A briefing on UV Curing

For Information only

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1. Major Advantages of UV Curing Process

Most UV inks and coatings are 100% solids with no volatile or flammable solvents. The wet film thickness deposited on the substrate does not decrease significantly during UV curing from evaporation of ingredients. The chemical components used in UV curing react very rapidly upon exposure to high intensity UV light, which allows high production outputs. The chemical reaction creates a crosslinked polymer network in the properly cured UV ink or coating. This provides excellent chemical or solvent resistance and excellent abrasion resistance properties. The high solids allow very high gloss to be achieved under proper conditions. The process is much more energy efficient than conventional drying processes. UV curing requires much less energy than electric or gas drying since the UV light can be easily focused where it is needed at the substrate surface. The chemical components used in UV inks and coatings contain stored energy in the molecules, which is released when the coating is irradiated with UV light. This enables the UV process to be designed to handle heat sensitive substrates. Water and solvent inks and coatings require more energy to evaporate the carrier during drying. The curing equipment is relatively compact and can be mounted in tight spaces on printing and coating equipment. Since UV products don’t evaporate, they do not dry on press and are easy to clean up.

2. Types of Chemistry Used to Formulate UV Coatings

There are two major types of chemistries used in UV curing, free radical chemistry and cationic chemistry. Acrylate monomers (reactive diluents) and oligomers (reactive resins) are the primary components of the free radical based formulations, giving the cured coating most of its physical characteristics. Acrylate monomers are low viscosity components which are the major component of low viscosity formulations used in flexo and gravure applications. Acrylate oligomers are the major component in UV rotary letterpress and offset coatings. Photoinitiators are required to absorb the UV light energy, destabilize to form free radicals, which attack the acrylate group C= C double bond and initiate polymerization. Additives are used to control coating slip, gloss, stability, rub resistance, antistatic, and other physical properties. Typical additives often include silicones, waxes, and inhibitors.

Cationic chemistry utilizes cycloaliphatic epoxy resins and vinyl ether monomers as the primary components. Photoinitiators absorb the UV light to form a Lewis acid, which attacks the epoxy ring initiating polymerization. Similar to acrylate chemistry, additives are used to improve coating performance.

3.Advantages and Disadvantages of the Two UV Chemistries

Acrylate chemistry is the most widely used because of its versatility. More raw materials are available to achieve a complete range of properties. Some acrylate raw materials are made in high volumes and are priced very competitively; this enables formulation of lower cost UV coatings. However, specialty acrylate resins which yield much better performance in demanding ink and coating applications, are often much higher in cost. This accounts for the large spread in UV product cost and performance. Better solvent and abrasion resistance can be achieved with acrylates. They have better compatability with water and solvent borne inks. Acrylate coatings are inhibited by oxygen at the coating surface. This has a slowing affect on the coating cure, especially in very thin coatings, less than 1 micron. Nitrogen inerting is sometimes necessary to achieve optimum properties, especially abrasion resistance. Since most UV presses do not have

nitrogen inerting capabilities, formulations must be designed to overcome this inhibition and still yield excellent performance.
Cationic formulations are generally lower in shrinkage, which can result in improved adhesion. They are also slower to develop full cure, and post cure is a major factor. Baking can be used to achieve excellent solvent resistance on heat stable products. These coatings generally have excellent barrier properties to water vapor and gases such as oxygen and carbon dioxide. The raw materials are generally lower in toxicity, possessing lower skin irritation potential. They also can be formulated to provide low odor and low extractables. Because they are acid catalyzed upon UV exposure, any amines will inhibit curing completely. These coatings can not be used over waterborne inks, which contain ammonia or amines. Solvent borne polyamide inks are also a problem, as are basic papers and UV products that contain amines. This limits use in many printing applications where incompatible materials are used extensively.

4. UV Coating Properties Required for In-Mold Label Applications.

The In-Mold label process involves insertion of the die cut and stacked label into the bottle or container mold cavity just prior to blowing or injecting the molten polymer into the mold. The label insertion equipment can jam if the label does not have the proper characteristics. The label must lay flat so that it feeds smoothly and then nests properly inside the mold cavity. The tendency for the label to curl can be increased significantly by shrinkage of the UV coating. Therefore, the formulation must be designed to minimize shrinkage stress on the label. Factors that affect shrinkage include type of formulation, UV coating thickness, label stock film thickness and density, UV ink and coating coverage, and size of the label. The label stack feed system also requires that the labels have excellent lubricity. The UV coating must have excellent slip qualities in order for the top label to release from the label below without jamming. The UV coating must also have antistatic properties for film In-Mold label stocks. Static electrical charges will cause labels to stick to each other causing jamming.
Once the label is applied to the container, protective and cosmetic properties are required of the UV coating. Most blow-molded containers have a satin or lower gloss finish. The UV coating can enhance label graphics by having high gloss qualities that stand out from the rest of the bottle- - - or, if the customer prefers, can match the gloss of the bottle providing a no label look. Label protection is one of the primary functions of any UV coating. In-Mold applications are usually very high volume applications. The labeled containers can be subject to severe punishment during automatic filling, boxing and shipping. It is essential that the label UV varnish have excellent abrasion resistance properties. The UV varnish must also provide good product resistance properties. Solvent resistance and or water resistance are often required. The type of label ink used will have a significant effect on final performance. UV flexo or rotary letterpress inks generally have better product resistance. Water and solvent inks can have a retarding affect on the UV varnish cure. Volatiles that are still in the ink can be absorbed by the UV coating and interfere with proper curing. Ambient humidity, type of stock, and percentage of ink coverage can all affect quality of cure.
In mold films usually are polyethylene based which results in a tough flexible film. This requires that the UV coating have excellent adhesion and toughness. The UV coating must stretch with the film at the edge of the label in the die cutting process. If the UV coating does not have enough elongation, it will crack and chip at the label edges. Adhesion of the UV coating is a function of several parameters. First a print treated receptive film surface is required to obtain

good wetting and adhesion of the UV coating. The UV coating must have low shrinkage to minimize stress at the film/UV-coating interface. The resin and monomer components used in the formulation must have a good affinity to the particular film substrate. The UV coating must be completely cured at the interface, any unreacted material will weaken adhesion. UV coatings are often loaded with a fluorescent tracer for machine readability. The intensity of the fluorescence is greatly affected by the background color of the printed label. White is the best background since it reflects the light back at the label reading equipment. Dark colored inks will absorb light and decrease the fluorescent intensity significantly.

5. Factors That Affect the Gloss and Performance of UV Coatings

Proper flowout is very important for achieving high gloss in UV coatings. Formulation additives such as silicones are used to improve the smoothness and gloss of the coating. Wax additives usually have a detrimental effect on gloss and are sometimes used to produce a satin finish. Silica flattening agents are used when a very low gloss is required. Viscosity is an important feature of any UV coating and is usually adjusted to the particular application equipment. On films generally lower viscosity will provide better flowout. Viscosity is greatly affected by temperature. Lowering the ambient temperature will cause a rapid increase in viscosity and reduce flowout.

Surface energy of the substrate is very important and is usually measured in dynes. Higher dyne levels indicate a better ink and coating receptive surface. An approximate rating system for UV coatings is as follows: above 44 is excellent, 40-43 is good, 37-39 is fair, 34 - 36 is marginal or a potential problem, below 33 is trouble. This is not by any means a universal test, many films, inks and coatings behave differently. UV coatings have different abilities to wet surfaces which is referred to as surface tension. The higher the surface tension the poorer the coating will wet and flowout. Therefore, the surface tension of the UV coating must be lower than the film's surface energy in order to achieve good wetting.

