

EB curing – a promising radiation technology

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UV flexo has become the standard in narrow web printing, but in wide web flexo printing it did not really make it. Will electron beam (EB) curing be more successful as it offers advantages over UV curing?

Electron beams are very energetic. This has been known for quite a long time. Already in the 1950's the first experiments with EB curing of inks took place. But in those days the generation of electron beams required rather large and complex machinery. It was not until the eighties that a viable solution was found and the curing installations became more compact. Nowadays, a hundred web offset machines in the USA are already running with EB curing. Last year *Comexi* demonstrated the first wide-web flexo press with EB curing. The process, called *WetFlex*, has been developed in co-operation with *Sun Chemical* for the inks and *Energy Sciences Inc (ESI)* for the dryer. *ESI* can be considered as a front-runner in EB curing and supplied most of the information for this article (see *FLEXO & GRAVURE INT'L* 3-2006, p. 66).

How does it work?

Electrons are the smallest of the elementary particles, much smaller than the protons and neutrons which form the nucleus of an atom. The negatively charged particles circle around the positively charged atom nucleus. In a molecule the joint electrons take care of the binding between the atoms which build the molecule. So, electrons have an influence on the molecule structure. E.g. when »free« electrons are accelerated and penetrate into an ink layer, they will lose speed and transfer their energy into the ink. This transferred energy excites the ink molecules and forms a cloud of secondary electrons and free radicals. Just as with UV curing these free radicals initiate a chain reaction which transforms the monomers and pre-polymers of the ink into a network of cross linked poly-

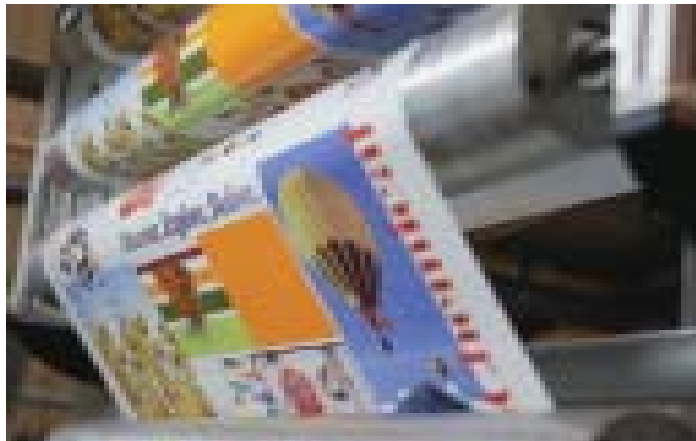
mers. Contrary to UV curing, EB curing does not need photoinitiators to initiate this process. The absence of photoinitiators make odour, yellowing and skin irritation obsolete. It also makes the curing process suitable for food packaging. Curing takes place in a fraction of a second. As there is no post-curing, the printed web can immediately be further processed. The printing inks and varnishes contain 100% solids and are solvent-free.

The curing installation

EB curing is all about accelerating electrons. This happens in a vacuum chamber, where one or usually more metal filament wires are arranged parallel to the web direction. The metal wires are heated up to a temperature of about 2000 °C and then they start to emit electrons. This is the same effect as in an incandescent lamp, where the electrons create photons. A large difference in voltage between the negatively charged metal wires (the cathode) and the positively charged exit window (the anode) accelerates the electrons. On their way to the exit they pass a grid which directs them onto the substrate to be treated. The vacuum chamber is closed with a thin Titanium foil with a thickness of a few micron. The electrons pass the foil and then reach the substrate, which runs at a short distance from the foil. When the electrons pass the

Left:
The *Comexi* press at the introduction of *WetFlex*. The *ESI* dryer can be seen on top of the press.

Right:
A view in the *Comexi* press during the *WetFlex* demonstration.



foil they lose some of their speed. To limit the loss of electron energy, the foil is extremely thin.

