

Architecture and Design of a High Resolution, Wide Format Printing System for Check Production

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Abstract

Check Technology Corporation of Minnetonka, MN has developed a high performance, large format, check production system called Imaggia. A core component of Imaggia is the Gemini electron beam imaging print engine purpose-built for Check Technology by Delphax Systems of Mississauga, Canada.

These systems are producing daily at both check and other security document printers in France, England and Canada.

Imaggia uses an innovative dynamic collation strategy to pick multiple types of cut sheet paper stock in the exact "book" sequence necessary for the final document. These can be printed with 100% variable information, sheet to sheet, across the full media dimensions of 18" x 22" at a speed of more than 100 sheets per minute (200 ppm).

Introduction

In this paper we will look at the unique and challenging requirements of the financial security printing market, the conventional check printing process, and the evolving market demand for increased document personalization in smaller quantities. Finally, we will examine Check Technology's Imaggia system, the fully variable-content digital printer, which responds to these challenges at a price and performance level competitive with the traditional process.

Unique Requirements of the Security Documents Market

Designing a comprehensive, variable content digital printer, capable of "on-demand" printing of a complete checkbook -- in one all-embracing production-scale process, cover to cover -- means handling some of the most challenging printing problems and ranges of paper stocks.

No Mistakes Allowed

Using a checkbook as a specific example of a secure document, some unique requirements must be met for a successful production. Extraordinary measures must be taken to avoid inadvertently printing or inserting one customer's checks into another customer's checkbook. Neither can the producer afford to print checks with missing or skipped sequence numbers, or that do not exactly match the separate MICR line information.

Erasable Security Inks Pose Production Challenges

International banks typically insist on pre-printed base stock with built-in, anti-counterfeiting measures, such as the use of erasable inks. These are designed to render it impossible to mechanically erase or alter information on the check without revealing the attempt. This presents a direct contradiction. Check printers want a system that securely fuses toner to and into a surface that contains erasable inks designed specifically not to be receptive to over-printing with the hot or high pressure processes of electrophotographic non-impact printing.

Such inks also are prone to contaminate the image transfer, creating a need to develop special purging strategies within the system.

Paper Weights Vary Widely

Carbonless papers are commonly used as an interleaved duplicate sheet, especially in North American checkbooks. Most laser printers cannot pass these through their fusing station effectively without breaking the microcapsules.

Worse still, carbonless papers are lightweight -- typically less than 14 lb. stock -- rendering them difficult to handle successfully in high speed, cut sheet printers.

At the other end of the paper spectrum, the checkbook cover is heavyweight tag stock, up to 135 lb. material.

Customer Requirements vs. Banking Industry Standards

Check layouts are dictated by a detailed code developed by the American National Standards Institute. This allocates significant sections of the check surface real estate to specific purposes. Little room is left for the increasing consumer appetite for extensive personal information and graphics. We have had to accommodate this by permitting tight vertical font leading strategies going well beyond typical desktop publishing requirements or norms.

A Toner That Does It All

Another well-known, unique characteristic is the need to design a general purpose toner satisfying a single print engine solution.

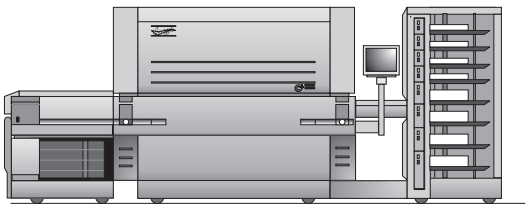
First, the toner must satisfy world banking authorities' requirement that Magnetic Ink Character Readable (MICR) lines be printed and magnetically read on each check. This toner also must be capable of producing excellent commercial standard print quality -- 600 dpi for fine point-size text, line graphics and half-tones. The industry standard set by the traditional offset lithography process is the target to be met.

MICR lines not only need to meet magnetic signal strength and geometric criteria; the printed characters also must withstand up to 30 check reader/sorter passes within the financial clearing system, perhaps after being mangled in the mail or creased in the pocket of the consuming public. These sorters are very fast and can apply significant mechanical abrasion to the MICR line. The toner formulation must be tough enough to withstand this abuse, yet not so tough that the toner itself abrades or contaminates the reader/sorter magnetic heads. Furthermore, the same toner has to meet a host of other criteria dictated by the engine performance, print quality and permanence demands. We will discuss some of these issues later in this paper.

