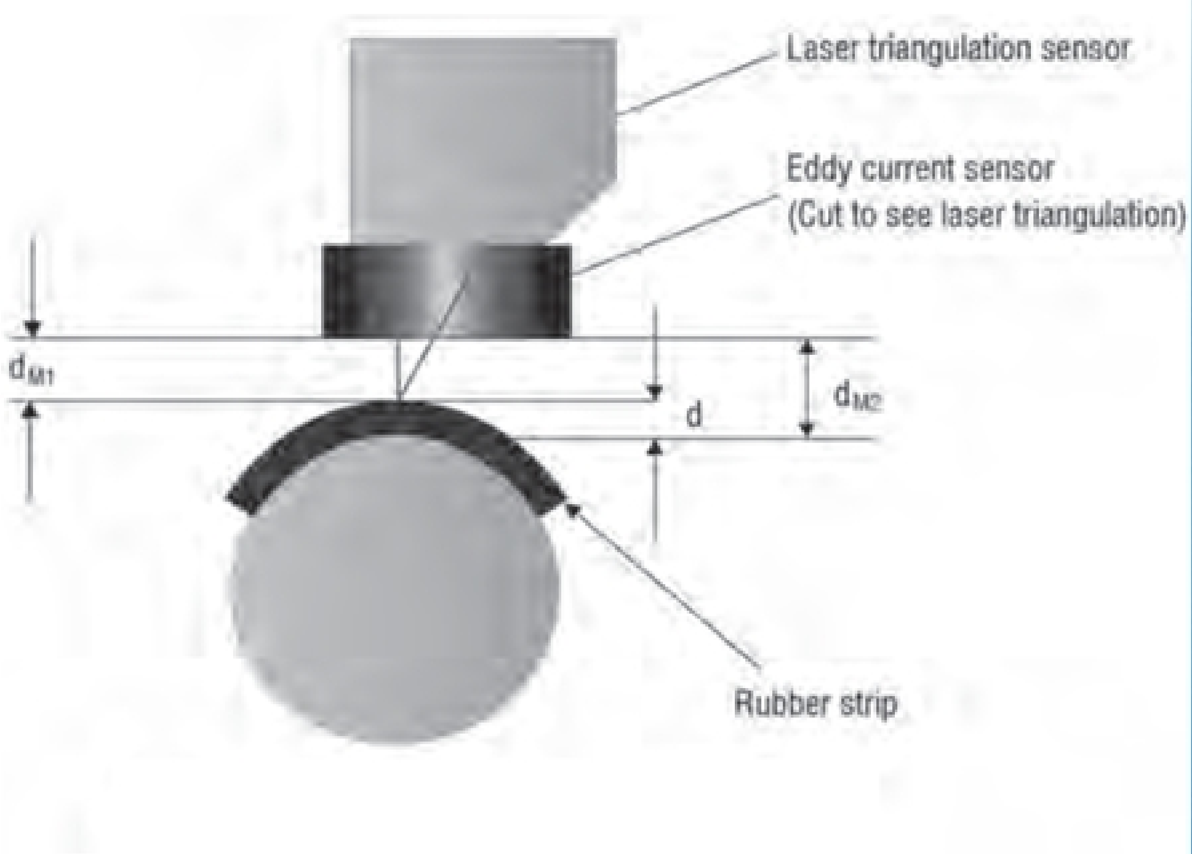
Combined sensors

The precision of optical profilometers can be improved using advanced combi-sensors, which can be arranged in three different configurations



Optical displacement sensors are commonly used for non-contact thickness measurement in extrusion or calender lines. There are two ways of arranging the sensors geometrically. Two sensors can be integrated opposite to one another in the profilometer, or a roller can be used as a counterpart. Mechanical components are used for the positioning of the displacement sensors, which is an important factor in the measurement process. Positioning precision can therefore be influenced by temperature gradients caused by the material or the environment. There are ways to overcome this challenge.

One method is to design the mechanical structures in such a way that they are nearly constant and their changes are much smaller than the required accuracy when they are affected by temperature influences. In most cases this is very expensive or fails. The more efficient way is to measure the impact using additional sensors and to compensate for influences based on mathematics. This combination of a measurement sensor and a sensor that detects the thermal effect on the mechanical base is called a combi-sensor. The following explains three different models of combi-sensors.

