

UV-applications in the automotive industry

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1. General advantages and applications of the UV-technology

The importance of light curing as a basis of low emission coating and printing procedures has been steadily growing over the past years. Although VOC reduction and avoidance is of primary importance, there is a number of further reasons for UV-curing technology that can't be ignored any more by current and future industrial coating procedures, such as:

- Economy thanks to short curing times, high production speeds, short plants and less energy costs.
- Less time for dusting because of short curing times.
- Production of scratch-resistant coatings, which are at the same time chemically, mechanically and solvent resistant.
- Can be processed at once, e.g. smoothing and stacking.
- Low thickness layers are required. Unused coating material can be recycled as it has only been cured in the UV-lamp area.
- Less heating-up of the substrate surface.

The use of UV-curing ink and varnish systems is a possibility of respecting the environmental EU laws becoming stricter. Beside water varnish technology and powder technology, UV is one of the three future technologies in the surface sector.

The application range of UV-technology today is used by the graphics industry with its various printing and varnishing processes, industrial applications as well as applications in the automotive industry.

2. Current applications in the automotive industry

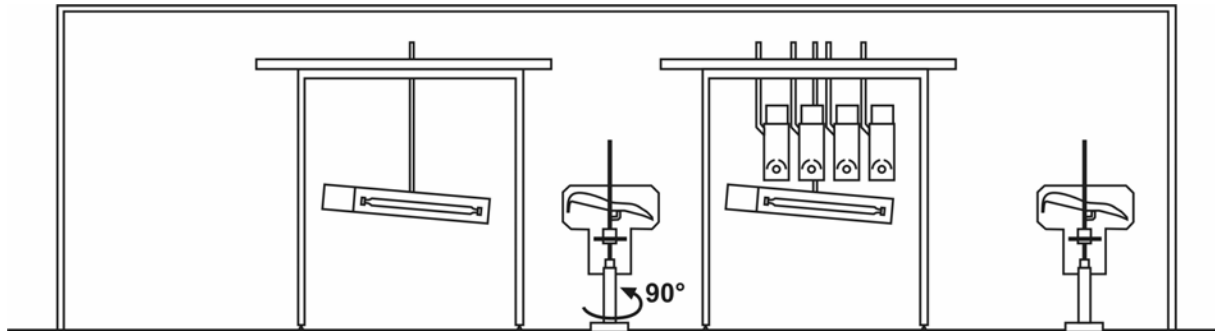
The adoption of UV-curing by the automotive industry has been effected by the component suppliers over the past ten years. The following applications are state-of-the-art today: headlamp lenses, reflectors, protection strips, central consoles, instrument panels, indoor wood decorating, screen printing of instrument boards and measuring instruments, cylinder-head gaskets, steering wheels, UV-adhesive for anti-noise mats, black parts (pumps, gear units, linkages), brake linings, clutch linings, wheel hubs, car windows, etc. The mentioned applications which are by no means complete show the variety of UV-technology in the automotive field, which is already applied to three-dimensional objects, even for outdoor applications.

2.1 Varnish curing on headlamp lenses

For some years polycarbonate lenses have displaced the older glass lenses providing greater geometrical design flexibility and lower weight. Polycarbonate, however, must be varnished as it is not scratch resistant and has a tendency to yellowing. UV-varnishing provides the properties required by the end-user (hardness, resistance to chemicals, light protection...). Compared to conventional heat varnishing, the UV-process offers further advantages such as considerably reduced process times, reduced space requirements for the unit and an increased resistance of the substrate against dirtying between coating and curing.

With the UV-varnishing of headlamp lenses UV-technology has achieved a break-through in the field of outdoor applications with weather-proof varnish systems. There are meanwhile many long-term experiences.

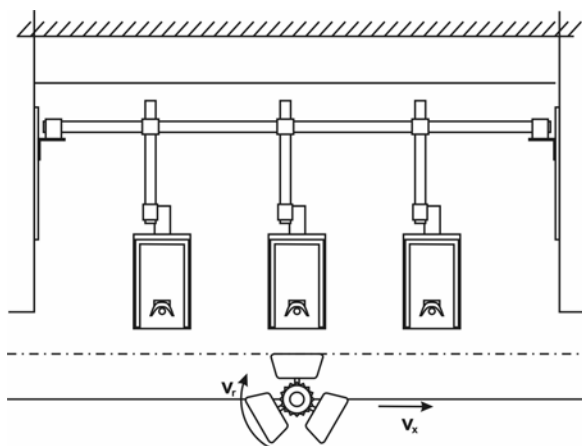
A possible UV-unit concept for headlamp lenses could be as follows: After application and the subsequent flash-off zone the UV-varnish is cured on the headlamp lens. To reach all edges with UV-light, the UV-unit can be divided into two areas. In UV-area 1, the lens is irradiated from top and from the side. Between the areas the headlamp lens is turned by 90°. In UV-area 2, the lens is irradiated from the side. Depending on the geometry of parts, simplified unit designs are also possible.



