FEATURE

Selecting UV-Curing Equipment for Wood and Building Products Applications

By Susan Mitchell

This introductory article is intended for those just learning about UV curing. Some of the resources listed at the end of the article provide more in-depth technical information.

No matter what your specific product is, hardwood flooring or mouldings, wood furniture components or cabinetry, windows, concrete floors or tiles, vinyl siding, etc., there are some common considerations for selecting a UV-curing equipment solution. This article will discuss some of the fundamental considerations including how to begin, technology types, new vs. retrofit, turnkey systems vs. in-house, light shielding, controls, warranties, operating costs and safety.

When and How to Begin

You can't begin your equipment search too early in most cases. The ideal situation is to involve both the equipment provider and your chemistry formulator in your process development. The chemistry formulator may need to tweak his formulation to meet your application or performance needs, and the equipment supplier can determine early on the best lamp configuration, wavelengths and energy needed for the production rates desired. Sometimes the formulator and equipment supplier can help each other give you more efficient processing and/or better properties.

So once you've decided you may need UV-curing equipment, how do you begin selecting the best equipment? First, educate yourself about the basics of UV curing and the commercially available equipment. Then you will be prepared to approach various equipment suppliers and know the right questions to ask to make the best selection for your process. Reading the rest of this article will move you well down this path and direct you to additional resources.

Dream Manufacturing Process

Secondly, begin to envision your dream manufacturing process. UV curing often makes your dream possible. Envision various ways to hold or convey the parts, how to apply the coating, ink or adhesive, and how to expose the parts to UV energy. The UV equipment will be determined primarily on your desired process and, of course, the chemistry to be cured. These will be discussed more in a moment.

Add a Pinch of Reality

Okay, now that you've done some dreaming, it's time to add a pinch of reality. Think about your application and determine if it's relatively common, or will it require a custom solution. For example, there are many flat-line wood coating and finishing systems available that incorporate sanding, coating application and curing. But maybe you just want to retrofit your existing line, so that's something you can manage and

TABLE 1

Comparison of turnkey, outsourced custom and in-house retrofit systems

	Turnkey "Standard" Systems	Outsourced Custom System	In-house Retrofit or New System
Initial Cost	Middle	High	Low
Timing	Fastest	Middle	Slowest
Other	Best for common applications, especially new finishing lines.	Best for unique applications, look for previous UV experience.	Often a significant learning curve for UV aspects. Find suppliers who can support your engineers.

design in-house. Or maybe you have an excellent in-house engineering group who can design and integrate a retrofit or new finishing system. And, of course, there are always budget and time considerations. See Table 1. For example, in-house engineering may cost less, but take longer than an outside source. Whichever way you decide to go, even turnkey, you'll still want to have a basic understanding of UV curing so you can ask the right questions and know you're getting the right equipment for your operation.

Basic UV-Curing Technology Options

There are four basic UV-curing technology options: arc, microwave-powered, xenon and light emitting diode (LED). Certainly arc (sometimes called electrode) and microwave-powered (sometimes called electrodeless) are the two most commonly used in industry, though the others have their appropriate application areas. Here, we'll discuss their basic operation. Table 2 summarizes their operating characteristics.

Arc or electrode UV-curing lamps have electrodes at either end of a quartz tube, operating using the same principles as fluorescent lamps in offices. Arc lamp systems are generally less costly initially and are available in a variety of lengths. However, arc lamps do not last as long as microwave or LEDs (due to degradation of the electrodes) and don't have stable output over their short life (typically drops 25% in first 1,000 hours). Arc lamp output drops off even more for the longer wavelength, additive bulbs. To ensure uniformity across a

Arc lamps.

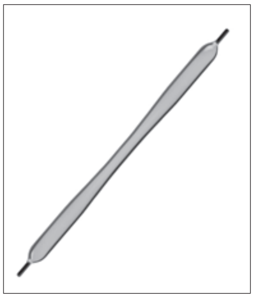
flat-line process, arc lamps are typically overlapped because their output drops off at the bulb ends. Arc lamps generally have longer restrike times, so shutters are used when a process requires lamps be shut off for short periods, such as some type of indexing conveyor line or when an automated line stops intermittently or unexpectedly.

Microwave-powered lamps are simply a totally enclosed quartz tube. Instead of striking an arc between two electrodes to excite the gasses in the bulb, microwave energy penetrates the quartz to excite the gasses. These lamps are available in 6-inch or 10-inch wide modules and placed side-by-side for the width desired, or arranged around a three-dimensional (3-D) part.