The space between the foil and the substrate is filled with an inert gas, usually nitrogen. This prevents the electrons from contacting oxygen molecules as the oxygen in the air reacts more easily with the formed free radicals than the ink components. Just as with UV radiation this limits the curing process. Moreover, the oxygen will be ionised and build ozone.

Penetration depth

The accelerating voltage is expressed in kiloVolt (kV) and the accelerating energy of the electrons entering the substrate in kilo-electron Volt (keV). The energy of the electrons and the density of the material to be cured determine the penetration depth of the electrons. Electrons accelerated by a voltage of 70 kV up to 125 kV are very suitable for the curing of printing inks and varnishes. In general, a voltage of 110 kV cures inks up to a thickness of 30 micron. To make sure that the inks are completely cured, the energy dose at the bottom of the ink layer should be about 80% of the dose at the top of the ink layer. The penetration can be made visible with depth dose profiles.

By varying the number of electrons or the current the dose rate can be altered. This rate is expressed in kiloGray meter per minute (kGy m/min). The higher the accelerating voltage or energy, the deeper the penetration of the electrons. In this way the energy and the dose rate can be adapted to the thickness of the ink layer and the printing speed.

EB curing is a cold process; there is no heat or IR as is the case with UV curing. The process only gives a slight rise in temperature, a few degrees Celsius, in the substrate. Only for very heat sensitive substrate cooling may be necessary. The curing process does not dry out paper substrates.

EB curing can handle a wide range of inks and varnishes, including heavily pigmented, metallic inks. After drying the ink surface shows a high gloss. The scratch, abrasion and chemical resistances of the cured layer are very good.

Shielding

Energetic electronics produce X-rays when absorbed by matter. This natural phenomenon is used in commercial X-ray equipment. Therefore, electron beam equipment has to be shielded. To prevent the emission of radiation all critical components of a curing installation are plated with steel or lead. The web is never lead in a straight path through the dryer, but makes an angle at the entrance and at the exit of the curing installation. This prevents radiation from directly going outwards. The radiation immediately stops when the EB curing system is turned off, so there is no danger in opening the system for inspection or maintenance.

As the curing installation only contains a few moving parts, maintenance is rather simple. Wear is minimal and limited to cathode wires, window foils and a few other parts such as O-rings. The life-time of the cathode wires is about 7000 working hours and of the foil 2000 hours.

Expensive?

EB curing installations are not cheap, prices start from about EUR 300,000. But there is only one installation needed at the end of the printing press, which cures all the inks and varnish. With EB curing the printing process is wet-on-wet, so without inter-colour drying. *ESI* offers the compact *EZCure* installations for web widths of 500 mm (20") up to 1650 mm (65") and standard EB curing systems for web widths from 450 mm (17.7") up to 3000 mm (118"). The energy consumption is about 20% of that of a UV installation and a tenth of thermal cure. Also the inks are cheaper than UV inks. Indeed, the ink compositions are comparable but EB inks lack the expensive photoinitiators.

Applications

EB curing has already gained a strong foothold in the coating industry. E.g. it is used for applying protective coatings onto packaging materials. As no photoinitiators are used, it is safe for food packaging



The EZCure, an EB curing installation by ESI.

materials.

It has been practised for over 20 years now in web fed offset. More than 100 curing installations are in operation, mainly in the USA, on web offset presses printing cartons. Lately, also flexible packaging is produced on these presses. At first, wide-web presses were equipped with EB curing like those of *Komori-Chambon* and *MAN Roland*. But now, also mid-size offset presses of *Müller Martini* and *Drent Goebel* are offered with EB curing. The curing process is not suitable for sheet-fed offset, gravure and inkjet printing.

WetFlex for wide-web flexo

The big news is, of course, that EB curing is now entering the wide-web flexo market. In June 2006 *Comexi* invited more than 500 customers to its open house where EB curing was introduced under the name *WetFlex*. The project was a co-operation between *Comexi*, *Sun Chemical* and *ESI*. *Sun Chemical* has developed *UniQure* inks for the process. These inks are provided with a mechanism for wet trapping through the press. According to *Sun Chemical* the *UniQure* inks virtually eliminate taint and colour. The high colour strength is said to offer a significantly better mileage than conventional flexo inks, while the cured print has inherent resistance properties that allow it to be used in the home and garden products market. As practically no heat is produced during the curing process, it is ideally suited for the production of shrink sleeves.

