Accurate thickness measurement of e-coats

In this article, we discuss shortcomings of traditional tactile thickness gauges for process control of electrocoating and present non-contact thickness gauges based on advanced thermal optics (ATO) technology as a suitable substitution.

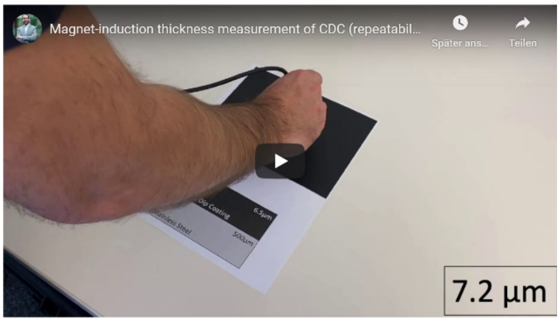
Nils Reinke, co-CEO coatmaster AG

Electrocoating is a widely used industrial process in which colloidal particles are deposited on an electrode under the influence of an electric field. Other names used for the electrophoretic deposition process are cataphoretic dip coating (CDC) or anodic dip coating (ADC). Cataphoretic dip coating, also called "cataphoresis", is an electrochemical process in which the workpiece is coated in an immersion bath. It is well suited for coating complicated structures and large quantities. Cataphoretic dip coating is a standard process to ensure corrosion protection for vehicle bodies.

1 A car body immersed in a cataphoretic dip system.

Many properties of electrocoating are directly influenced by the thickness of the coating. On the one hand, the diffusion barrier against corrosion-promoting substances such as water and oxygen rises with increasing layer thickness. On the other hand, the mechanical resistance of the coating increases with decreasing layer thickness. Therefore, there is an optimum which should be kept within the smallest possible tolerance limits in the coating process. In contrast, narrow tolerance fields are a challenge for traditional measuring probes with repeatability in the µm range. To achieve test equipment capability, the repeatability of the probe used should be 1/40 of the given tolerance window. For instance, a tolerance window of 4µm results in repeatability of 0.1µm.

Video 1 shows a test of the repeatability of a magnetic-induction probe when measuring the thickness of a 6.5µm thick CDC coating on a steel sheet. The sample sheet was cut out of a larger plate. The coating thickness is homogeneous within 0.2µm across the sheet.



1 Video: Magnetic-induction thickness measurement of a cathodic-dip-coating on sheet metal (repeatability)
https://www.youtube.com/watch?v=AbJvb3icFjo

The analysis of the repeatability results in a standard deviation of 0.7µm for the magnetic-induction probe. This method would only be suitable for a tolerance window of 30µm or more. In addition, the probe can penetrate soft coating in contacting processes as microscopic analysis reveal. Next, the influence of edge effects on the measured coating thickness is demonstrated. Edge effects occur when the electromagnetic field from the magnetic-induction probe exceeds the geometric boundaries of the measured sample. In video 2 the measurement is first carried out in the middle and then at the corners of the test sheet.

2 Video: Magnetic-induction thickness measurement of a cathodic-dip-coating on sheet metal (edge effects)
https://www.youtube.com/watch?v=9qxQkNm2uNU

As the video shows, the determined layer thickness is thicker at the edges than in the middle. Here, the test probe cannot distinguish between the edge area and a virtually greater distance to the sheet metal due to higher coating thicknesses. Typically deviations of 10-20% from the originally measured value occur. In the proximity to edges and if the radius of curvature of the substrate varies, the probe hast to be recalibrated.

A suitable non-contact technology is Advanced Thermal Optics (ATO), in which the test area to be measured is heated over a large area by a light pulse. A high-speed infrared detector is used to measure the temperature dynamics of the heating and subsequent cooling. The layer thickness is determined from the measured temperature dynamics using algorithms that simulate the heating and dissipation of heat. The diameter of the measuring range of typically 2-10mm is adjusted by the measuring distance. Within the measuring range the coating thickness is averaged, so that precise coating thickness measurement is possible even on rough surfaces (e.g. through a sandblasted substrate). Since the heat always travels perpendicular through the layers, the measuring device can also be used at an angle or on strong curvatures. The method is robust against distance changes.

Video 3 shows repetitive measurements of the coatmaster Flex that is based on ATO technology at a working distance of about 10cm.

3 Video: coatmaster Flex measures the coating thickness of a cathodic-dip-coating on sheet metal (test of repeatability)
[*https://www.youtube.com/watch?v=Ox1gkXl1RcY*](https://www.youtube.com/watch?v=Ox1gkXl1RcY)

The analysis of the repeatability results in a standard deviation of 0.07µm. The coatmaster Flex is already suitable for a tolerance window from around 3µm.

Next, test coatmaster Flex is tested for an influence of edge effects. In video 4, the coating thickness measurement is carried out first in the middle and then at the corners of the test sheet.

4 Video: coatmaster Flex measures the coating thickness of a cathodic-dip-coating on sheet metal (influence of edge effects)
[*https://www.youtube.com/watch?v=45cOmmKZFDs*](https://www.youtube.com/watch?v=45cOmmKZFDs)

The coating thickness measurement in the middle and at the corners shows a neglectable variation. Edge effects and the influence of the substrate geometry are therefore negligible with ATO technology.

In summary, the ATO is a suitable technology for measuring coating thicknesses of CDC layers with narrow tolerance windows. Due to the geometry-independency of this technology, it can also be used on complex shapes such as car bodies. Furthermore, a layer thickness measurement in gaps and cavities is possible. The adjustable measuring area allows measurements on structured sheets and screws. The non-contact technology also enables a thickness measurement of the CDC layer in wet conditions before drying. Deviations in the coating process can thus be quickly detected and corrected.

Author

Prof. Dr. N. A. Reinke
Co-founder, co-CEO
coatmaster AG
CH-Winterthur
Tel. +41 52 2120277
info@coatmaster.com
www.coatmaster.com