ELECTRON BEAM TECHNOLOGY: RESPONDING TO INDUSTRY NEEDS

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Electron Beam Technology: Responding to Industry Needs

by

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Abstract

Low energy electron beam equipment installations have continued at a reasonably constant pace despite the economic recession of the past few years. Web offset printing, which remains the largest market segment, plastic film cross-linking, and silicone release coating, account for the majority of the new production lines. Other applications, particularly wood/particle board coating, play a lesser but increasingly important role in maintaining the momentum of the movement toward electron beam processing. This paper describes developments in equipment performance -size, speed, accelerating voltage, reliability, inerting which have enabled the processors to meet increasingly more demanding requirements and focuses on web offset printing in describing a new standard processor designed to match the specifications of presses from five major manufacturers.

Introduction

Electron beam equipment manufacturers have endured a business slowdown similar to that experienced by capital equipment manufacturers in general as a result of the world wide economic recession. The unhealthy economic climate caused potential users to defer their equipment purchases and suppressed the anticipated increase in new installations. Nonetheless, new installatio- ns have continued at a steady, if not exciting, pace providing some reason for cautious optimism toward future growth of the industry.

In the two year period spanning Raffech Europe '91 and Raffech Europe '93, we see trends indicating continuing interest in particular applications. Looking at RPC's supply record, one-third of the new installations are dryers for web offset lithogr-aphic printing, one installation is for curing coatings on large wood panels, and the remainder are divided evenly between plastic film crosslinking, curing silicone coatings and "others".

Many of the processors supplied in this period have not required performance breakthroughs and the emphasis has been on improving reliability and maintainability. Exceptions to this are the development of higher performance inerting systems and higher processing capacity for high speed siliconizing and web offset printing.

The current status of electron beam equipment performance, including a new design particularly suited to web offset printing, is described in this paper.

Wood Coating Lines

Processing capacity requirements for wood coating lines are not difficult to achieve, as the maximum speeds are on the order of 80 mpm. Most of the challenge is in conveying the coated panels and providing efficient nitrogen inerting. The panels can be three meters or longer, more than one meter wide, and range in thickness from a few millimeters to more than 40 mm. Additionally, the thinner panels in particular can exhibit considerable warp. As a result the entrance and exit slots into the processor must be large in comparison to the dimensions used for most other types of processed products, making it more difficult to control nitrogen consumption and trap x-radiation.

We have commissioned a processor at Byggelit - Royal in Sweden which is representative of the current state of the technology for this application. In order to provide radiation shielding and nitrogen inerting, a conveyor inside a lead shielded and nitrogen inerted tunnel was designed. The overall length of the tunnel is 16 m and the electron beam is located near the midpoint. Panels enter the conveyor tunnel at an elevation of 1,100 mm above the floor and exit the conveyor 660 mm higher, the elevation difference being needed for shielding of the x-rays from the 250 kV electron beam. Panels of the maximum size of 3,000 mm x 1,250 mm x 40 mm are processed at 80 mpm.

These specifications are quite typical for other wood coating lines now under consideration, although some would coat larger panels. Current technology appears capable of satisfying all current requirements in this application.

Plastic Film Cross-linking

Cross-linking enhances the physical characteristics of the film, increasing the tensile strength and raising the melting point. Inerting is not required because oxygen doesn't inhibit the process. The state-of-the-art is presently defined by production machines approximately 2,540 mm wide operating at speeds of 305 mpm. Chill rolls are generally not used, but specific products may require their use. The production of the cross-linked film is typically a 20 shift per week operation which demands that the electron beam processors have a high degree of reliability.

At present there doesn't seem to be much interest in wider lines or higher speeds for cross-linking. There are indications that nitrogen inerting may be specified for future machines and perhaps as retrofit packages on existing machines as a means to avoid the environmental problem of ozone disposal. Several companies are examining the trade-offs involved in the equipment and operating costs for nitrogen generation as an alternative to ozone destruction. In this application also the near term requirements are well within current technology capabilities.

Silicone Release Coatings

Specially formulated silicone coatings applied to a plastic film or paper web by an offset gravure or smooth roll coater are cured at high speed by electron beam processors. The coating weight is typically one gram per square meter or less and electron beam accelerating voltages of 200 kV or less are sufficient to penetrate and cure the product with a typical dose of 25 kGy. The coatings are sensitive to the presence of oxygen during the curing process. Oxygen concentrations above approximately 50 ppm will. inhibit curing.

