Electron Beam Curing: An Important Option for Sustainable Packaging

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Abstract:

High energy costs, climate change, and carbon emissions have forced various industries to evaluate the way they do their manufacturing. Due to this, the packaging industries are focused on sustainable packaging, and low carbon foot print as some of the terminologies being discussed globally and being mandated by consumer companies. This presentation will address what sustainable packaging is; and how energy curing, and in particular electron beam curing, is now recognized as a critical option in providing sustainable packaging.

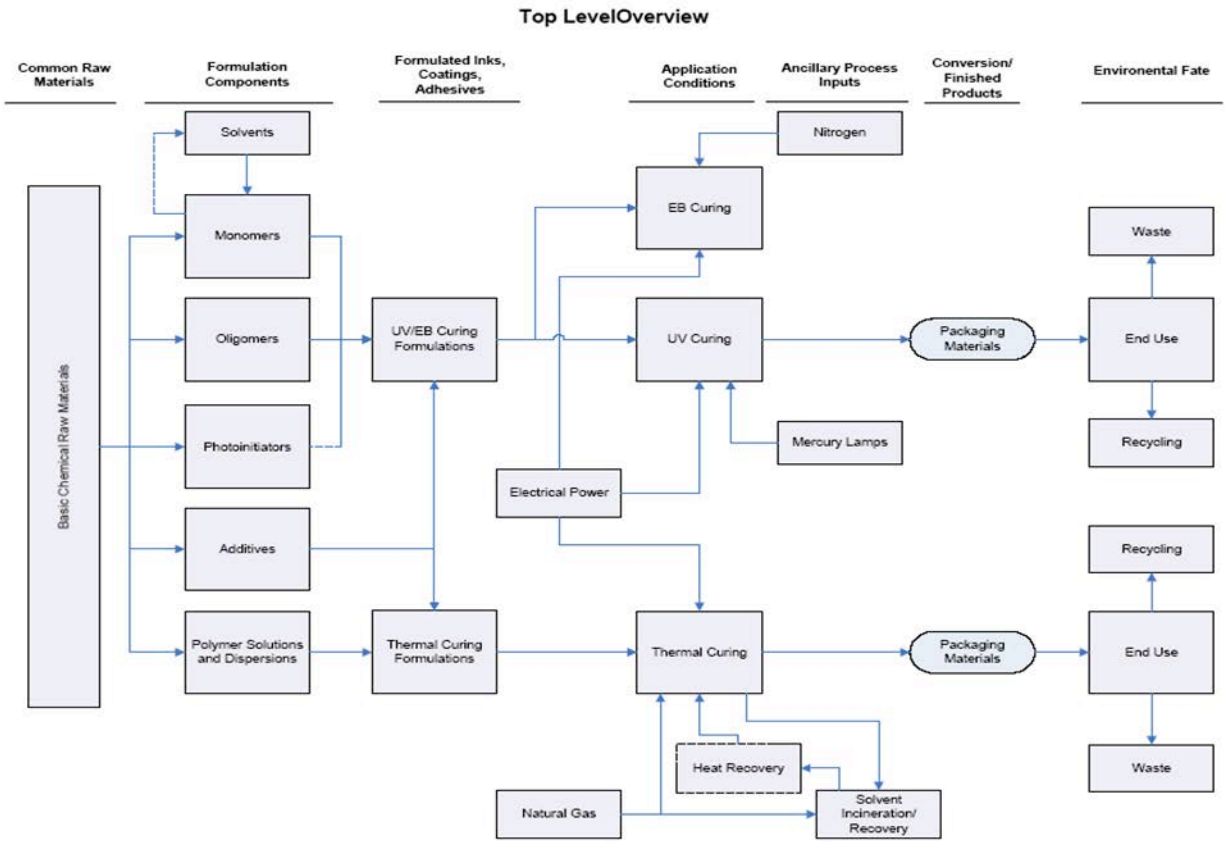
New Challenges for the Packaging Printer

Further to the usual technical and commercial problems that must be solved on a daily basis, printers of flexible and other packaging materials are increasingly confronted with several "modern" issues that must be dealt with or solutions found for. Packaging is becoming a commodity; there is wild competition especially from developing countries having lower labor and other overhead costs. Increased market growth and increased competition is forcing converters to be more productive leading to consolidation, obsolete plant close downs and new equipment purchases.