Equipment design is a significant factor in achieving a high gloss or smooth coating. The distance between the application of the coating and the UV curing lamps affects the time the coating has to flowout. Because UV coatings are 100% solids, there is no solvent present to lower viscosity and aid in leveling. Increasing the distance between application and curing can significantly improve gloss on nonporous substrates such as films and foils. The wet film thickness also has a significant impact on gloss. Thicker coatings increase the mobility of the top surface of the UV coating which can smooth out faster providing a higher gloss. The application equipment controls the coating laydown pattern and thickness. Flat or rotary screen equipment is used to apply coatings from 4 microms to 100 microns. This is one of the best methods for appling a smooth heavy laydown of coating and generally provides very high gloss values of 85 to 95 at 60° when sufficient flowout time is provided, however, it usually limits production speeds. Gravure equipment is sometimes used for application of UV coatings. It requires a low viscosity of 100 cps or less to achieve good flowout. Gravure presses operate at fairly high speeds, 400- 800 FPM, and tend to apply a relatively thick and heavily patterned coating. Therefore the need for a very low viscosity and sufficient flowout time is imperative. Flexo application equipment is one of the best methods for achieving a smooth uniform coat weight between 2 - 12 microns. Very high gloss coatings can be achieved when adequate flowout time is provided. Viscosities range from 50 to 5000 cps with the average being between 100 - 400 cps depending on the application. Higher viscosity coatings tend to go on heavier and decrease mileage for a particular anilox. Unfortunately, most narrow web presses do not provide adequate flowout to achieve a very high gloss at speeds greater than 200 FPM. Letterpress equipment applies a very thin and uniform coat weight of about 1-2 microns. It requires a relatively high viscosity to allow proper transfer between the rollers. Typical viscosities range from 2000 to 20,000 cps. Letterpress paste inks are significantly higher in viscosity than UV clear coatings. UV offset coatings range from 70,000 to 120,000 cps and also apply a very thin coat weight of 1-2 microns. High gloss coatings can not be achieved with letterpress and offset application equipment..

Other factors that influence gloss and also coating performance include foam, surface bloom, paper or film porosity and smoothness and surface energy of the substrate. Excessive foaming in screen, gravure and flexo applications will create pits or voids in the coating which will decrease gloss and, if severe enough, product resistance. Surface bloom is when some of the unreacted components of the UV coating migrate to the coating surface causing a hazy or foggy surface. Something is generally wrong with the formulation or curing conditions resulting in too much unreacted material migrating to the coating surface. Inadequate drying of inks under the UV coating can slow the cure or leave unreacted components in the cured coating, which can cause fogging. Substrate porosity and smoothness has a major affect on coating gloss and product resistance. Porous papers will soak up low viscosity UV coatings preventing proper gloss development and product resistance. Absorbtion into the paper stock can be a major problem since uncured UV components that remain underneath the paper surface will create possible migration problems which can seriously degrade the label product resistance and can cause contamination of the labeled product. Indications of a porosity problem are stronger than normal odor from uncured components, poorer gloss and product resistance than is usually obtained with the UV varnish. Some matte films can also have a high porosity. These types of stocks should generally be avoided. However, if they must be used consult your coating and ink supplier for proper recommendations as these problems can be overcome by use of either primers or special varnishes. Surface energy of the substrate has a major effect on coating smoothness, since the coating will bead up on low energy surfaces. Corona treatment will enhance surface energy on many film substrates. It helps vaporize any surface contaminants, such as film additives or plasticizers, if present, and etches the film surface. Effectiveness of the treatment will last for different time periods depending on the particular type of film.

6. Review of Important Properties of UV Coatings

The primary purpose of UV coatings for In-Mold Label applications is to provide protection to the label. This includes product and abrasion resistance. Most In-Mold applications are polyethylene bottles for shampoos and detergents. Therefore excellent water and detergent resistance are more important than solvent resistance. Excellent solvent resistance does not necessarily mean good water or detergent resistance. Because these are heavy bottles when filled, abrasion resistance is very important so the label graphics do not disappear during shipping. In-Mold UV coatings must have good toughness and adhesion to polyethylene films. There can be no cracking or chipping at the label edges.

In-Mold label UV coatings must have minimal shrinkage. Shrinkage is a bigger problem on film labels than on paper. Increasing solvent resistance generally increases shrinkage. This can be compensated to a large extent by decreasing the UV coating deposit, since shrinkage increases as

the coat weight increases. Excessive shrinkage can cause edge curl, adhesion loss, cracking and chipping. Flexibility improves as you decrease the coating thickness.
Oxygen inhibits the UV acrylate curing reaction so that thinner coatings are slower to cure. Amines inhibit the cationic UV curing mechanism and must be avoided if this chemistry is considered. High humidity will also have a retarding effect on cationic systems.
Blocking increases with smoother high gloss coatings on film. UV coatings must have good slip and anti-static properties for In-Mold applications.

7. Summary

UV coatings are used very successfully for In-Mold label applications. However, the product must be optimized for the specific properties required in your application. Convey all the necessary properties needed for your application to your ink and coatings supplier, and they will be able to provide their best product for your application.

UV-powder is a new technology to coat MDF panels. As compared to existing technologies, UV powder coating enables almost any shape, curve or edge profile to be seamlessly coated, thereby allowing new and more creative furniture design. **Any shape**, curve or edge profile, can now be Engineered wood such as MDF can be coated and finished in an economical one-step operation. This solvent-free process offers high utilisation of material with minimal waste. UV powders are available in a range of colours, textures and special effects. Material performance is excellent and meets the stringent DIN standard for kitchen and office furniture. Lines to apply UV-powder on MDF panels have been set up in Europe and in America for MDF panels. coated by **one layer** of coating.

UV Curing Technology Advantages

The change in state from liquid (wet) to solid (dry) is almost instantaneous as UV curable material is passed through a UV drying system. A diverse range of substrates is suitable for UV printing and coating, from heavy-gauge metal sheet to thin-gauge polymeric films.

UV curing offers:
Instant drying
Low operating cost
Improved quality
Reduced space
Clean and efficient

UV material performance provides:
Rapid cure
High-color saturation
Good light-fastness
Good heat-fastness
Good flexibility
Good adhesion
High process resistance

The UV decoration process offers:
High in-line gloss finish
Wet equals dry film thickness (no solvent removal)
Reduced dot gain (wet on dry printing)
Excellent color control
Long open times on press
Reduced wash-ups
Faster make-ready

The UV curing process offers:
Low odor
Low residual volatiles
Low toxicity
No solvent
No VOC
Reduced energy

Relationship between Pigment Properties and UV-curing Efficiency

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Abstract

Increasing legislative pressure on VOC restrictions and economic rationalization will reinforce the role of the UV-curing technology in the future developments of the coating industry. One of the key success factors for the expansion of UV-curable systems will be the possibility to further enlarge the scope of applications to more sophisticated pigmented coatings than white and to obtain a comprehensive range of shades without limitations in terms of pigments and pigment combinations.

The problem with such systems is the difficulty to cure them effectively due to the light absorption of pigments that puts the initiators in the shadow, reduces their photolysis, diminishes radical production and cure efficiency. With a novel class of photoinitiators based on the chemistry of bis-acylphosphinoxides ("BAPO"), a major step has been made in achieving effective cure of pigmented and coloured coatings. On the other hand little research has been done by manufacturers to optimize the pigments properties for maximum UV-curing efficiency [1]. Preliminary investigations on this approach are reported here.

Introduction

Material colouration can be obtained in principle with dyes and/or pigments. By incorporation into solvents or binders, dyes and pigments will behave differently, the former being entirely soluble compounds whereas pigments will disperse as insoluble particles. The physical and optical properties of pigment particles are strongly depending on their crystal form and size, whereas the properties of dyes are essentially linked to their molecular constitution [2,3].

The optical properties of colourants play a essential role for their effective use in UV-curing applications. For dyes the main influencing factor is the absorption behaviour, whereas for pigments not only the absorption characteristics but also the light scattering and reflection are essential parameters (Figure 1).

In recent years, a real breakthrough has been made on curing white TiO2 pigmented formulations thanks to the use of BAPO type photoinitiators.

The peculiar feature of BAPO is their UV absorption spectra tailing into the visible range up to 430nm (Figure 2). The sharp cut-off of TiO2 around 370 nm allows the initiator to absorb the UV-VIS radiation in the 370 to 430 nm range emitted by standard medium pressure mercury vapor lamps and produce enough radicals to effectively through cure even thick coating sections. Blends with á-hydroxyketone initiators are actually needed to improve the surface cure properties. Such combinations are today ´state of the art´ for white coatings.

In contrary to the sharp absorbance edge of white pigments around 370-380 nm, coloured pigments have much larger absorption bands covering both the UV and visible radiation ranges. For BAPO initiators, the 370 to 430nm zone is of particular importance and any colourant that absorbs in this area reduces the efficiency of photoinitiator photolysis thus reducing the formation of initiating radicals. As a consequence, coloured layers are more difficult to cure than white coatings. Several evaluations on curing coloured coatings have been reported [4-7] . Until now no definitive correlation between curing efficiency and optical properties of the pigments have been predicted.

