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UV Curing • In Control

Using UV LEDs to Cure Fiber Optic Cables

Fiber optic technology has come a long way since its introduction in the 1960s. Its use in telecommunications, in particular, has created high demand for fiber optic cable and consequently a requirement for high-volume production of optical fiber.

Fiber optics manufacturers are turning to new, high-irradiance UV LED curing systems to enable faster and higher-volume production. UV LED curing systems' high efficiency, long lifetime and low cost of operation are also helping to significantly reduce manufacturing costs.

OmniCure® AC9 Series UV LED Fiber Curing System with Custom Focusing Lens.

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Glass optical fiber is produced on a multi-story drawing tower. At the top of the tower, a preform is heated and pulled to a thin strand at speeds in excess of 3000 mpm (Figure 1). Two layers of coating material such as acrylate polymer or polyimide are applied to the fiber in concentric layers and then rapidly cured with high-intensity UV light.

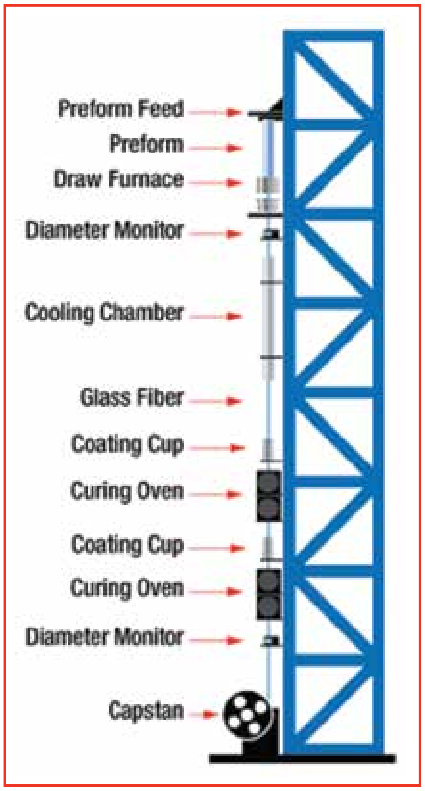

Fig. 1 — Typical fiber coating tower.

High-intensity UV arc lamp or UV microwave excited lamp systems are traditionally used to cure the fiber coatings in manufacturing. These systems generate UV light by passing electric arcs or microwaves through a mercury and/or metal halide-filled glass tube, creating a high-pressure mercury vapor. The wide spectral output (<200 to >800 nm) of UV lamps is effective for curing fiber optic coatings, but these lamps have disadvantages including frequent downtime, excess heat generation and high operational costs.

While UV lamps have been the curing equipment used to date for fiber optic coatings, the wide spectrum of wavelengths produced by UV lamps is inefficient, as curing is best achieved in the 250 to 420 nm range. For this application, the energy produced by UV lamps outside this range is wasted. UV lamps also consume a lot of electricity to generate enough light to cure optical fiber at production speeds. Each UV lamp used in a fiber curing tower can use as much as 6kW of electrical power.

UV LED systems on the other hand, are much more energy-efficient and therefore also significantly more cost-effective. Because a single UV LED curing system can use as little as 600W of electricity, it doesn't take long for the cost savings from reduced electrical consumption to return the investment on LED system installation.

The light generated by UV LED curing systems is in a narrower spectrum at specific peak wavelengths, for example 365 or 395 nm, with a full width half maximum of only about 20 nm (Figure 2).

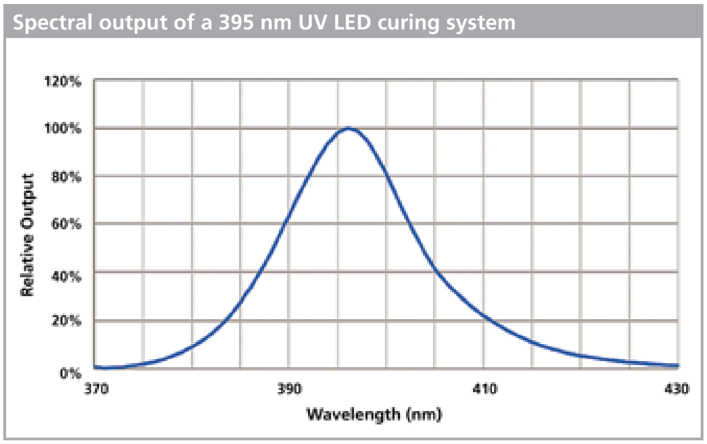

Fig. 2 — Spectral output of a 395 nm UV LED curing system.