The Conventional Check Printing Process

We need to look at the pros and cons of traditional technologies used in conventional check printing to ensure we achieve a net improvement in most, if not all, areas of comparison.

The conventional process consists of modifying a sheet-fed offset press to print a single "personalized" plate design on a pre-collated set of sheets compiling most, but not all, of a complete checkbook. The modifications include adding mechanically indexed impact printing numbering wheels, typically working through a consumable MICR ribbon, and the use of a very short run, disposable paper offset plate.



Imaggia MG20

Advantages With Hidden Costs

The advantages of this process can be illusory. Evolving over many years of press offset process technology, print speed is relatively high. However, this is partially negated by the poor operating efficiency needed to manually re-load a plate, pre-imaged off-line, for every checkbook run (say every 50 sheets) and re-set the multiple numbering wheels every time.

The incremental cost per sheet printed may be low, but less so when adding the maintenance cost. The equipment generally is very old, needing relatively high maintenance and attention.

The printer's mindset may by that the equipment is very economic, since it already is "written off." However, the conventional process carries other significant hidden cost factors. Significant contributors are the extensive pre- and post-collation processes, the pre-plate imaging steps, and the relatively high waste of make-ready and numerous inter-sheets required to pass through the dynamic mask changes.

Paper feeding reliability - this is one key challenge to match with a hot electrophotographic process.

Limited Personalization Capabilities

The disadvantages of a traditional process stand out more clearly. The ability to introduce personalized information, or true variables, within a single checkbook product is very limited.

The "smoke and mirrors" method is employed. Mechanical plates obscure and reveal different portions of the plate for print transfer at different stages of the checkbook run.

The checkbook is a perfect vehicle for inserting personalized marketing information. With a conventional press-based production process, this is virtually impossible without extensive post-collation labor.

Labor Intensity Introduces Security Risk

The whole press process, especially collation, is very labor intensive and introduces measurable risk of human error in a security document product. It demands a difficult combination of skilled operators, performing a repetitive job, supplemented by frequent inspection stages to catch errors that might slip through.

Profit at the Expense of Fewer Choices for the Customer

Finally, the process may only be economic if the printer can run 40 or more pages between plate changes. This is the underlying reason why North American consumers are given little choice when they reorder checkbooks. They receive multiple quantities of books with large numbers of checks in each one, every time they order.

It's a necessity forced upon them by the economics of traditional offset print process. In fact the international model, and likely to transfer to America, is a trend to "short-run" checkbooks and temporary "starter kits" for new customers. Furthermore, the current phenomenon of bank mergers is driving a need to regularly change nameplates on base stocks.

The Imaggia Solution

Check Technology set out to solve all these problems at a price and performance level competitive with the traditional printing process. The result is Imaggia MG20, a fully variable-content digital printer.

Key Features

- **Multi-bin dynamic collation** - any sheet picked in any sequence
- **Single "nip" paper path** - employs transfuse process, no unfused/fixed toner carried on paper medium.

Imaging and development entirely separate process for transfer of toner to paper medium.

- **Low temperature & pressure print engine** - conformal coating on transfuse belt distributes pressure such as to achieve a relatively low lineal pressure at the dwell region of the transfuse nip. A variety of toners have been characterized that require a transfuse temperature in the range 120 to 145 degrees C.
- **Standard finishing system interface** - allows economic connection of a variety of CTC and third-party finishing products according to a customers application requirement.
- Integrity protection features
- NT based system server
- Windows WYSIWYG Format Designer application program

Paper Handling

A dynamic collation strategy picks, in sequence position, 18" x 22" sheets from multiple stock types

These sheets are processed through a unique de-skew and registration station before delivery to the print path where 100% variable data imaging can occur at speeds over 100 feet per minute.

Preheating of the paper and the unique single "nip" paper path of the print engine ensure excellent permanence of a custom MICR toner, designed to service the world-wide check printing market.

Unique Print Engine Technology

The paper path is perfectly straight, no bends - hence permitting the high paper weight support, and delivering high handling speeds. This architecture is unique for industrial strength, sheet fed production printers.