TABLE 2

Operating characteristics of arc, microwave-powered, xenon and LED lamps

Characteristic	Arc (electrode) Lamp	Microwave-powered (electrodeless) Lamp	Xenon (pulsed or flash) Lamp	LED
Life	500-2,000 hrs.	3,000-8,000 hrs.	40-1,000 hrs.	50,000 hr+
Stable Wave-length Output	No	Yes	Yes	Yes
Stable Energy Output	No	Yes	No	Yes
Shutters	Yes	Not Usually	No	No
Cooling	Air or water	Typically air	Air or water	Conductive
Heat to Substrate	Highest	Middle	Very Low	Very Low
Other			Contains no mercury, multiple shapes	Low energy output and limited wavelengths



Microwave-powered lamp.

Microwave-powered lamps have very stable output and long life, though they do tend to be more expensive for wide flat-line systems. Microwave-powered lamps restart in seconds, so shutters are not required. RF detectors are incorporated into this type of system to ensure there's no leakage of microwave energy from the lamps.

Xenon (also called pulsed or flash) lamps are constructed like arc lamps, but use xenon instead of mercury in the bulb and typically operate in a pulsing fashion. They deliver multiple, 10 or 15 per second, very high-intensity pulses of energy to the substrate. The bulbs can be configured into a variety of shapes, deliver very little heat to the substrate, and do not require shutters.

LEDs (light emitting diodes) are popping up everywhere for visible light applications requiring long life, such as traffic signals and automotive lighting. LEDs suitable for UV-curing applications are beginning to emerge. Typically, many individual LEDs are arranged into an array to illuminate a larger surface area. LEDs are attractive owing to their very long life and low heat, but are currently available in limited wavelengths and their energy output is low compared to arc and microwave-powered systems.

How to Choose

The type of UV-curing equipment, specific bulb type, and orientation to the part will depend on the chemistry, pigments, overall process design, and maintenance considerations. Most pigmented coatings or thick clearcoats or adhesives cure best with a long wavelength, metal halide additive

Figure 1

Spectra for D bulb (13mm)

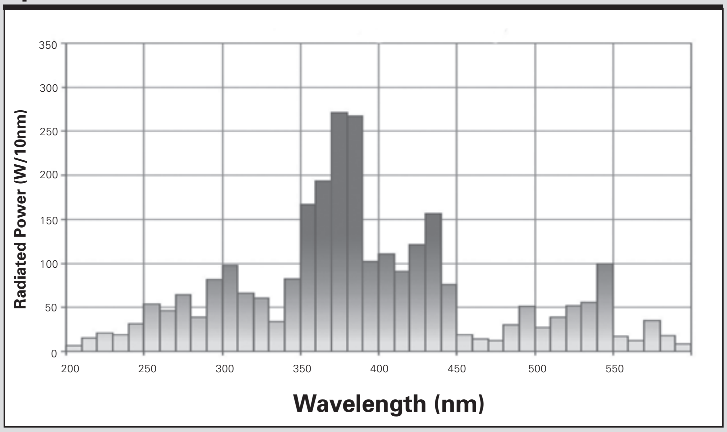


Figure 2

Spectra H bulb (13mm)

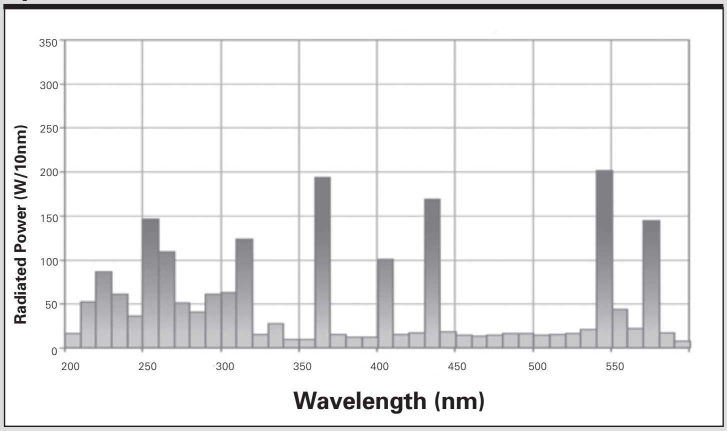
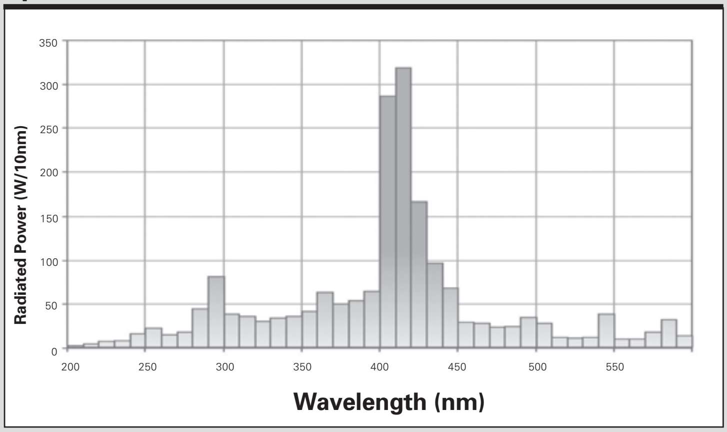


