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Inspection of Coatings Using Terahertz Time Domain Spectroscopy System

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Coatings and paints are used in almost all branches of modern industry. Mostly as a material for corrosion protection. It is understandable that failure of coating is critical for ability and time of protection.

Failure can occur for many reasons

- improper selection of coating material for given substrate – lack of compatibility or chemical reactions,
- bad adhesion (blistering, flaking, peeling),
- strong exterior action as chemical exposure, abrasion, weathering,
- poor or inadequate surface preparation or improper application as surface,
- contamination, too low surface profile, pinholes, overspray, improper drying, lack of cure,
- incompetent design of structure – sharp edges, skip welds.

Modern paints, especially those for automotive industry are very complex chemical mixtures. They contain resins and curing agents (they build up the coat), pigments and solvents. Moreover they contain plasticizers, extenders, catalysts, fungicides and so on. This mixture is applied as a very thin layer of 50 - 60 micrometers in thickness. And then all components have to react properly; resin reacts with curing agent or with oxygen or water from the air. The solvents have to evaporate in proper time, the other non-volatile components must build up the continuous film of constant thickness within curing (or drying) time. As explained, there are many factors that can cause coating failures.

There are also many methods of examination of coating failures. They can be roughly divided into methods that allowed on site investigation and methods used in laboratories. One can also divide these methods into simple methods (not demanding complicated equipment) and methods using a sophisticated laboratory equipment. The most simple method is macroscopic examination, followed by microscopic examination. Usually, the next step of failure analysis is chemical analysis of the coating and corrosion products. This can be made by Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) with energy dispersive x-ray spectroscopy (EDS). Eventually as confirmation for analysis conclusion one can use Accelerated environmental exposure tests; salt spray (fog) tests, humidity tests, and ultraviolet light (QUV) exposure complemented by electrochemical impedance spectroscopy (EIS).

As one can see according to complex causes of coating failure it is normal to use very complex methods for investigations of coating failures. These methods mostly deal with failures that already occurred and can be seen (or their adverse effect). But how can we find defects of coats that cannot be seen because of presence of pigments in multilayer coatings, without damaging the tested structure. One of such methods is the terahertz time domain spectroscopy. This paper presents utilized setups, applied image processing algorithms, results of preliminary tests and results of measurements achieved for various kinds of coatings and base material. The coatings containing selected kinds of defects were also prepared and evaluated. The presented results show that the terahertz method can be a good alternative in case of composites' testing.