The optical properties of pigments can be considerably modified by varying chemistry, particle size and distribution, crystal shape and crystal modification. How such changes influence the efficiency of UV-curing will now be analysed in the next section. The goal of the study is to better understand the relation between the photophysical properties of pigments and cure efficiency in order to be in a position to develop adequate products in terms of pigments and initiators for achieving best cure performance.

Experimental Part

Absorption, remission, direct and integral transmission spectra were recorded using a Perkin Elmer Lambda 900 UIV/Vis/NIR Spectrometer.

Thermosetting alkyd films: the pigments were dispersed at 1% level into an Alkyd/Melamine binder system and the coatings were applied at 100 g/m2 on transparent foils resulting in ca 40 microns dry films. The pigment dispersion degree was controlled by microscopy.

UV-curable formulations: for the UV-curing experiments, formulations based on 65% Polyesteracrylate/ 15% HDDA ,10% TMPTA and 10% pigments were used. To achieve 35-40 microns cured films, the wet paint application was about 60g/m2. White chipboards were used as substrates and UV-curing was realized with two 80W/cm medium pressure mercury vapour lamps with a belt speed of 3 or 5m/min.

As photoinitiators blends of BAPO and á-hydroxyketone were used (IRGACURE 819 and IRGACURE 184, see Figure 2). The pendulum hardnesses were assessed according to the Koenig method.

Results and Discussion

Particle Size variation of CI Pigment Red 254

In a first series of experiments, the parameter that was under investigation was the particle size variation of a selected pigment, the CI Pigment Red 254.

The chemical structure of PR254 (or Dichloro DPP) is 3,6-Bis-(4-chloro-phenyl)-2,5-dihydro-pyrrolo[3,4-.c.]pyrrole-1,4-dione and is shown on Figure 3. Different particle sizes of this pigment have been obtained by common techniques of crystal growth inhibition or crystal growth conditioning.

Figure 4 shows the particle size variation determined by ultrasedimentation according to the technique described by Joyce Loeble [8]. In addition the specific surface areas were measured according to the BET-method [9].

The hiding power of the pigment is determined by its scattering coefficient. This coefficient is a function of particle size and the difference of the refractive indices of the pigment and the vehicle. Within the series of PR 254, the sample 254/4 is close to the maximum of the scattering coefficient resulting in highest opacity (lowest color difference over black and white underground) within the visible light region (see Figure 5). For smaller particle sizes and surprisingly also for larger particle sizes the transparency increases.

For the reasons already mentioned, the UV-VIS region between 370nm and 430nm is an important wavelenghth area as pigment transparency in this area is required for effective activation of the BAPO initiator.

Figure 6 displays the direct transmission spectra of samples 254/1 to 254/5 in this area. It can be seen that the transmission values vary and show all a maximum at ca 390-395 nm. Figure 7 summarizes the transmission values at this maximum for all samples. It is easily recognizable that the lowest direct transmission and in consequence the maximum scattering and reflection is again obtained with the sample 254/4. By comparing Figures 5 and 7 we can deduce that the effect of particle size on maximum transmission in the UV-VIS area and transparency in the visible area show quite remarkable similar trends. The opacity is highest and the direct transmission at 395 nm is lowest for the samples 254/4 and 254/5.

Effect of particle size on UV curing results

Figure 8 shows the results with the UV curable Polyesteracrylate systems in function of the particle sizes of PR 254 [5]. Different blend ratios of BAPO and á-hydroxyketone have been used. The line speed of the UV equipment has been run at 3 and 5 m/min. The results clearly indicate a direct relation between cure efficiency improvement , in terms of film hardness, and increase of particle size. This is in spectacular contradiction to the direct transmission values and the transparency levels as seen in Figures 5 and 7. From these data it was expected to have the greatest difficulty to cure the systems with the sample 254/4. As this is not the case we must admit that a simple “ high transmission window” of the pigments is not the only neither a major factor to get favorable cure properties.

Correlation

In contrary to dyes, which show “pure” transmission/absorption characteristics, the photophysical behaviour of pigments is influenced by light scattering and reflection. In this case one uses commonly the so-called “ integrated transmission” values to characterize the pigments behaviour. The direct transmission spectra discussed precedently are excluding the influence of scattering and reflection. These are “pure” transmission spectra. The scattered and reflected light in the UV-VIS wavelength areas clearly will have an influence on the through cure of pigmented coatings . The Figure 9 shows the variation of maximal intensities of the integrated transmission between 370 and 430nm for the particle size series of the PR 254. In contrary to the direct transmission values that show , in function of particle size a minimum for sample 254/4, the maximal integrated transmission values increase almost linearly with the growth of the particle size. It appears now very clearly that the particle size dependance of the curing efficiency (Figure 8) follows the same tendency as the integrated transmission values in the tested PR 254 series (Figure 9). The conclusion of this part of the study is that maximizing cure efficiency will require a careful pigment selection by highest integrated transmission values in the critical 370-430nm range to the photoinitiator rather than by simple direct light transmission characteristics.

Other Pigments

Figure 10 displays the integrated transmission curves including the scattering and reflection contributions of three yellow Iron-oxides. All three pigments have nearly the same transparency measured in the visible light area. However from the integrated transmission data it can be predicted that the efficiency of UV-curing should increase in the series BAYFERROX Yellow 3910, BAYFERROX Yellow 930 to BAYFERROX Yellow 3950. This is exactly the case [10]. The UV-curing results are indicated in Figure 11. For BAYFERROX Yellow 3910 an acceptable film hardness can only be achieved with a thinner thickness than for the two other Iron-oxides.

Conclusions

As the results of this study demonstrate, the efficiency of UV-curing is found to correlate well with the integrated transmission spectra of the pigments used which include the scattering and reflection contribution in the critical 370 to 430 nm wavelength region, where the BAPO photoinitiators absorb. Predicting cure performance on the sole transparency in the visual light area might not be accurate and lead to wrong results.

The photophysical properties of pigments as the light scattering and reflecting behavior in the UV-VIS region of 370 to 430nm play an essential role in the photocuring efficiency of pigmented UV-curable systems catalyzed by BAPO initiators. The possibility is given to pigment manufacturers to influence and optimize the required properties by varying particle sizes, shapes and eventual surface treatments of a given pigment chemistry. The position of the integrated transmission maxima in the critical wavelength area can be shifted by changing the pigment chemistry. To better match the absorbance peaks of the photoinitiators with these transmission maxima is another way to improve through cure efficiency. This gives the photoinitiator producers means to determine new product profiles for more effective photopolymerization catalysts.

Case Study No. 18 – UV-Cured Coatings

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Background

Prestige was founded in 1967 and produces all-wood, semi-custom cabinetry. Oak, maple, cherry, and hickory are the primary wood species and are finished with eight different stain colors. While some plywood veneers are used, there is no particle boardin any of Prestige's products. Prestige operates one shift, five days per week. There are 240 employees, including sales staff and drivers; 170 of these employees are hourly employees on the manufacturing line. The finishing line has 29 employees: 18 on the spray line, 6 on the flat line, 4 to clean the finishing room at night, and 1 maintenance employee specifically for the finishing operations. Prestige has an annual production of 117,000 units, but anticipates this number will rise in 1999. The change to UV-curable coatings began in 1992, as a the result of Prestige's search for a higher-quality finish.

Manufacturing and Coating Operations

On average, it takes seven days to mill, finish, and assemble an order. Prestige receives raw lumber and planes it to size. The lumber is sanded, ripped, and cut to length. A tthis point, the pieces are sorted into four classes to provide a better color consistency in the final product. Three of the classes are purely color classes: light, medium, and dark. The other class is for a product that showcases the knots in the wood to create a more "rustic" appearance. As a result of utilizing the knotty material, Prestige has reduced their wood waste. After sorting, the pieces are glued together and cut to size. Cabinet components are finished prior to assembly. Prestige operates two automated finishing lines: a flat line and a spray line. There also are two small spray booths, one for touch-up and repair and one to apply coating to parts that cannot be finished on the automated lines. The pieces that cannot be finished by the automated lines make up a small percentage of production and include items such as shelf edges and Queen Anne legs. The coatings in both spray booths are solvent-borne and are applied using HVLP guns.

