UV Curing Technology

Improvements in equipment and inks continue as the UV curing market experiences steady growth. Plus, a look at electron beam curing for narrow web systems.

By Jack Kenny

And now for the good news: In the narrow web segment of the packaging market, ultraviolet curing of inks and coatings is growing. The use of UV inks and the equipment used to cure them are rising steadily, according to industry suppliers. New presses are coming equipped with UV stations throughout, and the retrofit business is healthy.

"Absolutely it is still a growth market," says Mark Hahn, vice president of AAA Press International, Arlington Heights, IL, USA. "We are still seeing significant interest, especially from those who have bucked the system for years and stuck with water based inks. They are starting to find that the buyers of labels are educated enough that they want UV. It offers 100 percent solid ink, match quality time after time, as well as the obvious features that converters like, such as reduced setup time."

"We have definitely noticed that the strongest UV equipment market in this difficult 2009 economy is the label and narrow web converter," says Elinor Midlik, president of Prime UV, Carol Stream, IL. "This segment of the UV equipment market has continued to grow over 12 percent per year. A conservative estimate of growth for 2009 is still over 10 percent. Our narrow web customers continue to invest in new processing lines, and are hopeful that the recovery will be sooner than in other applications and markets. An added impetus to the growth is the drive for sustainability. Consumers as well as packaging buyers believe that 'less' is better, and label converters are installing UV systems as part of their sustainability efforts."

"North America has traditionally been a water based market, but there is steady growth in UV due to a lower cost of operation of UV versus water based inks, more consistent processes, and the higher quality that can be achieved," observes Jeff Feltz, director of product development for Mark Andy Inc., which owns UVT, based in Milford, OH, USA. "Additional growth is being driven by traditional label converters moving into shrink markets."

Europe, he adds, is dominated by UV: "No significant growth, but it is still the dominant ink system used."

Brian Wenger, president of GEW Inc., North Royland, OH, also notes the widespread use of UV curing among Europe's converters. "The great majority of narrow web converters in Europe are printing full UV," Wenger says. "I believe that they were more easily converted from UV letterpress to UV flexo. We have seen significant growth in full UV printing in the US over the last few years. More and more, printers are realizing the benefits of UV printing."

Rodger Whipple, president of Xeric Web Drying Systems, Neenah, WI, USA, estimates that "90-plus percent of the work that's done in narrow web in Europe is UV. In North America it probably has been 40 to 50 percent, and it's growing to be 60 to 70 percent. That's new equipment purchases, rather than the total market."

"That's where we are, especially today with fewer new press installations taking place in the market."

Ink technologies

Curing inks and coatings using ultraviolet light has been around for decades. It began to penetrate the narrow web label market significantly in the early to mid-1990s. Back then, presses employing UV were putting it to use as a varnish, but growing interest in curing the inks themselves with UV began attracting more attention. Growth was slow but steady, and challenges along the way were met both by the UV equipment manufacturers and by the ink companies.

"Today ink formulators have far more resin choices when developing UV inks," says Wenger. "Finally, UV companies have resins made for specific applications, such as shrink, film, paper stocks, and folding carton. More choices mean better inks. What sticks out most in my mind is the use of cationic inks. Years ago many shrink sleeve producers had to use cationic ink to achieve the shrinkability. Today the ink suppliers have achieved the shrinkability with free radical inks, and now most shrink sleeve printers are now using free radical inks."

Formulators of UV inks can now get more pigment and more color from inks, Wenger notes. "UV inks are better suited to the application as viscosity can be controlled without sacrificing color strength," he says. Furthermore, UV inks can adhere to a wider range of materials, he adds. "This has opened the door for inks that can perform multiple functions equally well. As an example, some inks can adhere to classic films like BOPP and also adhere to today's materials like HIPS, APET or even PLA."

"UV technology today produces very little ozone, and the only solvents produced are in the cleanup process," says Mark Hahn. "Being that the ink systems are 100 percent solids, they can sit in the ink pan and not evaporate. Today, ink makers are working on ways to make the photoinitiators more friendly. The ink systems are definitely evolving. Early on, some colors were difficult to cure, such as the opaque whites. The learning curve is in the past now. The ink companies have done a great deal of research."

Newer inks have higher opacity and density, says Jeff Feitz of Mark Andy. "This allows the use of finer anilox rolls to achieve bolder spot colors and more opaque whites. Also, lower odor inks that are non-migrating have been developed and have gained acceptance in some food applications."

"Our sense is that the inks are more printer friendly," says Rodger Whipple. "The ink manufacturers have been using..."
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fewer photoinitiators, and that will require a little more power, saving the cost of the ink. In certain instances, to make ink more cost effective requires more power.