The engine runs at comparably low temperatures and lineal pressures compared to conventional Xerographic processes.

This permits printing on and handling of various complex media, not otherwise easily printed with fused toner technology.

Finishing

After imaging, the sheets are cooled and resynchronized for delivery to various finishing module options

Multiple processors are distributed throughout the system to coordinate collating, registration, print engine/image synchronization and output delivery systems.

A complex example of a full on-line system implementation will be discussed.

Integrity Features

Given the sensitivity of the printed material, various security features are incorporated into the system to guard against misfeeds, double picks and print sequence loss resulting from a paper jam.

Bar code scanning is provided to automatically verify pick sequences using auto-detecting code algorithms. Further advanced extensions are planned on this strategy, extending to verifying precise print features and real-time MICR quality verification.

Windows NT Client Server

An NT based system server is used to manage and merge customer data with graphics content into a dynamic format for delivery to the built-in system RIP. A new NT & Win95 application program, Format Designer, substantially reduces the time necessary to layout and preview repetitive, graphically oriented check styles and similar forms.

Overview

The Imaggia is a unique, next generation check, and other alternative application, variable digital printing system Its unique features will be fully illustrated in this paper

Approaches to the Architecture - Printers vs. Digital Presses

There are two distinctly different approaches to setting up the system architecture in high speed variable data printing solutions:

A modeling the system as a "printer"

B modeling the system as a "digital press"

The difference is that the "printer" is able to print completely different pages from page to page. The digital press, like a press, duplicates an image or a set of images over several pages, most of the time.

The majority of the data does not change. The data that does change from page to page tends to be sequential or related in one way or another.

Printer Approach

This approach offers many future possibilities for the system, certainly beyond main line check printing, e.g. check writing, direct mailing and demand publishing applications.

In this mode, the system must be able to handle a PDL at full speed.

Normally requires a large amount of processing power, memory and the attendant additional hardware and software development efforts compared to the "digital press" approach.

Digital Press Approach

This approach very closely models the current offset press printing methods. Images are pre-processed before the run starts. There is very little change in the data from page to page, compared to the "printer" approach.

Because there is little variability, this approach can reduce requirements on computing hardware.

It also tended to integrate into existing U.S. check production operations much more directly.

The Imaggia system has rapidly evolved from an initial Digital Press architecture towards that of a full Digital Printer system.

Alternative applications, International Check printing evolution and a trend to more complex, short run check books in North America have all reinforced this migration effort.

Labor Cost Reduction

Pre-collation no longer a necessary process - Imaggia will dynamically pick form up to 8 different bins containing one or more stocks/pre-printed material, collating and printing each, as required, on the fly.

This is done this with any size sheets in the range 11" x 11" to 18" x 22" size sheets, including handling heavy tag stock (up to 135 lb.), lightweight carbonless or duplicate material (14 lb.).

An operator can re-load bins whilst the Imaggia is drawing material from an alternate bin - allowing literally uninterrupted production flow.

Trouble-Free Operation

Paper handling issues like jams and missed-picks are extremely rare - if they occur, including false-doubles, the Imaggia will detect the problem and, as required, divert such sheets whilst maintaining a record of the event to allow automatic recovery and continuation of the printing job without loss of a critical sheet.

The high performance is facilitated by the unique, single "nip" paper path through the Gemini engine. Sheets are accelerated through the collation system into sequence position (typically 1in. paper gaps maximum) , adjusted for accurate process direction pre-registration and "no skew" before delivery into the print path. This includes a pre-heating track to ensure excellent toner permanence and supplementary active registration to control long term registration characteristics.

After printing the sheets are cooled and position re-synchronized for delivery into various finishing system modules.

Toners - MICR & Otherwise

The engine can print with fully MICR-capable or regular toners.

This permits full support of any bank check applications (the primary target market of the technology) or other variable printing applications requiring the characteristics built into the Imaggia, e.g. personalizing calendars, lottery tickets and ID documents.