The flat line is a horseshoe-shaped roll coating line, used mainly for flat components such as cabinet box parts. The conveyor operates at 40 feet per minute. Pieces first go through a dual-sponge roll coater that applies solvent-borne stains or whitewash. One roll is used for all stains, but the white coatings require a separate roll because it is too difficult to clean the white coatings
completely from the roll. A reclamation system is in place to catch all excess coating and funnel it back into the coating reservoir. The pieces then are conveyed through a series of three brushes that eliminate the hand wiping step. The stain then is sanded by an automated brush-sander and conveyed to a roll coater. These rollers are a combination of rubber and steel that apply the 100 percent solids UV-curable sealer. The line then moves under two UV lamps to cure the seal coat. A second coat of sealer

is applied and cured, and the piece is brush-sanded. Two coats of UV-curable topcoat are applied; the first is cured using two UV lamps and the second is cured using four UV lamps. Pieces then pass through the line again to be finished on the opposite side. The automated spray line is a circular line, with a cycle time of 15 minutes. The entire finishing process consists of three passes through the line and takes about 45 minutes. The spray line is used for pieces that are not entirely flat, such as doors, drawer fronts, face frames, and moldings.

After the pieces are loaded onto the conveyor, they are hand sanded. A solventborne stain then is applied by the automated spray system. The system has electronic eyes that sense when product is passing through the booth, and spray coating only when product is present, which helps to reduce overspray. The spraying mechanism contains six chambers: two for stains, two for sealer/topcoat, and two that are empty. The coatings are directly pumped from 55-gallon drums located in the paint kitchen. There are four arms with two guns each that move in a circular pattern and are aligned to ensure coating is applied to the front or back and all four sides of a piece. All of the guns on the automated spray line are air-assisted airless, and have transfer efficiencies of 50 to 60 percent.

After the stain is applied, the pieces go through a stain wiping machine and the edges are hand wiped. Components then are conveyed through a gas-fired oven to flash off the solvent in the stain and pass under three sets of UV lamps for curing. The pieces continue on the conveyor and pass through the second automated spray booth where the first coat of UV-curable sealer/topcoat is applied, then through a gas-fired oven where 3 coating solvent flashes off and under another set of three UV lamps for curing. The pieces then are sealer-sanded, turned over, and go around the line a second time for stain, sealer, and topcoat. The pieces go around the line for a third and final time, and UV sealer/topcoat is applied first to one side, then the other (no stain is applied on the third pass). The pieces then are taken off the finishing line and are ready for the assembly line.

Gluing Operations

Prestige previously was using a two-part formaldehyde glue that had to be mixed before application. In 1992, they began using all waterborne or hot melt adhesives. The quality of these glues is equivalent to the previous glue system, and the associated formaldehyde emissions have been eliminated.

Cleaning Operations

Neither of Prestige’s finishing lines requires extensive cleaning. The flat line requires little cleaning; the brushes and sponge rollers are cleaned with a no-HAP cleaning solution. However, Prestige still uses acetone on the automated spray lines because an alternative cleaning solution has not been found that can do an adequate job. The automated spray line has four different dedicated coating lines fed into it, which reduces cleaning due to color changes.

Conversion to UV-Cured Coatings

Prestige previously had an overhead and cart line and was finishing with air-assisted airless and conventional spray guns. Their coatings were traditional solvent-borne stains, sealers, and topcoats. In 1992, while investigating higher-quality finishing systems, Prestige decided to switch to a waterborne UV-curable finishing system.

From July 1992 to March of 1993, Prestige used a waterborne UV-curable sealer and topcoat on their automated spray line. The quality of the coatings they were using was poor, with an assortment of problems. The finish was very durable, but the appearance was not acceptable. Prestige had to replace thousands of dollars of product because of bad finishes. In March of 1993, Prestige switched to a solvent-borne UV-curable sealer and topcoat in the automated spray line. This system is still in use today.

Prestige was very disappointed with the waterborne UV-curable coatings. They had visited the supplier's lab to see the finish quality before installing the system, but never achieved results similar to what they had seen. Prestige is happy with the finish they are producing currently, using the solvent-borne UV-curable materials. The finish is durable and of comparable quality to their previous finishing system.

One of the main problems Prestige encountered with the solvent-borne UV-curable system was maintenance. The UV-curable coatings are very sticky and difficult to clean from the equipment, especially on the spray line. The only product that Prestige has found that does a good job is acetone. The flat line is easier to clean and Prestige has found a no-HAP cleaner that does a good job.

Another problem with the UV finishing system is repair. The UV-curable material cannot be spot repaired like the traditional solvent-borne coatings. When an entire piece needed to be refinished with the old system, the piece was placed in a wash-off tank filled with acetone to strip the damaged coating. However, the acetone does not strip off the UV-curable coatings; instead the entire piece must be sanded down to bare wood and refinished or entirely replaced. Other finishing problems include additional sanding and impurities in the coatings. Prestige does have filters in the lines to screen out the majority of impurities in the coatings, but occasionally receives batches that have enough impurities in them that the filter does not catch them all.

The operators did not have much trouble with the transition between coating systems.The systems are highly automated, but to achieve the finish Prestige requires, the spray line is operated with twice as many people as the equipment manufacturer suggested. The main reason for the extra labor is sanding. Because Prestige produces a true raised panel, an automated sander would only sand the raised center.

For this reason, Prestige does all finish sanding on the automatic spray line by hand. However, prefinishing sanding can be done by a sanding machine and Prestige is in the process of implementing an orbital sander for prefinish sanding to reduce labor requirements.

Costs

The capital costs for the new finishing system were high, around $1.2 million. However, that cost included a new building in which to house the finishing lines, so the actual capital cost to the UV-curing and finishing equipment was much less than $1.2 million. An additional $150,000 was spent for associated electrical equipment.

The costs of operating the UV-curable coating line also are higher, as the coatings themselves are more expensive and the usage per cabinet is approximately the same.

Prestige also replaced the conventional guns in their spray booth with HVLP guns at a cost of $155 each.

Emissions

Prestige is a major source and is subject to the Wood Furniture NESHAP. The majority of the current emissions are from the stains and the spray booth that is used for touchup and repair. The emissions from the main finishing processes have been reduced significantly since the change to UV-curable coatings. Because of the changes in production, the best comparison is in pounds of VOC emissions per unit of product. With the old solvent-borne finishing materials, Prestige was emitting 2.7 pounds of VOCs per unit produced. After the change to UV-curable coatings, this number was reduced to 1.63 pounds of VOCs per unit produced, a 40 percent emissions reduction.

New UV-curable coatings for rubber extrusions save time, money, waste and space

by Steve Butler, European Sales Manager for Flexible Finishes, Whitford Plastics

In general, fluoropolymer coatings used to coat automotive sealing systems are spray-applied, directly after vulcanisation of the rubber during the extrusion process, and then thermally-cured in a series of conventional microwave or IR ovens.

But this conventional cure process is costly, inefficient and results in high overhead costs. Whitford, manufacturer of the largest, most complete line of fluoropolymer coatings in the world, has developed a range of waterborne coatings (marketed under the name Xylan® 2525) that can be UV-cured with no sacrifice in performance. Using a UV-curable system in a continual extrusion process means an enormous increase in the speed of cure, leading to significant waste reductions, lower energy costs and huge space savings.

Why automotive manufacturers coat their sealing systems

Rubber sealing systems play an important role in vehicles of all shapes and sizes. Without them, it is virtually impossible to make a window wind and remain water-tight. Automotive door and boot seals, including primary and secondary seals for weatherstrip and glass-run applications, are commonly manufactured from extruded EPDM. It is often necessary to apply a coating to the seal to improve the end-use properties. These include low friction, non-stick, freeze-release, noise reduction, and chemical, weather and abrasion resistance properties. Automotive manufacturers usually set specifications for each of these parameters.

The bulk of each rubber seal is invisible when the window or door is closed, but some parts are visible as a black border between the glass and the window frame, or around the inside of the door. Nowadays designers endeavour to colour co-ordinate these parts of the seals with the rest of the interior of the car, and this can be achieved through the use of fluoropolymer coatings. In this application, the coatings also have to offer UV-resistance and easy-clean properties.

