Reliable Measurements of Textured Surfaces

Until now it has only been possible to measure the thickness of coatings at the edges of perforated metal baking sheets. As a result, the layer of coating around the perforations is sometimes too thick and this in turn can cause cracks to form. For the first time, a non-contact measurement process is available which allows the coating thickness in the area of the holes to be measured quickly, non-destructively and with high precision.

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Measuring the thickness of coatings for quality assurance and process control purposes has always been a challenging task. This is true in particular in the case of uneven surfaces and special substrates, such as stainless steel. An effective solution to the problem has not been available until now. The consequence has been some wastage during the production process and unnecessary time spent on quality control, rectifying faults and potentially also remanufacturing components. For all of these reasons, accurate, fast measurements and readily available data not only reduce costs but also help to make processes more sustainable. This allows companies to use their production capacity, materials and energy more efficiently.

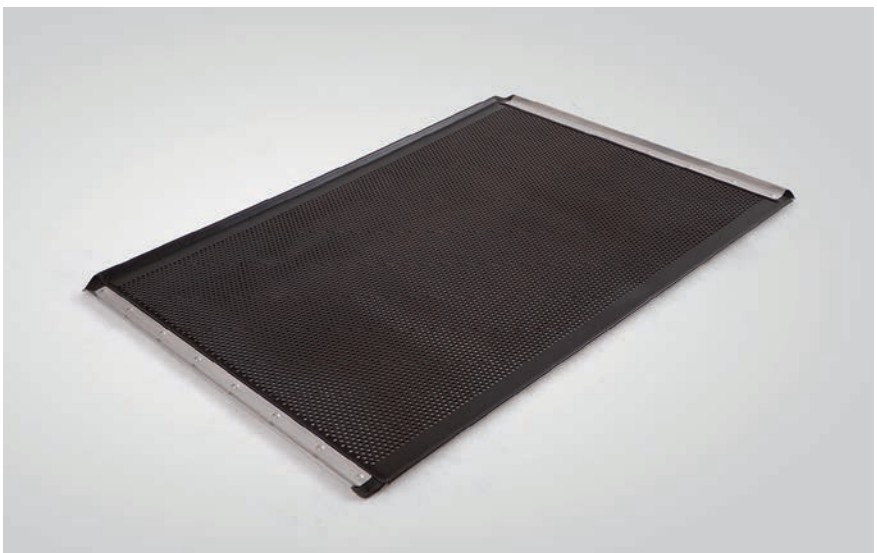

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Figure 1 > The perforations in the aluminium baking tins guarantee continuous ventilation and keep energy consumption to a minimum.

Costly and time-consuming contact measurements

In the past, contact methods were used to measure coating thickness and this could only be done after the coating had been cured and cooled. As a result, there was a delay between the coating being applied and the identification of problems, which included coatings that were too thin or too thick. Depending on the process, this delay could be anywhere between 30 minutes and several hours. In addition to the fact that these contact measurement methods were not reliable on textured surfaces, they were also costly and time-consuming and could not be guaranteed to provide consistent quality assurance and process control results. In order to resolve this problem, ILAG decided to work with a customer to evaluate a system that can measure coating thickness on the production line. ILAG is a leading manufacturer of non-stick coatings for consumer goods, such as cookware, baking tins and small electrical appliances. The company's production plants are located in Wangen in Switzerland and in the greater Shanghai area in China. Its basic development and product development departments are based in Switzerland.

High standards for the production of commercial bakeware

Baking tins used in commercial bakeries have to meet high standards, because baking is a time- and resource-critical process. There has been considerable downward pressure on the price of bakeware for some years and the market has become increasingly consolidated. This price pressure explains the need for highly efficient production processes and for cost-effective coatings that guarantee a long service life for the end products.
Commercial baking tins are generally made from perforated aluminium sheet

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Figure 2 > Sample panel with perforated and non-perforated areas and bonded coating thickness disc.

