

Digital Printing in Industrial Packaging Applications: Current Status and a Road Map for Success

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Abstract

In this paper, we investigate the progress in the application of ink jet printing technology to industrial package printing. With the phenomenal success of the ink jet printing technology in the SOHO environment, there is an intense interest among both ink jet printing system manufacturers and the packaging industry in using this technology for packaging applications. In the past, there have been some applications of ink jet technology in packaging, especially for low resolution and low speed applications like case coding, bar coding and the like, with continuous ink jet being the main technology of choice. Currently, the DOD technology has matured to the extent that it is becoming the preferred technology for high quality and high resolution printing systems. We believe that ink jet technology, through recent advances, has reached a stage where it could be used to develop printing systems for applications in package printing. These applications can span the range from printing just variable information to full package printing. We will give details about the packaging application from the end user's perspective and address issues such as resolution, speed, and reliability, etc. Also considered are issues like environment, user interface, manufacturing integration, and acceptance on the factory floor, which are all key elements for the successful implementation of the technology. We will detail our experience over the past couple of years as an end user trying to incorporate this technology and the lessons learned in the process.

Introduction

Ink jet technology has become increasingly popular in different printing applications including small office home office (SOHO) printing, textile printing, as well as some customized printing applications, like mailing labels, etc. The next logical application for this technology is in industrial packaging for consumer products and the like. The application of digital printing technology, in particular ink jet technology to consumer packaging opens new ways to customize the packaging and product promotions and marketing. Ink jet technology is ideally suited for application in this area provided it could meet the quality and the throughput requirements of this application. Though there have been attempts in the past to use this technology for packaging applications, it is only the recent advances in technology developments that have made it possible to meet the demands of some of these applica-tions. In this paper, we detail our experience in trying to adapt and develop ink jet printing systems for consumer packaging applications, including the lessons learnt and a possible printing system that will meet the needs.

Before we explore the application of ink jet technology to consumer packaging, it is necessary to understand the requirements that this particular application demands. It is also worth noting that apart from the different quality issues associated with various packaging applications, some of these requirements depend upon where in the packaging process the digital printing is planned to be implemented, as well as how much of the printing will be done using the digital technology. Ideally, a complete system with an integrated printing and packaging operation will provide the most flexible platform for product customization and manufacturing flexibility. However, this goal is beyond the reach of the technology currently, and a hybrid system employing traditional printing and digital technology in the packaging process is an option which may provide many attractive benefits. It is important to realize that even in a customized packaging application, the whole of printing does not change from copy to copy. Some of the information is fixed among all packages, and only some of the information keeps changing. So one of the ways in which the digital technology could be utilized is by using it only to print the variable information at an appropriate point in the process. Though the throughput and the print quality issues depend upon the particular packaging applications, we could get some general guide-lines for specific applications. For example, most packaging applications use Gravure or Offset printing and the printing is done in very high speed presses. The efficiency of these traditional printing techniques is due to the speed of printing as well as

the dependable quality and reliability. Among the two types of ink jet technologies, i.e., continuous ink jet (CIJ) and drop on demand ink jet (DOD), the CIJ technology has had some success in applications relating to industrial high speed printing like date and bar coding, and personalized mailing systems. Of late, the DOD technology has started to make inroads into some of these application areas. There are many advan-tages of using the DOD technology including simplicity, affordable cost, reliability, more ink formulation options and the possibility of getting high quality printing. Some of the issues that need to be addressed are drying times, water and abrasion resistance, reliability and speed.

Conventional Printing/Packaging

The current packaging systems utilize pre printed materials which come in either as large label rolls (used in packages known as soft packs), or as blanks (used in packages known as hard packs) in units of a few hundred. The feeding mechanism will depend upon whether label rolls or blanks are used. Large amounts (typically hundreds of thousands or millions) are printed using traditional printing techniques. When the volumes are large and if the printed information on the packages does not vary, the traditional printing is very cost effective. When the produc-tion schedule could be fixed in advance, the system works quite well. But in practice, the changes in supply and demand mean that it is seldom that production schedule is fixed in advance. Last minute changes are a rule rather than an exception, and as a result, a large amount of buffer stock of the packaging material has to be maintained to accommodate these changes as and when they occur. So in consumer packaging industries, it is common to have huge warehouses filled with the pre printed packaging materials. Such storage will mean inventory maintenance and track-ing as well as significant wastage due to excess materials and obsolescence in graphics or materials due to aging.

The foregoing makes it very clear that if package printing could be incorporated in a packer system, then there are several advantages which result in significant cost savings. Though this fact has been recognized for some time, it is only now that the developments in technology have made it possible for major players in the industry to seriously consider this option. An understanding of the strengths and the limitations of the digital technology, and incorporating this technology in an intelligent manner will assure success, avoiding difficult problems like metallic printing for the time being. However, significant invest-ments and developmental efforts need to be made before the technology will be mature enough to meet the needs, and gain widespread acceptance. The advantages of flexible printing/packaging will provide significant compe-titive advantages as well as new ways of marketing and customization for early adapters of this technology.

