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Punctiform
Multi-track
Scanning
Traversing
with laser
with ultrasound

Thickness Measurement – with and without contacting

Tactile and non-contact thickness measurement

On almost all modern production lines, exact knowledge of the thickness of the produced material is an important parameter for:

- checking the required tolerance
- automatic control of the press or calender
- saving costs by producing at the bottom tolerance level

OPTI*mess* thickness measurement systems supply a sufficient number of measured values online depending on the production speed independently of structure, colour and temperature of the material to be measured.

Measuring methods

A basic distinction is made between a contacting and non-contacting thickness measurement. The choice of method to be used depends on different criteria:

- material composition (homogeneous or inhomogeneous)
- material structure (solid, ductile or e.g. sticky)
- material thickness to be measured
- required accuracy
- measuring spot size
- measuring speed

Tactile measurement systems operate mainly with measuring rollers or rails which are pressed onto the material at different forces and the thickness is then determined by the amount of their deflection. Non-contact systems usually use laser, ultrasound, capacitive, inductive or air-cushion sensors as well as radiometric sources of radiation as measuring transducers. Each of these measuring methods has specific advantages and disadvantages depending on the material to be measured which favour or restrict its application or make it impossible.

Measurement layouts for thickness measurement systems

Basically there are three arrangements depending on the method used.

1. One-sided thickness measurement against a reference

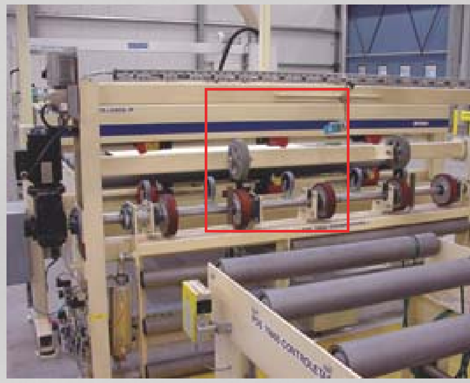
The respective sensor is arranged here above the material and measures against a reference which is below the material. This reference may be either a fixed plate or a roller over which the material is moved. The sensor is zeroed against the reference and then measures the fed material. The difference is the thickness. It is important that the material has contact with the reference throughout the measurement because otherwise an incorrect thickness will be measured due to an air gap or material deposited on the reference. The reference roller has therefore established itself for practical purposes. The touching of the material is guaranteed by the looping angle. The concentricity error of the roller must be much smaller than the required measuring accuracy to receive reliable values.

2. Two-sided thickness measurement

By arranging one sensor above and one below the measuring medium the thickness measurement is made as a difference measurement. Each sensor measures the distance from the material. Subtracting both measured values from the calibrated basic distance of the sensors gives us the thickness. Since both sensors operate absolutely in synchronisation, a vertical movement of the measuring medium (e.g. due to vibrations or roller errors) does not cause an error in the thickness measurement. The calibration of the measurement layout is slightly more complicated. It can be done manually by measuring a target of known thickness to give the basic distance from the individual measured values of the sensors plus target thickness. But it can also be done automatically by swinging in a reference target in the absence of a measuring medium. In this arrangement it is important to have a sturdy measuring frame, designed as a C or O frame so that the distance between the sensors does not change during the measurement. Basically the measurement can be performed as a single or multi-track measurement.

