Technical Paper

Electron Beam Technology for Converting Applications

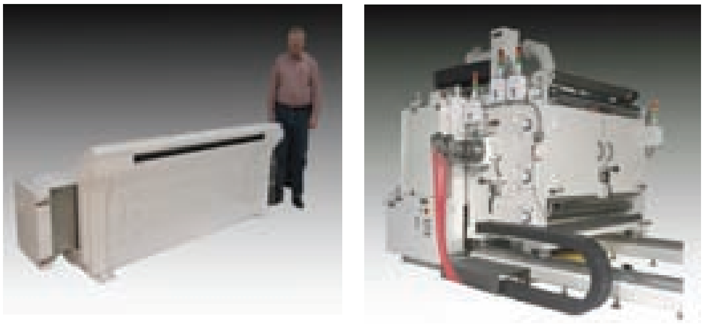
By Stephen C. Lapin, Ph.D.

Electron beam (EB) technology has been used in converting applications for more than 30 years. The use of EB is driven by a number of factors, including product performance, product consistency, high throughput, energy savings and the absence of solvent. The nature of EB technology can also enable unique converting applications that are not possible by other means.

A new generation of lower cost, more compact EB equipment has been recently introduced (Figure 1). This equipment operates in the range of about 70 to 150 kV. This equipment is well suited for curing of inks and coatings used in package printing applications. A number of articles have been written focusing on these printing applications. It is perhaps somewhat less well known that this same new generation EB equipment is also well suited for a variety of nonprinting converting applications. For the purpose of this discussion, converting applications are grouped into seven basic processes.

Figure 1

New generation EB equipment compared to original industrial equipment



1. Film Crosslinking

Film crosslinking is the largest single EB application. Polyethylene and polyethylene copolymers are well known to undergo crosslinking upon EB irradiation (Figure 2). Other

Figure 2

Film crosslinking

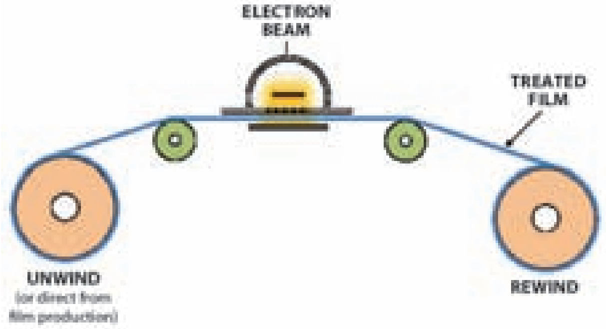
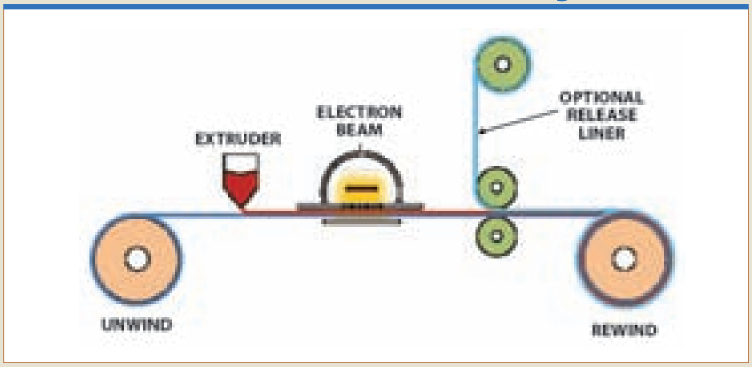


Figure 3

Pressure-sensitive adhesive crosslinking



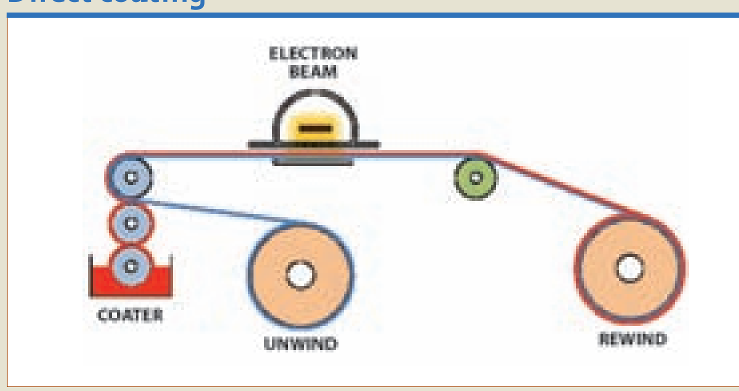
polymers may undergo chain scission or a combination of scission and crosslinking, depending on the polymer. The most common use of polymer crosslinking is to create heat-shrinkable films. Crosslinking can also be used to modify the physical and thermal properties of the films. New-generation, low-voltage EB processors may be effective for crosslinking of films up to about 0.002 to 0.004 inches thick. Penetration of thicker films is achieved with higher voltage (150 to 300 kV) industrial EB-processing equipment.