This means that the full spectrum of energy produced by the LED is in the effective curing range of the fiber coatings. When used to cure fiber optic coatings that were optimized for the broader spectrum of Hg lamps, LEDs' narrow spectrum may create some challenges. To ensure successful curing, it is important to work closely with the coating supplier and to run material testing with the LED systems.

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UV arc lamps require replacement every 1000 to 4000 operating hours, while UV microwave-excited lamps require replacement every 6000 to 8000 operating hours, adding to costs and process downtime. Other consumable items include the magnetron of UV microwave systems and reflectors which must be regularly cleaned and replaced, increasing downtime and expense for parts and technical support.

High-output, air-cooled UV LED curing systems are easily incorporated into a fiber drawing tower. LEDs have innovative thermal designs with typical operational lifetimes of greater than 40,000 hours. UV LED systems further reduce downtime and replacement costs compared to lamp-based systems by using efficient, reliable constant-current drivers, which require no ballast or magnetron replacement.

Curing fiber coatings in this application requires focusing enough light energy onto a tiny fiber surface in order to effectively and to fully cure the coatings. The light must be optimized for a specific working distance from the emitting window of the curing system and the fiber. UV lamp systems will often incorporate external reflectors on the opposite side of the fiber to recycle the light energy that does not initially hit the small target, to increase the curing efficiency and uniformity on all sides of the fiber.

UV LED curing systems with advanced LED light-engine design and front-end optics can maximize irradiance at the fiber. Customized lenses produce a highly focused beam of light from the LED to maximize the UV energy that hits the very thin fiber strand and optimize curing efficiency. Divergence of light from the LED source can make it challenging to maintain high irradiance over working distances, but custom optics resolve this issue by maintaining the irradiance virtually unchanged at typical working distances of 10 to 18 mm used in fiber coating (Figure 3).

The configuration of LED systems can be designed to fit a specific manufacturing process and coating material. For example, two LED systems can be arranged so that focusing lenses face each other, to produce uniform UV intensity at the fiber. The ability to arrange UV LED systems in a lens-to-lens configuration eliminates the need for an external reflector, saving additional costs and downtime compared to lamp-based systems.

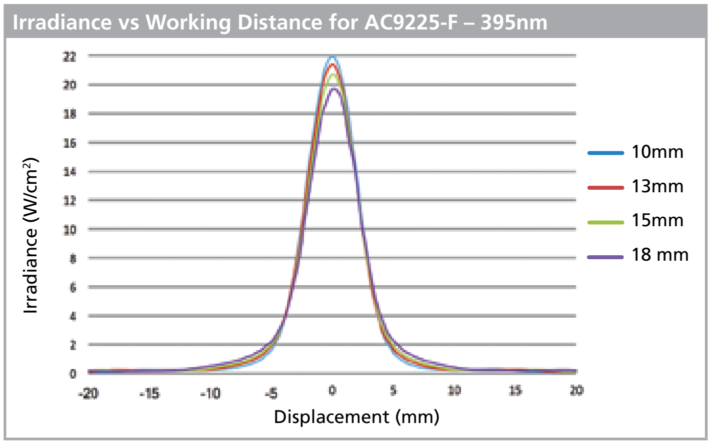

Fig. 3 — Irradiance vs. working distance for a UV LED curing system with custom lens.

UV lamps also produce ozone by radiating wavelengths under 200 nm. The ozone requires filtering and an exhaust system for venting to the outside. Expensive stacks and scrubbers are needed for production facilities to meet EN14001 requirements. The narrow-spectrum UV LED curing systems do not produce light below 200 nm, and therefore do not generate ozone, eliminating the need for external venting. This further reduces operating costs and simplifies compliance with environmental standards.

LED Systems Arranged in a Lens-to-Lens Configuration for Fiber Curing.

Conclusion

Demand for fiber optic cable has grown significantly to meet the needs of telecommunications applications and others. To satisfy an increasingly high-volume market, fiber manufacturing speeds are ramping up and cost savings are prioritized. New high-irradiance, air-cooled UV LED curing systems that boast high efficiency, long lifetime and low electricity consumption are increasingly being used along with or instead of UV lamp technology to significantly reduce operational costs and improve efficiencies in this high-speed manufacturing application.

About Excelitas Technologies

Excelitas Technologies® Corp. is a global technology leader focused on delivering innovative, high-performance, market-driven photonic solutions to meet the lighting, optronics, detection and optical technology needs of global customers. Serving a vast array of applications across biomedical, scientific, safety, security, consumer products, semiconductor, industrial manufacturing, defense and aerospace sectors, Excelitas Technologies stands committed to enabling our customers' success in their end-markets. Excelitas Technologies now has approximately 6,700 employees in North America, Europe and Asia, serving customers across the world.

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