This application continues to be the most demanding in terms of nitrogen inerting requirements because of the combined requirements of high speed, low oxygen concentration, and economically reasonable nitrogen consumption rates.

Successful coating and curing at speeds of 600 mpm have been demonstrated on a 1250 mm wide European Demonstration facility in Hamburg with nitrogen consumption of 0.006 scm/m^2. Table I shows that the cost of nitrogen is less than 1% of the total cost of substrate and coating, even when coating inexpensive BOPP film.

TABLE I. Relative cost of nitrogen, silicone coating and substrate. Substrate material, 15 µm BOPP; coating weight, 1 gm/m^2; web speed, 600 m/min.

	Cost per 1000 m^2 (DW1000 M2)	**Percentage (% of total)**
Substrate	110.00	76.87
Coating	32.00	22.36
Nitrogen	1.10	0.77
TOTAL	143-10	100.00

The highest speed in production lines is 305 mpm. This speed is achieved on lines ranging in width from 2100 mm. to 3300 mm. It is anticipated that future lines will push the speed into the range between 300 and 600 mpm.

The interest in electron beam cured silicone coatings continues strong. An 840 mm wide BroadBeam® processor has recently been installed on another European pilot line with a view toward further development of this application.

Web Offset Printing

The use of electron beam "dryers" to cure 100% solid inks and coatings in the web offset lithographic printing process remains the largest single industrial application for electron beam processors operating below 200 kV, with more than 50 dryers now in use.

Most of the dryers are approximately 1,020 mm wide; the overall range is from ~10 to 1,320 mm. Electron beam energy doses of 20 to 30 kGy at voltages less than 200 kV are used to cure the solventless inks and coating~, which are printed wet-on-wet. Until recently, all of the presses printed on the top side of a horizontally moving web and the maximum press speeds were in the range of 245 to 305 mpm.

A New Generation of Presses

Within the last six months there have been two installations of a new press configured to print on the bottom side of the web at speeds up to 450 mpm. Several press manufacturers are introducing top side printing presses with printing speeds above 370 mpm. Higher speed presses create a requirement for dryers with high processing capacity and efficient high speed nitrogen inerting.

Web offset presses print on a variety of substrate surfaces ranging Erom "very smooth" poly coated paperboard to "rough" uncoated recycled paperboard. Noticeable differences are observed in the efficiency of nitrogen inerting for different substrates at high speeds.

Figure 1 shows the type of BroadBeam® dryer now installed on the two new bottom printing -press lines. The printed web enters at the bottom, moves vertically through the horizontal electron beam, and exits at the top of the dryer. Electron beam window foil lifetime in excess of 2,000 hours of continuous operation at 1,200 MRMPM (mega-rad meters per minute) is achieved by using a water cooled window support plate of a new design. Convection cooling of the foil is not required. In addition to the upgraded window foil cooling and nitrogen inerting systems, the dryers are now supplied with either a programmable logic controller based control system, or the microprocessor based system.

A New Generation of Processors

The announcement of the development of new high speed printing presses by several manufacturers coincided with the decision by RPC to develop a new standard processor especially compatible with web offset printing and also suitable for other applications. Discussions with press manufacturers and users continued during the entire development project in order to validate the functional and engineering specifications of the new processor. As a result, we have produced a new standardized processor that without customization is ideally matched to web offset presses from the leading manufacturers.

"Ideally matched" signifies a dryer satisfying the requirements of all "users", including plant managers, maintenance technicians, press operators, and product line managers; everyone with a direct or indirect interest in the equipment, during the entire lifetime of a project from equipment selection and purchase through installation, setup and continuing operation. "Requirements" groupings include performance, maintenance and reliability, capital and operating cost, convenience and safety.

The balance of this paper describes some of the features found in the system.

Configuration

A principal objective for the design of the dryer was to make it possible to install the dryer, without customization, into the widest possible range of web offset press lines. The necessity to customize to accommodate specific web entrance and exit heights and angles has been a continuing cost and delivery time factor for electron beam processors. Now, with additional press manufacturers adding to the number of press models available, standardization of the interface has become even more essential.

The new dryer has an interface compatible without customization with (at minimum) fourteen press models from five press manufacturers, in web widths ranging from 520 mm to 1150 mm.

The dryer provides full output within the accelerating voltage range of 150 to 175 kV with power provided by a conventional three-phase dc high voltage power supply. It can be specified with either the standard processing capacity of 1,000 MRMPM or the 1,200 MRMPM high performance option.