Figure 3

Spectra V bulb (13mm)



(350-430nm, often referred to as "D" or "V") type bulbs for efficient through cure. White inks cure easily with a V bulb. Most thin, clear coatings are best cured with a short wavelength mercury bulb (250-300nm, often referred to as "H"). Your chemistry formulator should provide a UV-cure (exposure) specification for their chemistry. Figures 1-3 show bulb spectra.

UV-Curing System Specifications

All UV-curing systems consist of a lamp head, called an irradiator or housing, which contains the bulb and reflector. The lamp head is controlled by a power supply or ballast, which is connected to the lamp head via electrical cables. If the process requires multiple systems, then typically a control cabinet will house the power supplies and a master controller. Often the UV-system controls are tied into the overall finishing process control scheme. Access panels to the curing chamber will have a safety interlock to prevent worker exposure to the UV energy.

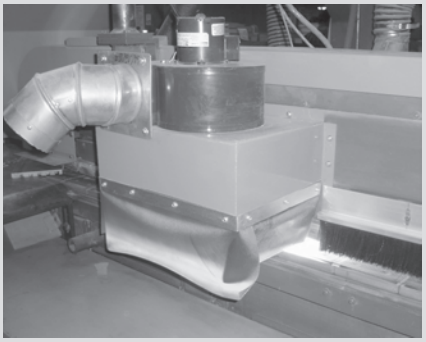
Cooling Requirements

For proper operation, the lamp head must be cooled, so there is also some type of cooling mechanism such as a blower or cooling water to maintain bulb temperatures. Push type air-cooling systems move air over the bulb down onto the substrate, which avoids pulling inks and coatings up onto the bulb and reflector, thus reducing maintenance and maintaining UV output. Exhaust ducting is also recommended to remove ozone (if generated by the UV lamp) and any volatilized materials away from workers. Consideration needs to be given to the ducting (piping in the case of water cooling), blower mounting and electrical needs.

Wood Drawer Manufacturer Improves Quality with Conversion to Microwave-Powered UV Curing

Carolina Drawers, located in Lexington, N.C., began making wood drawer components in 1992 for furniture and kitchen/bath cabinetry companies. From the beginning, they used UV curing for finishing the Birch plywood components, primarily because they knew the 100% solid UV coatings would eliminate the need for any environmental permitting.

Drawer components are cut to size, sanded and then the edges finished on an edge finishing line and finally, the flat sides are finished on a horizontal flat line. In both cases, a clear, 100% solid, 20-50 sheen UV coating is roll coated onto the part surface.



Carolina Drawers' edge finishing line.

Originally, arc UV lamps were used for curing both edges and flat surfaces. However, on the edge finishing line a 36-inch arc lamp placed along the conveyor was needed to cure the coating. This left no space to install sanding and de-nibbing between coating/cure stations. So, in 1998 they retrofitted two microwave-powered, six-inch UV lamps onto the finishing line to replace the arc lamps. The coating could now be cured with only 12 inches of UV lamps, freeing up 24 inches of space on the conveyor to install a sander and de-nibber. This greatly improved the coating quality of the edge finishing, which now includes de-nibbing between coats and a final de-nibbing. As production needs increased, Carolina Drawer needed another edge finishing machine. This time they bought a used frame and assembled the sanding, de-nibbing and UV-curing components onto the frame themselves.

Jeff Mast, president, says the only problem they had in the beginning was with the cooling air, but once they used outside air instead of plant air that problem was solved. Particulates in the plant air, primarily wood dust, were clogging the air filters and cutting down on the cooling airflow. Today, Carolina Drawer finishes about 40% of their total volume in their 80,000-square-foot Lexington facility.

When asked what advice he'd give to someone who hasn't used UV technology, Mast replied, "Is there really anyone who doesn't use UV? It's just common sense, especially for flat stock where the roll coating and UV curing is so easy and, of course, environmentally friendly."

Like others in the wood industry, Mast says they feel pressure from China and have responded by outsourcing to China where it makes sense. He says China is the current low cost region, but in the future it'll be global, some other new lost-cost region will emerge. To survive, manufacturers have to constantly be thinking about outsourcing where it makes sense and using the best, most efficient technologies such as UV to ensure their domestic operations are competitive, and producing high-quality products on time.