When ultraviolet light hits UV curable inks, coatings and adhesives, the photoinitiators in the compounds decompose into free radicals, or excited oxygen molecules. These bond with monomers and oligomers to form a matrix of bonded polymer chains, creating, in effect, a solid film of polymer.

During the curing process, the bulbs in the systems produce UV light as well as IR (infrared) light. The IR isn’t needed for the curing, but it’s there and it’s hot, which has always presented a challenge for printers, especially on plastic film.

Most bulbs used in narrow web UV curing today are made of quartz and contain mercury vapor. The IR comes from the quartz, not the vapor. Cooling down the UV curing process therefore, has been a main concern of the equipment manufacturers. They have employed negative cooling, which draws heated air from the curing chamber; positive cooling, using pressurized air blown onto the bulbs, and mixing lamp air with room temperature air.

Several years ago the manufacturer introduced what came to be called cool UV. ‘This is a method to reduce the amount of IR energy being transferred to the web,’ says Jeff Feltz. ‘Cool UV in some cases will remove enough heat from the web to work for a specific application and eliminate the need and expense of a chilled idler system.’

‘Cool UV made its place into the marketplace as the shift was to run thinner unsupported films,’ says Brian Wenger. ‘IR can damage these heat sensitive substrates.

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designed to run heat sensitive materials. This is the correct way to control the IR on the substrate. You get maximum UV intensity and don’t have to worry about the intensity was removed. This meant slower running speeds. Most press manufacturers have now incorporated temperature controlled drums, or rollers, onto presses designed to run heat sensitive materials. This is the correct way to control the IR on the substrate. You get maximum UV intensity and don’t have to worry about the substrate. Even if you are running non-heat sensitive material, you don’t want to introduce unnecessary heat into the press. The key is to remove the IR through the proper use of reflector material, coatings, and the internal mechanical design of the lamp head, but not significantly reduce the UV output.’

Challenges

‘Films can be a challenge when it comes to heat,’ says Whipple of XericWeb. ‘It depends on the film material itself and the thickness of the material, and how susceptible it is to collecting the heat and causing problems. There are instances where it makes more sense to incorporate the UV lamp head with a chill roll, so the film substrate remains cool while you are blasting all this energy at it.’

‘Heat is the single biggest challenge with UV,’ says Feltz of UVT, ‘especially when dealing with heat sensitive materials, such as films. There are many drivers to reducing film usage, including sustainability and cost reduction. As films get thinner, heat management becomes more challenging.

‘The challenges for a printer always have been difficult substrates,’ declares Elinor Midlik of Prime UV. ‘The solution has been UV printing. Since label printers are known to print on a wider variety of substrates than any other printer, they have adopted UV as their ink of choice for all the substrates printed.’

Mark Hahn says that those printers who use metal halide bulbs face challenges. Ten percent of printers use metal halide bulbs, which run 30 to 35 percent hotter than standard mercury vapor bulbs. ‘The heat requires more control, and it also reduces the life of the bulb. They take more power to fire and it’s harder for the arc to get across. With a metal halide bulb you need more ballast and other components.’ Hahn also said that lack of knowledge about substrate technologies can confound printers, ‘such as trying to cure films with UV barriers.’

For many printers not experienced in UV, the biggest challenge is showing the benefits of printing full UV, which outweigh the increase in cost for UV inks,’ says Wenger. ‘UV inks are more than twice the cost of conventional inks, but UV inks are 100 per cent solids. By weight, you get roughly double the mileage by using UV inks.’

Emerging trends

Elinor Midlik says, ‘An interesting technological trend that we have been noticing is that more narrow web printers are installing UV silicone release coating lines, many of which require nitrogen inerted UV processing chambers. We are able to install the nitrogen inerted processor right in line with the press and coating applicators. This one-pass technology has become a driver for many state-of-the-art narrow web printing facilities.’

Hahn sees growing interest in UV inkjet. ‘A lot more folks today are looking at UV inkjet printing systems,’ he says. ‘They require 600 watt metal halide bulbs for curing. The ink is deposited through a small nozzle, and it has limited particulate, which limits the photoinitiator package in the ink. These systems can only go with the higher wavelengths.’

Jeff Feltz says, ‘There continues to be development in the area of UV approved inks for direct food contact. With regard to curing, LED curing and xenon are technologies to keep an eye on.’

LED curing – What and when?

About a decade ago, a new form of UV curing emerged that utilized LEDs – light emitting diodes. First and foremost, they promised low heat. At the moment, this technology isn’t being utilized in the narrow web field, but researchers are paying attention to it. (If your dentist is using a light to cure the compounds used to fix your teeth, that’s LED curing.)