Defining the web path through the dryer presented significant engineering challenges because of the existing constraining factors. The presses are all of the "variable repeat" type, meaning that the repeat length of the printed pattern can be varied within prescribed limits. This is accomplished by changing the diameter of various rolls within the presses, a procedure which also changes the web height. Changes in web height on a given press due to repeat length changes tend to be on the order of 200 - 300 mm for the narrower web presses and even greater for the wider presses. The press manufacturers specify maximum and minimum allowable values for the angle from horizontal with which the web exits the last print station, and also for the web height. The web enters the dryer at a fixed height above the floor, therefore the web entrance angle into the dryer changes when the repeat length is changed.

Inside the radiation shielding of the dryer the web must wrap around one or more rollers in order that the lead shielding can trap x-rays and prevent them from coming out of the web entrance and exit slots. Rollers cannot be allowed to contact the printed side of the web until after it has passed through the electron beam and the inks and coatings have been cured. Any rollers which do come in contact with the printed side of the web should be accessible without opening the processor shielding so that they can be cleaned if uncured inks or coatings are inadvertently deposited on their surfaces.

Roller diameters and web wrap angles must be chosen with regard to maintaining the mechanical and surf-ace integrity of the different printing substrates which can range from thin plastic film to heavy paperboard.

The orientation of the electron beam window and the method for opening the shielding need to be chosen so that routine replacement of the electron beam window foil can be accomplished quickly and easily.

As the plane of the window becomes more vertical, the distance between the web entrance height and the minimum height of the web inside the dryer increases. Unless one is willing to consider placing parts of the dryer below floor level, the presses with lowest web heights place a severe constraint on the window plane orientation.

Our new dryer has successfully accommodated all of these physical constraints. V.1ith three available web entrance heights (838, 914, 991 mm) it accepts webs from fourteen presses, with press e3dt angles ranging from 10° downward to 11° upward. Three 100 mm dia. rollers contact the unprinted side of the web; the printed side contacts only a 150 mm dia. exit roller. The surface of the e3dt roller can be inspected and cleaned without opening the processor.

The dryer occupies significantly less space than its predecessors. in-line length (in the web direction) has been reduced 28%, from approximately 2540 mm. to 1830 mm. Maximum height has been reduced 19% from 2260 mm to 1830 mm. Regard has been given to the external appearance by creating a design which blends harmoniously with modem printing equipment. The external surfaces are panels which can be completely removed to gain access to the primary shielding and the electrical and mechanical systems inside the processor.

Double doors on the operator end of the dryer open for access to the beam absorber assembly. These doors are outside the shielding and can be opened while the processor is operating. The electron beam window is accessed by powered lowering and outward motion (perpendicular to the web) of the beam absorber assembly on self contained rails. A complete window foil change, from power down and back to full power, takes less than two hours.

Controls

The control system, based on the Siemens S5-103U PLC, is housed inside a swingout rack at the utilities end of the dryer, the preferred and customary location as indicated by our discussions with users. An optional separate enclosure for the local controls is available.

The PLC controls the set points for electron beam voltage and dose, automatic or manual operation of the vacuum system, and all interlocks and alarms, including a "wet ink" alarm which alerts the press operator to conditions which might result in uncured product passing through the dryer.

In the standard system configuration, a remote panel is supplied for installation at the press operator control console. An optional remote unit with CRT display of all controlled and monitored functions is also available.

The Siemens PLC can communicate with the various PLC control systems used by the press manufacturers, making it possible to integrate display of the dryer parameters with those of the rest of the press fine.

A local control panel for the nitrogen inerting system is located on the web exit side of the dryer. This panel contains the controls necessary to set and monitor the nitrogen flow to each of the nitrogen distribution points. 'The panel functions through the Siemens PLC. Six different combinations of flow settings can be stored in memory and recalled as needed for efficient inerting of a specific substrate.

The systems for supplying filament current and controlling the filaments and control grids have been simplified for easier maintenance and calibration. in BroadBeam® processors, the filaments and grid control circuits are contained on a "floating deck" that operates at the full accelerating voltage and is electrically isolated from earth potential by a single high voltage isolation transformer. Control signals and measured parameters are transmitted between the floating deck and earth potential via fiber optic links.

In the new system, controls for the filament circuit and many other circuit components have been moved to the primary side of the high voltage isolation transformer and operate at earth potential. The number of fiber optic links has been reduced from eight to five and the number of printed circuit boards reduced from three to one. The heat generated by high voltage deck components has been reduced by more than 50%.