As discussed in the introduction - the toner development is very challenging in this application. Firstly excellent behavioral characteristics within the engine for consistently good print quality with adequate operational margins are essential. Secondly, accommodating the often competing interests of MICR performance and security ink compatibility. Coates, Delphax and Check Technology have perfected this formulation using a polyester binder resin technology but with the key addition of a friction-reducing release additive to ensure low impact on reader sorter mechanisms while maintaining good permanence and fusing using a high softening point binder systems. *Reference 1*

The engine can print at 600 dpi permitting good quality half-toning for images, graphics and logos etc.. The engine runs at a comparably low temperature compared to conventional Xerographic processes - in the range of 125 to 145 degrees C - permitting printing on and handling of various exotic materials not otherwise easily printed with fused toner technology.

Other Features

- Speed is very high - 22 i.p.s., extendible in the future to 30 i.p.s. and more.
- Registration is excellent for this class of sheet fed technology.
- Consumable running costs are very low - including all consumables as well as toner. The design goal was to match the most efficient offset press-based check systems.

The system includes CTC's Standard Interface capable of supporting many varieties of finishing systems including stackers, slitters, gluers and staplers.

Front End System

The front end print system software includes an NT based print administrator/server. This permits integration with, for example, Sequel-server engines to allow high speed variable print data for high-end mail merging, custom form creation.

The system includes sophisticated report generation capabilities, both collecting job and print engine-specific logging data.

CTC offers a highly performance-tuned file database front end interface and is also supporting the industry standard PostScript II print description language - the latter is especially appropriate for graphic arts variable print applications.

Front-End Application Support

The System Administrator NT workstation server supports the programming and importing of Customer Data, Paper Stock types, Format names, Pick Bin Configurations, Sequence, Check Style, Format design and job characteristics.

A new NT & Win95 application program - Format Designer -- substantially reduces the time necessary to layout a check styles.

High Performance Sheet-Fed Check Production

The complete architecture is designed to permit effectively uninterrupted check job production -- e.g. running without a hold-up for a 30,000 sheet run in a one shift operation.

The Imaggia automatically producing 1000's of fully collated check orders continuously, including changes in styles and graphics features from order to order, *without pausing!*

The Printer Engine

– The Imaggia MG2O print module is based on the Delphax Gemini print technology. Its functional specifications are:
– Base resolution is 600 x 600 dpi of both image and MICR characters.
– Base resolution is interpolated to produce print quality that is visually effectively indistinguishable from an offset press.
– Print speed is 101 18.5" x 12" sheets per minute.

Stock from 14 lb. to 135 lb. can be printed in any sequence.

New technology print process can often enable printing on carbonless forms, coated stocks, foils, and other traditionally "difficult" stocks.

The print process is similar to an offset press plate and blanket process.

Toner is dry when it is added to the printer and is transformed into a semi-liquid state within the system. The image is then placed onto paper utilizing a heated belt.

Specific Engine Application Requirements

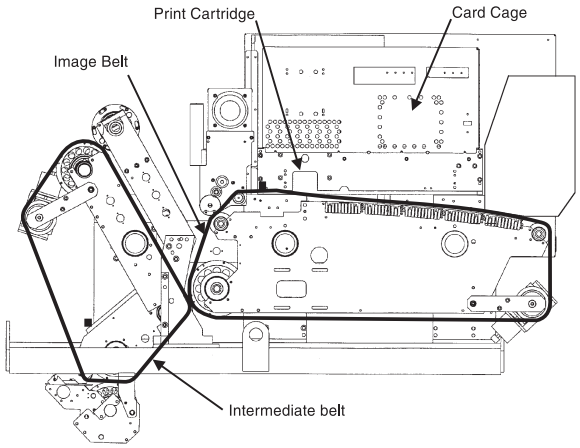
Key is the MICR capability, E13B and CMC7. Must be able to print carbonless (NCR), cardstock, etc.

Image permanence must achieve tape pick-off resistance >98% and a crease resistance >93%.

Delphax's electron beam imaging technology was selected coupled with a mono-component, magnetic conductive toner to achieve the required print quality and speed performance. *Reference 1*

MICR Capability

This employs a Dual belt Transfer / Fuse (Transfuse) permitting complete separation of imaging and fusing functions and carrying various other operational advantages.



The Gemini Engine

Modes of Operation (Stock Presentation)

The stock for Print jobs can be presented in one of three ways.

No-collation Stock Presentation

No-collation or normal stock presentation requires collation on the printer where each different stock type is loaded into separate bins.