In the first, the laser triangulation sensor measures the top side of the rubber strip (d_{M1}). The eddy current sensor is not affected by the target and measures the surface of the roller, i.e. this sensor indirectly measures the lower side of the rubber strip (d_{M2}). The coordinate systems of the two sensors are synchronized in a calibration procedure, so that the thickness (d) of the strip results in $d = d_{M2} - d_{M1}$.

With this approach, neither the runout of the roller nor the geometric changes induced by temperature gradients affect the thickness measurement as the eddy current sensor detects these two parasitic effects. If only a laser sensor is used, and the runout is taught once before production starts, and afterward all temperature effects are ignored, changes to the geometry due to temperature can give incorrect information on the thickness measurements.

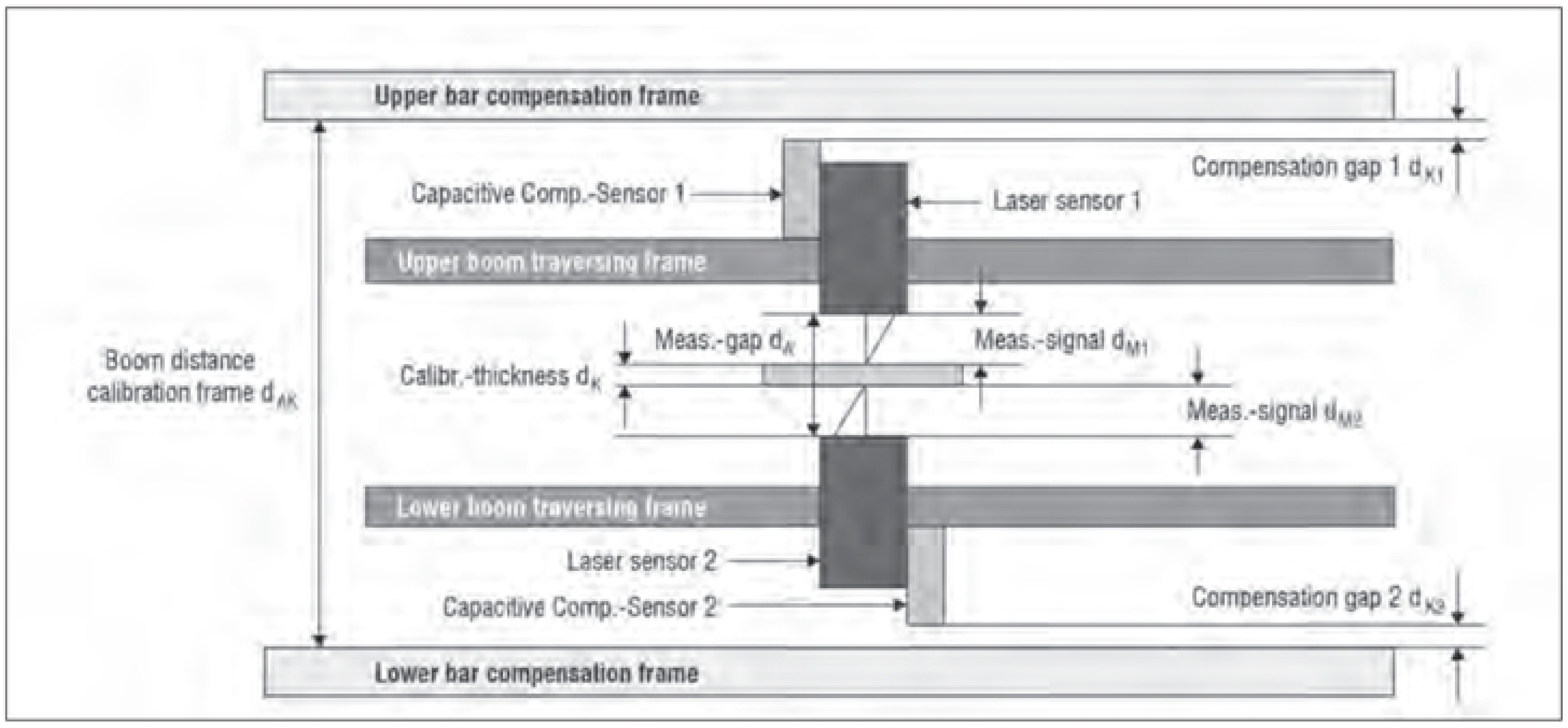
When using eddy current sensors to measure against curved objects, one has to consider that the position of the sensor in relationship to the roller influences the linearity. This is why the characteristic curve of the eddy current sensor is calibrated by software after the assembly process when the position of the sensor to the roller is fixed.

