

Closed Loop Control of the Coating Thickness in Powder Coating Machines

A new measurement and control system allows for full quality control of powder coating thicknesses before curing. In the most advanced version of the system, the booth control unit adjusts the quantity of powder automatically on the basis of the measurements until the coating reaches the required thickness. This avoids the need for the safety margins that are commonly applied to the powder quantity settings in practice and, therefore, reduces powder consumption.

Modern powder coating machines should ideally be set up to meet the operator's individual requirements. In order to keep factors such as the level in the fluid container, the compressed air, the supply of fresh powder, the charging behaviour of the coatings and the environmental conditions as consistent as possible, machine operators generally make daily adjustments. The following criteria are essential in ensuring that the plant is operating cost-effectively and that the quality requirements are met:

- A high level of initial application efficiency from the automated system
- As little manual coating as possible
- A consistent powder circuit
- Even coating thicknesses
- Fast, high-quality colour changes
- Low energy consumption
- High availability of the powder coating plant (no machinery faults)
- A process which is reliable in the long term and produces consistently high-quality results

Coating settings with safety margins

Another important criterion is the coating thickness, which is often vaguely defined and inadequately tested. For example, the measurement points are not specified and measurement templates are rarely used. Generally, only a lower limit is given for coating thicknesses and, in addition, in many cases they are either measured not frequently enough or at irregular intervals.



The coating thickness is measured continuously before curing from a distance of between 5 and 50 cm. Measurements can also be made on moving and tilted parts.

In order to ensure that the quality objectives are still met, the operating staff add safety margins to the coating settings on the principle that it is better to apply a coating that is too thick than to risk producing rejects. As a result, the coating thicknesses are always at the upper tolerance limit, which means that too much powder is being used unnecessarily.

A practical measurement system is needed

Until now, there has been no practical measurement system available that

could carry out rapid measurements before the curing process on a moving conveyor and that produced identical measurements before and after curing. The existing testing procedures were costly and time-consuming and failed to offer end-to-end quality and process control. Measurement methods that make contact with the surface, such as magnetic induction and eddy current procedures, could be excluded immediately because they can only be used after the parts have been cured and cooled. Destructive measurement processes are laborious and only suit-

able for random samples. Conventional non-contact measurement devices, such as lasers and beta emitters, produce fast results, but involve a significant risk because of the radiation they emit.

Measurement in real time

Winterthur Instruments has developed the CoatMaster measurement de-

vice, which can resolve these problems. The CoatMaster measures the thickness of coatings before or after curing. The non-contact, non-destructive measurements are made in real time, including on moving and tilted parts. No harmful radiation is emitted during the measurement process. The device can be used on a variety of materials, component shapes and colours with a very high level of reproducibility. Rough surfaces can also be measured with good repeat accuracy.

Advanced thermal optics and digital signal processing

The measurement principle is based on advanced thermal optics (ATO) and digital signal processing. A computer-controlled, pulsed light warms the coating. A high-speed infrared detector behind the lens monitors the resulting change in the surface temperature remotely. The surface temperature falls with characteristic dynamics that depend on the thickness of the coating and the thermal properties of the substrate material. Specially developed algorithms analyse the dynamic change in the surface temperature and this allows the coating thickness and other properties to be measured quantitatively and reproducibly.

Measurements on curved surfaces and edges

As the device measures coating thickness from a distance of between 5 and 50 cm over a measurement area ranging in diameter from 2 to 20 mm, it is possible to measure coatings on components with highly complex shapes, including in corners and angles, on narrow edges and on internal and curved surfaces.

The measurement range is between 1 and 1000 μm and the measurement

Average reduction in coating thickness in μm					
Area in m^2/anno	3	5	8	10	15
100000	3 150	5 250	8 400	10 500	15750
500000	15 750	26250	42 000	52 500	78750
1 000000	31 500	52 500	84 000	105 000	157 000
2 000000	63 000	105 000	168000	210 000	315 000

Annual potential savings (in euros) from reducing the coating thickness (powder price: €7.00/kg; specific weight: 1.5 g/cm^3)

process takes 20 to 1000 ms, with a standard deviation between 2 and 0.1%, depending on the coating and the substrate. The device can measure moving and also tilted parts with powder coatings less than 100 μm thick up to a conveyor speed of 20 m/min. with an angle tolerance of $\pm 60^\circ$. Depending on the specific model, the measurement distance can be up to 60 cm, with a distance tolerance of more than 10 cm. In practical use, the time period between two measurements is generally 3 s.

Different versions available

Winterthur Instruments and J. Wagner have worked together to develop a joint solution in which the CoatMaster measuring device is integrated into powder coating machines either in a static location or with automated positioning using lifting systems or robots. The device measures the coating thickness continuously and automatically directly after the powder has been applied and displays the measurements immediately on the screen of the powder coating machine.

Different versions of the device are available. The simplest version shows the measurement on the screen and the operators manually adjust the coating parameters depending on the deviation from the required coating thickness. The more advanced version of the device (closed loop) sends the measurement directly to the powder coating machine control system. If the measurements are outside the tolerances, the control system adjusts the quantity of powder continuously and automatically until the required coating thickness is reached. This prevents the application of an excessive amount of powder and avoids the need for the safety margins on the powder quantity settings that are generally used in prac-

tice. The result is a reduction in powder consumption.

Alongside powder savings, the new system offers additional advantages:

- Avoidance of rejects
- Quality control and a stable process because of constant adjustment and monitoring
- Process reliability as a result of full quality control of all workpieces instead of sporadic checks of individual parts
- Immediate identification of problems with the powder coating machine or the process
- Evidence of process reliability from full parts documentation

Winterthur Instruments is constantly working on identifying new areas where its devices can be used, including measuring the thickness of coatings on thermally sprayed metals and ceramics. As well as monitoring the thickness of powder coatings, the device can also be used to measure paint thickness before and after drying and to measure thin plastic and slide coatings quickly and accurately. It can even measure coatings on textured and sand-blasted surfaces with a high level of reproducibility. The new measurement and control systems are already in use in mass production processes. (Ke)

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