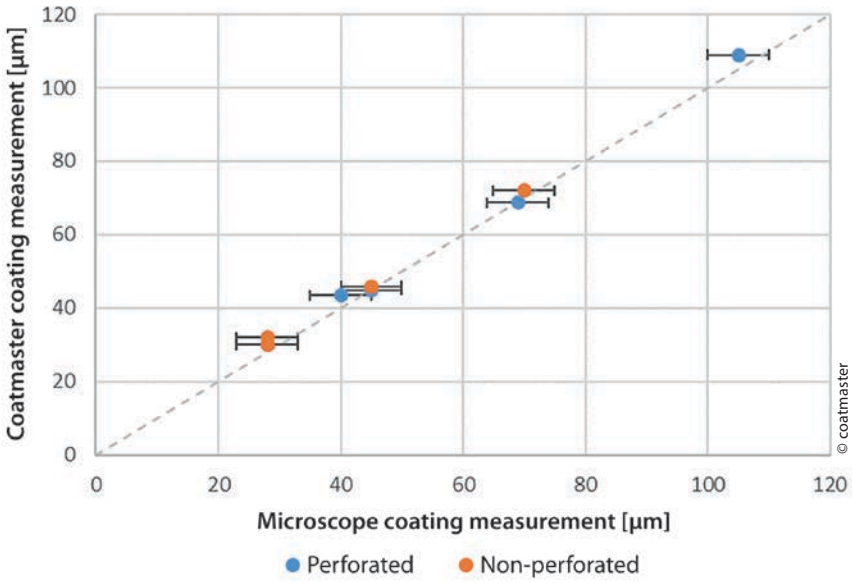

Figure 3 > The non-contact measurements and the microscope measurements correspond in the perforated and non-perforated areas (R2 = 0.99).

(*Figure 1*). The perforation ensures that the bakery products, such as baguettes, are continuously ventilated. This allows the moisture which builds up as the dough is heated to escape through the holes and the result is a crisp finished product. The perforations also help to keep the energy needed to cook the bread to a minimum. A non-perforated tin uses more energy to reach the required temperature than a perforated tin.

In the bakeware sector it is normal for coating thicknesses to be measured on the non-perforated edge of the tin, because until now it has not been possible to make quick and reliable measurements near the holes.

A comparison of three measurement processes

In order to develop a measurement method in the perforated area, ILAG commissioned a university to investigate different coating thickness measurement processes and determine their suitability for measuring the surface of a textured aluminium baking tin. ILAG applies a two-layer coating to its aluminium tins. The university tested a variety of processes for measuring the thickness of the coating: a contact eddy current system (which could only be used in the non-perforated areas), a destructive measurement method using a 3D microscope and non-contact measurement with the advanced thermal optics (ATO) system from coatmaster.

The eddy current and ATO systems were calibrated on the non-perforated surface at the edge of the tins. The non-contact method was used to make measurements

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Figure 4 > The fast, accurate, non-contact process is ideal for use in an industrial setting during production.

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Figure 5 > In addition to systems that can be used for fully automated coating thickness measurement during the production process, a mobile hand-held device based on the same technology is also available.

in the area around the holes. For comparison purposes, the coating thickness in both areas was measured with a 3D microscope (*Figure 2*). The results of the tests at the edge of the tins were similar using all three methods. In the perforated area the comparison showed that the non-contact measurement corresponded with the microscope measurement (*Figure 3*).

Thermal coating test in less than one second

The coatmaster measuring device measures the coating thickness using a thermal method in around one tenth of a second. The standard deviation of the measurement is less than 0.25 µm, in contrast to the microscope measurement where the standard deviation can be as much as 2.5 µm, depending on the type of microscope used. In comparison with the microscope, the coatmaster device for the first time provides the opportunity to carry out non-destructive, non-contact measurements in the perforated area with a much greater accuracy than the destructive method.
The laboratory results show that the coatings in the perforated area are up to 50% thicker than at the edge of the tin. When the measurements are only made at the edge, if often emerges that the coating around the holes is too thick. If the coating is thicker than the specification, this can lead to undesirable effects such as cracking. The cracks can cause the tin to corrode more quickly or, in the worst case, can result in the coating providing an inadequate barrier against migration from the substrate. Both of these shorten the service life of the baking tins. The outcome is that they have to be recoated more quickly, resulting in higher costs.
The coatmaster device gives coaters the option of measuring the coating thickness around the holes. The fast, accurate, non-contact process is ideal for use in an industrial setting during production (*Figure 4*).

Identifying process deviations quickly

The coatmaster system, combined with the processing and provision of the appropriate data, allows process deviations to be identified quickly and corrected automatically, without the intervention of quality control staff. This not only speeds up production and cuts staffing costs, but also ensures that the products meet the required standard of quality, because the coating process can be fully documented for all components.
By correcting excess levels of coating quickly, material use can be reduced by between 10 and 30 percent. In addition to the systems that can be used for fully automated coating thickness measurement during the production process, coatmaster also offers a mobile hand-held device based on the same technology (coatmaster Flex) (*Figure 5*). It is important not to underestimate the importance of giving the coated end products a longer service life. This is made possible by applying the coating in a controlled and traceable way at the required thickness. Measuring the coating thickness accurately allows the spray process to be adjusted immediately in order to prevent cracks from forming. This reduces the risk of the end products being prone to corrosion. //

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