2.2 Varnish curing on reflectors

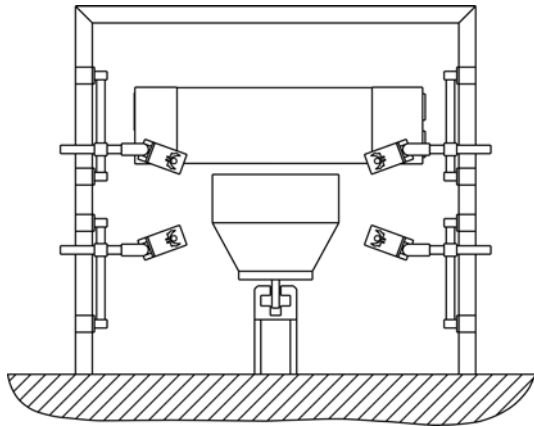
Reflectors for cars are normally built by plastic-materials and must possess a highly light reflective surface. For the production of reflectors 2 or 3 UV process steps are necessary. In a first step, the plastic surfaces are irradiated with UV-light to increase surface tension for a good flow and adhesion for the following UV-curable varnish. After varnish application and flash-off zone the UV-varnish is cured by UV-light in a second UV-zone. The UV-varnish should form a smooth surface suited for the following metallizing in a vacuum deposition chamber. After metallizing, it is possible to apply varnish once again, if there is no vacuum deposited protection layer. Here also the renewed application of UV-curable varnishes according to the above process is possible. The benefits of the UV-process are a short process time, reduced space requirements and a good lacquer performance.

There are some unit-concepts available on the market, depending on the kind of application (spraying or flooding). A possible concept for an UV-unit could be, that the reflectors are set up on a chain conveyor and are irradiated from below by crosswise arranged UV-units. Turning this systems by 180°, it is also possible to have the reflectors positioned on a floor conveyor and irradiate them from top. A further variant are cycloid conveyors. Thereby a rotary shaft with a feed mechanism in x-direction is fitted with several reflectors. Over this transport several UV-units are arranged crosswise to the direction of pass providing 3-dimensional curing of the parts.



2.3 Varnish curing on instrument panels

Instrument panels and also similar parts like central consoles are UV-coated for optical reasons. It is thereby possible to give a wood like appearance to plastic parts. Above that, UV-varnish provides mechanical resistances (e.g. scratch resistance). After varnish application and the normally necessary flash-off zone, the different parts pass a UV-zone consisting of several UV-units.



A possible unit design could be the following one: four angular-adjustable UV-units are arranged in the direction of passage. Additional irradiation is provided from top by means of crosswise arranged UV-units. It is also possible to suit the individual UV-units according to a light channel to the contour of the part. The number of the UV-units depends on the geometry of the part as the UV-units are arranged over the extent of the part.

3 Potential for car body varnishing

Scratch resistant coatings serving as surface varnish for cars especially attract the attention of customers, car manufacturers and designers. In this application, UV-technology can offer the following benefits:

- Possibility of improving product quality. Using UV-curing varnishes it is possible to get scratch and chemically resistant surfaces, which was not yet possible up to now.
- The amount of refinishing work can probably be reduced thanks to the fast curing reaction and quickly obtained dry condition.
- UV-varnishes are environmentally friendly thanks to a low content of organic solvents (depending on formulation)

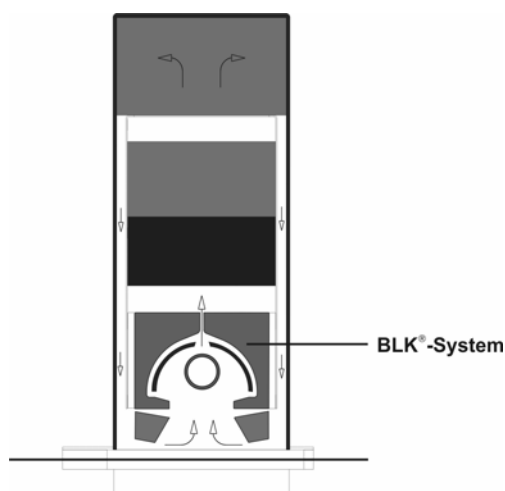
3.1 UV-module design

A unit design with a combined air/water cooling has been realised for car body varnishing. Hereby each lamp module is enclosed by a supplementary case to create an own air circulation.