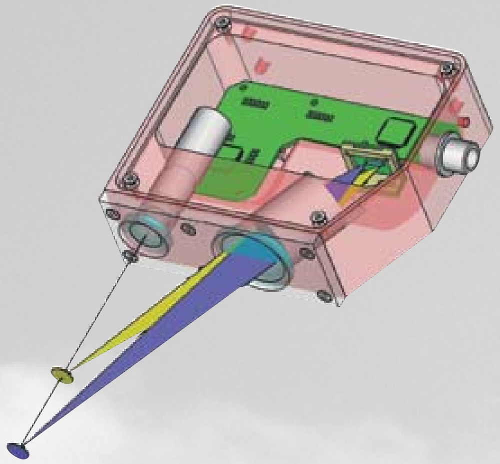
3. Traversing thickness measurement

If a thickness measurement is desired not only in individual tracks but over the whole material width, a traversing thickness measurement can be used. Here, like in the single track measurement, one sensor is mounted above the material and measured against a reference or the thickness is measured with two sensors above and below the material with the difference that the sensors are mounted on a linear guide. The upper and lower sensors are coupled by a common drive so that they can be moved in synch. Traversing widths of more than 5 m can be covered in this way. A zigzag measuring line is produced on the material when the product is transported through the system and the sensors are traversing. A transverse and longitudinal profile of the material thickness can be derived from this in the further processing software. Since the vertical guidance errors of the linear guides are included directly in the thickness, a so-called traverse error correction must be recorded prior to the measurement, saved in the software and corrected later with the recorded measured values at the respective measuring position.



With the OPTI*mess*, UDM and DMS systems described here it is possible to manufacture customised thickness measurement systems as tactile or non-contact systems for almost all materials and temperatures as single track or multi-track systems or traversing systems.

Thickness measurement with laser sensors



Punctiform OPTI*mess* laser triangulation sensors, OPTI*scan* laser triangulation scanners or light section sensors and OPTI*line* shadow measuring systems are used here. The advantages of the laser measuring technique in the field of thickness measurement are:

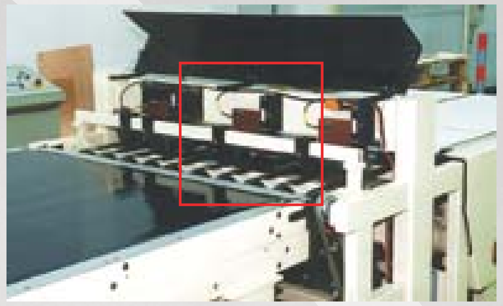
- no material contact
- independent of the colour of the material by control of the laser power
- independent of the composition of the material
- high local resolution due to small measuring spot
- high measuring frequency (up to 50 kHz)
- great distance from material possible
- measurements on hot surfaces possible

For measurement on completely transparent materials a special laser sensor, which operates in direct reflection, is required.

In the thickness measurement with OPTI*mess* sensors, a laser point is projected on the material for laser triangulation and a line for scanners and light-section sensors. This point is transmitted to a detector by a receiver optic fitted underneath a bracket. This may be a PSD (Position Sensitive Detector) or CCD (Charged Coupled Device) detector.

The PSD detector offers the greater measuring frequency (bandwidth), the CCD detector on the other hand has lower noise and therefore higher sensitivity. By selective reading out of the pixels an exact division between the surface reflection and reflection out of the material is possible. This is particularly important with partially transparent materials.

Punctiform thickness measurement (single and multi-track)

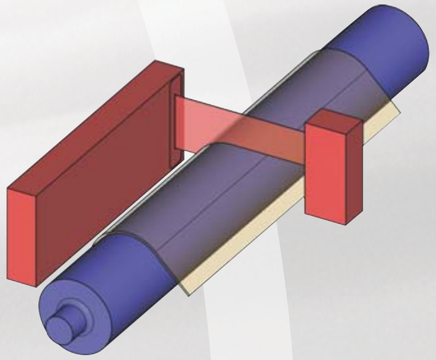


The punctiform thickness measurement is performed directly at the point where the laser beam hits the object in the case of stationary objects and along the line which the laser point projects onto the material in the case of measuring objects passing by underneath the sensor. The measurement can be made as a reference measurement with one sensor or as a thickness measurement with two sensors per measuring track. C-brackets, O-frames or complete measuring modules with automatic calibration and their own drive belts are available as measuring frames.