Lamp Power

Most UV systems literature specifies the "lamp power" or input electrical power in watts/in. (watts/cm). This simply indicates the general power class this system falls into, but tells nothing about the UV energy output specifically. For example, UV systems are commonly available in 200 W/in. or 600 W/in. So in general, this just indicates that one has much higher power requirements and likely higher UV output. If you multiply this input power by the bulb length, which is also typically provided, this gives you the total input power required. So a 6-inch, 600 W/in. lamp requires 3,600 watts of input electricity.

UV Output

Most UV-systems literature also specifies what type of reflector, elliptical or parabolic, is used. The reflector sits behind the bulb to collect and project the UV energy down onto the substrate. If a parabolic reflector is used, then the UV energy will be spread over a larger area with less intensity (irradiance, W/cm^2). If an elliptical reflector is used, then the UV energy is focused into a narrow band at a specific distance from the face of the lamp head. In general, elliptical reflectors deliver more of the UV energy generated by the bulb down onto the substrate at a higher intensity for a typically more efficient cure.

Unfortunately, UV-equipment suppliers do not have an industry standard to indicate UV output in irradiance or how that varies over a given area of substrate. Some suppliers can provide this data upon request. The best way to compare lamp performance prior to purchase and ensure the UV system will meet your needs is to run tests in independent labs, on your own line, or in the UV-equipment suppliers' lab.

Typical UV Lamp Configuration Considerations

There are some basic lamp configuration considerations depending on your part shape, size and handling. The most common UV curing is linear processing in which parts move in a linear fashion past stationary UV lamps. For example, flat wood panels, hardwood flooring, and cabinet doors are typically placed on a horizontal conveyor, roll coated or sprayed and then UV cured. The UV lamps are arranged in a row across the width of the conveyor with the lamps in focus on the substrate surface. Another example, shaped mouldings or profiles can be vacuum coated and then passed into a UV-curing chamber with lamps positioned at various angles around the moulding to expose all of the coated surfaces. A linear curing process can be exactly duplicated in a lab without scaling it down or using a reduced output adaptation.

Mouldings are cured with UV lamps positioned to expose all coated surfaces.

If your part doesn't lend itself to linear curing, then 3-D curing may be needed. Typically for 3-D curing, the UV lamps are mounted on adjustable fixtures (and may move as the part passes) and/or the parts may be rotated as they travel past the lamps. In general, the more degrees of motion of the part and lamps, the fewer the number of UV lamps needed. However, this can increase the cost of automation and controls in the system, so it is a trade-off.

Medium-density fiberboard (MDF)-powered coated panels are being cured by UV lamps.

Selecting a Supplier

It may be that different UV-curing technologies can meet your requirements. If so, compare such factors as on-going maintenance costs, spare parts and energy costs. Most suppliers can readily help you estimate these factors for their equipment. If you are sure you want a particular UV-curing technology, be sure to specify this to a turnkey or custom integrator, otherwise they'll use what's best for them.

In addition to being able to supply a UV system that will meet your processing requirements, you may also want to evaluate a supplier's warranties, service options, global capabilities, engineering support and so on depending on what's important for you down the road. If you plan to put this UV-curing process in your other plants around the world, then you may highly value a supplier who can service the UV equipment and train your plant personnel, no matter where they are located.

Summary

Some additional resources are listed to further your education about UV-curing technology. RadTech International and its members are always willing to assist. Let us help you make your manufacturing process dreams a reality with UV curing! ◗

Resources

The following resources are available at RadTech's Web site—*www.radtech.org:*

- *RadTech Report* Buyer's Guide, Jan/Feb 2006 issue—both UV equipment manufacturers and integrators/finishing systems are listed.
- RadTech Glossary—commonly used terms in the UV-curing industry.
- UV/EB Curing, A Safe Choice CD—produced by RadTech's Environmental, Health & Safety Committee. The CD contains about 20 minutes of video covering safety practices for UV/EB-curable formulations and is suitable for individual or group training/education.
- UV Measurements CD—developed by RadTech's UV Measurement Focus Group and provides all levels of information, basic and advanced. (Available for purchase from RadTech at $24.95 each.)

Other resources include:

- Significant Factors Affecting the Efficiency of the UV Curing Process, R.W.Stowe, June 2001, IUVA Congress, Washington, DC.
- Some Economic Factors of UV Curing, R.W. Stowe, May 1994, RadTech '94 North America, Orlando, FL.
- Equipment for UV Curing, R.W. Stowe, *American Ink Maker,* 2003.
- Radiometric Methods for UV Process Design and Process Monitoring, R.W.Stowe, *Journal of Coating Technology,* Vol. 75, No. 938, March, 2003, pp. 69-75.

—Susan Mitchell is marketing manager for Fusion UV Systems, Gaithersburg, Md.

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