The change in the macro economic picture in packaging in turn is changing market conditions for package printers: Runs are getting shorter due to the social evolution of society and finished packaging products being shipped across various countries; quality requirements are increasing and, last but not least, sustainable packaging, lower carbon foot print targets and high energy costs are forcing printers to look at technologies that are environmentally compliant. Nothing goes any more without sustainability! The topic finds great attention in trade of consumable goods and in the packaging industry. It is interesting to note that there exists no common agreement for the definition of "sustainable packaging"... But what is sustainably packaging? Let us have a look at how the Sustainable Packaging Coalition (SPC) defines sustainable packaging[1]:

A. Is beneficial, safe & healthy for individuals and communities throughout its life cycle;
B. Meets market criteria for performance and cost;
C. Is sourced, manufactured, transported, and recycled using renewable energy;
D. Maximizes the use of renewable or recycled source materials;
E. Is manufactured using clean production technologies and best practices;
F. Is made from materials healthy in all probable end-of-life scenarios;
G. Is physically designed to optimize materials and energy;
H. Is effectively recovered and utilized in biological and/or industrial cradle to cradle cycles.

Today there exists no sustainable packaging yet. If one were to do a flow diagram based on the above for sustainable packaging cradle to grave approach it would be very complex as shown:



However, if we were to just compare various drying technologies used for printing to make a functional flexible packaging product and compare the energy consumption, carbon foot print associated with it, a gate to gate approach. The task would be simpler and manageable.

In this paper we present solutions for the converting of packaging materials with coatings, inks and substrates that are environmentally friendly, ecological and are produced with least amount of carbon footprint.

We indicated above some of the major issues facing the package printer. One can change the printing method. Use less material by optimizing the package, by choosing high quality printing method. Buy and install modern and efficient printing presses to obtain improved print quality. Or use inks and drying technology that has no VOC and has the lowest carbon foot print.

Several factors influence the decisions to be taken and actions to be implemented. The right choice of (printing) equipment, for instance, depends, on the customer base and the type of printed products to be made. An important factor is the choice of the appropriate drying technology. It not only is an important factor in energy consumption and thus influences operating costs; it also has a great influence on the type of products that can be printed and on the quality of the printed products. High quality printing can perhaps eliminate lamination and allow mono-film package with surface printing. This approach would reduce packaging materials, would be easily recyclable, features very important towards sustainable packaging. Thermal drying for water and solvent based inks and coatings consumes a lot of increasingly expensive energy, produces heat that can damage the substrate and it emits VOCs, which needs to be managed adding energy, producing CO_2 and costs. It also. The alternative is radiation, or as it is now called, energy curing: EB or UV. Before looking at these alternate drying or curing methods, let us have a brief look at the printing methods used in packaging printing to day and the development of printing methods.

Printing Methods for Packaging

Gravure Printing

Gravure printing is the printing method of choice, if high quality prints and long runs are required. Runs of 50’000 meters are a minimum requirement. The print quality is excellent, printing inks are relatively inexpensive and the production speed is high. The disadvantages of gravure printing are its high pre-print costs (gravure cylinders), long set-up times and high costs for thermal drying energy, solvent recovery or incineration and CO_2 reduction. Gravure inks contain 80 % and more solvents or water. Important technical developments did not take place in the past years in gravure printing. EB or UV curing can not be used in gravure printing due to the low viscosity of the inks.

Flexo Printing:
Flexo printing or flexography went through a remarkable development in the past years. Several suppliers provide solvent and water based flexo inks so they are moderate in price. Flexography is often used by small to medium sized companies producing a relatively good quality. However, pre-print costs for anilox cylinders and plates are also high and getting close to the costs involved with gravure printing. Energy consumption is high and the users deal with the same problems as the user of gravure printing when solvent based or water based inks are used.

To address the shortcomings of flexo printing UV curing was introduced. Print quality of UV cured flexo improved substantially, and VOC problems were addressed, too. In the past years several flexo stack presses and a few CI flexo presses were equipped with UV curing, replacing the thermal curing ovens between the ink stations. But the success of UV curing in flexography was moderate due to issues related to UV curing and remains limited to in-line presses and for substrates that are not heat sensitive (aluminum foil, paper board). Overcoming the deficiencies of UV curing in flexo printing, the latest and most revolutionary development is the EB CI-Flexo ink process. It allows printing of 8 or 10 colors wet-on-wet and EB curing of all ink layers after the last printing station, without interstation drying[2,3]. The print quality is very high with an extremely low dot gain, improved resolution (up to 70 lines per cm), higher gloss, more intensive pigmentation and superior abrasion, wear and chemical resistances[4]. As is the case with all EB applications, energy consumption is considerably lower than with any other drying method. The picture below shows a low voltage EB unit installed in a CI flexo press.

