UV Robotics Note: The following article, reprinted Courtesy of RadTech International North America highlights robotic UV Curing work being aided by members of the UV Robotics Team and North American Automotive UV Consortium but is an independent project of the authors and companies contained herein. We hope this article will be helpful in describing the benefits of the robotic curing approach.

3-D UV Technology for OEM Coatings

By Dr. Thomas Raith, Markus Bischof, Michael Deger and Elisabeth Gemmler

Introduction

DaimlerChrysler Development has been researching UV-curing clearcoats for many years. High-quality paints are needed for painting vehicles. UV paints are known for their good properties. The challenge is using UV technology for painting the complex surface of automobile bodies.

A UV-technology center was built in the DaimlerChrysler Research and Technology Center in Ulm, Germany (Figure 1). In a clean room area, components with dimensions of 1.50 m x 1.60 m can be painted. This is the size of an S-class hood.

The line consists of a spraying booth and a paint dryer in conventional technology. The core component of the line is a robot guiding a UV lamp (Figure 2).

Figure 1: Layout of the UV Technology Center

The components are on a special transportation cart throughout the entire painting process. For manual spray application, the height is freely adjustable. For UV hardening, different stops are used to bring it exactly into the position to which the robot programming refers. For the hardening of hoods, the robot needs a wide reach. A reach of 3.60 meters was achieved with a seventh robot axis. The UV lamp wattage can be adjusted from 2-4 kW; the tube lamp is 20 centimeters. Compact design was important in order to reach all areas of the component. The goal is to achieve an even distance between the UV lamp and component surface.

Figure 2: Robot with UV lamp

Safety Technology

When building the UV Technology Center, safety was the highest priority. The robot workroom is completely enclosed.

Figure 3: Robot booth with sliding door

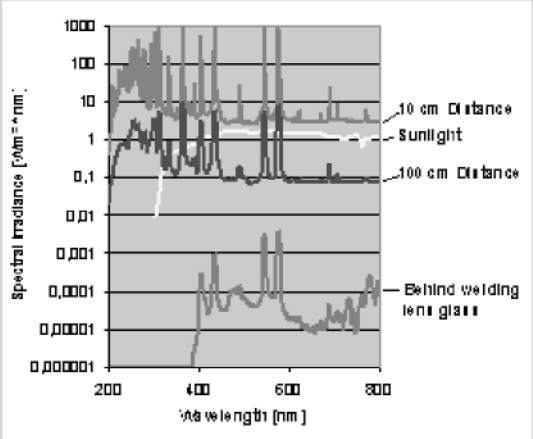
Figure 4: Sliding door with welding lens

The sliding doors are equipped with sensors that monitor access (Figure 3). The UV lamp can only be turned on after the doors have been closed. In order to implement the UV technology, it is important to eliminate danger from UV light in the production process and the repair shops.

Yet, it is possible to observe the hardening process. For this purpose, the sliding doors have welding lens screen glass (Figure 4).

Welding lens glass is available in different protection classes (Figure 6). The protection effect of welding lens glass with protection class A9 is shown in Figure 5. The diagram is a logarithmic representation of the spectral

Figure 5: Protection effect of welding lens glass



irradiance of the UV reflector at a working distance of 10 cm. At a distance of one meter, which is the distance between the UV lamp and sliding door, the spectral irradiance in the ultraviolet and blue spectrum is still very high. Behind the welding lens glass, only very little UV light and visible light can be measured. A comparison with the spectral irradiance of sunlight demonstrates the hazard potential.

the surface must be radiated in a suitable way. This means that the radiation must lie within the upper and lower tolerance limits of the respective paint system. Since UV lamps are not a point source

Figure 6: Transmission welding lens glass

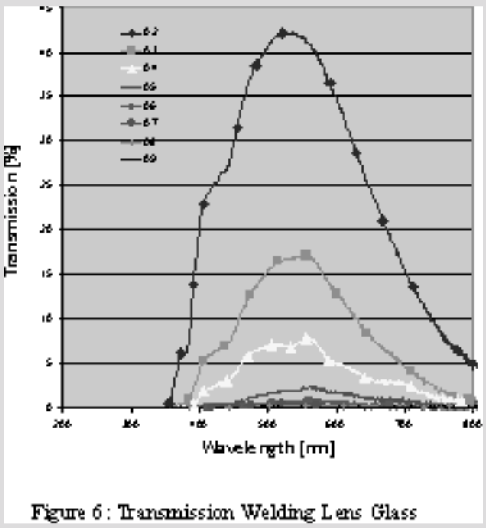
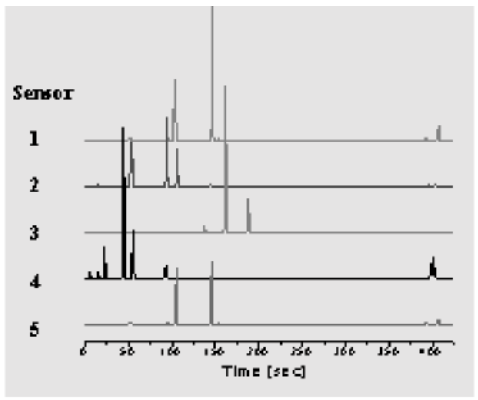


Figure 6: Transmission Welding Lens Glass

Radiation Geometry

The surface of automobile bodies is a complex structure. The use of UV-hardening paint systems requires the ability to radiate with UV light in a defined manner. Each unit area of

Figure 7: Irradiance—Different locations on a hood



of light, it is not possible to radiate complex surfaces evenly. Figure 7 shows the UV hardening of a hood. The path program was created manually (Figure 8). The curves indicate the course of the irradiance at different locations on the hood. The irradiance time line during hardening was measured with an eight-channel meter (Figure 9).