Conventional, heat-cured coatings

Typical polyurethane dispersion (PUD) coatings for this market contain a lubricant and are spray-applied directly after vulcanisation of the rubber as part of the extrusion process. After application of the coating, a second cure cycle is required to cure the coating itself. Usually this involves a series of convection 'tunnel', microwave or IR ovens. (Figure 3).

Before the curing step the coating has little abrasion or chemical resistance and is often 'tacky' to the touch, even when the carrier (either water or organic solvents) has evaporated. The heat-driven cure facilitates the reaction of the cross-linker with free OH-groups to form a fully cross-linked polyurethane.

Such heat-cured coating systems are well accepted in the industry and are often specified by the automotive manufacturers. However, the cure process has a number of significant disadvantages:

- Facilitating the cure process is a costly and inefficient process overhead. The tunnel ovens for the curing process involve high energy costs and significant machinery investment.
- They occupy a significant amount of expensive production space: Typically at least 30 per cent of the space required for an extrusion line with online coating application is occupied by the ovens facilitating the heat cure of the coating.
- They are slow.
- They generate significant waste.

Advantages of UV-curable coating systems

UV-curable coatings are well known in non-automotive industries. Many of the coatings used in the furniture industry, for example, are cured by UV radiation. One of the most important advantages of UV-curable coatings over conventional air-drying or heat-cured coatings is the speed of cure. Typically a UV-curable coating is cured in less than a second. A conventional air-drying wood coating needs minutes, if not hours, to dry completely. This difference in speed of cure facilitates much higher line speeds - an enormous economic advantage.

The UV-cure mechanism also generates a film with increased chemical resistance, as a more 'rigid' network of covalent bonds is formed during the cure process. Typically these UV-curable wood coatings are 100 per cent monomer systems. That means they contain no additional solvents, but only UV-curable monomers and/or oligomers, and solids like pigments, fillers etc.

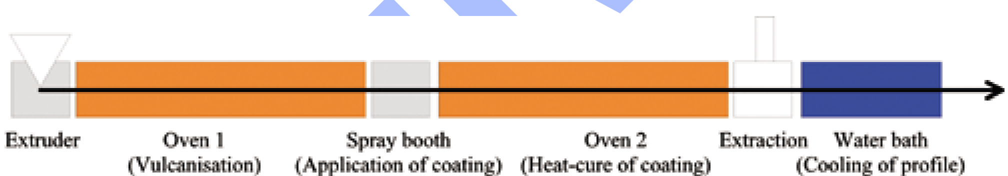

Figure 3: Simplified representation of an EPDM-extrusion line with online coating application and conventional heat-curing (not to scale)

Application of UV-cure technology to coatings for automotive sealing systems

Existing heat-cured fluoropolymer coatings for rubber sealing systems are already chemically cross-linked. So increasing chemical-resistance is not the objective. The aim is to develop a product that offers the benefits of the well-established heat-cured coatings, but with the short, almost immediate, curing time of a UV-curable coating.

Transferring these benefits of UV-curable coating systems to a continuous extrusion process leads to the following:

Space saving

The space occupied by a conventional hot-air oven is typically 30m long. Yet the UV-curing system requires space on the extrusion line of only about 5m. The UV-curing system consists of a short set of IR lamps, followed by the UV-oven itself. The IR lamps are necessary as the majority of coatings used in today's automotive industry are waterborne, and it is necessary remove the water, via the IR lamps, before the UV-cure takes place (Figure 4).

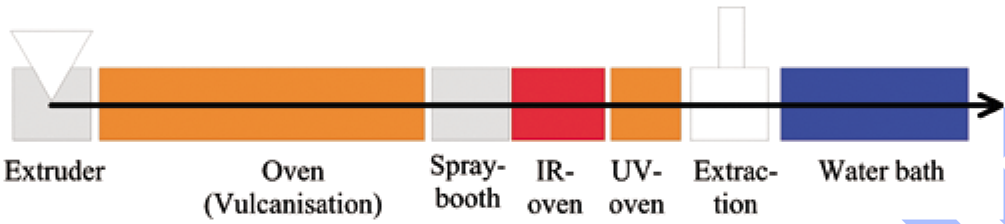

Figure 4: Simplified representation of an EPDM-extrusion line with online coating application and UV-curing (not to scale)

Easy installation of UV-curing equipment

The required UV-curing equipment can easily be installed on to the existing extrusion/coating lines, at the same time freeing up expensive manufacturing space occupied by the defunct 'tunnel' oven configuration.

Lower energy costs

Using 'tunnel' ovens requires pre-heating the oven before the coating of the extrusion profile can commence, and then maintaining this elevated 'working' temperature even when the extrusion line is idle. UV-lamp systems can be put on standby, shuttered operation when not in use and, when needed, can be operational almost instantaneously.

Reduced waste

As with any continuous process, there is always an amount of waste generated during the time before the required running conditions are achieved. In extrusion lines, the difficulty is often obtaining the correct wet-film/dry-film thickness of the coating. On current heat-cure lines, the dry-film measurements are taken after a cure cycle lasting 1.5-3 minutes long. Further, several spray gun adjustments may be required to achieve the correct coating thickness. When combined with a typical extrusion speed of 15 m/min, this equates to a substantial amount of waste coated profile. For the UV-coating process, since the time of cure cycle is greatly reduced, the corresponding amount of scrap profile is significantly less.

Increased line speed

During the past few years, many modern extrusion processes have been developed. State-of-the-art extrusion lines for EPDM profiles can run at up to 50 m/min. Yet, with the current PUD coating systems, it is not possible to cure the coating at the high line speeds because:

- The required oven capacity, approximately 100m in length, would require too much investment in machinery, consume huge amounts of energy for heating, and would require too much space, or would not fit in typical production facilities.
- As PUD coatings are typically tacky until they are fully cured, the coated profile must run though the 'tunnel' oven without touching any parts of it. This is possible at the current oven lengths, but cannot be managed at the oven lengths needed for these high line speeds.

Opening the door to more environmentally-friendly substrates

UV-cure coatings can be used on a much wider range of substrates than traditional heat-cured coatings. At the moment EPDM is the most widely used substrate, but it is not recyclable. Thermoplastic elastomers (TPEs) and thermoplastic vulcanisates (TPVs) are therefore becoming more and more popular for automotive applications as they can be recycled more easily. However, as they are thermoplastic, they cannot be coated with the existing heat-cured coating systems due to the high cure temperature. Whitford's UV-curable coatings overcome this problem by eliminating the need for high temperatures from the curing process.

UV Curing module for Web offset

UV curing system for web offset has been developed after long years of test and trials by Advance Curing System, the pioneers in India in the field of ultraviolet and infrared technology. This system incorporates all the features available to suit the modern working environment and to suit the latest models of web offset press that are being manufactured today. Compact and rigid in construction, and flexible in operation has enabled the system most compactable to all the universally well-known web offsets. The advance features make it communicate with the control systems of the press making it more flexible and easy in operation.

Constructed in aluminum with designed reflector, shutter mechanism operating on pneumatic rotary activators, designed cooling design, with air jacket insulation adds to its features for long and continuous trouble free operation. Separate control panel, stand alone monitors feather touch key pad, controls and regulates the UV lamp with total Programmable Logic Control. Safety features of international norms adds to its credit. Unique design, compact and elegant finish makes it competent to the international market. Special fixtures for end of the press, for turner bar, for straight or slant feeds are available. Installation at site and training by our staff. Available with different voltage inputs to suit different countries. ACS also manufactures UV and IR systems for end of the offset, for laboratories, for screen printing, for 3D curing and various custom built requirements.

For more Information:contact

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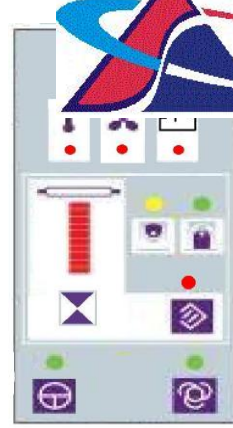

UV Curing for End of Sheet Fed offset

UV curing system for end of the sheet fed offset has been designed with flexibility in mind. Years of experience in graphic industry knowledge of ultraviolet concepts has enabled to bring about trouble free stand alone UV curing for end of sheet fed offset. UV curing has been proved the most efficient source in print drying, added to many advantages that are provided to the printers in offset. Today, as the consumables like inks are coatings are easily available it has initiated most of the printers to change over from conventional printing to UV printing. It must also be noted that UV clear coating eliminates the lamination, which is an added advantage, saving lot of time, manpower and multiple laminating machine's as the coating is done at the speed of printing. More over printing on plastics with UV, inks have made way to various new innovative products.