According to a recent report by EXFO Photonic Solutions, a Canadian company, the development of high power short wavelength LEDs in the late 1990s "created the potential of a solid state ultraviolet/visible curing source. The benefits of LEDs are low heat, portability and low power consumption. These advantages are particularly attractive for the curing of various adhesives, inks, and coatings in applications where dimensional stability of the substrates is required. However, current LED devices are limited in wavelength (normally, > 380 nm) and power in the UV region. This leads to difficulty in the curing of some materials.’

Rapid cure, no heat on the substrates, even intensity of radiant power over the curing area, long lifetime of the bulbs – these are highly desirable. But there are other issues.

‘People are interested in the idea of using LEDs for curing,’ says Whipple. ‘At this point the technology is suitable for inks that are specially designed to work with LED lamps. Unlike a mercury system, they put out a light at one specific wavelength. So the photoinitiators in the ink have to be matched to that particular lamp. As far as we can tell there are only specific lamps and only one or two wavelengths that are possible. Those wavelengths are not down in the range that are useful for typical free radical type inks, which are most commonly used for narrow web printing.’

Feltz puts it simply: ‘The curing speeds required for the narrow web market cannot be attained with LED curing at this time.’

‘I don’t think that this technology is fully developed for the narrow web label market, yet,’ says Brian Wenger. ‘Some of the issues are the cost of the LEDs and the wavelength they use. LED’s output is only one wavelength in the UV spectrum. Typically, inks are geared to the full UV spectrum of medium pressure mercury vapor lamps. I do not think the inks are developed for this technology to be used in a high speed production environment. I could be wrong, but I have yet to see one label printer using this technology.’

Mark Hahn of AAA Press expresses the most enthusiasm for it. ‘It’s an emerging technology, it may come up. Every light source is going to put out certain wavelengths, or none. LED puts out all of them, but not in the intensity that you need. It’s used sparingly in lab environments today. It is progressing to the point at which they can capture more of the energy. Plus, it’s green technology: it has very little heat output; you don’t have to worry about IR. It’s a question of whether they can gather the energy and aim it at a web.’
Predictable and durable
Rodger Whipple sums up the UV curing experience from his perspective as a supplier to narrow web converters. “It is a much more predictable system, in the sense that with water or solvent based inks the press operator has to be continuously monitoring and controlling the pH and viscosity of inks to control the end product. Whereas with UV ink, it is put into the press and can be run basically out of the can. There is no need to monitor the pH or viscosity. So during the course of a press run, the chemistry of the ink doesn’t change. Also, at the end of the day there is no need to take the ink out of the press, because there is no reason that it will cure on the press, in the ink tray. The printer can leave it and come back the next day and run it again without a lot of cleanup.

“The final image depends on what the printer is looking for and what he is willing to use. In general, it will be a much more durable product and a higher gloss image.”

Electron beam for narrow web? It’s here

EB, or electron beam curing, has been around for about 30 years, almost exclusively in wide web. The equipment is large, complex and expensive. It is used quite extensively for food packaging because of its benefits. EB cures inks and coatings instantly, thoroughly, with low heat and no aroma.

Today it is available for the narrow web printer. Advanced Electron Beams (AEB), of Wilmington, MA, USA, has taken the complexity out of the EB system and modified it for use on narrow equipment.

“UV has found its home in narrow web,” says Josh Epstein, product manager and director of marketing for AEB. “But it has a hard time with food packaging because of the photoinitiators, the smells, the extractability. Food carton packaging is printed using either solvent or water based inks, or EB curable inks.”

In an EB system, electrons are produced in a vacuum chamber by sending a current through a tungsten filament. The electrons are accelerated using a high voltage, up to 150,000 volts, and they pass out of the chamber through a window, usually made of titanium. “Then they are aimed, passively, in a direction like a cloud or a stream,” says Epstein. “Within the air they will lose energy quickly, so they have a 6” to 8” operating window. Once they hit a surface within that window they impart their energy: They sterilize, disrupt cellular composition, and cure inks.”

Both UV and EB inks have pigments and resins diluted in monomers, Epstein adds. “During curing they form longer chains, polymers, and form solids. The difference between the two is that UV needs a photoinitiator as a catalyst, which splits out free electrons, driving the polymerization process. EB eliminates that step. There are no photoinitiators. Also, the electrons don’t just stop when they hit the surface. They go further, up to 200 microns, or eight mils. They go deep into the ink layer and deliver energy to the boundary layer. EB delivers a high degree of energy down to the bottom of the ink layer.”

The photoinitiator process is time based, he says. Ultraviolet rays excite the photoinitiators, “and for some period there is excitement going on. But EB does it all at once. And EB doesn’t care about the color. UV can’t penetrate well into certain colors, but EB has no problem. It’s a good, even, quality cure all the way through.”

An EB station, Epstein adds, would optimally be installed at the end of a UV press to do a final, full-through cure.