Jobs running in this mode need to be setup so that the job knows where stock is loaded.

The printer is then responsible for picking the correct stock in the correct order for each image printed.

Partial Collation

Partial collation refers to sets of stock in multiple bins and is similar to no collation in that stock is picked from multiple locations but the stock in some or all bins may change through the stack.

This allows multiple bins to be assigned different stocks.

When multiple jobs requiring several stock types are grouped together, the stock is collated into sets.

Full Collation

Full collation presents stock to the printer in the same order it is to be printed.

This mode reduces the number of bins requires and the intelligence required for picking the correct sequence.

Reloading of some stock or ejection of a run when there is an error in collation or a jam occurs is required.

PostScript

In the absence of a clear *Open Standard* in the industry for the variable, personalized printing of security documents like checks – CTC is developing a PostScript-based front end language in conjunction with key customers.

This will support all three collation modes.

Process Flow for PostScript Centric Digital Printing

A PostScript file can contain multiple images for a given Order Group and are combined into a Postscript file.

In addition to images, the file is embedded with special header information (stored as PostScript comments) that contains folio information for the Run.

The complete file then has all information needed to describe and run the job.

The process used to build up the Digital Press PostScript starts with grouping customer orders together by common attributes. The details of the files are then combined into a single PostScript file.

Later multiple PostScript files can be joined together into a batch or block of runs and redefined as a single run or job. PostScript files may be run in a single order group or the file can contain several order group files concatenated together.

In the event that Partial or None Pre-Collated stock presentation is used, the printer would need to be notified of the different types of stock to allow the Operator to load the stocks in separate bins.

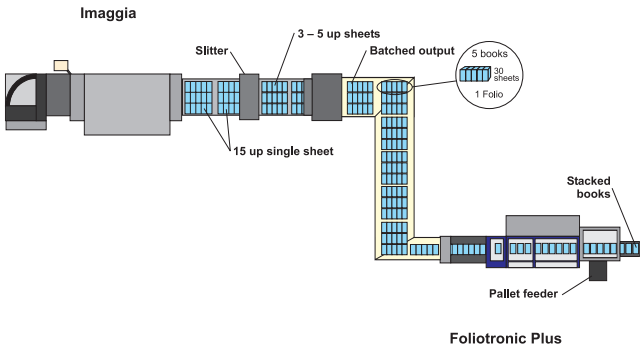
Application Example

The plan view below illustrates a fully automatic check book printing and binding system starting directly with completely un-collated, blank, large format paper stock.

The Imaggia initially feeds an on-line slitter developed jointly by CTC and Rollem, UK, and interfaced by the CTC Standard Interface. In this example - checks are printed 15 up(per sheet) - in 3 columns of 5 checks each - typically comprising multiple customers' checkbook pages. The slitter separates these into 3 individual "slices" of 5 checks each and batches them into 30 sheet piles. These are then conveyed and fed individually on line to the CTC Folotronic guillotining, stapling and edge binding system.

They are guillotined as they enter the binding section, thus permitting fully complete, individual checkbooks to be delivered - effectively directly into ready-prepared mailing

boxes, the mailing label being also automatically printed simultaneously on the Imaggia.



An Imaggia/Slitter/Batcher/Conveyer/Folio Example - Plan View

This is but one example of an advanced, automated check production system incorporating all the purpose-built features of the Imaggia to move on form traditional offset-press-based, highly manual operations.

Conclusion

This paper has reviewed many of the special requirements that need to influence the design and implementation of a production digital variable MICR printer if it is to satisfy the market requirements of check printing and similar security applications whilst being an attractive alternative to current conventional processes often based on specialized offset press technology.

References

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2. Sam Theodoulou, *IS&T 49th Annual Conference* September 1997, Seattle, GEMINI: A technologically advanced platform for high speed, wide format electronic printing.

Biography

Peter J. Wood holds a B.S. in Physics and is a chartered engineer (MIEE). He has specialized in the development and application of electronic color pre-press product technologies for the professional printing, publishing and corporate in-house markets. He also has been involved in the innovation and management of electronic page make-up systems, electronic screening, RIP subsystems and the world's first digital CMYK color scanners.

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