2. Pressure-Sensitive Adhesive Crosslinking

Most types of pressure-sensitive adhesives (PSAs) may be EB crosslinked (Figure 3). This includes hot melt, syrups, solvent- and water-based PSAs. The specific chemistry of the adhesive polymer backbone determines the behavior upon EB irradiation. The most common application is EB crosslinking of hot-melt, pressure-sensitive adhesives. Hot-melt adhesives are thermoplastic and must have melt and flow properties to facilitate their application. These processing properties may come at the expense of performance properties—particularly under elevated temperature end-use conditions. EB crosslinking is known to improve the sheer, heat and chemical resistance of hot-melt, pressure-sensitive adhesives. EB crosslinking of hot-melt PSAs in many cases can provide an environmentally friendly alternative to solvent acrylic PSAs. Applications for EB-crosslinked PSAs include free-film adhesives, high-performance tapes and label stocks.

Figure 4

Direct coating



3. Direct Coating

There is a large variety of functional coatings that may be cured using EB technology (Figure 4). EB-curable release coatings are well known. They include premium silicone release coatings used in the manufacture of release liners for PSAs. Silicone and non-silicone release coatings may also be produced for use in various industrial applications.

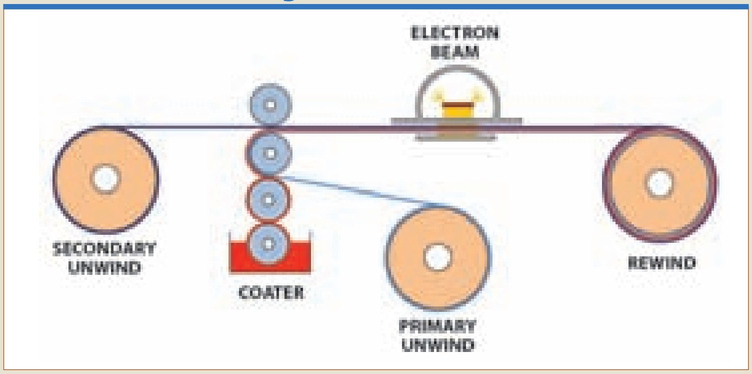
EB-curable coatings can be used together with vacuum-metallization processes. Premetallization primers may be used to provide a uniform receptive surface for subsequent metallization. EB coatings over the metalized surface can enhance or preserve barrier properties of the film. EB can also provide corrosion protection for the metal layer under some end-use conditions.

The use of EB protective coatings is well known. An example is EB coatings for decorative paper that is subsequently laminated to furniture or countertops. The crosslinked nature of the EB coating provides the desired resistance to damage from staining and scratching.

EB excels at curing pigmented and filled coatings. The ability of EB to penetrate opaque materials allows curing of coatings that cannot be cured using UV technology. Examples include magnetic media and abrasive binders. Curing of pigmented and filled coatings may be achieved by new-generation, lower voltage (70 to 150 kV) or higher voltage (150 to 300 kV) equipment, depending on the thickness and density of the coating layer.

FIGURE 5

Adhesive laminating



4. Adhesive Laminating

The advantages of EB-adhesive laminating have been described in recent publications (Figure 5). The most important advantage is instant bonding, which allows immediate quality control testing, slitting, die cutting and shipping. Instant bonding also enables in-line lamination with other converting processes. EB laminating has been commercially successful in select packaging applications, including folding cartons (film-to-paperboard) and flexible packaging (film-to-film and film-to-paper).

Non-printing converting applications may also benefit from EB laminating technology. Potential applications include lamination of metalized, holographic and specialty films to paperboard or plastic card stock; and manufacture of paper, film and foil-based, pre-laminated packaging substrates. The new generation of lower voltage EB equipment has adequate power to penetrate many substrates for effective curing of underlying adhesive layers.

5. Transfer Coating

EB technology can be used very effectively for transfer coating (Figure 6). Advantages include the elimination of thermal dryers needed for solvent- and water-based adhesives, and instant curing to give a permanent bond. EB transfer coating is also a cool process that allows transfer to heat-sensitive substrates. An inherent advantage of any transfer coating process is the highly uniform surface that is defined by casting the coating on the original carrier film. Applications include the transfer of metallized layers as well as a variety of other specialty coatings and decorative layers.

A variation of EB transfer coating involves pattern printing of the adhesive. Upon curing through the film, the coating is transferred in the pattern defined by the printed adhesive. This process eliminates the use of expensive, hot stamping dies.