The specific module design offers the following benefits:

- Integration in ovens by circulated air is possible (temperatures up to 150 °C).
- Air interchange with oven hardly exists. Due to this fact, the air balance of the oven by circulated air is not influenced (reduction of waste by dust).
- Supply air and exhaust air lines for the UV-module are no longer necessary. Openings in the oven can be dropped. Thanks to dropping supply air and exhaust air lines, the UV-module is more mobile and manageable.
- Removing of air for lamp cooling is not necessary. Dropping of air preparation for supply air, that means, preparing of the air space from which the cooling air is taken, can be dropped.
- The UV-module is able to work with and in oxygen reduced conditions.
- Differently doped UV-lamps can be used to adapt the demands of chemistry.
- UV-output measuring and monitoring can be integrated.

Figure 4: BLK-U



3.2 UV-process control

To provide process security, it is indispensable to keep the UV-output on a constant and controlled level. To meet this requirement, IST METZ has developed the closed UV-control circuit combined with on-line-UV-measurement by means of a UV-sensor. The UV-sensor is installed in the module or in the production level.

It is not the installed, electrical output that is being adjusted here, but the actual UV-output reaching the object which is measured and/ or monitored.

There are several possibilities of using this UV-measurement.

a) UV-output measurement

In this system the measured UV-value is displayed. If the UV-value falls below the setpoint value, an acoustic or visual alarm will be activated. Via the control unit, the required electrical output can be supplied subsequently if available.

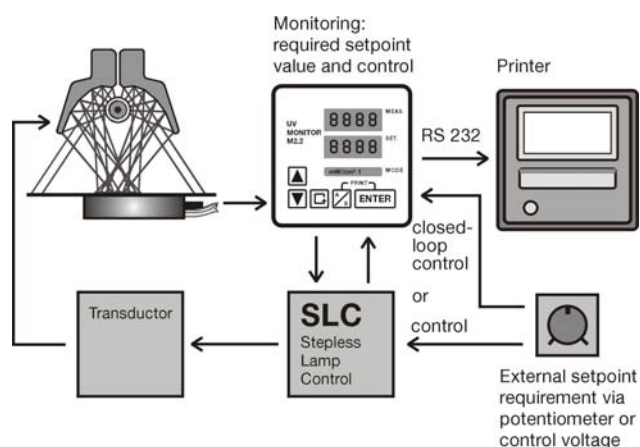
b) UV-output control

The measured UV-value may also be used as an electric setpoint value. It means that the control unit increases the electric output at the UV-lamp when the measured UV-value falls below the rated UV-value.

c) Speed-related UV-output control

In this variant the UV-limiting value is not fixed but varies according to changes in conveyor speed. This implies that the UV-radiation dose is always constant.

In all three processes the measured UV-value may be printed out for documentation purposes.



3.3 UV-unit design for car body varnishing

The configuration of UV-modules for the varnishing of a car body might be as follows. The individual UV-modules will be suited according to a light channel to the contour of the car body. Depending on the size of the required UV-dose tolerance of the coating, a moving apparatus for the modules is not required any more. Should the dose tolerance be not large enough to level out distance variations of some hundreds of millimetres, the UV-modules must follow up the car shape similar to a car wash line.

In case of undercuts and hollow spaces to be coated and cured, the unit manufacturer as well as the chemistry must contribute in view of the movement device of the module and the dose tolerance for coating.

From the chemical part there is a possibility of using so called Dual-Cure-Systems. In this system the UV-cross-linking is combined with a further thermal drying. The thermal drying makes sure that the coating will be cured on parts which are difficult or not to reach by UV-light and that a useable surface will be produced.

Furthermore it is possible to integrate UV-modules on robot-arms. With the help of corresponding door or hood openers the individual parts of a car body can be reached by UV-light and the coating can be cured.

3.4 Starting with UV in the car body varnishing

We think the first-class properties of UV-varnishing are only necessary on those parts which are later on exposed to extreme pressure (resistance to car wash and to chemicals).