Advance Curing System has developed UV curing machines, which are more convenient to change over from conventional printing to UV printing. ACS machines are built above the hurdles of operation process. These machines are custom built to suit any of your offset press depending on the width. The number of UV lamps is installed depending on the speed in which the production is done by the printer. All safety features are incorporated which makes the system easy for the operator. Cooler UV for PVC and Plastic card manufacturers.

ACS end of the press UV systems are designed to be installed at the delivery end of the press. The vacuum conveyor of variable speed transports the printed or coated sheets and takes it to the UV curing chamber and cures it. The cured sheets are then passed on to the delivery conveyor. The various options provided in the system make it flexible to suit the need of the printer. Systems are available from 24 inches to 48 inches curing width. UV with or without infrared chamber for conventional applications. 1, 2 or 3 UV lamps depending the speed of the press are available. Stand-alone control panel with complete digital readout of the parameters, cooling of the lamps, vacuum blower are mounted on castor wheels for easy installation and handling. Systems are available with 415V + 5% 50 Hz. (other voltages to suit different countries). The system is complete with installation and training provided by the staff of ACS. All technical information are available from ACS, we not only provide systems but solution. If you need any further clarification, get in touch with the pioneers.

ACS UV Technologies
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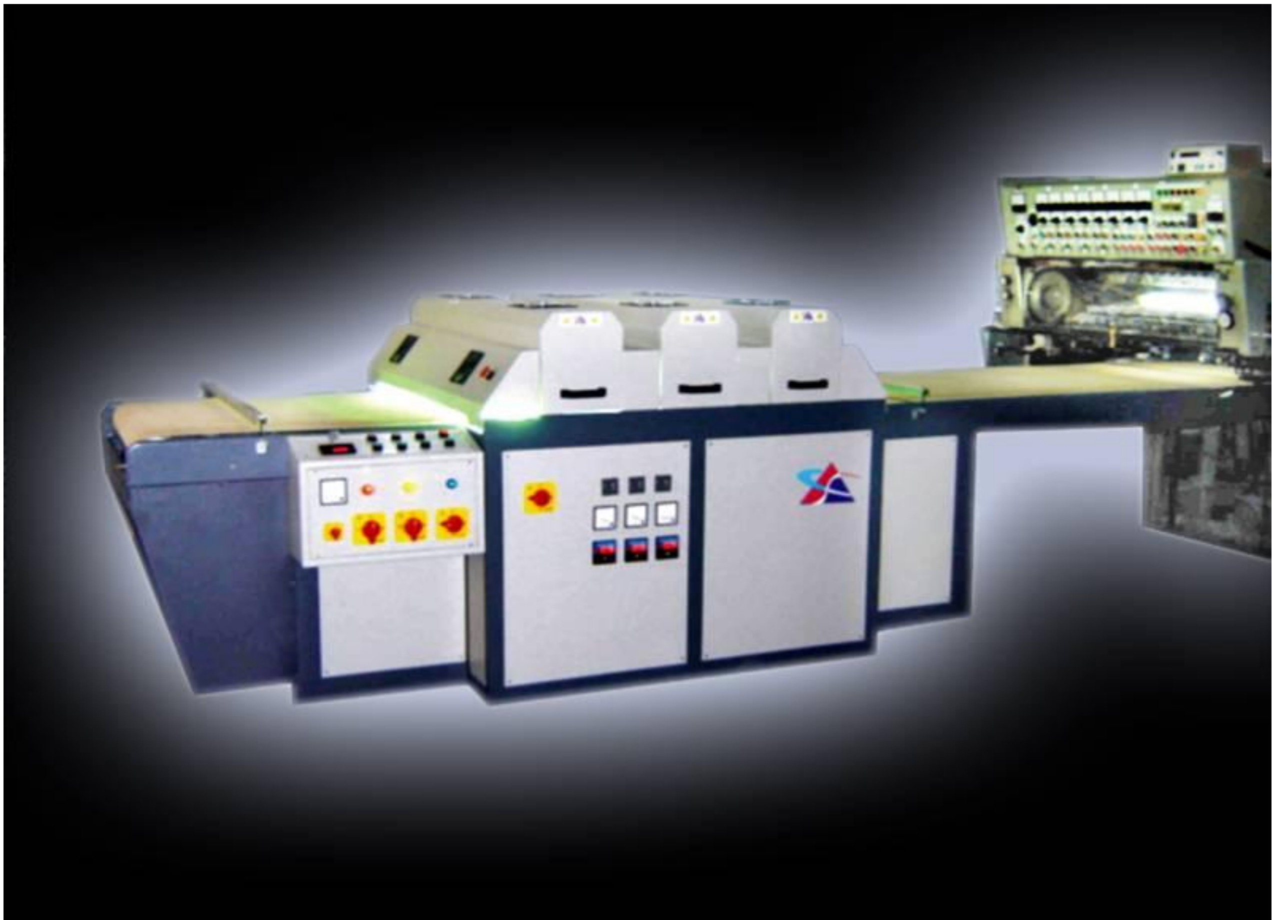
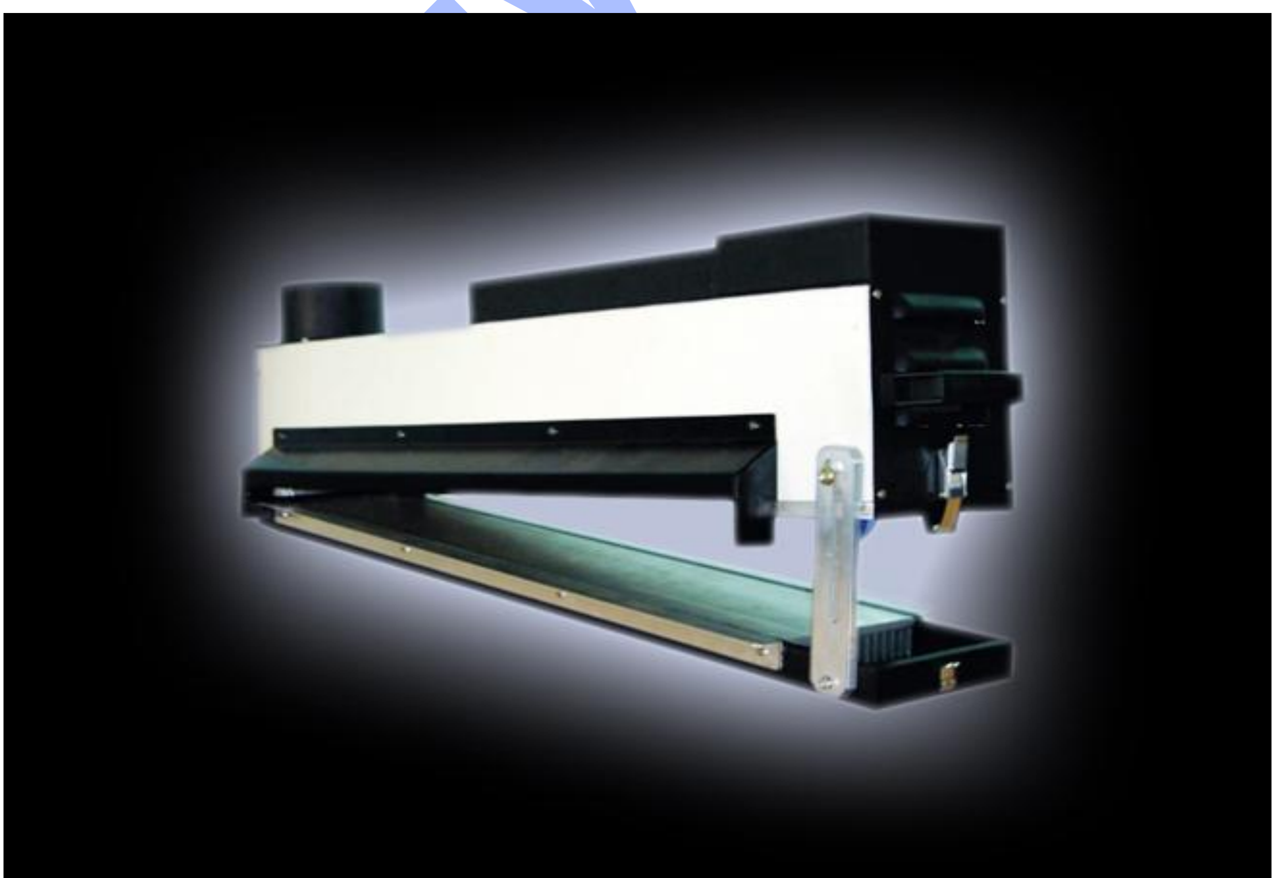


UV Curing for Engineering Industry.