Linear thickness measurement (scanning or traversing)

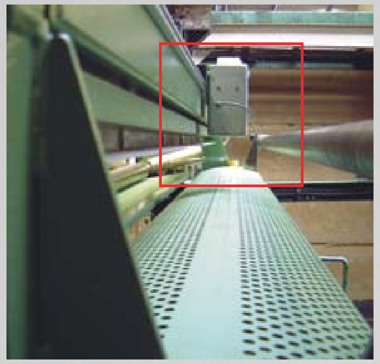
This thickness meaurement takes place with OPTI*scan* laser scanners or light-section sensors or over greater widths with a traversing mechanism and two punctiform OPTI*mess* laser sensors. The lateral position is picked up as an additional value apart from the distance information by the laser scanners so that the thickness or the thickness profile along the scanned line is recorded. Over smaller widths the laser scanners or light-section sensors offer the advantage that no additionally moved parts are necessary and scanning frequencies of about 20 Hz are possible. On the other hand, the traversing mechanics, designed as a C-frame, offer the possibility of reaching measuring widths up to 5 metres.

Thickness measurement according to the shadow principle



In the shadow principle with OPTI*line* sensors a laser line of parallel light is generated and projected on a CCD line opposite. When a material is inserted in the measuring gap this leads to a partial shadowing of the laser line on the detector. For thickness measurement it is necessary for the material to be measured to be deflected by a roller. The difference between the roller (zero) and the material surface picked up by the shadow measurement system is the material thickness.

Thickness measurement with ultrasound



In the UDM series of ultrasound systems an ultrasonic pulse is generated in the sensor and sent out to the material surface where it is reflected and received back by the same sensor. Because we know the speed of sound in air the distance from the object surface and thus the thickness can be determined. Since the speed of sound of air changes very considerably with temperature, the ultrasonic sensors are equipped with online temperature compensation. This is achieved by a reference post in front of the sensor which has a known distance which is measured with every measurement of the medium. If the reference distance changes due to a change in temperature the actual measurement can be compensated with this change.

The advantages of ultrasonic measurement are

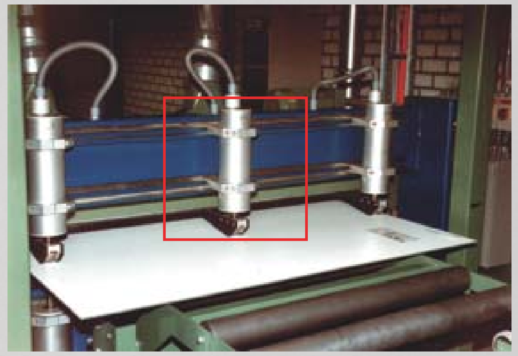
- a good measurability of porous or coarsely structured surfaces by large integrating measuring spot
- totally independent of material colour and composition
- the measuring capability of transparent materials (glass)

From the mechanical arrangement of the sensors as a one or two sided and traversing thickness measurement the arrangement of the sensors in the ultrasonic measurement is identical with the laser measurement.

The restrictions: Measurements should only be made at material temperatures of < 50°C despite the compensation. The measuring frequency of 200 Hz is way below that of the laser and no profile measurement is possible because of the size of the measuring spot.

Tactile thickness measurement

Tactile thickness measuring systems of our DMS series are optimally suited wherever it is possible to touch the material and where the applied pressure of the measuring rollers or rails does not alter the thickness. The user must be prepared to accept the sometimes visible traces on the material.



The tactile measurement systems usually consist of a measuring roller or rail which is connected to a piston rod. An adjustable pressure is applied by a spring or compressed air through the piston rod. The piston rod is coupled to an incremental distance measuring system which converts the distance of the piston rod into a measured value. The biggest advantage of these very robust systems over the non-contact systems is that the accuracy does not depend on the size of the measuring range because the division of the integrated measuring system and thus the accuracy is independent of the length of the incremental system.
Tactile systems are therefore ideal for steelworks and in the timber industry (chipboard manufacture). When measuring steel strips, a wide measuring range caused by the waviness of the strips can be covered without impairing the measuring accuracy. Another advantage is in the direct zeroing of the tactile systems by the contacting of the measuring rollers when there is no material in the measuring line.

Thickness measuring software

A special, Windows NT-based thickness measuring software enables, depending on the sensor layout used, the

- calibration of the measurement layout,
- distance or time-dependent measured value recording,
- display and storing of measured values,
- recording of the traverse error correction,
- tolerance monitoring and
- regulation of calenders or presses.