Figure 8: Creating a path program

Figure 9: Measuring the irradiance eight-channel meter

Simulation

If UV technology is to be transferred to the production process of a vehicle painting line, then one should be able to calculate the hardening lines and the movements of the hardening units. Simulation tools are needed for this purpose. The goal was to calculate the radiation at each individual point of a component for a given path program. In the first step, the radiant field of the UV reflector was measured at 8,800 measuring points. The robot movement can now be shown in a simulation. At the same time, the irradiance is calculated from the robot programming data, the CAD data of the component and the radiant field of the UV lamp for each location of the component, which is shown in Figure 10.

Figure 10: Simulation

The simulation tool is to be developed further. The optimized lamp arrangement and the lamp movements for a given radiant characteristic will be determined from an inverse calculation. In order to perform these calculations, the radiant characteristic for the UV paint used must therefore be known.

Material Characteristic Data

The hardening behavior of individual UV paints is different and depends on the reactivity of the paint. Therefore, it is necessary to determine the material characteristic data for paint (Figure 11). The material characteristic data defines the influence of the radiant characteristic on the paint properties. The irradiance and thus the distance between UV lamps and painted area have a large influence on the paint quality. Using a model clearcoat as an example, it was examined whether a large lamp distance could be compensated for by longer exposure time.

The model clearcoat is normally completely hardened after an exposure time of six seconds and an irradiance of 3,300 w/m (Figure 12). This irradiance corresponds to wattage of 100 w/cm at a distance of 10 cm. The integral of

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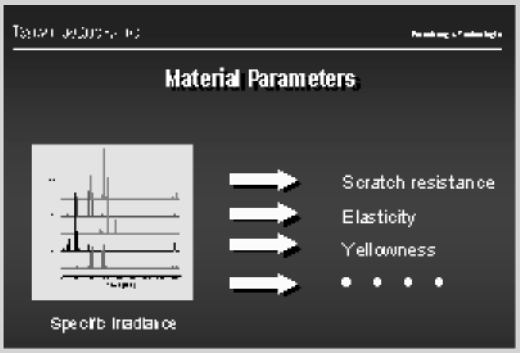
Figure 11: Material characteristic data



irradiance over time is the energy density. In this experiment, the energy density is 20,000 j/m (Figure 13).

When hardening complex surfaces, larger lamp distances may have to be accepted, resulting in significantly reduced irradiance. Different samples of the model clearcoat were hardened at different levels of irradiance.

Figure 12: Material characteristic data

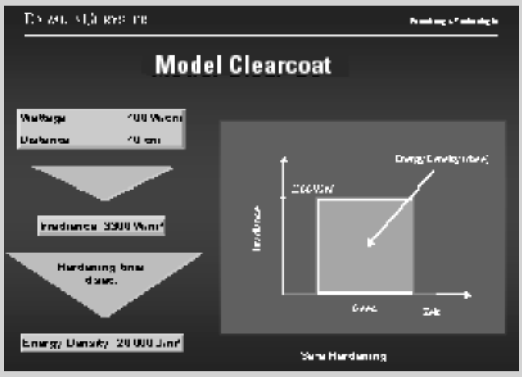
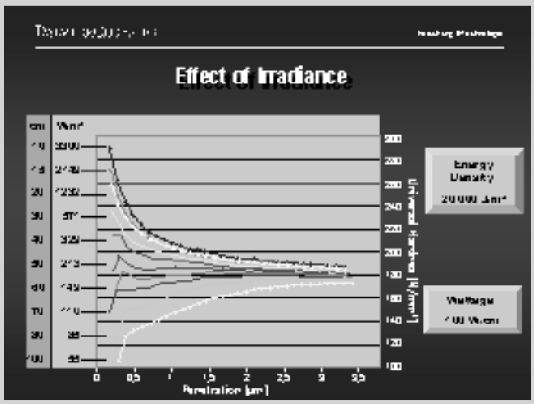


Figure 13: Effect of irradiance



Lower irradiance was compensated for by longer exposure times. The energy density was 20,000 j/m for all samples. Figure 13 shows the result of the subsequent micro-hardness test. Differences were found primarily in the surface hardness of the samples, which is important for scratch resistance. Higher levels of irradiance can achieve higher surface hardness.

Outlook

The UV Technology Center now offers the opportunity to examine the use of UV hardening on different complex component shapes. The potential of pure UV systems can be compared to the potential of dual cure systems. Different paint systems can be applied to components, which are examined in driving operation. Thus, the quality of the paint job can be ensured, and paint inspections in the lab can be augmented.

The work in the UV Technology Center will enable further statements on process capability. In addition to the topic of work safety, this also applies to questions of component life and process cost estimates. ~

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UV Robotics Note:

The robotic UV equipment used in this work was furnished by IST Metz, GmbH, a contributor to the UV Robotics team and member of the North American Automotive UV Consortium. For more information about this equipment contact UV Robotics or email pmillsoh@aol.com