In bulk form, the *UniQure* inks have the low viscosity associated

with flexo printing. Once printed into a thin film, the ink phase changes to give a high tack surface, similar to offset. This allows the next layer to trap effectively without drying. This makes the process independent of the colour sequence on the press. Even when not yet dried, the printed ink is said to have very stable properties with dots and solids retaining structure. This allows for a high resolution in the graphics thanks to screen rulings up to 80 l/cm (203 lpi).

The inks do not dry until cured. They can be washed up and cleaned with water.

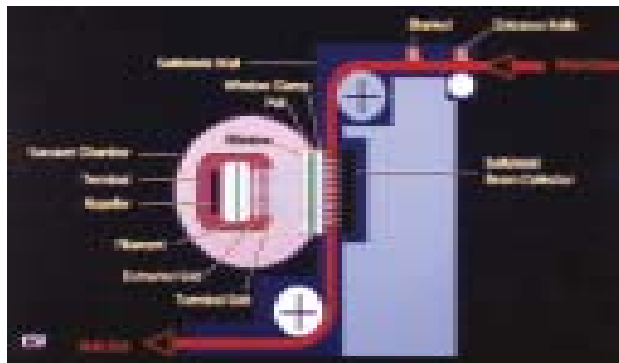
After curing the print is ready for all common finishing processes such as off-line varnishing or laminating. The high gloss and the resistance against abrasion and scratch could even make this finishing superfluous. The inks are available in CMYK colours and a number of spot colours, including green, orange, lilac and opaque white.

At *Comexi's* headquarters in

Girona/E, *WetFlex* ran a seven-colour job on an *FW 1508* gearless CI flexo press at a speed of 300 m/min (984 fpm). According to *Comexi*, the ink consumption was reduced from 4.5 g/m² for conventional flexo down to 2.2 g/m² for EB curable inks. Existing presses can be retrofitted for *WetFlex*.

First users

This year a number of CI-presses with *WetFlex* will come into operation. One of them is at the German company *Uniprint Knauer GmbH* (the former *UV-Flex GmbH*) of Aichstetten in Germany, who installed a ten-colour 1350 mm (53") wide *Flexpress 16S* of *Fischer & Krecke* adapted to *WetFlex*. The specific properties of the *UniQure* inks required some extensive modifications of the automatic inking and wash-up system. The inks have to be temperature controlled to ensure an optimum processing temperature in all production conditions.



Schematic reproduction of the Electrocare EB Processor of ESI.

Similarly, the inking and wash-up cycles of the *Autoclean* system had to be adapted to the properties of the new inks.

It is a notable sign that this company specialised in UV flexo takes the step to EB curing. It looks like wide web flexo, at last, will get the radiation curing technology, which will push it another step forward.

Another *WetFlex* first is for *Constantin Druck* belonging to the *Schulz Holding* in Baden-Baden/D.

EB Protocol

RadTech Europe and the department for Surface Treatment Technology of the *German Engineering Federation (VDMA)* diagnosed the possibilities of EB curing at an early stage. In June 2006 they launched the EB protocol for the printing and coating industries. It is an extension of the already existing UV Protocol. The document is acknowledged as a common reference by national health, safety and environmental bodies in Europe. The UV/EB Protocol provides a comprehensive list of conditions for safe application of UV and EB technology, focussing on the three significant hazards related to radiation technology: inhalation of or contact with dangerous substances, inhalation of ozone and exposure to radiation. The Protocol's standards cover both the compounds of UV and EB inks and lacquers, and the design and construction of printing and coating machines. Also included is a series of detailed recommendations for industrial operators.

The UV/EB Protocol can be down-loaded at www.vdma.org/uv or at www.radtech-europe.com/UVProtocol.html