Web offset Printing:

Offset or lithography is a printing technology featuring high print quality with low pre-press, set-up and operating costs. Photographic plates used as the image carrier cost a fraction of gravure cylinders or anilox rolls. The print quality is high and allows for finest prints and consistent execution of color from run to run. In the USA web-offset printing is used since more than 20 years for packaging printing, mainly on folding cartons, for both food and non-food products. The development of the VSOP and other web-offset printing presses featuring variable sleeves for easy and fast change of the print format opened the possibility to economically print shorter runs of rigid and flexible packaging materials. The picture below shows an below shows a low voltage EB dryer in a VSOP 850 web-offset press. EB curing, used to dry wet-on-wet printed offset inks without interstation drying since more than 20 years, was the natural choice for these new variable sleeve web-offset presses as the drying method. To day EB drying in web-offset is not only used for printing folding cartons, but increasingly to print on clear, opaque or on metallized film for flexible food packaging. Often a clear protective varnish is applied over the wet inks and EB cured or dried in-line with the inks[5]

Case Study of a 10 kG Heavy Duty Bag for Lawn and Garden Fertilizer:

Let us consider package converting an outdoor lawn and garden bag as shown in the figure. For incumbent package structure printing is done by conventional solvent based flexography reverse printing on a 30 micrometer thick polyethylene film, which is then adhesive laminated using solvent based adhesive to a 75 micron white polyethylene film The total thickness of the package 110 micrometers, comprising of the films, adhesive and ink.

With energy curing route using the EB-Flexography printing process one could use one layer of white polyethylene film 75 micrometer thick, surface printed with EB-Flexo inks, and using 3 micrometer EB coating to provide protection and other required end use properties. The high print resolution of EB curable flexo inks, provides improved print graphics. The EB coating provides improved gloss, shelf appeal, protection and controlled COF better than the laminated structure and in addition using 25 % less material.

Comparing the energy used to dry the solvent based inks requiring thermal drying after each print station and then an overhead dryer, versus the electron beam curing requiring no interstation drying is as shown in the following Table:

Table

Total Energy Consumption CI Flexography Printing Line Using
Solvent Based Inks and EB Inks

Item	Solvent Press kW	EB Press kW
Gas Dryer	197	None
Incinerator	162	None
Electric	15	55
Cooling	79	23
Nitrogen	None	72
Total consumption	453	150

Assumptions:

Width	1300 mm
Substrate	LDPE
Number of colors	8
Product speed	350 m/min
Solvent	Ethyl acetate
Heat	Natural gas forced hot air

Energy consumption is 66% less using EB curing versus thermal drying for printing operation. Please note in this exercise no attempt has been made to account for the energy required to dry the solvent based adhesive, nor the energy associated in the logistics involved in the adhesive lamination operation step which is not required using EB curing route.

Conclusion

Printers today are under significant pressure to provide high quality printing on various substrates and to reduce costs and carbon foot print at the same time.

Moving forward with gravure printing, which has been an incumbent for many years in providing high quality printing, will result in a loss of market share, in most cases EB-CI flexo, and some to EB offset printing because they offer improved print quality, lowest carbon foot print, less packaging, at reduced cost all important aspects towards sustainable packaging. The case study for heavy duty lawn and garden bag presented in this paper resulted in

- 25 % less packaging material vesrus the incumbent laminated structure
- 66% less energy consumed in just the printing operation.
- Monolayer packaging are easier to re-cycle and re-use compared to laminates
- EB-Flexo printing and coating provides better print fidelity, gloss, protection at a cheaper cost

EB curing either by CI flexo or by web-offset technology provides the most economical and the lowest carbon foot print option. At the same time it also provides capabilities of running a wide range of different substrates at very high print quality[6]. EB inks are food packaging friendly and contain no VOC[7]. EB is indeed the only curing option that helps to provide sustainable packaging.

References

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