Other Benefits

Standard BroadBeam® dryers provide greater than 98% available uptime. The new dryers are designed to equal and exceed this figure. As part of the effort to improve reliability and reduce cost, the total number of parts has been reduced by approximately 40% and the number of different parts has been reduced by 45%. Features such as fewer components on the high voltage deck, integration of the vacuum system control with the PLC system, and simplified mechanical structures all contribute to increased reliability and better performance at lower cost. Standardization of the design for the fourteen presses is in itself an important cost savings and reliability improving measure. Standardization also means that the delivery time for new dryers is reduced and installation into the press line becomes more routine and faster.

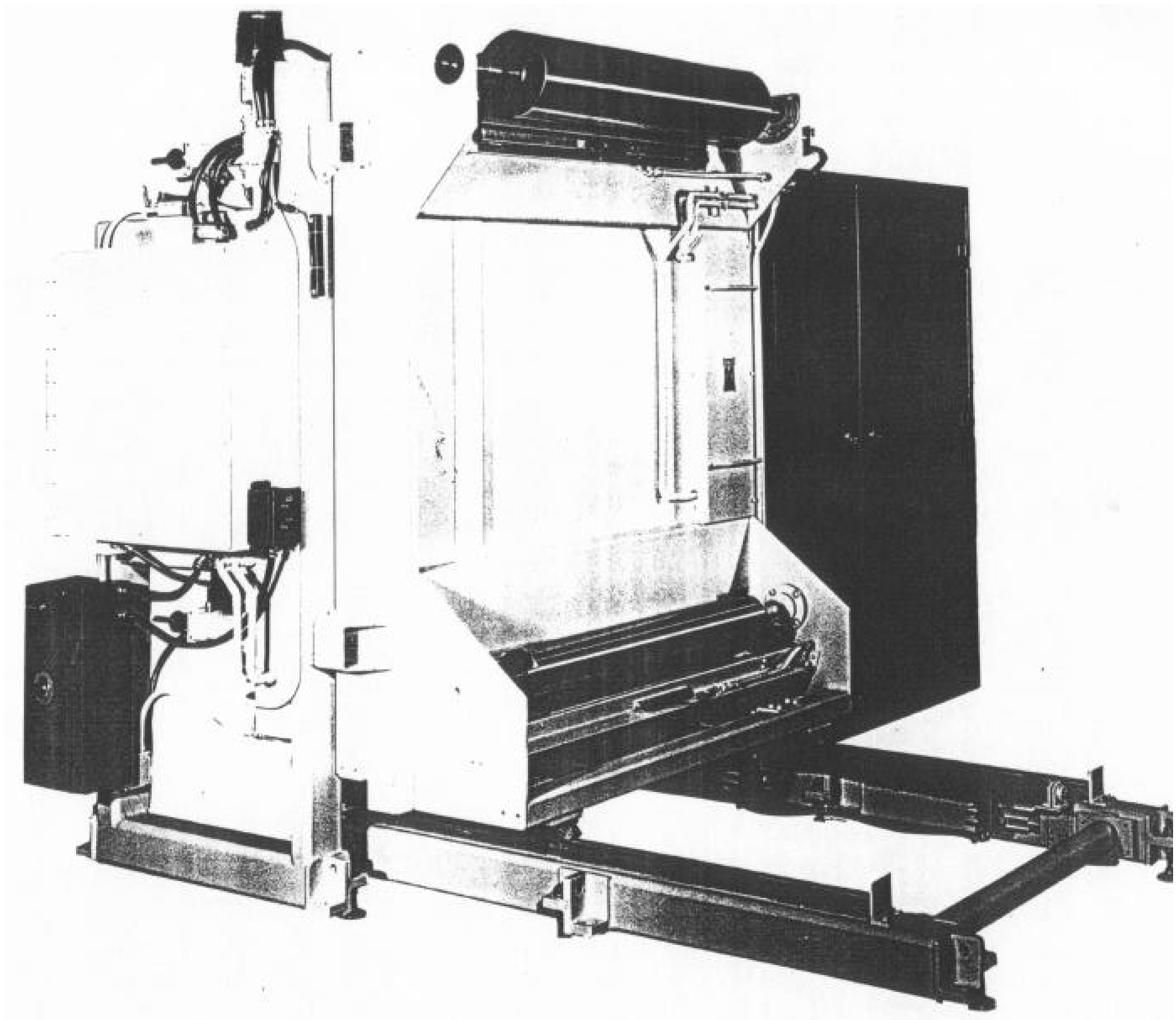

Figure 1. BroadBeam® dryer for high speed curing of web offset inks and coatings.