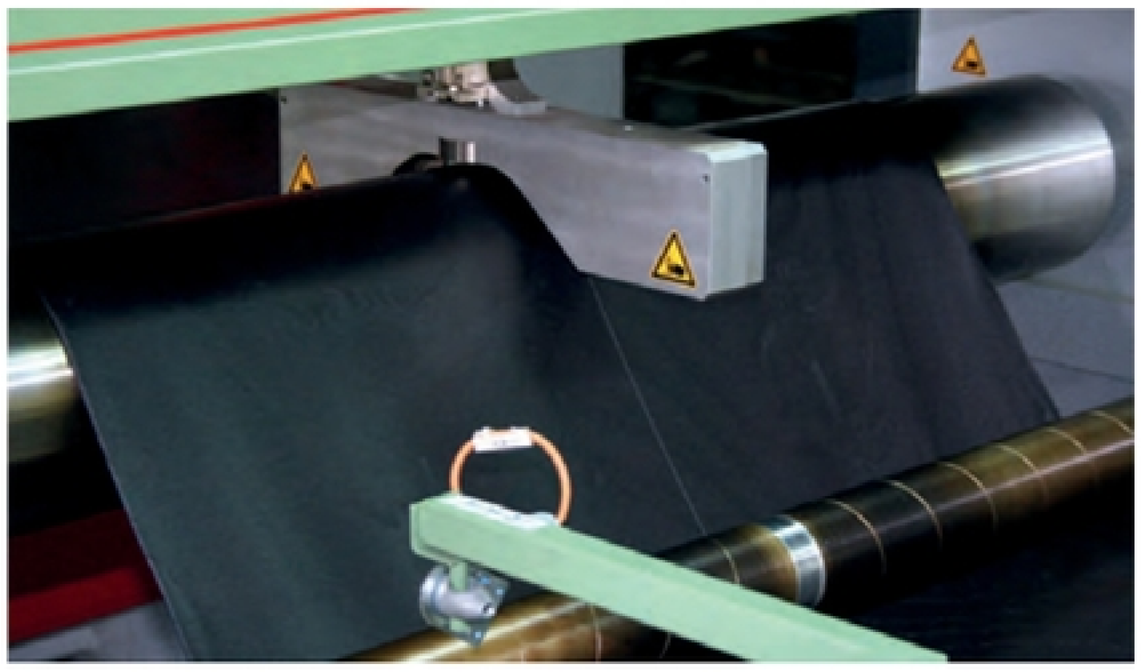
Above left: Diagram shows the basic principle of thickness measurement

Above: One possible combination is a thru-beam and an eddy current sensor

Below: Micro-Epsilon's patented principle of a compensation frame

Another principle, which also involves a roller, combines a thru-beam sensor and an eddy current sensor. The job of the eddy current sensor is the same as previously described. The thru-beam sensor detects, similar to the laser triangulation sensor, the upper edge of the material. The advantage of the thru-beam sensor is that it is independent of the surface conditions. This means that this type of sensor measures the surface of the rubber and that of the roller. This is necessary for the calibration of the assembling tolerances. This is a real





Above: Thickness measurement using the company's TCP 8301.EO system

challenge for the triangulation sensor as it is quite sensitive to the surface color. Furthermore, the degree of gloss is an issue that must not be ignored. This combination is much more robust and easy to use in industrial production.

Two laser triangulation sensors measure against the target material from top (d_{M1}) and bottom (d_{M2}). The distance (d_A) from the upper to the lower sensor, which gives the measuring range, is measured using a certified gauge block with the thickness (d_K) so that the range results as $d_A = d_K + d_{M1} + d_{M2}$ and the thickness (d) of the target is calculated by $d = d_A - (d_{M1} + d_{M2})$.

With the different impacts of the heat radiation on the upper and the lower bar of the frame caused by the hot rubber, the range (= d_A) changes. This can be seen in the calculated result of the thickness. In order to compensate for this effect, capacitive sensors are combined with laser sensors and an additional, temperature stable frame is integrated (left). If then the range changes, this is also recognized in the signal of the capacitive sensors. $d_A = d_{AK} - (d_{K1} + d_{K2}) - C$, with $C = d_{AK} - (d_{K1} + d_{K2} + d_A)$ from the calibration.

The advantage of this method compared with controlled cooling is that here the well-known result of the change is measured and compensated for. With the cooling, a change is not known as it is not monitored. **tire**

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