to optical laser sensors that are equipped with a measurement point or line. Based on industry examples, application differences will be highlighted.

Eddy Current Sensors

Industrial environments are often dirty, dusty, humid and oily. Machines may have to withstand large temperature fluctuations. In the existing environment, often there may be little installation space for the sensors. For measuring displacement, distance and position under such conditions, eddy current sensors are ideal, as they can be reduced in size and can be exposed to higher pressures. The eddy current principle finds applications in the measurement of electrically conductive materials that may have ferromagnetic or non-ferromagnetic characteristics.

A coil that is integrated into the sensor is charged with high frequency alternating current. The coil's electromagnetic field induces eddy currents in the conductive measurement object, causing the resulting alternating current resistance of the coil to change. This change of impedance causes an electrical signal, which is proportional to the distance between the measurement object and the sensor coil. The high frequency field lines emanating from the sensor coil easily penetrate non-metallic materials, which allows for measurements even at high levels of contamination (dust and dirt), pressure or oil. This characteristic also makes it possible to perform measurements on metallic objects that are coated with plastic, for example, when measuring the thickness of layers of substrate. The eddy current sensors are adaptable to high temperatures.



In order to improve the flexibility of the eddy current sensors, Micro-Epsilon developed the Embedded Coil Technology (ECT) sensors that require no conventionally wound coil at all. Instead, a two-dimensional coil is embedded in an inorganic material in such a way that this ensures stable geometrical shape and temperature. Entirely new geometries and sizes can be achieved using these sensors. The entire evaluation electronics is integrable into the sensor. Therefore, ECT sensors can be adapted to special installation conditions. ECT sensors are suitable for extremely harsh application conditions such as the alignment of mirror segments in telescopes, in ultra-high vacuums in semiconductor production or for measuring the milling gap of refiners in the paper industry.

Capacitive Sensors

In the capacitive measuring principle, sensor and measurement object form the plates of an ideal capacitor: If an alternating current flows through the sensor capacitor at a constant frequency and amplitude, then the amplitude of the alternating voltage on the sensor is proportional to the distance to the measurement object. A capacitive measuring system – as an electromagnetic process – measures all metals with stable sensitivity and linearity. Capacitive sensors can also measure insulating materials. However, the measurement gap needs to be kept free and clean as an additional dielectric in the gap is detected, distorting the measurement results. Achieving resolutions far below one nanometre, capacitive sensors are one of the most precise measurement systems in the market. They are applied wherever precise and stable results are required in order to measure vibration, deformation and thickness.

CDs are produced by injection moulding. The required compression mould is manufactured in several steps by galvanisation. In the first step, a so-called "father master" is made from the glass master by applying a thin nickel layer onto the silicium or glass master where it is subsequently separated from. In the case of higher volumes of copies, additional mother masters and stampers may be produced. In order to control the galvanisation bath, capacitive sensors inspect the thickness and profile of the matrices between the production steps. One sensor is positioned above and another below the die, which is moved between the sensors during measurements. The die thickness is calculated from the difference between the two distance measurement values. In order to determine the thickness profile, the die is rotated. The capacitive sensors measure the distance to the die at a measurement frequency of 2,000 Hz and to nanometre precision.

The Right Choice

With its high precision, measurement speed, compact size and fast data processing, non-contact measurement technology offers many benefits. The user can choose from different measurement systems. Each principle comes with its own particular advantages and limitations that all need to be carefully considered. Conventional sensors for standard applications may be chosen and ordered from a catalogue or via the Internet. However, demanding applications with higher resolution, robustness, temperature stability, linearity or special mounting and installation conditions often require special solutions and custom designs that are adapted to the customer's specifications. Qualified, experienced technical support, independent of the measurement principle, is necessary for an optimal solution. Intelligent Integration is an engineering task and can only be assessed on the basis of the measurement result. ☐

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