Advance Curing System is proud to state that, its find itself in the global list of manufacturers who custom build UV curing machines for Engineering Industry. Basically the design handling of the product depending on the size, shape, print area, print quantity, speed, heat sensitivity and production speed are taken care of.

ACS has developed special UV curing systems for well known companies like Titan Watch assembly division Hosur, Molex India Ltd. Bangalore,GE Thermometric India, Naval Physical & Oceanographic Laboratory, Cochin, Carbone Lorraine, Freemans Measures ltd, Hindustan Latex ltd. Just to name a few.

Various types of transport system are incorporated depending on the product, and the point at which curing is required. Flat conveyor, Teflon type, stainless steel type, roller conveyor, pneumatic push movements, PLC controlled and touch screen functions are incorporated to make our system par to any imported machines and to commentate the world market, not only with the technology but price too.



UV Curing machine
For Screen Printing and Coating Machine.

This system is basically designed and built for screen-printing application. Screen-printed flat products has to be manually put on to the curing conveyor, curing is instantaneous.

Fabricated in mild steel with Teflon coated fiberglass conveyor, the vacuum frame is provided below the conveyor. UV stations are fixed on the conveyors; cooling is provided for UV lamp housing.

Quartz UV lamp is mounted in mirror polished reflector, the power supply to the lamp in installed in the control panel.

This unit is provided with the main drive, which is mounted in the UV station. The drive incorporates a DC motor, gearbox and accessories necessary for the movement of the conveyors. The control is variable and digital indication with readout of the speed in Meters/min is made available on the front panel. Various conveyor widths from 6 inches to 42 inches are available in 1, 2 and 3 lamp version with or without Infrared drying.

Control panel consisting of operating switches that are illuminated, interlocked between circuits wherever necessary. Phase indication, voltage measuring for each phase, conveyor speed indication and variable pot to set the required conveyor speed. UV hour indicator for lamp life is provided. Fuses are provided for each line, over load relay for motor protection all enclosed in a powder-coated cabinet.

Safety features such as emergency mushroom, quick blow of fuse are standard features in the UV system.

For more information contact:,

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ACS LIGHT CURING APPLICATIONS

Over the past decade, Advance Curing System has assisted many companies to establish successful utilization of UV curing in their manufacturing or laboratory processes. Because many individuals are not yet familiar with the countless possible uses of UV light and curing, we have listed below some of the applications we have encountered which may be similar to uses you may require in your business:

- Wire tacking and coil termination.
- Lens assembly and optical component bonding.
- Optical fiber connections; tacking and splicing.
- Screw locking.
- Fixing of components on PC boards.
- Tamper proofing adjustable components.
- Repair of PC Board sealing.
- Components sealing and protection
- Forming and potting of components.
- Bonding cover glasses to microscope slides, photodiodes, filters, solar cells, etc.
- Jewelry manufacturing.
- Luminescence/Fluorescence Activation.
- Penetrant dye crack detection.
- Conformal coating of PC boards
- Semiconductor die conformal coating for moisture protection (hermetic package)
- Masking of PC board holes before wave soldering
- Instant silk-screening
- Securing transformer ferrite E-cores
- Bonding wound cores to PC boards
- Coating of golf club heads and private label logos
- Doming applications on pins (medallions, badges and tokens)
- Wafer masking
- Wafer contamination inspection
- Resurfacing of car and subway windows
- Splicing 36-millimeter movie film (editing)

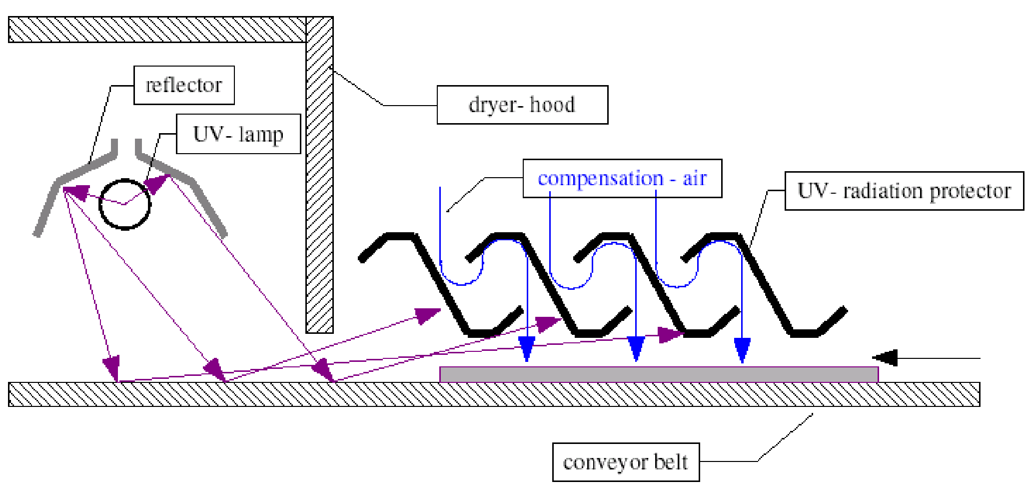
- Fiber optic cable coating
- Fiber optic cable alignment/splicing
- Touch screen coating
- Printing numbers on insulation wire (marking)
- Curing inkjet printing on latex gloves
- Finger nail polish curing
- Bonding of heavily plasticized PVC, thermal plastics (Polycarbonate or ABS)
- Dental appliances (Denture modifications at dentist office)
- Dental ceramics (alumina) accelerated aging
- Contact lens molding/forming
- Corrosion resistant and anti-fouling coatings
- Protective coating of plastics
- Inspection of correct hand scrubbing techniques (When the hands are placed in the cabinet any remaining lotion will fluoresce under the ultraviolet lamp, demonstrating the flaws in the hand washing technique)
- Curing of labels
- Strobe UV synchronized to fast conveyors shows damages on the prints or other surfaces. The frequency of the strobe can be adjusted
- Wafer polishing inspection.
- UV adhesive curing
- UV ink curing
- UV print curing on plastic
- UV print curing on offset
- UV print curing on Web
- UV print curing on inkjet
- UV varnish coating
- UV wood coating
- UV lamination.
- UV circular print curing for CD’s.
- Endless applications……………………………………………………

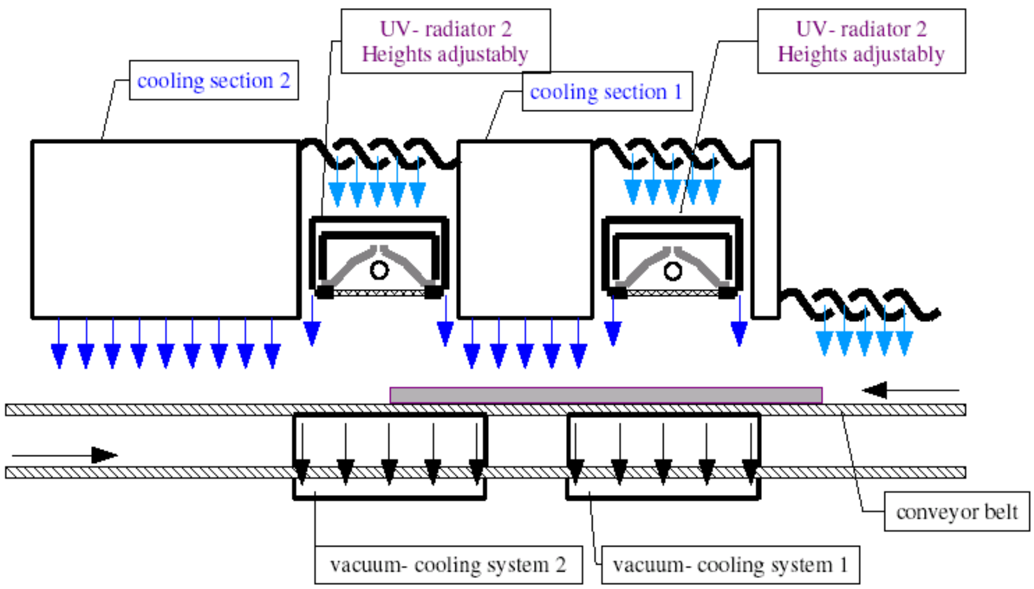
The ACS UV24 stand alone dryer is a special high performance Ultra Violet drying system.