Packaging Options

A variety of materials have been used in packaging applications, the most common being paper and plastic. Among these, paper may be the most widespread material in different forms like soft packages, hard packages, and cartons and cases. Apart from holding and protecting the product, the packages also serve as decorative and adver-tising media for the products they contain. We have decided to target the paper packaging for implementing the digital printing technology. The type of packaging machin-ery will vary depending upon whether soft packages, which use roll labels, or hard packages which use hard blanks are used. The variable information in these packages is usually limited to a portion of the printing on the package. Typical examples of the variable information being date and bar codes, ingredient information, region or country specific codes, or different languages for the global and export markets. Once the technology is successfully implemented, it could be used for other marketing and promotional applications as well.

Although the speed and resolution requirements vary greatly depending upon the product and package in ques-tion, we could summarize the range of requirements as follows: Product speed ranging from a few tens to several hundreds pieces per minutes, the most common speeds being 100-300 per minute. Resolution required range from 200 dpi to 600 dpi achievable with Gravure or Offset printing, with good abrasion and water resistance as well as fade resistance. Generally speaking, pigmented inks are necessary to meet these requirements. If the digital printing unit is appended to the packaging machinery, then it is imperative that it meet the quality and the speed require-ments of the product line. Some of the other issues to be considered are the drying time for the ink as well as any residual solvent retention which may not be acceptable, and material handling on the factory floor.

Implementation Options

Customized printing could be incorporated in the industrial or consumer packaging process at different steps in the process. For complete flexibility, printing should be incorporated as a part of the final packaging step. This system provides total flexibility, as the printing could be changed on the fly, providing all the advantages of a truly on demand printing/packaging system. However, the printer and the packing unit are completely tied together, with the result that any problems with the printer will shut down the whole unit. Moreover, such a system will need real time on line inspection to verify the integrity of the printing, which adds more complexity to the process. Some of the other issues to be considered are the drying times, need to vent solvents, and material compatibility of any residual solvents from printing, etc. The second option is to have a just in time printing operation close to the final packaging operation, but separate from the packaging unit itself. Such a scheme will not provide the complete flexibility of a

print/package unit, but provides many advantages compared to the conventional process. The last option is to incorporate digital printing along with the conventional printing systems in a hybrid printing unit, and use the flexibility offered by the digital printing at the conventional printer itself. Among the three, this scheme is the least flexible and provides only a few advantages. However, such a system might provide the necessary throughput and customization required for some applica-tions. Though less flexible compared to the other two, the major advantage of such a scheme is that the printing and the packaging steps are separate, and thus will not result in shutting down the packaging unit every time problems arise in the printer.

Table I. Requirements for industrial applications.

Runnability	*No missing jets* *No jamming* *Uninterrupted run per shift*
DPI	*About 300 dpi for text*
Printing Speed	*~ 150 ft/min*
Short term periodic maintenance	*Once a shift* *Cleaning cycle less than 10 min*
Print Quality	*Print density comparable to Gravure* *Dry time of less than of 3 - 10 sec. depending on application* *No smearing* *Print tolerance/registration of 0.03"* *No satellites*
Robustness	*Print independent of fluctuations in packaging environment* *Print adjustment available* *Printer integratable with current process control*
Ink	*Compatible with environmental and any other (e.g. regulatory) requirements*
Auxiliary Systems	*Vision control for print verification and rejection if needed*

Elements Required for Success

It is needless to say that if the technology has to be incorporated, then any additional demands the technology puts on the process and the operator have to be more than Offset by the impact the technology has in terms of return on investment (ROI). However, it should be realized that there is a paradigm shift when the digital printing is incor-porated, providing additional opportunities for customiza-tion and marketing, whose impact on the business is as yet intangible, but may be quite substantial. Some of the elements that are required for success are enumerated in the following: Since the packaging also provides an image for the product and works as an advertising/marketing tool as well, the quality achieved by the new technology should be comparable to the current quality standards. This requirement may be relaxed in some cases where only a small portion of the printing is digital, i.e. date or bar coding for example. If the implementation is done on the packaging unit itself, then it is necessary that the unit be seamlessly integrated. Moreover, the operator should not be burdened with additional tasks due to the added piece of the equipment. The system should be reliable enough as not to adversely affect the reliability of the packaging unit and should not reduce the throughput. The system should be compatible with the overall process control and auto-mation of the packaging unit. It should be easy to operate and service, so that the operators do not have to go through complex training for its operation and mainten-ance. It should support quick changeovers of different brands, and be easily replaceable and upgradable. These and other technical requirements are summarized in table 1.

Technology Options

It has been already pointed out that multi deflection contin-uous ink jet technology has been successfully used in packaging applications for printing limited information like date coding. However, the quality of printing from this technology is very poor. The binary CIJ systems could provide better quality and throughput in the packaging applications, but it is not very easy to incorporate it in a production environment. It might be suitable for a hybrid printing system where the variable information is printed at the converters. Drop on demand technology shows the most promise, and with new technology development and system integration could be incorporated in an integrated print/package system.