It would certainly be helpful to limit UV-coating and curing of seals to visible areas, where UV-curing is unhindered. From our part it is most practicable to use existing coating-lines on solvents or water-base to integrate UV-units. Special models or high-value car bodies using quality as a distinguishing feature should be the starting point.

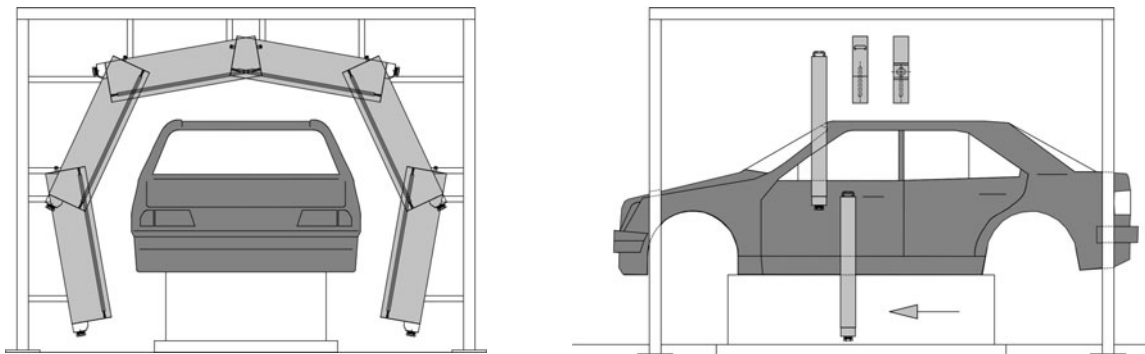


Figure 6+7: Car in a UV-tunnel, front view and lateral view

4 Outlook on further planned applications in the automotive sector

New developments of raw materials, inks and varnishes (like Dual-Cure-Systems with post-curing in a drying oven or on room temperature, binder with a better stability on metal or formulation for outdoor use) are making many more applications possible for UV-curing.

The following UV-applications might result:

- refinishing of cars
- priming of car body parts made of plastic
- scratch-proof coating of car body parts made of plastic

Refinishing of cars

Car repairs have become possible with the development of UV-cross-linking fillers and clearcoats polymerized by UV-light and equipped with heat-curing components for shadow areas.

The use of UV-curing systems shortens the drying period by half considerably decreasing the costs of a car repair. The risk of bad varnishing due to dust is limited thanks to the shortened drying interval. Furthermore, the surfaces can be used immediately after curing and are chemically and physically resistant.

For this application, it is very important to have a homogen light distribution without shadows on the object. It is planned to use combined curing devices like UV/IR-dryer or UV/convection oven-dryer.

4.1 Priming of car body parts made of plastic

Glass fibre reinforced plastics are increasingly used as materials for car body parts. The reasons are a cost-effective manufacturing, lower tool costs, lower weight, corrosion-resistance and permeability for radio waves for phone and satellite systems.

As a consequence of the production process, automotive components are often composed of several parts which are clipped and assembled after extrusion. According to the concept of the car manufacturer (online/inline-varnishing) the car body parts will have to resist to the subsequent dryers.

The car body parts are primed in order to seal open edges and to avoid popping due to the porosity of material. According to the material, conductive or non-conductive versions can be used.

A remarkable feature of UV-systems is the fact that the curing reaction takes place $< 60^{\circ}\text{C}$ and that undesired popping can be avoided. Subsequent treatment and rejects are considerably reduced.

In this field UV-units may be either designed as cycled units with the respective rotation possibilities or as flowline systems.

From the chemical side Dual-Cure systems are planned for a subsequent cross-linking of shadow areas by a thermal component.



4.2 Scratch-proof coatings of car body parts made of plastic

For the same reasons like automotive series varnishing (i.e. scratch and chemical resistance) there is a demand of placing the same kind of system on the market for the plastics sector.

From the varnish side, however, the elasticity of the material must be taken into account.

Design engineers suggest similar systems such as described under point 4.2. Dual-Cure-systems are required as they provide good properties in the shadow areas. Only the heavily used external parts must have all the features inherent to the UV-component.

The development possibilities of UV-technology are not yet exhausted by no means. In a partnership-cooperation between customers, ink and coating manufacturers, raw material manufacturers, OEM's and UV-unit manufacturers the mentioned application methods can certainly be further developed and verified.