ACS UV24 - systems are high tech- products in up to date technology. It gives you highest performance for an unbeatable price.

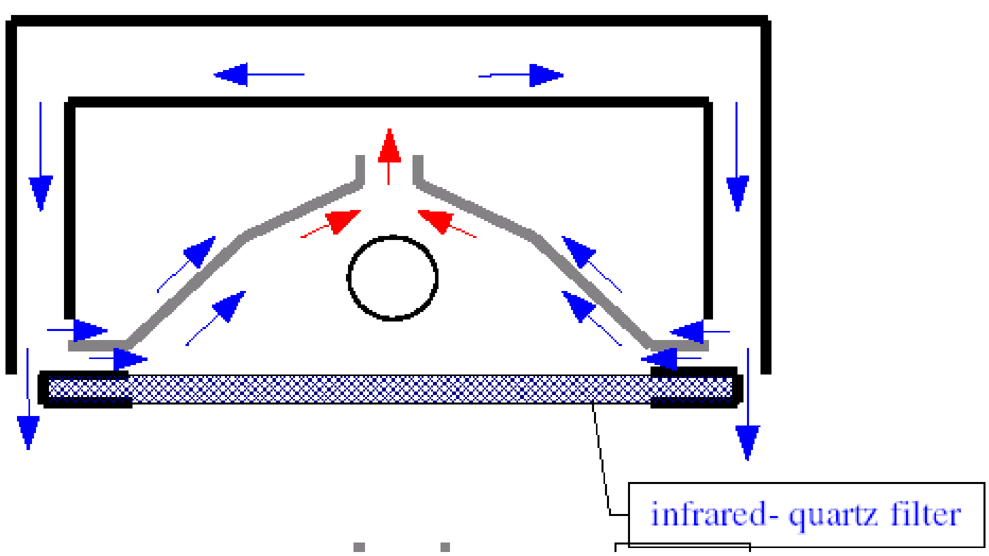
Advantages for the printing industry:

. Unrestricted screen permeability
. Consistent batch print quality
. Pollution free, no solvent load
. Drying time in seconds, much higher cycle times
. Place saving drying units
. Best chemical and mechanical stability of the prints
. Economically, less energy consumption

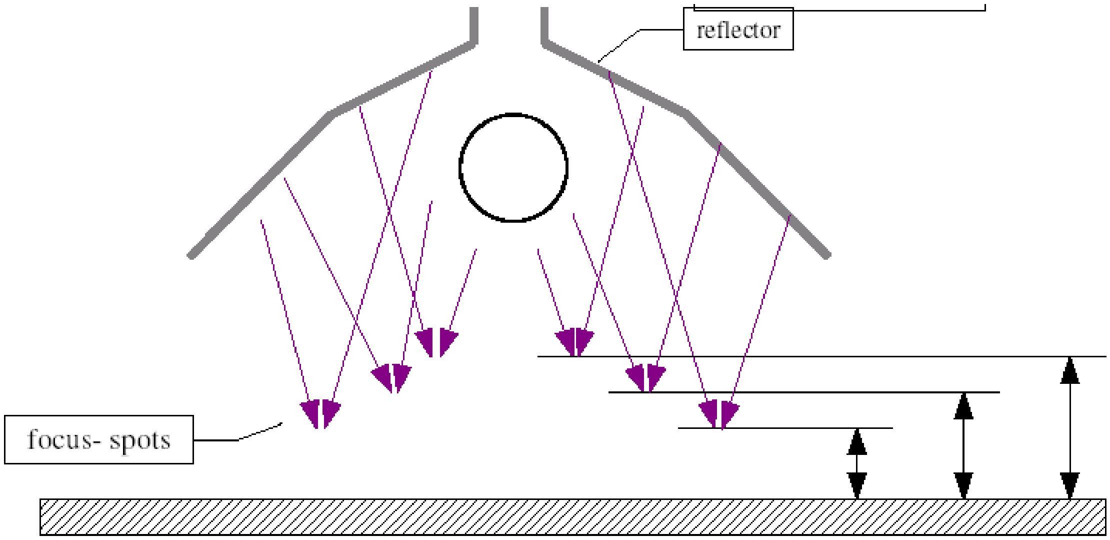


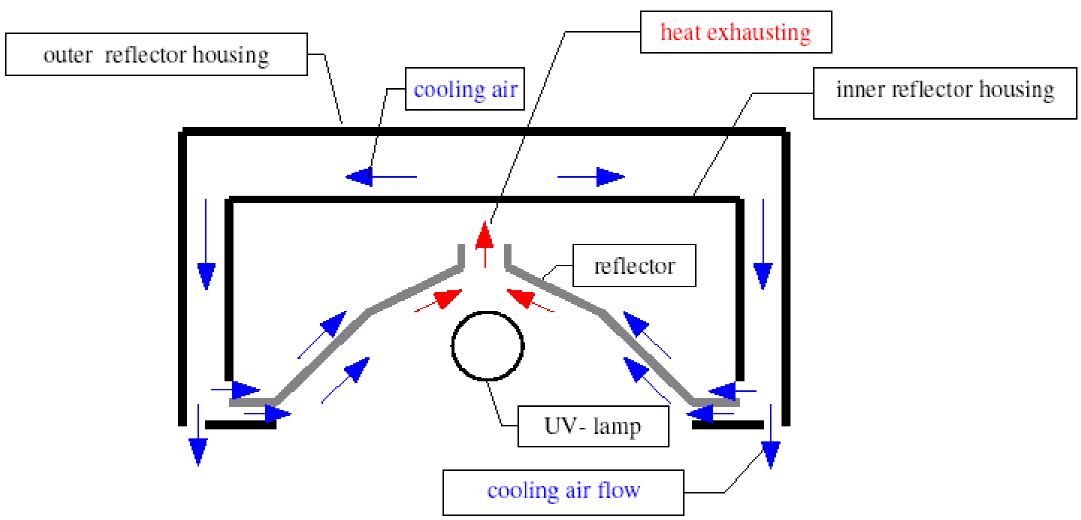


cooling section 2
UV- radiator 2
Heights adjustably
cooling section 1
UV- radiator 2
Heights adjustably
conveyor belt
vacuum- cooling system 2
vacuum- cooling system 1



infrared- quartz filter


reflector
focus- spots


outer reflector housing
heat exhausting
cooling air
inner reflector housing
reflector
UV- lamp
cooling air flow

ACSUV06 UV- drying systems contains following advantages:

High Output - curing power max. 140 W/cm (connection possibilities: 100, 120 or 140 W/cm).

ACS – Focus7- Reflectors. Focus points in several high's are spaced out UV- power in a big field. This is the guaranty for perfect curing results for all applications.

ACS- Air-Jacket Technology -Air Cooling Reflector Housing. The reflector is cooled down on both sides and additionally the printing material directly.

Super-Power UV “self- regulation“automatic- transformers.

.ACS “guiding air flow system“air guide and cooling system. Specially excess pressure sub atmospheric pressure for best results in material transport.

High efficient ebm „ heavy duty“-ventilators for best drying results.

HDCF (heavy duty construction frame) is made for hardest industrial work.

Easy and exact controlling with digitally instruments. Big state controlling lights and a text LCD display for easy using and controlling.

Siemens SPS- computer controlling.

ACS Chill, optional chilled air for bopp and plastics.

Infinitely variable conveyor speed control with digitally display.

Speed Track Rollers from ACS are designed to automatically track the conveyor belts.

High quality glass fibre conveyor belt with guiding system for accurate tracking.

Conveyor failure controlling.

Gas powered lifts for easy hood lifting.

Complete faced system including electrical components and ventilators.

ACS drying- systems contains technically high tech performance for the best price on the market.

Please check all these advantages and compare it with standard systems. So you will see that ACS UV- system is the best choice you can have.