As is well known, there are two types of DOD ink jet technologies, thermal and Piezo. We think that the recent advances in Piezo technology have made it possible to use this technology in an integrated print/package unit. Some of these developments are the reliability of the technology, as well as the fact that the printheads last for billions of drops, and can jet several gallons of ink reliably. Piezo printheads are currently available from different vendors with number of nozzles ranging from about a hundred to about 500. The nominal resolution of these printheads is quite low, from less than about 80 – to around 180 in some cases. The maximum print swath available is less than 3 inches. The printheads have been successfully used with a variety of inks, ranging from simple water based dye inks to solvent and oil based UV and hot melt inks.

Fig. 1 shows a block diagram of a printing unit which could be appended to the front end of a packaging unit using blanks. As far as the packaging unit itself is con-cerned, its operation is hardly changed as it still depends on the blank feed from the conveyer belt in the front. The operator will do the same blank loading operation, only in this case, the blanks will have regions spared out so as to receive digitally printed variable information. For a practi-cal system, we need a print swath of at least an inch or

more, with about 2 inches perhaps being suitable for many applications. This means that to achieve the required resolution, printheads have to be stitched to together. Much of the system integration effort will go towards engineering the printhead stitching and the blank feeder mechanism. A post drying unit might have to be incorporated to facilitate drying as the drying time available is limited. A vision system to inspect the print may also be necessary to assure the print quality with a mechanism to reject any misprinted blanks.

These auxiliary units are easily incorporated within the system shown in fig. 1.

Biography

Henry M. Dante is currently at Philip Morris research and development where he is responsible for implementing digital printing technologies. He got his Ph. D. in Electrical Communication Engineering from Indian Institute of Science, Bangalore and worked as a faculty member in Electrical Engineering in India and at Tufts University, Medford. He has been with Philip Morris from 1988 where he has worked on developing vision systems, process control, modeling and simulation and implementing new technology.

Georgios Karles received his Ph.D. in CHE from the University of Texas at Austin in 1990. He then worked at the University of Texas as a postdoctoral fellow investigating heterogeneous catalysis. From 1992 to 1997 he was with International Paper in Tuxedo, NY working on developing papers with tailor made properties through chemical or physical modifications. George has been with Philip Morris since 1997 working on specifications for packaging materials and assessing and implementing new packaging and printing technologies.

Arup K. Basak is a research staff member with Digital Printing Group at Philip Morris USA, R & D Center, Richmond, Virginia. His research interests include solution chemistry, reaction mechanisms, chemical synthesis, thermodynamics and physical chemistry. He has a Ph. D. in Chemistry with vast experience in colloids, polymers, as well as in analytical and applied chemistry.

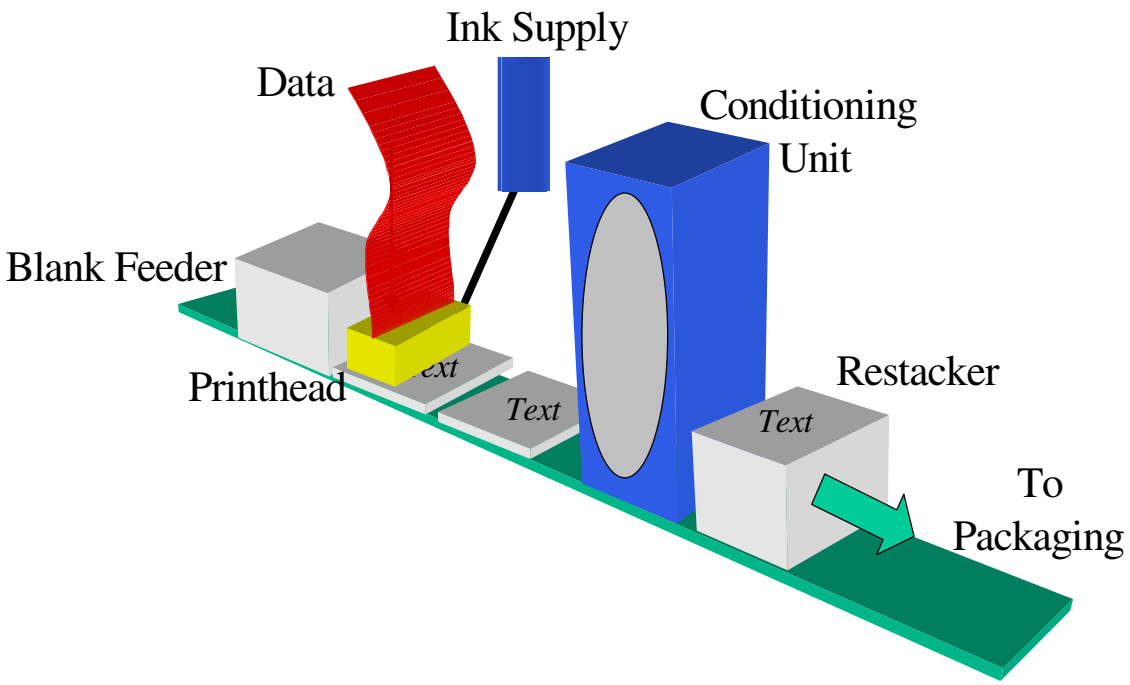

Figure 1. Schematic of prototype printer for printing variable information on packaging.