6. Backside Embossing

The process of EB backside embossing is shown in Figure 7. Many different types of substrates can be used, including paper. The voltage of the EB equipment should be appropriate for penetration through the substrate. The pattern defined by the embossed drum can produce almost any feature size ranging from one micron to more than several inches. Pattern reproduction using EB technology is known to be more accurate than thermal embossing. The resulting embossed coatings are highly crosslinked, which results in excellent chemical- and thermal-resistance properties. Manufacturing of casting papers is an established application of this technology. The casting papers are used for the subsequent production of textured vinyl and urethane-based films that are found in many consumer products. Patterns defined by EB casting can also be used to produce a

FIGURE 6

Transfer coating

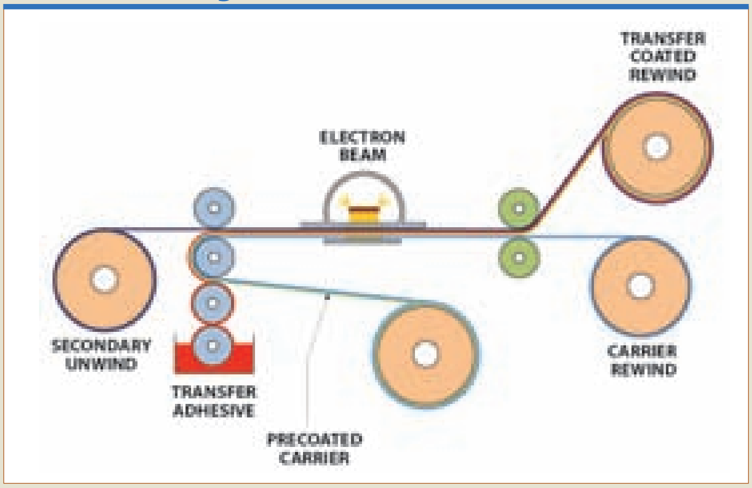


Figure 7

Backside embossing

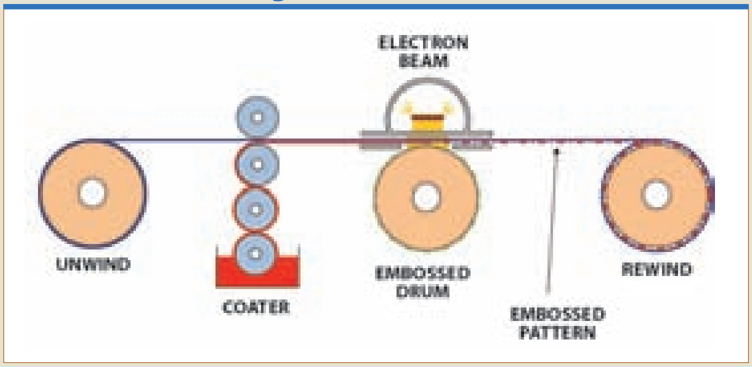
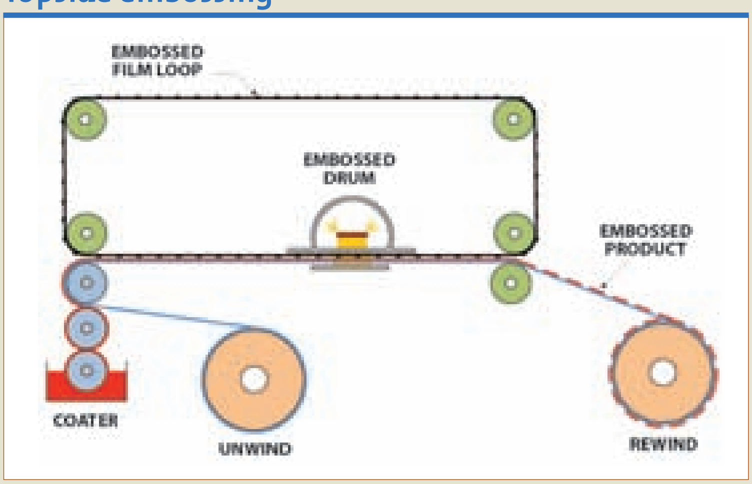


Figure 8

Topside embossing



wide array of unique tactile and optical effects, including reflective materials and lenticular or holographic images.

7. Topside Embossing

Topside embossing is similar to backside embossing and has many of the same inherent advantages and potential applications (Figure 8). In the case of topside embossing, the pattern is defined by a "parent" film. The parent film may be a roll or a continuous loop. It should be designed to resist damage from EB exposure and also cleanly release the coating upon curing. The pattern on the parent film is accurately reproduced on the new substrate upon curing.

Conclusion

EB technology may be used in a wide variety of converting applications. EB provides environmental and energy saving advantages compared to thermal curing processes. The nature of EB technology can enable unique converting processes. The development of smaller, lower cost equipment makes EB an attractive technology for expanded use in converting applications.

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