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TenStep Supplemental Paper

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Measuring Quality in Product Appearance

The global marketplace has seen the entry of a number of competitors offering consumer products, each trying to woo customers with high quality products and services. With a wide range of product choices available, customers look not only at quality and cost, but also for excellent product appearance. The way a product looks has a significant impact on the perception of its quality. Manufacturers are now working towards achieving finer product finishes to promote products.

Customers give special priority to good finishes for a wide range of manufactured products from different industries. These include furniture, glass, and automotive industries. The external appearance of all these products depends on the effectiveness of the finish coatings, which in turn depends on their applied thickness. Manufacturers now emphasize coatings that give the appearance of quality, endurance and protection from the environment. A thick coating makes a product susceptible to cracking while a thin one gives the product a faded appearance. In either case, it loses its appeal.

Monitoring the coating process is vital, and data of thickness measurement enables a manufacturer to control processes and ensure that coatings are applied uniformly and within tolerances. At the same time, tracking the thickness of coatings also helps manufacturers to save on both material and labor costs. Substrates (any surface to which a coating is applied) are varied in nature, like metal, wood, glass, plastic and composites; therefore, every coating and substrate combination has unique properties. One type of measuring device cannot give reliable results all the time. Coatings on multiple substrates need different tools for different substrate-coating combinations. This is expensive and, given the fact that some thickness measuring devices are destructive in nature, costs get further compounded.

Conventional Methods of Measuring

Two commonly used thickness measurement devices for metallic products are magnetic induction and eddy current gauges. They are non-destructive by nature and ideal for measuring coatings on ferrous and non-ferrous metallic substrates, respectively. They are insensitive to the type of non-ferrous and non-conducting coating being measured. However, because they are sensitive to the properties of the substrate material, they cannot measure the thickness of coatings applied on non-metallic substrates. Also, these devices cannot discriminate between individual layers in a multi-layer coating process.

Similarly, coating thickness on plastic and other non-metallic substrates are conventionally determined using the measuring microscope. Unlike the magnetic induction and eddy current instruments, measuring microscopes distinguish individual layers in a multi-layer coating. However, they require a sample cross section of the part to be measured. Obtaining cross sections necessitates gouging or cutting the part, and hence, the measurement is destructive. Moreover, preparing correct cross-sections is a time and labor intensive task. Thus, traditional devices are only suitable for processes with a minimum number of measurement samples and where a minimum destruction of parts (by cutting) occurs.

Ultrasound Technology

The introduction of ultrasonic technology in measuring coating thickness has overcome some of the limitations of conventional measuring devices. The practical applications of ultrasonic devices are widespread as they can measure a wide variety of substrate and coating combinations, like the thickness of finish coatings on both metallic and non-metallic substrates. The applications in the non-metallic segment include composite aerospace and automotive components, molded plastic components, glass and wood. Ultrasonic devices can measure relatively thick coatings as well as coatings whose thickness is less than 25 microns.

An ultrasonic device is a one-dimensional acoustic microscope that provides a cross-sectional image through one point on a surface. It works by sending an ultrasonic pulse/signal through a coating or material. The pulse is reflected back by any particle or interface that it encounters, like an echo. The transit time of the ultrasonic pulse is measured and the thickness is calculated using a sound velocity conversion factor. The sound velocity is a function of the mechanical or acoustic properties of the coating or material. The accuracy of ultrasonic devices is sensitive to the properties of the measured material or coating. Different sound velocity factors (or calibrations) are required for different coating materials. In certain cases, manufacturers use a generic set of calibrations, while in others, they may need specific sound velocities.

Because they are non-destructive, ultrasonic thickness measuring devices enable manufacturers to take many readings from a single part or a few readings from many parts without affecting the parts in any manner. Some of these devices allow for the measurement of multiple layers of coatings, and they directly measure every layer of a multiple layer build. This helps in tracing the source of common film-build related defects like sags and solvent popping. Since operators can view the thickness of different layers at the exact point of defect, they can easily detect the defective layer that is out of specification. Thus, process tuning and adjustment processes are simplified.

A Word of Caution

Just like all imaging systems, multilayer ultrasonic devices may not be able to differentiate and contrast all combinations of coatings or materials that a manufacturer uses. Since the measurements are dependant on the differences in acoustic or mechanical properties of adjacent layers, it may not be possible for the device to contrast individual layers when the layers exhibit similar properties. In such situations, the manufacturer can obtain a total thickness measurement of the combination of non-contrasting layers.

The cost and size of these devices depend on the features, capability, accuracy and services provided, like operator training and calibration details. However, these devices have provisions for a larger range of measurable thickness, and hence they are used in many applications. Thus, by eliminating time-consuming, labor intensive, destructive or indirect measurements, ultrasonic devices provide operators with accurate measurements, who in turn use them to trace defects and suitably adjust the process, in significantly less time.